Automotive Information Index

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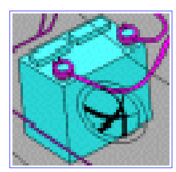
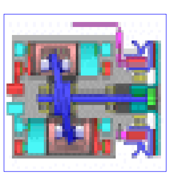

Electricial Systems


A/C & Heating Systems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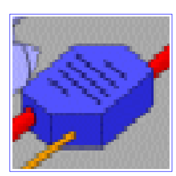
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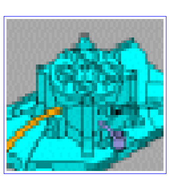
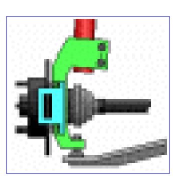
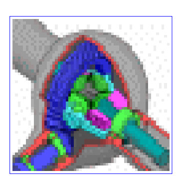

Fuel & Intake Systems


Suspension & Steering


Drive Train

[About Auto-Insight And This Program]

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Mostly Text Version

Please Select Area Of Interest Below

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SERVICE DEPARTMENT

INQUIRY FORM

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We are sorry but Autoshop-Online is currently closed for service questions.

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AUTOSHOP ON LINE

SERVICE DEPARTMENT

HOW IT WORKS

The Service Department is where the AUTOSHOP Online team answers your questions and helps you solve problems regarding your car. Here are the steps in submitting an inquiry.

INQUIRY FORM

Based on our many years of experience, we've developed an Inquiry Form that will help you give us the information we need to assess your automotive needs. Please fill out the form as completely and accurately as you can. Then choose the delivery method that suits your needs: either electronic or fax. We will forward the form directly to the appropriate team of experts, who will begin working on your inquiry right away.

RESPONSE TIME

The team will respond to your request by the end of the next business day. If necessary, the team may contact you for more information, either by email or phone (if you give us your phone number).

ADDITIONAL HELP

You may ask a follow-up question during the week after receiving our initial response. There is no additional charge for this follow-up question as long as it relates to the original inquiry. Either use the Further Assistance Form in our Customer Feedback Department, being sure to include your case number, or send reply email directly from the email response delivered to you. (You can also fax a follow-up question if our response was delivered by fax: be sure to include your case number.)

PAYMENT OPTIONS

The fee is $29.95 for each inquiry. You may select from a number of payment methods. We accept the following major credit cards: American Express, Discover, MasterCard, and Visa. You can also use First Virtual, the Internet payment system, which enables simple, secure financial transactions over the Internet.

See the About Security section for details on how these payments are handled over the Internet. Or you can complete the fax version of the inquiry form and credit card authorization.

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SERVICE DEPARTMENT

FURTHER ASSISTANCE

We are sorry but Autoshop-Online is currently closed for service questions.

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EXPERT ADVICE YOU CAN RELY ON

AUTOSHOP ONLINE

YOUR FIRST STOP FOR ANSWERS ON AUTOMOTIVE REPAIR, MAINTENANCE AND OPERATION.

SERVICE DEPARTMENT

VISIT THE SERVICE DEPARTMENT FOR INTERACTIVE

SERVICE DEPARTMENT

DIAGNOSTICS AND ADVICE ON THE CARE AND MAINTENANCE OF YOUR VEHICLE. OUR STAFF OF CERTIFIED TECHNICIANS WILL TACKLE ANY ISSUE FOR JUST $29.95.

CAR CARE TIPS NEW

WE'VE TEAMED UP WITH THE CAR CARE COUNCIL, THE MOST WIDELY RESPECTED SOURCE OF AUTOMOTIVE INFORMATION IN NORTH AMERICA. AUTOSHOP-ONLINE BRINGS YOU THIS EVER-EXPANDING LIBRARY OF FREE INFORMATION REGARDING PREVENTIVE MAINTENANCE, FUEL CONSERVATION AND THE SAFE OPERATION OF MOTOR VEHICLES.

car care council

TIPS

AUTOMOTIVE 101 NEW

AUTOMOTIVE 101 IS A FREE TUTORIAL ON THE INNER WORKINGS OF THE MAJOR SUBSYSTEMS OF THE MODERN AUTOMOBILE. YOU'LL FIND EXTENSIVE INFORMATION ON TOPICS SUCH AS THE ENGINE, DRIVE TRAIN, SUSPENSION, HEATING & AIR CONDITIONING AND MORE.

AUTO 101

About AUTOSHOP-Online

WELCOME to AUTOSHOP-Online, the United States' largest independent car and truck repair helpline. Since 1987, our automotive experts have helped professional mechanics solve over a half-million difficult repair problems. Through AUTOSHOP-Online, you now have direct access to experts and information for solving your automotive problem.

Have you ever wished you could...

- Ask someone other than your mechanic about what's wrong with your car?
- Anticipate what major repairs may be in your car's future?
- Get independent advice if your car isn't repaired correctly the first time?
- Get assistance from factory-trained technicians and do the repairs yourself?

The AUTOSHOP-Online team is staffed by factory-trained technicians with years of troubleshooting experience who have earned the highest ratings awarded by various car manufacturers: Honda Top Tech or the Master Technician rating from makers like BMW, Chevrolet, Chrysler, Ford, and Nissan.

AUTOSHOP-Online also provides valuable information at no cost including:

- Automotive 101
- Tips from the Car Care Council
- And check out What's New for site updates and some recommended links, including:
  - Our Hot Links
  - Government Recall Notices

Visit the Service Department and submit your problem or question to one of our five car-line teams: Asian, Chrysler, Ford, European, and General Motors. Whether we draw on past experience or utilize the combined talents of the team, we will provide expert advice you can rely on. (**Currently Closed**)

And to be sure, we support these teams with a huge collection of automotive reference materials, including over 5,000 original factory service manuals, three electronic libraries with up-to-date recall and technical service bulletins, plus our own Identifix(TM) database, which contains the most frequent repair problems and their solutions for over 10,000 different makes, models and years of vehicles. And since we tackle another repair every minute, our knowledge base continues to grow.

Get the answer to YOUR automotive question or repair problem for only $29.95, by visiting the service department. Your satisfaction is guaranteed, and we will respond by the end of the next business day. (**Currently Closed**)

AUTOSHOP ONLINE

To contact us call toll free:
800-288-6220
USA and Canada, 8:00 am to 6:00 pm Central Time, Monday-Friday

AUTOSHOP-Online Recognition

NetPresence, Inc. awarded AUTOSHOP-Online the "Best of Buy IT OnLine" on 10/31/96. Check out their review: "...We particularly like the high level of confidence you instill in visitors.... You put forth your credentials, apply your extensive resources, and guarantee your answers. "**This should be the first stop when car trouble strikes!**"

Featured as one of Car and Driver's Favorite Web Sites. (We appreciate that it's near the top of the list, too!)

Selected as InfiNet's Categorically Cool Site of the Day, for commercial sites, for 2/9/96.

Selected for the Microsoft Network's Pick of the Week, listed under Interests and Fun, for the week of 1/24-1/31/96.

Whatsnew@AUTOSHOP-Online

Keep your eye on this page for the latest information about helpful automotive services at AUTOSHOP-Online and elsewhere on the Internet. Some examples of what's new and what's coming...

"National Car Care Month" Press Kit

> The 1996 National Car Care Month Press Kit, produced by the Car Care Council, is available now. National Car Care Month is a nationwide effort by businesses, civic groups, the government and the media to focus motorists' attention on the need to maintain and repair their cars. Although events are held throughout the year, October is an ideal time for motorists to get their cars ready before winter strikes. You can download the official Press Kit in PDF format from our Tips department.

TIPS From the Car Care Council

> As a standing feature of AUTOSHOP-Online, we provide a series of FREE autocare hints for owners of all types of vehicles. Now we've teamed up with the Car Care Council, the most widely respected source of automotive information in North America, to bring you an ever-expanding

library of free information regarding preventive maintenance, fuel conservation and the safe operation of motor vehicles.

AUTO 101

Announcing the arrival of our comprehensive, FREE automotive information service, which we call AUTO 101. Through our partnership with a publisher of automotive educational materials, you are now able to explore the complexities of the modern automobile and all of its major mechanical and electrical systems, right here at AUTOSHOP-Online. It's just like having a mechanic in the family.

HOT LINK

The Automotive Service Association (ASA) has launched a new site dedicated to assisting consumers and automotive service professionals. ASA is an international organization made up of approximately 12,000 member-businesses that work to deliver excellence in mechanical, collision and transmission service to consumers.

Features on the growing site include the online version of *AutoInc.*, the official publication of ASA, and a shop locator, directing consumers to a nearby ASA member shop that provides the services they need.

Visitors to the site will also find general Automotive Tips and Consumer Research. And a little digging uncovers insider tips to service technicians, and detailed articles of interest to those working on cars, whether professionally or at home.

SAFETY NOTICES

From time to time, the United States National Highway Transportation Safety Administration (NHTSA) publishes automotive safety notices. This information is available by make and model, by calling the Department of Transportation Auto Safety Hotline at 888.327.4236 (888-DASH-2-DOT).

NEW! This information is now searchable on the WWW. Use this link to go directly to the NHTSA Safety Problems & Issues page.

SERVICE DEPARTMENT SAMPLE QUESTIONS TIPS HOME PAGE

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MAINTENANCE TIPS
FROM THE CAR CARE COUNCIL

[Jump to Car Care Library Index]

CAR CARE COUNCIL NEWSLETTER

Download the 4-page (136K) Spring 1997 Newsletter from the Car Care Council. This quarterly publication requires the Adobe Acrobat Reader, which you can download free from Adobe.

The Spring 1997 Newsletter includes the following articles:

- Used Car Book Could Save Buyers A Bundle
- "Good Question . . ." by Cathy Reichow
- This Mother's Day Surprise Her With An Automotive Gift
- Celebrate Procrastination Week...
- There IS Something We Can Do About Rising Costs...
- Oxygen Sensors: A Key Component...

Previous Newsletters:

The Winter 1997 Newsletter includes the following articles:

- New Computer Program Offers Help On Car Care
- "Good Question . . ." by Cathy Reichow
- Quiz Book Can Add Fun & Challenge To Car Care
- Thinking Of Keeping That Leased Car? Check It Out.
- Winter Can Be A Tough Season On Your Vehicle's Paint Finish

The 1996 National Car Care Month Press Kit includes the following articles:

- Your Car Care Tip Can Win A Prize
- Autumn Is No Time To Neglect Your Tires
- Finding Good Mechanics In High-Tech Times
- Exhaust Emissions Check Telss A Lot About Your Engine
- Good Maintenance Records Boost Car's Trade-In Value
- Annual 7-Point Cooling System Checkup Can Benefit Automotive Consumers
- Be A Part Of A Great Environment Success Story By Properly Maintaining Your Motor Vehicle
- Changing Seasons Are Car Care Reminders
- Strong Batteries Boost Winter Car Starts
- Road Improvements Can Help Improve Traffic Safety
- Give A Good Squeeze To Detect A Bad Hose
- Play It Safe: Air Bags And Anti-Lock Brakes
- Shock & Struts--More Than Just A Comfortable Ride!

The Spring-Summer 1996 Radio Scripts include the following:

- Fuel Injection
- Dead Battery?
- Cooling System
- Owner Neglect
- Owner's Manual
- Brakes
- Exhaust Emissions
- General Maintenance
- Check That Leak
- Tire Safety
- Lighting
- Tires & Alignment
- Used Car
- Interior
- Communications
- Anti-Lock Braking System
- High Speed Driving
- Parking Brake
- Ride Control
- Replace or Rebuild

Spring 1996 Newsletter

Winter 1996 Newsletter

CAR CARE LIBRARY

The extensive Car Care Council Library has been made available to AUTOSHOP users and is listed here. Look for new articles in the following categories as they are added:

- Brake Systems
- Choosing An Auto Mechanic
- Climate Controls
- Cooling Systems
- Electrical Systems
- Emissions Controls
- Fuel Economy
- General Maintenance Tips
- Paint, Appearance And Upkeep
- Preventive Maintenance
- Suspension Components
- Tire Care
- Transmission Dos And Don'ts
- Used Car Wisdom

Brake Systems

Choosing An Auto Mechanic

Climate Control

Cooling System

Electrical Systems

Emissions Control

Fuel Economy

General Maintenance Tips

Paint, Appearance And Upkeep

Preventive Maintenance

Suspension Components

Tire Care

Transmission Dos And Don'ts

Used Car Wisdom

Car Care Corner

From Car Care Council: Your source for car care features and fillers.

Winter 1997 Features:

- New Computer Program Offers Help On Car Care
- "Good Question . . ." by Cathy Reichow
- Quiz Book Can Add Fun & Challenge To Car Care
- Thinking Of Keeping That Leased Car? Check It Out.
- Winter Can Be A Tough Season On Your Vehicle's Paint Finish

Date of next issue:

March, 1997

Topics to be covered:

- Service Record Keeping
- Quiz Book
- Sensors
- Drive Line Quiz
- Vehicle Inspection

Car Care Council editorial information is distributed free of charge and is available upon request. All information is available for reprinting in other publications.

Car Care Council is a nonprofit 501(c)(3) organization dedicated to providing motorists with information on the importance of vehicle maintenance and repair.

Catch us on the Web at: www.peoplevision.com/carcare.
E-mail: carcare@infinet.com

—January, 1997

Update

Cathy Reichow, co-owner of Dan R's Automotive Sales & Service, ASE Certified auto parts specialist and President of the Toledo, OH Chapter of Automotive Service Association is now an editorial contributor to Car Care Council.

Her articles will cover frequently asked questions by motorists. Her response will hit right at the heart of issues motorists contend with every day. We think you will find her subjects of interest to your readers not only in the automotive sections, but also in general interest and women's sections.

Let us know how you use her articles.

New Computer Program Offers Help On Car Care

Car Care Council

Here's a great way to turn your computer into a piece of car care equipment. Just slip Carley's Car Care Guide into your IBM-compatible personal computer and you'll have an electronic book at your fingertips.

It provides helpful hints and detailed instructions on all aspects of basic maintenance. It also features a huge glossary of technical terms.

In addition, there are articles on technical subjects of current interest, such as anti-lock brakes (ABS), air bags, emissions, computerized engine controls and many more.

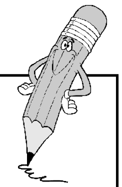
The Car Care Guide, an MS-DOS program that also can be run under Windows, comes on a 1.44 MB, 3.5 inch diskette. It requires a mouse, VGA or SVGA color monitor and hard drive.

You can order your guide by sending a check or money order for $14.95 to Car Care Council, Dept.WE7-CCG, One Grande Lake Drive, Port Clinton, OH 43452.

car care council

One Grande Lake Drive / Port Clinton, OH 43452 / (419) 734-5343 / (419) 732-3780 (fax)

"Good Question . . ."



Co-owner of Dan R's Automotive Sales & Service, ASE Certified Auto Parts Specialist and President of the Toledo, OH Chapter of ASA, Cathy is now an editorial contributor to Car Care Council whose purpose is to educate motorists about vehicle maintenance and repair.

by Cathy Reichow

Q. My yellow check engine light comes on—what does that mean?

A. When a yellow check engine or service engine soon light comes on, you should make an appointment to have your vehicle checked. What that light means is that the computer is sensing a problem. It could be very minor such as a sensor out of range or it could be that a sensor needs to be replaced. If a <u>red</u> light comes on, your car needs immediate attention. Shut off the engine and have it checked out right away.

Q. I took my car to a shop and they charged me for two hours of diagnostic charges. Why does it take two hours on the diagnostic machine to find out what is wrong with my car?

A. Unfortunately there is no "magic machine." What it requires to accurately diagnose today's vehicles is a combination of a few things. First the technician needs to properly road test the vehicle, then he may do a visual inspection of your vehicle.

He may do a series of scan tests, computer code tests, fuel pressure and volume test, wiggle and tap tests, and finally he may need to scope the engine—this all requires time. It's not unrealistic for today's vehicles to require 3 to 4 hours to accurately diagnose a driveability concern.

Q. Do I have the right to ask what brand of parts a repair shop used on my car?

A. When you take your vehicle to a shop for repair, you should not only get an itemized bill with part number and brand name, but it should list everything that was done on your vehicle. The best advice I can give you is to find a shop that does this—gives you a detailed invoice of what was performed and what parts were replaced. You should be offered to see or take your old parts if you want to. It's also great if the shop can document if there is anything else your vehicle may need in the future. That way you can budget for future needs.

Q. I was in an accident where the right side of my car got hit. The air bag did not go off—how come?

A. Most cars that are equipped with air bags have three sensors that activate the air bag system. When you are involved in an accident two out of the three air bag sensors need to be activated for the air bag to deploy. Most sensors are located in the front of the vehicle; therefore, unless you have nearly a head on collision, the air bag will not deploy.

Q. The yellow ABS light comes on for my brakes. Does that mean I won't have any brakes?

A. When the yellow ABS light comes on that means that something for the ABS system is not functioning properly therefore your ABS system will not function. The ABS (anti-lock brake system) is designed to work in panic stops. It keeps the wheels from locking up and skidding. Your regular brakes will function the way they were designed to work from the factory. ABS is, however, a very important safety feature and I would recommend you have the system checked by your shop as soon as you can.

Four out of five cars
need maintenance. Is
your's one of them?

Quiz Book Adds Fun And Challenge To Car Care

Car Care Council

If you'd answer "true" to the statement that spark plugs should be removed and oiled periodically or that a lock-up torque converter is an anti-theft device, *The Car Care Quiz Book* may be for you. That's the title of the fact-filled book being offered by the Car Care Council.

Written for the motorist who's more than passively interested in keeping his/her vehicle operating safely and dependably, the book consists of 11 chapters of multiple choice quizzes, each followed by a chapter of answers.

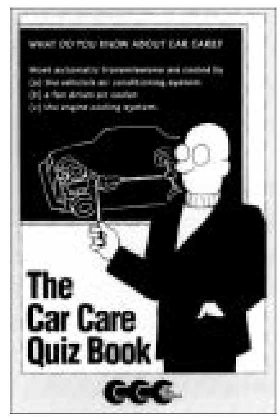
To add a light touch to the text, the author sprinkles some whimsical choices among the 330 possible answers. For example, "for maximum freeze protection, your antifreeze mixture should be:
a) half antifreeze & half water.
b) pure antifreeze.
c) 70% antifreeze & 30% water."

"Detailed explanations to each question are serious, as are the introductions to each chapter," emphasizes Don Midgley, President of the nonprofit industry group. The 91-page book presents an important, often complex subject in concise and easily understood terms.

According to Midgley, automotive maintenance need not be an intimidating topic. Because of its challenging, sometimes humorous style, this book offers the reader an enjoyable as well as money-saving experience.

The Car Care Quiz Book was written by the Council's editor, Art Nellen; illustrations are by cartoonist Terry Colon.

The publication is offered for $5.95. To order, please send a check or money order to Car Care Council, Dept. WE7-B, One Grande Lake Drive, Port Clinton, OH 43452.



Thinking of Keeping That Leased Car? Check It Out.

Car Care Council

Leasing has become a popular way of acquiring a vehicle. For those who face the decision regarding turning the vehicle in at the end of a lease vs. taking ownership, Car Care Council offers a suggestion: invest in a comprehensive inspection by an independent expert before the lease has expired. This is especially important in the case of a high mileage vehicle.

A vehicle with 50,000 miles or more may need maintenance and repair work that can add hundreds of dollars to the cost of acquisition. The check list should include such parts as drive belts, brake pads, filters and fuel ignition system components.

While few, if any, of these components will need attention on most lease-end vehicles, the possibility of excessive wear or damage does warrant a close inspection.

Even in early stages of a lease, a damaged rubber CV boot, for example, can soon lead to expensive repairs. Car Care Council offers a pamphlet that includes a comprehensive check list for anyone responsible for the maintenance and upkeep of a vehicle.

For a free copy, send a business-sized, self-addressed envelop to Car Care Council, Dept. WE7-XI, One Grande Lake Drive, Port Clinton, OH 43452.

Car Care Fillers

Car Care Council

ANTI-LOCK BRAKES—Anti-lock brakes can drastically reduce accidents, but only if they are used correctly. Many motorists are still pumping the brake pedal, says the Car Care Council. For safe stops with anti-lock brakes, apply firm and continuous pressure to the pedal and continue to steer normally.

WINTER—Driving in a blinding snowstorm is no fun. But, if you have no choice in the matter, it's reassuring to know your car is up to the task. Good tires are a "must." For clear vision you want plenty of anti-freeze washer solvent in the reservoir and good wiper blades. Be sure all lights are working, too.

Make sure both you and your car are ready for whatever old man winter can send your way.

Winter Can Be A Tough Season On Your Vehicle's Paint Finish

I-CAR

Snow, rain, ice, road salt and gravel - all can contribute to the deterioration of even today's durable finishes. Yet, there are some simple things you can do to help protect your vehicle's paint this winter and throughout the year.

"Caring for your car's paint is obviously a good investment," says David Heckeler of I-CAR, a nonprofit collision repair training organization. "A well-maintained finish enhances the vehicle's value at trade-in time. More importantly, the paint helps prevent rusting of sheet-metal parts."

Therefore, one of the best ways to protect your vehicle's finish, according to Heckeler, is to park out of the elements, whenever possible. If you do have to park outdoors in the winter, don't use an ice scraper on anything but the windows; scraping ice or snow off painted surfaces is likely to damage the finish.

If you live in an area that uses road salt to melt ice or snow, Heckeler says it's a good idea to frequently clean and rinse areas of the vehicle where salt might collect. This includes the engine compartment and wheel wells, lower trim pieces, and inside door edges.

Another culprit identified by Heckeler is gravel used to improve traction on slippery roads. It can be damaging to a vehicle's finish.

Slow down, not only to avoid losing control of your vehicle, but also to reduce the amount of gravel kicked up onto your vehicle and the vehicles behind you. Stay far enough back from the vehicle in front of you so that you're not driving into a spray of gravel.

I-CAR suggests other ways to protect your vehicle's finish throughout the year:

· Avoid parking in direct sunlight, particularly in the summer. Parking in a garage or shady area is desirable, but try to avoid parking under trees that may drip sap onto your vehicle.

· Remove tree sap, bird droppings, gasoline or other harsh materials from your vehicle's finish as quickly as possible.

· Wash the vehicle when it is cool and parked out of direct sunlight. Wet it down thoroughly, then wash using warm water, a clean, soft wash mitt or sponge, and a car-wash soap. Never wash any panel unless it is thoroughly wet. Start with the roof and work your way down and around, rinsing each section as you finish. To rinse, take the nozzle off the hose and just let the water flow freely over the entire car. Dry it with a clean chamois or soft towel.

· Wax your vehicle at least twice a year. Wax only when the vehicle is clean and cool. Having it in a garage or enclosed area will help prevent dirt and dust from blowing onto the finish while waxing. Use a high-quality car wax, apply it with a wax applicator, and remove it with a clean, soft cloth.

WHEN WASHING ISN'T ENOUGH

If part of your vehicle needs repainting, choose a repair business carefully. Poor paint work may have a big impact on its resale value.

In choosing a repair and painting business, look for evidence that the technicians have been properly trained in paint matching and application.

Most paint manufacturers offer technician training in the proper use of their products. Further, look for evidence that the technicians have received current training in collision repair and refinishing.

"Preparation, color matching and application are among the courses offered by I-CAR for body and paint technicians," Heckeler says, "We want to match not only the appearance of the original paint, but also its durability and corrosion protection."

The I-CAR Gold Class Professionals designation signifies that at least 80 percent of a shop's staff are I-CAR trained. The Gold Class designation was established to help consumers identify businesses that have invested in proper training.

By requalifying for the Gold Class designation every year, repair businesses and insurance claims offices demonstrate their commitment for the I-CAR philosophy of restoring vehicles to pre-accident condition. For the location of an I-CAR Gold Class business near you, call 1-800-ICAR-USA.

From Car Care Council: Your source for automotive-related radio scripts.

Spring/Summer—1996 Topics

- Fuel Injection
- Dead Battery?
- Cooling System
- Owner Neglect
- Owner's Manual
- Brakes
- Exhaust Emissions
- General Maintenance
- Check That Leak
- Tire Safety
- Lighting
- Tires & Alignment
- Used Car
- Interior
- Communications
- Anti-Lock Braking System
- High Speed Driving
- Parking Brake
- Ride Control
- Replace or Rebuild

Date of next issue:

August, 1996

Car Care Council radio scripts are distributed free of charge. They include a commercial break for selling time to car dealers, automotive service and parts outlets or other automotive-related advertisers.

Because the information is authoritative and generic, this material is suitable for use as public service announcements with no commercial connections.

Car Care Council is a nonprofit 501(c)(3) organization dedicated to providing motorists with information on the importance of vehicle main-tenance and repair.

— May, 1996

Send Us Those Postcards!

The Council would like to know how you're using its materials. Please take a few minutes to fill out the enclosed postcard and you may even win a portable CD-player. Get those cards in by May 15, 1996. We'll let you know who won in the next issue of "On The Air With Car Care."

FUEL INJECTION

HERE'S A MULTIPLE CHOICE QUIZ FROM THE CAR CARE COUNCIL. WHEN YOUR FUEL INJECTION EQUIPPED CAR RUNS POORLY, IT MIGHT BE DUE TO A FAULTY FUEL PUMP. THE REMEDY COULD REQUIRE:

(A) REPLACING THE CARBURETOR.

(B) DRAINING THE GAS TANK.

(C) INSTALLING A NEW IGNITION SWITCH.

WE'LL BE RIGHT BACK WITH THE ANSWER.

(COMMERCIAL BREAK)

BACK TO OUR QUIZ. CAR CARE COUNCIL SAYS (B) IS CORRECT. ON SOME FUEL-INJECTED VEHICLES THE FUEL PUMP IS INSIDE THE GAS TANK, WHICH COULD NECESSITATE DRAINING THE TANK TO REPLACE IT. AS FOR ANSWER (A) THERE IS NO CARBURETOR ON A FUEL-INJECTED ENGINE . . . AND (C) THE IGNITION SWITCH WOULDN'T LIKELY AFFECT THE WAY YOUR CAR RUNS.

One Grande Lake Drive / Port Clinton, OH 43452 / (419) 734-5343 / (419) 732-3780 (fax)

RIDE CONTROL

CAR CARE COUNCIL ANSWERS A QUESTION I'VE HAD ABOUT AUTOMOTIVE TERMINOLOGY. YOUR CAR MAY HAVE SHOCKS, STRUTS OR A COMBINATION OF BOTH. SO WHAT'S THE DIFFERENCE? THE COUNCIL OFFERS SOME USEFUL INFORMATION THAT WE'LL PASS ON TO YOU RIGHT AFTER THIS.

(COMMERCIAL BREAK)

WE'VE BEEN TALKING ABOUT CARS . . . SPECIFICALLY, ABOUT SHOCK ABSORBERS AND, ON LATER MODELS, STRUTS. SINCE THE 1920'S, SHOCK ABSORBERS HAVE BEEN USED ON A CAR TO CONTROL ITS SPRING ACTION . . . THE ADVENT OF FRONT WHEEL DRIVE HAS CHANGED THE SUSPENSION SYSTEM OF A CAR. NOW A STRUT, CONSISTING OF A SHOCK ABSORBER AND COIL SPRING . . . FORMS A MAJOR COMPONENT OF THE SUSPENSION SYSTEM. IF YOUR CAR BOBS UP AND DOWN OR SWAYS ON TURNS, YOU MAY NEED NEW SHOCKS AND/OR STRUTS. WHEN IN DOUBT, CHECK IT OUT.

REPLACE OR REBUILD

HERE'S AN INTERESTING NOTE FROM THE CAR CARE COUNCIL. BETTER RUSTPROOFING COMBINED WITH LONGER LASTING INTERIOR FABRICS MEAN EVEN AN OLDER VEHICLE MAY STILL BE IN GOOD SHAPE, BUT THE ENGINE MAY NEED MAJOR WORK. CONSIDER REPLACING THE ENGINE INSTEAD OF THE CAR, SUGGESTS THE CAR CARE COUNCIL. THIS IS A DECISION THAT CAN SAVE YOU MONEY AND GIVE YOUR CAR A NEW LEASE ON LIFE. WE'LL TELL YOU MORE WHEN WE RETURN.

(COMMERCIAL BREAK)

WE'RE BACK WITH INFORMATION ON HAVING A WORN OUT ENGINE REPLACED RATHER THAN TRADING IN YOUR OLD CAR . . . YOU CAN HAVE A REMANUFACTURED ENGINE INSTALLED FOR UNDER $2,500 ON MOST CARS. . . POSSIBLY LESS THAN THE SALES TAX ON A NEW CAR . . . A REMANUFACTURED ENGINE SHOULD PERFORM LIKE NEW FOR YEARS AND IT WILL MAKE THE CAR WORTH MORE AT TRADE IN TIME . . . THERE ARE OTHER ECONOMIC BENEFITS AS WELL, SAYS THE CAR CARE COUNCIL. YOU WON'T BE FACED WITH INCREASED INSURANCE PREMIUMS. . . AND IF CASH OUTLAY IS A PROBLEM, FINANCING USUALLY CAN BE ARRANGED WITH LOW MONTHLY PAYMENTS. THE COUNCIL SAYS REBUILT ENGINES OF ALL TYPES ARE READILY AVAILABLE FOR ALL POPULAR DOMESTIC AND IMPORT CARS, LIGHT TRUCKS, VANS AND SPORT UTILITY VEHICLES.

DEAD BATTERY?

TODAY'S CAR CARE QUIZ IS ABOUT A COMMON MALADY. IT'S A BALMY SPRING MORNING . . . YOU TURN THE KEY TO START YOUR CAR AND THERE'S NO RESPONSE. NOT EVEN THE HORN OR LIGHTS WORK. YOUR CAR MAY HAVE DEVELOPED:

(A) A FAULTY STARTER SOLENOID.
(B) A CLOGGED GAS FILTER.
(C) CORRODED BATTERY CABLES.

WE'LL GIVE YOU THE ANSWER RIGHT AFTER THIS.

(COMMERCIAL BREAK)

BACK TO OUR NO-START QUIZ. THE REASON YOU COULDN'T START YOUR CAR WAS (C) . . . CORRODED BATTERY CABLES. CORROSION, USUALLY A GREENISH WHITE DEPOSIT ON THE TERMINALS, ACTS AS AN INSULATOR, PREVENTING CURRENT FROM FLOWING FROM THE BATTERY TO THE STARTER . . . AS WELL AS EVERYTHING ELSE ON THE VEHICLE THAT DEPENDS UPON ELECTRICITY. AS A PREVENTIVE . . . AND CORROSIVE MEASURE, SAYS THE CAR CARE COUNCIL. REMOVE THE CABLES, CLEAN THE CONTACT SURFACES AND RECONNECT THEM. BE SURE CONNECTIONS ARE TIGHT. APPLYING A CORROSION INHIBITOR, AVAILABLE AT MOST AUTO PARTS STORES, CAN PREVENT A RERUN OF THIS INCONVENIENCE.

COOLING SYSTEM

A SURVEY OF REPAIR SHOPS DISCLOSES THAT TWO THIRDS OF MORE THAN 8,000 COOLING SYSTEM REPAIR JOBS WERE DONE ON AN EMERGENCY BASIS. THAT MEANS THE VEHICLE NEEDING REPAIRS OFTEN HAS BEEN DISABLED ON THE ROAD. THIS LEADS US TO OUR CAR CARE QUIZ QUESTION: WHICH OF THE FOLLOWING IS CORRECT?
YOUR CAR'S COOLING SYSTEM:
(A) COOLS THE INTERIOR IN SUMMER.
(B) PREVENTS THE TRANSMISSION FROM OVERHEATING.
(C) NEEDS SERVICE EVERY 100,000 MILES UNDER NORMAL USE.
THINK ABOUT IT WHILE WE BREAK FOR THIS COMMERCIAL.

(COMMERCIAL BREAK)

THE ANSWER TO OUR CAR CARE QUESTION IS (B); THE ENGINE COOLING SYSTEM ALSO PROTECTS THE AUTOMATIC TRANSMISSION. CONSEQUENTLY, THERE IS DOUBLE JEOPARDY WHEN COOLING SYSTEM MAINTENANCE IS IGNORED. THE TRANSMISSION CAN BE DAMAGED BY ENGINE OVERHEATING. CAR CARE COUNCIL SAYS IT IS A GOOD IDEA TO CHECK TRANSMISSION FLUID AFTER A VEHICLE HAS OVERHEATED . . . AS FOR THAT HUNDRED THOUSAND MILE SERVICE INTERVAL, THAT ANSWER IS FAR FROM THE TRUTH. GIVE THE COOLING SYSTEM A GOOD GOING-OVER ANNUALLY, SAYS THE CAR CARE COUNCIL, INSPECTING ALL BELTS AND HOSES. THEN, AT LEAST EVERY OTHER YEAR, FLUSH THE SYSTEM AND REPLACE THE ANTIFREEZE.

OWNER NEGLECT

ANOTHER QUIZ FROM THE CAR CARE COUNCIL. WHICH OF THE FOLLOWING TOPS THE LIST OF INVENTIONS PEOPLE COULD NOT LIVE WITHOUT?

(A) TELEPHONE

(B) LIGHT BULB

(C) AUTOMOBILE

THE ANSWER MAY SURPRISE YOU . . . STAY TUNED

(COMMERCIAL BREAK)

WHICH OF THE FOLLOWING IS INDISPENSABLE IN YOUR LIFE? YOUR TELEPHONE, THE LIGHT BULB OR YOUR CAR? ACCORDING TO AN M.I.T. POLL, THE AUTOMOBILE WAS CHOSEN BY 63% OF RESPONDENTS AS THE INVENTION THEY COULD NOT LIVE WITHOUT. THE LIGHT BULB, PHONE AND TV, IN THAT ORDER, TRAILED BEHIND OUR BELOVED CARS.

SURPRISINGLY, AS MUCH AS WE DEPEND ON OUR VEHICLES WE CONTINUE TO NEGLECT THEM. NATIONAL CAR CARE MONTH INSPECTION LANES LAST OCTOBER DISCLOSED THAT NEARLY NINE OUT OF TEN VEHICLES NEEDED MAINTENANCE. WORN OR IMPROPERLY INFLATED TIRES ACCOUNTED FOR 73% OF THE TOTAL, FOLLOWED BY EXCESSIVE EXHAUST EMISSIONS.

OWNER'S MANUAL

YEAR AFTER YEAR, THE GLOVE COMPARTMENT OWNER'S MANUAL IS AMONG THE MOST WIDELY PUBLISHED BOOKS IN AMERICA. IT'S ALSO AMONG THE LEAST READ. TODAY'S CAR CARE QUIZ ASKS: WHICH OF THE FOLLOWING ADVICE IN THE OWNER'S MANUAL IS MOST COMMONLY IGNORED?

(A) FINDING AND REPLACING A BLOWN FUSE.

(B) PROPER TIRE ROTATION.

(C) SEVERE SERVICE MAINTENANCE.

YOU SAY YOU CAN'T EVEN FIND YOUR OWNER'S MANUAL? WE'LL HAVE THE ANSWER AFTER THIS COMMERCIAL.

(COMMERCIAL BREAK)

BACK TO OUR QUIZ. AS IMPORTANT AS IT IS TO KNOW ABOUT FUSE LOCATIONS AND TIRE ROTATION, SEVERE SERVICE MAINTENANCE DESERVES SPECIAL ATTENTION, SAYS THE CAR CARE COUNCIL. IF, FOR EXAMPLE, YOU DRIVE IN TEMPERATURE EXTREMES, UNDER DUSTY CONDITIONS, NORMALLY TAKE SHORT TRIPS OF LESS THAN 10 MILES . . . IF YOU TOW A TRAILER OR OTHERWISE SUBJECT YOUR VEHICLE TO TOUGH DUTY, YOU'LL NEED TO TAKE CARE OF MAINTENANCE SERVICES MORE FREQUENTLY. CONSULT YOUR OWNER'S MANUAL TO SEE IF YOUR TYPE OF DRIVING REQUIRES MORE FREQUENT SERVICE.

BRAKES

TODAY'S CAR CARE QUIZ IS ABOUT THE BRAKING SYSTEM. HERE'S THE SCENARIO . . . YOUR OLD RELIABLE SERVICE TECHNICIAN HAS HANDED YOU A BILL FOR BRAKE WORK JUST COMPLETED. IT INCLUDES AN UNEXPECTED CHARGE OF $100 FOR NEW ROTORS. SEEKING AN EXPERT SECOND OPINION YOU FIND THAT:

(A) NEW ROTORS ARE NEEDED ONLY WHEN BRAKES FAIL COMPLETELY.

(B) YOU SHOULD REPORT **OLD RELIABLE** TO THE BETTER BUSINESS BUREAU.

(C) ROTORS DON'T LAST FOREVER.

STAY TUNED FOR THE ANSWER.

(COMMERCIAL BREAK)

RETURNING TO OUR CAR CARE QUIZ . . . IF YOU SELECTED ANSWER (C) GO TO THE HEAD OF THE CLASS . . . BRAKE ROTORS DON'T LAST FOREVER. MOST SHOPS WILL RESURFACE THE ROTORS FOR SMOOTHER, QUIETER BRAKING ACTION. BUT WHEN THEY ARE CRACKED, DAMAGED OR ARE WORN BEYOND SAFE LIMITS, THEY HAVE TO BE REPLACED. CAR CARE COUNCIL EMPHASIZES THAT IT'S FOOLISH TO PINCH PENNIES ON SAFETY MAINTENANCE SUCH AS BRAKING SYSTEM REPAIRS.

EXHAUST EMISSIONS

THIS WEEK'S CAR CARE QUIZ QUESTION RECALLS WHEN YOU COULD BUY "LEADED REGULAR" GAS IN ANY SERVICE STATION. TECHNICALLY CALLED TETRA-ETHYL LEAD, THIS ADDITIVE CAME ON THE MARKET IN THE 1920'S AND BEGAN DISAPPEARING FROM THE SCENE IN THE 1980'S. THE REASON FOR GETTING THE LEAD OUT WAS:

(A) DAMAGE TO THE ENGINE.

(B) CARBON BUILDUP IN THE COMBUSTION CHAMBER.

(C) LEAD POSED A HEALTH HAZARD.

WE'LL COME BACK WITH THE ANSWER AFTER THIS.

(COMMERCIAL BREAK)

THE ANSWER TO OUR CAR CARE QUIZ SHOULD BE EASY FOR ANYONE FAMILIAR WITH EPA'S EFFORTS TO CLEAN UP OUR ENVIRONMENT. TETRA-ETHYL LEAD WAS INVENTED IN 1921 TO IMPROVE THE ANTI-KNOCK QUALITY OF GASOLINE. IT WORKED GREAT BUT IT POISONED OUR ATMOSPHERE IN TWO WAYS. FIRST, POISONOUS LEAD WAS BEING DUMPED INTO OUR AIR AND SECOND, LEAD FOULS SPARK PLUGS, CAUSING POOR RUNNING ENGINES AND HIGH EXHAUST EMISSIONS.

THE LEAD IS GONE BUT EXHAUST EMISSION PROBLEMS ARE NOT. RESULTS OF THE 1995 VEHICLE INSPECTION PROGRAM DURING NATIONAL CAR CARE MONTH DISCLOSED THAT 35% OF VEHICLES FAILED THE EMISSIONS TEST.

CAR CARE COUNCIL EMPHASIZES THAT PERIODIC DIAGNOSTIC CHECKS AND NEEDED MAINTENANCE ARE ESSENTIAL TO IMPROVING THE QUALITY OF THE AIR WE BREATHE.

GENERAL MAINTENANCE (20 SECONDS)

A DEFENSIVE DRIVER IS A SAFE DRIVER . . . AND YOU CAN BE DEFENSIVE EVEN WHEN YOU'RE NOT BEHIND THE WHEEL, SAYS THE CAR CARE COUNCIL. MAKING SURE YOUR CAR IS PROPERLY MAINTAINED IS YOUR BEST DEFENSE ON THE ROAD. HAVING YOUR TIRES, BRAKES AND STEERING CHECKED AT REGULAR INTERVALS PROTECTS YOU AGAINST PROBLEMS THAT ARISE DUE TO NEGLECT. NATIONAL CAR CARE MONTH STATISTICS REVEAL THAT NEARLY NINE OUT OF TEN CARS NEED MAINTENANCE OR REPAIR. IS YOURS ONE OF THEM?

TIRE SAFETY (20 SECONDS)

JET SKIERS PAY GOOD MONEY FOR CRAFTS THAT HYDROPLANE WELL, BUT IN THE AUTOMOTIVE WORLD, IT'S JUST THE OPPOSITE. THE CAR CARE COUNCIL REMINDS YOU THAT GOOD TIRES HELP KEEP YOUR CAR ON THE ROAD DURING RAINY WEATHER. TIRE TREADS SHOULD BE AT LEAST 1/16TH OF AN INCH DEEP AND INFLATED TO THE CORRECT PRESSURE. THESE CHECKS PLUS SENSIBLE DRIVING WILL HELP ENSURE A SAFER RIDE.

CHECK THAT LEAK (20 SECONDS)

HAS THIS EVER HAPPENED TO YOU? YOU'RE BACKING OUT OF A SHOPPING CENTER PARKING SPACE AND DISCOVER A WET SPOT UNDER YOUR CAR. IS IT FROM YOUR CAR OR FROM THE PREVIOUS OCCUPANT OF THAT SPACE? THE ONLY FLUID YOU SHOULD NOTICE UNDER YOUR CAR IS WATER THAT'S EVAPORATED FROM THE AIR CONDITIONER. TAKE A CLOSE LOOK BEFORE DRIVING ANY FURTHER, SUGGESTS THE CAR CARE COUNCIL. WHEN IN DOUBT, CHECK IT OUT; LEAKING FLUID CAN BE SERIOUS.

LIGHTING (20 SECONDS)

STUDIES SHOW THAT USING YOUR HEADLIGHTS IN DAYLIGHT CAN REDUCE ACCIDENTS SIGNIFICANTLY. IN FACT, DAYTIME RUNNING LAMPS ARE STANDARD EQUIPMENT IN MANY NEW CARS, BUT THE MORE THIS ACCESSORY IS USED, THE QUICKER IT NEEDS TO BE REPLACED. THE CAR CARE COUNCIL URGES YOU TO CHECK YOUR LIGHTS AT REGULAR INTERVALS, BECAUSE A WELL-LIT CAR IS A SAFER CAR.

TIRES & ALIGNMENT (20 SECONDS)

THE WINTER OF 1995-1996 BROUGHT RECORD BREAKING SNOW, FREEZING TEMPERATURES AND RAIN, PERFECT CONDITIONS FOR GROWING POTHOLES. THE CAR CARE COUNCIL SAYS LANDING IN ONE OF THESE STREET CRATERS CAN RUIN A TIRE OR AFFECT YOUR CAR'S WHEEL ALIGNMENT. LEFT UNATTENDED, THE CONSEQUENCES COULD BE COSTLY AND DANGEROUS. CHECK YOUR TIRES AND ALIGNMENT AT REGULAR INTERVALS; IT CAN SAVE YOU DOWN THE ROAD.

INTERIOR (20 SECONDS)

IS YOUR CAR'S INTERIOR INFERIOR? YOUR CAR'S INTERIOR FABRICS . . . CARPET, UPHOLSTERY, AND HEADLINER DESERVE ATTENTION AS DOES THE PAINT. GIVE IT A SPRING CLEANING, SUGGESTS THE CAR CARE COUNCIL. . . AND REPAIR WORN SPOTS OR TEARS. A WELL-KEPT CAR NOT ONLY HAS A POSITIVE EFFECT ON YOUR MENTAL OUTLOOK, A SUPERIOR INTERIOR ALSO ENHANCES THE TRADE-IN VALUE OF YOUR CAR, TRUCK OR VAN.

USED CAR (20 SECONDS)

CONGRATULATIONS TO YOU GRADUATING SENIORS. YOU'RE FINISHED WITH SCHOOL BUT YOU STILL MAY HAVE SOME HOMEWORK TO DO IF YOU'RE IN THE MARKET FOR A USED CAR. GO CAR SHOPPING WITH YOUR HEAD AND NOT YOUR HEART, SUGGESTS THE CAR CARE COUNCIL. USE A CHECKLIST TO COMPARE EACH CAR'S PROS AND CONS. FINALLY, LET A QUALIFIED TECHNICIAN THOROUGHLY CHECK OVER YOUR CHOICE BEFORE CLOSING THE DEAL.

COMMUNICATIONS (20 SECONDS)

DOES YOUR AUTOMOTIVE TECHNICIAN'S STATE-OF-THE-ART TESTING EQUIPMENT ELIMINATE THE NEED FOR ONE-ON-ONE COMMUNICATION WHEN YOU HAVE CAR TROUBLE? HARDLY! YOUR INPUT CAN BE HELPFUL IN DIAGNOSING MECHANICAL PROBLEMS. THE CAR CARE COUNCIL SUGGESTS THAT YOU TAKE SOME NOTES BEFORE TAKING YOUR CAR TO THE SHOP SO YOU CAN DESCRIBE ODD NOISES, HOW THE CAR DRIVES OR THE CONDITIONS UNDER WHICH THE PROBLEM OCCURS.

ANTI-LOCK BRAKING SYSTEM (15 SECONDS)

ANTI-LOCK BRAKES CAN DRASTICALLY REDUCE ACCIDENTS, BUT ONLY IF THEY ARE USED CORRECTLY. MANY MOTORISTS ARE STILL PUMPING THE BRAKE PEDAL, SAYS THE CAR CARE COUNCIL. FOR SAFE STOPS WITH ANTI-LOCK BRAKES APPLY **FIRM AND CONTINUOUS** PRESSURE TO THE PEDAL AND CONTINUE TO STEER NORMALLY.

PARKING BRAKE (15 SECONDS)

HAVING YOUR CAR STUCK IN "PARK" ON AN INCLINE IS FRUSTRATING; THE SHIFT LEVER JUST WON'T BUDGE. THERE'S AN EASY WAY TO PREVENT THIS INCONVENIENCE, SAYS THE CAR CARE COUNCIL. SIMPLY APPLY THE PARKING BRAKE BEFORE SHIFTING INTO "PARK." THIS PUTS THE WEIGHT OF YOUR CAR ON THE BRAKE WHERE IT BELONGS.

HIGH SPEED DRIVING (15 SECONDS)

AS SPEED LIMITS ARE BEING RAISED IN MANY STATES, PEOPLE SEEM TO BE "PUTTING THE PEDAL TO THE METAL" EVERYWHERE. IF YOU ARE ONE OF THEM, ARE YOU AND YOUR CAR UP TO THE CHALLENGE? CAR CARE COUNCIL SUGGESTS HAVING YOUR TIRES, STEERING AND BRAKES CHECKED AT REGULAR INTERVALS. AND REMEMBER TO CHECK YOUR SPEED, IT CAN SAVE YOU DOWN THE ROAD.

TRANSMISSION CARE

HAVING A TRANSMISSION OVERHAULED CAN COST BIG MONEY. WITH PROPER CARE YOU MAY NEVER FACE THIS EXPENSE, SAYS THE CAR CARE COUNCIL. STAY TUNED FOR A FEW VALUABLE TIPS.

(COMMERCIAL BREAK)

OUR FIRST TRANSMISSION TIP FROM THE CAR CARE COUNCIL . . . CHECK FLUID REGULARLY AND, IF IT HAS TURNED BROWN OR SMELLS BURNED, HAVE IT CHANGED. IF YOU NEED TO ADD FLUID, CHECK FOR A LEAK AND GET IT FIXED. ALSO, BE GENTLE WHEN USING DRIVE AND REVERSE TO ROCK OUT OF MUD. FINALLY, IF YOU DO A LOT OF STOP-AND-GO DRIVING OR TOW A TRAILER, CHECK YOUR OWNER'S MANUAL FOR SPECIAL SERVICE RECOMMENDATIONS.

From Car Care Council: Your source for car care features and fillers.

Spring 1996 Features:

Used Car's "Pedigree" Begins With Good Maintenance
Engine "Transplant" Puts New Life In Your Car
There's More To Spring Cleaning Than Meets The Eye.
Check Your Brake I.Q.

Date of next issue:

June 1, 1996

Topics to be covered:

Wheel Alignment

Vision & Visibility

Cooling System

Timing Belt

Auto Fact: Transmission

Car Care Council editorial information is distributed free of charge and is available upon request. All information is available for reprinting in other publications.

Car Care Council is a non-profit 501(c)(3) organization dedicated to providing motorists with information on the importance of vehicle maintenance and repair.

—March, 1996

Surf the Net!

Automotive Information Center, (AIC) a leading provider of new vehicle product information is displaying Car Care Council material on their AutoSite web page at **http://www.autosite.com**.

As a reminder, Car Care Council information can also be viewed at **http://www.autoshop-online.com**.

Used Car's "Pedigree" Begins With Good Maintenance Records

Car Care Council

The used car business is in the fast lane, passing new car sales at a surprising rate. For budget conscious shoppers a late model used vehicle, especially one that has been well maintained, is a viable alternative to a new one.

There's less risk in buying a used car today, according to Charles Pitts, of the National Independent Automobile Dealers Association, the nation's fastest growing trade association. "Newer cars hold up better and last longer than their predecessors," he claims. "Reputable dealers are fussier about their merchandise; warranties are better, too."

Whether buying from a dealer or private party, suggests the Car Care Council, ask for maintenance/repair records. When available, they are akin to a pedigree and add to the value of a vehicle. Documenting the car care history also enhances the vehicle you're selling, a good case for keeping them.

For used car shoppers the Council offers "The Used Car Buyer's Manual" that takes the reader, step-by-step, through the buying process.

Written by expert auto broker David J. Buechel, the 175 page book helps you avoid lemons, locate bargains and sell your old car. Also included are car care tips, a directory of reliable used cars and an inspection check list.

The book is available for $9.95 plus $2.50 shipping and handling ($12.45) from the Car Care Council, **Dept. Used Car**, One Grande Lake Drive, Port Clinton, OH 43452.

Engine "Transplant"
Puts New Life In Your Car

Car Care Council

When Al and Nancy B. searched for a vehicle in which they could travel comfortably after retirement, their selection narrowed to a used van. The appearance of this 10 year old customized beauty belied its 150,000 miles. It had everything the couple had been looking for at a price below what they had planned to spend. Body and interior had been well cared for but it needed major engine work.

After a few phone calls they found they could have a completely remanufactured engine installed for about $2,000-$2,500. The most important component of the van, consequently, would be like new with a warranty.

The retirees made a decision; go for it!

As new car prices escalate, buyers and/or owners of older vehicles face similar repair vs. replace decisions. Instead of shopping the car dealers, suggests the Car Care Council, first ask for the expert opinion of your automotive technician. He (or she) can estimate the extent of repairs needed.

"Because most car owners are familiar with the most common mechanical repairs, like replacing spark plugs or drive belts, we usually can take these services in stride," says Council President, Don Midgley. "Having an engine replaced with a like-new one is a procedure that has become familiar to many owners as they realize the economic benefits."

A remanufactured engine, as the term implies, is one that has new or reconstructed components. In addition to using many new components, other durable parts such as the block and crankshaft are cleaned and machined to factory specifications. Typically, pistons, rings, bearings and timing chain or belt are new.

After the rebuilt engine is installed, fuel, ignition and cooling systems are checked to be sure everything under the hood is in top operating condition.

The economic benefits of installing a remanufactured engine vs. "trading up" go beyond purchase price, concludes Midgley. You'll save on sales tax and insurance as well.

Car Care Council offers an illustrated pamphlet citing the benefits of remanufactured engines. For a free copy, send a stamped, self-addressed envelope to Car Care Council, **Dept. NEPMA**, One Grande Lake Drive, Port Clinton, OH 43452.

There's More To Spring Cleaning Than Meets The Eye

Car Care Council

When you see a few blades of grass sprouting from your floor mat, you know it's time to vacuum out the car. For most of us, the ritual of spring cleaning the car is therapeutic, even cathartic. What a great feeling to slide behind the wheel of a car that's been cleared of a winter's accumulation, inside and out.

Even more important than attention to cosmetics, says the Car Care Council, is spring cleaning in areas that affect the function of the vehicle.

How long has it been, for example, since you cleaned the battery connections? The corrosion that may have accumulated through the winter, acting as insulation between the battery terminals and their cable clamps, can disable even the best electrical system. Connections should be removed, cleaned and, after reassembly, treated with an anticorrosive product.

Because the air filter is an engine's number one dirt catcher, it eventually loads up with minute particles that can restrict the free flow of air to the fuel system. With inadequate air to mix with the fuel, your engine becomes a gas guzzler, eventually causing high exhaust emissions, fouled spark plugs and other problems. Replacing an air filter is a quick, and easy and inexpensive spring chore.

Include the cooling system in your spring cleaning. Flush the radiator and install new antifreeze - coolant.

Your engine oil is likely to be more contaminated in the spring than at any other time of the year because of condensation that can form in cold weather. If it has not been done within the recommended mileage interval, change the oil. Also, says the Car Care Council, the dirtiest oil in your engine is trapped in the oil filter, so you don't want to mix that with the new oil. Always have a new filter installed when you change oil.

Finally, in grandpa's days cleaning the spark plugs was part of the spring Saturday ritual. Not with today's engines. By the time the spark plugs are in marginal condition they should be replaced; you may face a long summer of driving before thinking of spark plugs again.

The Council emphasizes the importance of proper disposal of drain oil and antifreeze. Don't dump them on the ground or down the sewer. Check your auto supply store for the location of the nearest disposal site.

For more information on periodic car checks, mail a stamped, self-addressed envelope to Car Care Council, Dept. UH, One Grande Lake Drive, Port Clinton, OH 43452. They'll send you an illustrated pamphlet called "How to Find Your Way Under the Hood and Around the Car."

Check Your Brake I.Q.

Car Care Council

How long is one second? About as long as it took to read the last sentence; exactly how long it takes to cover an 88 foot stretch of highway at 60 miles an hour.

Imagine, at that speed, encountering a panic situation that demands immediate braking. You may need another second or two—using up at least 100 feet—to react to get your foot to the brake pedal.Then, all going well, a few hundred feet further down the road your car will come to a stop.

Depending on the reaction time, the type of vehicle and several other factors, including the mechanical condition of your car, you hay have traveled several hundred feet from the time you first encountered the situation until you're safely stopped.

A frightening scenario! In fact, a national survey of motorists discloses that loss of braking would be the worst possible mechanical crisis a driver could imagine.

Not surprisingly, says the Car Care Council, brake failure is the leading mechanical cause of highway accidents. To heighten consumer awareness about the vital vehicle system, the Council offers this multiple choice brake safety quiz.

1. You feel the brake pedal pulsate as you come to a stop. The reason may be:
   a. worn brake pads.
   b. overheated brake fluid.
   c. warped front rotors.
2. Your car steers to the right when you apply the brakes. The reason could be:
   a. a sticking left front brake caliper.
   b. low fluid in the master cylinder.
   c. a defective parking brake pulley.
3. What is ABS?
   a. Air Bag System.
   b. Anti-Lock Brake System.
   c. A computer system acronym.
4. Your brake warning light goes on. The most common trouble:
   a. a leak in the hydraulic system.
   b. a leak in the vacuum system.
   c. worn brake pads or linings.
5. A common early warning sign of brake trouble is:
   a. a harsh scraping or grinding sound when brakes are applied.
   b. the pedal falls to the floor when brakes are applied.
   c. the wheels lock when the car is driven in reverse.

ANSWERS

1. (c) is correct. The wobbling surface of a warped brake rotor will cause an uneven or pulsating action as you stop.

2. (a) is correct. The faulty action of the left brake causes stronger braking on the right side. The result, your car wants to dart in that direction.

3. (b) is correct. ABS is an acronym for anti-lock braking system. Anti-lock brakes are designed to prevent skidding and help drivers maintain steering control during an emergency stopping situation.

Determine if your car has an anti-lock braking system by noting whether an ABS light flashes on your dashboard during ignition, checking your owner's manual, or asking your dealer.

4. (a) is correct. When you see your brake warning light go on, go directly to a technician to find out what's wrong and have it fixed.

5. (a) and (b) are correct. The harsh noise indicates excessive wear, leading to damaged drums or rotors and eventual brake failure. The falling pedal means a problem in the hydraulic system; you're about to lose your brakes.

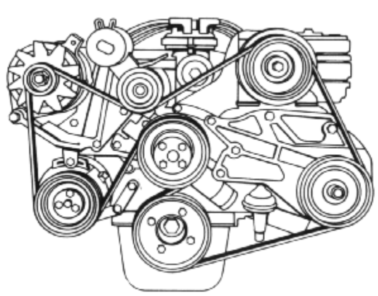
Questions like these are contained in the 90-page Car Care Quiz Book. Published by the Car Care Council, the illustrated book has informative text plus 110 questions and detailed answers covering the car from bumper to bumper.

It's available for $5.95 from the Car Care Council, **Dept. BOOK**, One Grande Lake Drive, Port Clinton, OH 43452.

Things You AUTO Know!

Depending on the year and model of your car, you may have as many as four rubber belts driving the air conditioner compressor, radiator fan, water pump and other components.

New cars have a single "serpentine" belt, as seen here, that drives everything. Failure of a belt can be catastrophic, if not inconvenient. Belts should be closely inspected and replaced as needed.



From Car Care Council: Your source for car care features and fillers.

Winter 1996 Features:

- Winter Storage Leads To Stale Gas in RV/Boat
- High Tech T.L.C. For Your Car
- Auto Fact: Batteries Get Weaker As Mercury Drops
- Opinions Vary On Car Care
- Low Mileage Used Car? Buyer Beware!
- Help Your Car Through The Cold Months Ahead

Date of next issue:

March 1, 1996

Topics to be covered:

- Spring Clean
- Vision & Visibility
- Cooling System
- Brakes
- Auto Fact: Tire Tips

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Catch Us On The Internet!

The Council's editorial materials are now available on the Internet. Our friends at Automotive Information Systems have given us a forum to display our information. We hope this makes your job easier!

http://www.autoshop-online.com

Winter Storage Leads To Stale Gas In RV/Boat

Car Care Council

Most of us who have tugged repeatedly on the starter cord of a power mower or outboard motor are familiar with the stale gas syndrome. Gasoline does not store well over long periods of time. After several months of storage, when it lies dormant in fuel lines or in the carburetor, gas may deteriorate due to oxidation, causing performance problems and obstructions in fine orifices. It also can damage rubber and other polymers in the fuel system.

The extra can of gas you may have kept around for an emergency also is a potential source of fuel system trouble, expecially if it has not had stabilizer added, which helps prevent deterioration of stored gas. While most small engine manufacturers recommend the use of this kind of product, they also warn against storing fuel for more than 30 days.

If you drive a pick-up truck, van or motor home with dual gas tanks, remember occasionally to switch from one tank to the other to avoid ending up with one tankfull of gas that's gone stale.

Car Care Council emphasizes that clean, uncontaminated gas is essential for fuel-injected engines, whose tiny orifices are vulnerable to impurities. Buy quality fuel and change fuel filters regularly, suggests the Council.

High Tech TLC For Your Car

Car Care Council

When the family car gets sick you probably worry about it. You're anxious to get Old Faithful into the shop, where you'll find a technician trained to diagnose its symptoms. His diagnostic equipment may look like the props from a science fiction movie but that's often what it takes to locate the trouble in today's complex, computer controlled vehicles, says the Car Care Council.

High-tech methods notwithstanding, the human element still must prevail. The service personnel generally do their best to maintain a high level of customer confidence, to treat every vehicle as if it were their own.

Performance problems in a late model car can be like human malfunctions except the car has several "brains," about a mile of wire and a complex system of sensors. Computers may play a role in numerous functions, including starting, steering, braking, climbing a hill, changing the inside comfort level and on and on. Microprocessors can turn on the lights, tune the radio, report how many miles until the gas tank is empty and, in some cases, lead the driver to his destination.

When any of the above functions and others fail, your technician turns to a computer to diagnose and correct the problem. Eventually he or she may tackle the repair with hand tools (special, of course) and the repair generally isn't likely to be a speedy one because of the crowded conditions under the hood.

Today's vehicles, despite their complexity, require far less maintenance and repair than their forefathers, says the Council. Unfortunately, as in the case of high-tech medical care, training and equipment don't come cheap.

Our cars not only are thinking for us, in some cases they can diagnose their own problems. With the help of computerized test equipment, trained technicians can locate and correct most driveability problems that, only a few years ago, would have eluded the best of them.

Urging motorists to recognize and act on signs of pending car trouble, Car Care Council offers a pamphlet entitled, "The Eight Most Common Signs Your Car Needs a Tune-Up." For a free copy, send a stamped, self-addressed envelope to Car Care Council, Dept. T, One Grande Lake Drive, Port Clinton, OH 43452.

Opinions Vary On Car Care

Car Care Council

"We had three people in one week come in with major engine failure due to neglected oil or cooling systems," says repair shop owner Rick Dube, of McAllen, TX. He says oil change is the most frequently neglected service among his customers.

Dube's comment was in response to a survey of Automotive Service Association members by the Car Care Council. The majority of respondents listed the cooling system as the number one area of neglect, with emission controls running a close second.

"While the National Association of Attorneys General Auto Repair Task Force is seeking ways to 'reform' the industry to help curtail unnecessary automobile repairs," notes Car Care Council President, Don Midgley, "many auto safety and air quality spokesman lament the degree of maintenance neglect that affects highway safety and air quality."

"We concur with a statement by N.A.A.G. that improved consumer education can help curtail unnecessary auto repairs. It also can help raise the motorists' level of awareness of the benefits of proper vehicle maintenance."

As ASA member Bill Pawlak, of TEAM Chevy-Geo in Westmont, IL, says it: "I wish people would read their owner's manual and invest in scheduled maintenance." He lists wheel alignment as the service most neglected on the cars coming into his shop.

For an informative pamphlet on the fundamentals of car care, send a stamped, self-addressed envelope to Car Care Council, Dept. UH, One Grande Lake Drive, Port Clinton, OH 43452.

Low Mileage Used Car Driven By Little Old Lady: Buyer Beware

Car Care Council

When young Jack Porter bought a beautiful 1977 Ford from his Aunt Maude, he figured it ought to be a really good deal. Having been driven only 23,000 miles in all those years, it should be in great shape.

To all outward appearances it was, and certainly Aunt Maude was honest. But Jack soon learned, the hard way, that a car that's been driven about 35 miles a week, little more than Sunday trips to church, can be filled with problems waiting to occur.

Consequently, driving the car the way it was designed to be driven, one thing after another arose. First it was the engine overheating. She hadn't had the cooling system flushed since Uncle Crandall died back in the mid '80's. "He always took care of everything," she lamented. Jack inherited the results of her ignorance.

Next, a ticking noise from the engine. It turned out to be a sticking valve lifter, the result of not having changed the oil in 4,000 miles. For most drivers that's a reasonable interval but for Aunt Maude it was more than two years of stop-and-go driving, the kind that can turn the oil to sludge. That sludge really messed up the inside of her engine and resulted in an expensive repair bill.

Also expensive was the replacement of the heater core, which disintegrated as a result of the neglected cooling system . . . not to mention a complete braking system overhaul because no one had looked at the brakes since before Maude and Crandall had taken their vacation trip.

Lucky for Maude that her neglected '77 Ford had not gotten her in some kind of trouble.

Jack has survived all of the fixing up and Maude now drives a new car which, thanks to the urging of her nephew, gets the more frequent service intervals recommended for her short trip, stop-and-go driving.

For anyone who drives relatively few miles a week, suggests the Car Care Council, it's a good idea to turn to the SEVERE, or UNIQUE DRIVING CONDITIONS section of your owner's manual. It's maintenance recommendations, which include more frequent service intervals for drivers who do a lot of short trip driving (under 10 miles), should be taken seriously.

The Council offers a brochure on the fundamentals of car care entitled, "How to Find Your Way Under the Hood and Around the Hood." For a free copy, send a stamped, self-addressed envelope to Car Care Council, Dept. UH, One Grande Lake Drive, Port Clinton, OH 43452.

Help Your Car Through the Cold Months Ahead

Car Care Council

One theme common to many TV commercials is car trouble on a cold winter day. The vehicle is disabled and its owner is stranded. The message, of course, is that such a crisis can be prevented through the use of the sponsor's product, be it a new battery or a cellular phone.

A seldom advertised aspect of preventive maintenance that deserves high marks for helping drivers avoid car trouble costs little or nothing. It's basic knowledge of the systems and components that should be checked and serviced to prevent failure and symptoms that signal pending failure.

Car Care Council says that, while some mechanical failures cannot be anticipated, most are preceded by some visible or audible indicator. One sample: the family that was stranded in snow when the battery went dead because the alternator light remained on due to a slipping drive belt. That predicament easily could have been avoided, first by the periodic inspection of drive belts and, later, by acting on the signal from the instrument panel.

Even if your vehicle is fairly new, use this winter check list. The Council reports four out of five vehicles that go through their inspection lanes need maintenance. And for additional tips on preparing one's vehicle for cold weather, send a stamped, self-addressed envelope to Car Care Council, Dept. W, One Grande Lake Drive, Port Clinton, OH 43452.

Winter Car Care Check List

✔Engine

- ❑ Tune-up / Check-up
- ❑ Air Filter
- ❑ Oil / Oil Filter
- ❑ Spark Plugs & Ignition Components
- ❑ Emission Control Systems

✔Exhaust System

- ❑ Muffler
- ❑ Exhaust Pipes
- ❑ Hangers/Brackets
- ❑ Catalytic Converter

✔Visibility

- ❑ Lights, turn signals, front & rear flashers
- ❑ Windshield wiper blades (winter)
- ❑ Windshield Washer Solvent
- ❑ Glass / Mirrors

✔Brakes

- ❑ Fluid
- ❑ Pads/Lining
- ❑ Hydraulic System

✔Cooling System

- ❑ Belts
- ❑ Hoses
- ❑ Pressure Cap / Thermostat
- ❑ Antifreeze / Coolant

✔Electrical System

- ❑ Battery
- ❑ Cables/Connections
- ❑ Charging System

✔Appearance

- ❑ Paint condition (scratches, etc.)
- ❑ Interior / Upholstery

✔Steering & Suspension

- ❑ Wheel Alignment / Balance
- ❑ Shock Absorbers & Struts
- ❑ Tire Inflation & Condition

✔Drive Line

- ❑ Transmission Service
- ❑ C.V. Joints
- ❑ Universal Joints

—Car Care Council

MAINTENANCE TIPS
FROM THE CAR CARE COUNCIL

Anti-Lock Brakes

If you don't already own a car or truck equipped with an anti-lock braking system (ABS), chances are you will before long. Industry analysts estimate half of all new cars and light trucks will be ABS equipped by 1995.

A potential lifesaver, ABS helps keep your car under control should you jam on the brakes on a slick road or under emergency conditions. The safety benefits will be reduced, however, without proper preventive maintenance and care. Neglecting ABS can also lead to expensive repairs down the road, according to the brake experts at AlliedSignal.

"Too many drivers, whether their cars have conventional brakes or ABS, make the mistake of thinking that replacing brake shoes and pads is all there is to proper maintenance," explains Tony Lux, ASE certified Answerman for AlliedSignal's Bendix brakes. "What they need to be more aware of is the system needs regular -- and proper-- maintenance to prevent expensive damage down the road."

What ABS Does

According to Lux, in vehicles with ordinary brakes, simply standing on the pedal under poor traction conditions is likely to cause one or more wheels to lock up, probably resulting in a skid. To avoid skids, expert drivers rapidly "pump" the brake pedal (releasing and re-applying it) when they sense wheel lockup.

"ABS provides a similar pumping action," Lux explains. "It automatically re-applies brake pressure under stopping conditions that make wheel lockup likely." But, he adds, ABS adds an advantage. "Unlike someone letting go of the brake pedal and stepping back on it, ABS can do it much faster, sensing impending skids and directing its `modulated braking' to whichever wheel, or wheels, would have locked otherwise."

How ABS Works

Lux says most of the brake parts in a car equipped with ABS are similar to those on cars without it.

"Although there are many similarities, cars with ABS have several additional parts," he explains. "ABS brake systems have speed sensors that measure wheel speed and relay this information to an onboard electronic control unit. This unit calculates vehicle speed and during a lockup, signals a hydraulic actuator which in turn applies and releases the brakes as many as 10 times per second."

Lux says speed signals from the wheels are sent to a central ABS computer. The computer compares wheel deceleration rates to the programmed vehicle while the car is braking. If any of the wheels are slowing more rapidly than the others, the computer can tell it's about to lock up. If the computer determines that a wheel is approaching lockup, it then sends a signal to the hydraulic valve block for that wheel.

"The hydraulic unit valve block contains a quantity of brake fluid under very high pressure," Lux explains. "it also has valves that can bleed off brake line pressure to any wheel(s) that may be about to lock up, while the other brakes keep working. Once the danger of wheel lock up has passed, pressurized brake fluid is again allowed to reach that brake, which resumes slowing the car. The process takes place very quickly and may be repeated several times each second."

Maintenance/Service Implications

Lux says most routine brake maintenance on ABS equipped cars and trucks shouldn't cost much more than servicing ordinary brakes.

"Anyone used to working on conventional disc and drum brakes can handle many routine brake jobs on a car with ABS," he says. "They require essentially the same procedures for replacing brake pads and shoes, and for resurfacing rotors and drums.

"Too many drivers, whether their cars have conventional brakes or ABS, make the mistake of thinking that replacing such `friction material' as brake pads and shoes is all there is to brake maintenance," Lux adds. "They need to be aware that it isn't and that all brakes -- with or without ABS -- need regular maintenance to prevent expensive damage. Skimping on maintenance with ABS can lead to even more extensive and expensive problems than with ordinary brakes."

AlliedSignal's car care expert explains that the hydraulic side of ANY car's braking system needs preventive maintenance. For example, regularly flushing out a car's or truck's brake fluid and replacing it with fresh fluid goes a long way toward preventing brake problems as the vehicle ages.

"That's even more important for a car with ABS." Lux adds. "The ABS modulator unit isn't just complicated and expensive, it will get damaged if the fluid in it is either dirty or moisture-contaminated. Since most brake fluid naturally absorbs moisture from the atmosphere, the only way to fight this problem is to regularly flush and replace the fluid every 2 years or 24,000 miles."

Lux emphasizes that anyone planning to work on the brakes of an ABS equipped vehicle **must** check service procedures before starting. Specifically, he recommends consulting the appropriate shop manual for the vehicle, and taking whatever precautions it lists.

"There are several types of anti-lock systems being offered on today's vehicles and it's important to know and understand what type you have," explains Lux. "The Bendix system, for example, has a modulator that contains brake fluid under pressure and must be depressurized before any work can be done. Other systems such as the Kelsey-Hayes and Teves, operate under little or no pressure but still require use of a manual specific to that vehicle."

Since ABS systems are relatively new, Lux suggests making sure that your mechanic is up-to-date on ABS service procedures. Fortunately, the extra steps needed to do certain ABS jobs are not complicated and don't cost much more than other brake work, and the benefits of properly maintaining your ABS brakes are worth the effort.

TIPS
FROM THE CAR CARE COUNCIL

The Car Care Council is a non-profit organization that was created over 25 years ago to educate motorists about the benefits of proper vehicle maintenance. With a membership body comprised of nearly 200 vehicle and parts manufacturers, service dealers and retailers, the Car Care Council provides information to car owners free of charge and with just one goal in mind: To protect the car owner's investment. The information that follows will help you to improve vehicle safety, fuel economy and longevity while protecting our nation's environment.

| Car Care Council | Maintenance Tips | Industry News | Car Care Quiz |
| Service Department | Home Page |

Industry News

The extensive Car Care Council Library of Industry News has been made available to AUTOSHOP users and is listed here. Look for new articles in the following categories as they are added:

- Clean Air Legislation
- Career Opportunities
- Community Involvement
- Consumer Trends

Clean Air Legislation

- NEW Cleaner Gasoline Has Come To Your Part of the Country (3/21/96)
- NEW Emission Testing (3/21/96)
- NEW What is the IM240 and Why Should Car Owners Learn More About This Program? (3/21/96)
- NEW What's New In Alternative Fuel Vehicles (3/21/96)
- NEW Proper Vehicle Maintenance (3/21/96)
- NEW Do You Really Want Clean Air? (3/21/96)

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Career Opportunities

- NEW CCAR: An Industrial Program That Benefits the Motorist (3/21/96)
- NEW A Future For Women As Automotive Professionals (3/21/96)

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Community Involvement

- NEW Community Campaign Improves Car Care Awareness (3/21/96)
- NEW Students/Teachers Collaborate in Car Care Event (3/21/96)
- NEW Teen Driving (3/21/96)
- Community Campaign Improves Car Care Awareness (1/31/96)

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AUTOSHOP ON LINE

MAINTENANCE TIPS
FROM THE CAR CARE COUNCIL

Cleaner Gasoline Has Come To Your Part of the Country

Reformulated gasoline (RFG) is one of our nation's most important strategies to reduce pollution from motor vehicles. On January 1, 1995, you found cleaner, or "reformulated," gasoline at local service stations if you live in those parts of the country with the worst ozone air pollution problems. Also, some areas with less serious problems have elected to use it. Others may do so in the future.

Reformulated gasoline is just conventional gasoline blended to burn more cleanly and not evaporate as easily. The U.S. Environmental Protection Agency has been working cooperatively with the petroleum and auto industries to make sure this new gasoline fully meets the needs of the American motorist.

Cleaner gasoline is waiting for you at the pump.

This means there will be less smog-forming ground-level ozone to damage sensitive lung tissue and make it harder for the lungs to function. When the noxious ozone level is high, joggers, people working or exercising outdoors, or people with various chronic health conditions or lung diseases may suffer symptoms such as chest pain, coughing, and stinging eyes.

Air toxics from tailpipe emissions or gasoline vapors also can be harmful. Some of the toxic compounds in gasoline (benzene, for one) and compounds created when gasoline is burned in the engine are known or believed to cause cancer. In fact, motor vehicles are estimated to account for roughly 50% of all cancers associated with exposure to air toxics.

Using reformulated gasoline reduces the total health risk to the public by reducing exposure to ozone and air toxics.

Reformulated gasoline will have no adverse affects on vehicle performance or the durability of engine and fuel system components, not even for high performance engines. In fact, the nation's major auto manufacturers support - even recommend - the use of reformulated gasoline. If you travel to a conventional gasoline area, you can fill up without any harm to your car.

Reformulated gasoline contains oxygenate additives that have been used in a significant amount of gasoline since the 1970's. Gasolines containing oxygenates may reduce gas mileage by 1 to 2 percent. Gas mileage is affected mostly by the type of engine and vehicle, driving habits, weather conditions, and vehicle maintenance. So, changing your driving habits and vehicle maintenance pattern could balance it out.

Using reformulated gasoline will not affect either the manufacturer's general warranty or the emissions warranty. For information on warranty provisions, see your vehicle owner's manual or consult a local auto dealer.

Recently, EPA has had discussions with various manufacturers of off-road engines (motorcycles, boats, recreational equipment, and lawn equipment) who have confirmed that using oxygenated fuels is acceptable, although some manufacturers offer special instructions when operating equipment on oxygenated fuels. While manufacturers' recommendations vary for the type of oxygenate that should be used in various applications, a report published in November, 1994 by Downstream Alternatives, Inc. (DAI) of Bremen, Indiana, revealed that most off-road engine manufacturers permit the use of oxygenated fuels not to exceed 10% ethenol or 15% methyl tertiary butyl ether 9MTBE) by volume.

RFG will cost a few cents more per gallon than conventional gasoline, but its a small price to pay for cleaner air and a healthy environment. So . . . now that cleaner gas is here, use it to protect your health.

REQUIRED AREAS

Los Angeles, Anaheim, Riverside-California

San Diego County-California

Hartford, New Britain, Middleton, New Haven, Meriden, Waterbury- Connecticut

New York, Northern New Jersey, Long Island, Connecticut Area

Philadelphia, Wilmington, Trenton, Cecil County, Maryland Area

Chicago, Gary, Lake County-Illinois, Indiana, Wisconsin Area

Baltimore-Maryland

Houston, Galveston, Brazoria-Texas

Milwaukee, Racine-Wisconsin

"OPT-IN" AREAS

The entire state of Connecticut

Delaware

Kentucky

Maine

Maryland

The entire state of Massachusetts

CAR CARE QUIZ

FROM THE CAR CARE COUNCIL

Watch this space for a page of interactive automotive quiz pages from the Car Care Council. Test your general automotive knowledge. (Below is a non-interactive sample.)

COMING SOON!

Electrical System Quiz

1. **A common reason for a battery to go down is**
   - ☐ **(A)** A loose alternator belt.
   - ☐ **(B)** A short circuit in the electrical system.
   - ☐ **(C)** Corrosion on the battery terminals.
2. **The best way to jump start a battery is to**
   - ☐ **(A)** Connect each terminal of the healthy battery to the corresponding terminal on the other battery.
   - ☐ **(B)** To connect corresponding terminals of the two batteries except to make the final connection on the vehicle with the dead battery to a good connection on the engine block or frame.
   - ☐ **(C)** To remove all terminals on both vehicles before making connections.
3. **When shopping for a battery you should look for one that has the most CCA's, which means**
   - ☐ **(A)** Cold cranking amps.
   - ☐ **(B)** Continuous cranking ability.
   - ☐ **(C)** Central circuit amperage.
4. **When a fuse blows it usually indicates you need one**
   - ☐ **(A)** Of lower capacity.
   - ☐ **(B)** Of the same capacity.
   - ☐ **(C)** Of higher capacity.
5. **A battery loses power as the temperature drops. At 0° F it produces only**
   - ☐ **(A)** 80% of its original power.
   - ☐ **(B)** 50% of its original power.
   - ☐ **(C)** 40% of its original power.
6. **The ignition switch**
   - ☐ **(A)** Opens the PCV valve when the engine is cold.
   - ☐ **(B)** Connects the battery to the starting and ignition systems.

- ☐ **(C)** Should be packed with wheel bearing grease every spring.

7. **If you turn the key to start your engine and you hear a clicking or chattering sound, the problem could be**
   - ☐ **(A)** Negative polarity in the solenoid armature.
   - ☐ **(B)** Corroded battery connections.
   - ☐ **(C)** A defective ignition switch.
8. **The #1 reason motorists call for emergency road service is**
   - ☐ **(A)** They're out of gas.
   - ☐ **(B)** Their car won't start.
   - ☐ **(C)** They have a flat and no spare tire.
9. **The measurement of load on a battery is in amperes (amps). Your headlights, for example, draw about 15 amps, the taillights 1.5 amps. By comparison, the starter may draw**
   - ☐ **(A)** 150 amps.
   - ☐ **(B)** 300 amps.
   - ☐ **(C)** 400 amps.
10. **You turn the key to start your engine and there's not even a click. The shift lever is in Park where it should be. Lights, horn, and other accessories work fine. The trouble could be one or more of the following**
    - ☐ **(A)** Defective neutral safety switch.
    - ☐ **(B)** Dead battery.
    - ☐ **(C)** Faulty ignition switch.

[Check Your Answers] [Clear Your Answers]

- Visit The Service Department To Submit Your Problem Or Question

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The Body (Overview)

The Body

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.

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.

Crash/Safety Features

What actually happens in a collision? The first part of that answer is that there are two collisions. The first collision occurs when the vehicle runs into another object. The second collision is when the occupant(s) hit the inside of the car. Neither a seat belt nor an air bag can do anything about the first collision, but they can be a great help to you in the second collision. They can minimize the impact between you and the interior of the car.

Safety belt use is more than a personal right. Injuries and fatalities resulting from motor vehicle accidents are reflected in the rising costs of auto and health insurance, and costs to employers in the form of lost days at work. The taxpayer also loses by having to support emergency medical response teams and social programs for the disabled.

Excuses, excuses!

1. "Seat belts are too uncomfortable."
   Of course, in a car accident -- without your seat belt -- you would smash into the steering column, slam into the dashboard, or crash through the windshield. This too, can be very uncomfortable.
2. "Seat belts wrinkle my clothes."
   Sometimes. Sitting also wrinkles clothes. Wearing clothes wrinkles clothes. Flying through a windshield REALLY wrinkles clothes.
3. "Only nerds wear seat belts."
   Really? It turns out that -- without seat belts -- nerds, jocks, cheerleaders, "A" students and average students would all fly through the windshield at the same rate.
4. "I'm a good driver."
   Nice as that is, good drivers can get hit by bad drivers, drunk drivers, or other good drivers with mechanical failures. Very few people intend to have accidents.
5. "Seat belts restrict my freedom of movement."
   This is true. Without your seat belt, you have all the freedom in the world--to crash into your windshield, to slam into your car's interior, or to be thrown from your car and slide along the pavement. Freedom is great.
6. "It's too embarrassing to ask friends to use their seat belts."

In 1984, 46,000 people died in car accidents. That same year, not one person died of embarrassment.

Safety in car design was recognized as being important even in the earliest cars. In recent years, however, it has become a fundamental subject in its own right. Active safety measures have been designed to reduce the likelihood of a car being involved in an accident in the first place, while passive safety measures assume that a collision is inevitable and then aim to reduce the severity of the injuries to the road users involved.

Until the late 1800's the British had a 2 mph speed limit for cars. There was an excellent reason for this. It was also required, for safety's sake, that each car carry two passengers with a third person walking in front. The job of the third person was to walk in front of the car to warn everyone that it was coming!

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.

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 rustproofing. 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 rustproofing 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 rustproofed. The best course is to take the rust preventative measures listed above.

Door Locks

Door locks must keep the door from opening in a crash situation and resist break-ins, but it should also be possible to open them if you lose the key. The door handle acts as a lever that pulls on a rod. The rod rotates the door latch. The various types of lock mechanisms interrupt the action of the door latch. The "striker" is a mechanism attached to the door post, or part of the car body. It holds the door shut or allows it to be opened when the door handle rotates the latch. The striker's job is to keep the door closed under normal conditions, or to hold the door closed if the door post starts to bend away from the door in a crash.

Power door lock mechanisms are operated by electric solenoids. Anti-burst door locks are a relatively cheap development, that have proven to be one of the most successful but unrecognized benefits of crash protective design.

Studies have shown that it is much better to remain in a car than to be thrown out, because if a person is thrown out, serious injury may result from contact with the road surface, and there is a great risk of being run over by one's own or another vehicle. It is, therefore, important that the doors should stay shut during a collision, and the design of a latch to do this has been perfected and introduced into almost all cars in the world.

An anti-burst latch provides resistance to tension forces of up to 3000 lb. (1360 kg) in all directions, by having a lock striker on the door which completely encircles a ring or plate mounted on the door frame. The system is designed so that it resists the forces generated in a collision both by the occupant striking the door on the inside and by the force of the impact on the outside. The result is that ejection, which was established as a leading cause of death to car occupants in 1956, has now been reduced until it has relatively little importance.

Window Winding Mechanisms

There are two types of window winding mechanisms; hand cranked and power.

Hand cranks work two ways. With "window winders," the crank turns a "sector gear" that pivots a pair of arms. The arms raise the "window carrier" and the glass. Some cars have fixed glazing in the rear doors so that the window cannot go up or down. The other type of window crank is a tape mechanism. It winds up a ladder-like tape made of plastic links. The plastic links are wound on to or off a spool to raise or lower the glass. The tape mechanism was introduced in 1980 GM cars. It saves weight and space. Its parts will not corrode when rainwater gets into the door, and it needs no lubrication.

First introduced in 1946, power windows use a small electric motor inside the door. The motor turns the crank that raises the window.

Door and vent windows 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 even when shattered.

Side Beam

The door's inner panel has crossbars, or heavy metal beams to provide strength to the door, and to protect the passenger from injury in the event of a collision.

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.

Door Hinges

The door hinge is a jointed, flexible device on which the door opens and closes. Its foundation is the center body pillar. The door is attached to the center body pillar by the hinge.

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.

Door Handle

The door handle is used to open the door, and as a way to release the door latch. It mates with a toothed wheel at the side panel of the door, called a rotor. When the door is closed, one of the teeth contacts the striker and causes the rotor to turn one tooth. If the door is completely closed, the rotor engages with the striker. The door can't open because the rotor is locked. When you unlock the door, the rotor can rotate and the door opens.

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.

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.

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.

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 unibody construction, the floor pan is attached to the several metal pieces that make up the chassis center section.

Firewall and "A" Pillars

The firewall separates the passenger and engine sections of the car. It's a flat piece of steel stamped with curves and punched with holes and openings for wires, tubes, and levers that extend into the passenger compartment. It goes up both sides of the dashboard and stops where it meets the roof panel. These pillars formed by the firewall provide the frame for the windshield and are called "A" pillars.

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.

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. This protects the consumer and is also very important for keeping the cost of automobile insurance to a minimum.

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.

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.

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".

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.

Driver's Side Mirror

The driver's side mirror is connected to the driver's side of the car's body. This mirror is a very important device, not for adjusting your make-up. It enables you, with a slight glance of the eye, to see places that you can't otherwise see without taking your eyes off the road.

The mirror is adjusted by the driver to suit the necessary visibility position (position of the head). Sometimes the mirror must be manually adjusted outside the car.

The mirror is also often controlled from the inside of car by a series of cables. The cables are connected to a "joystick" that allows you to tilt the mirror manually, or to an electrical motor that allows you to tilt the mirror by pushing a button.

So if your mom, husband, wife, etc., is displeased with you for re-adjusting all the mirrors, remind them that you're just being a safe driver!

Rear View Mirror

The rear view mirror is a wide rectangular mirror that you (the driver) use to view anything behind the car. You don't have to take your eyes off the road to turn your head around.

On most cars, the rear view mirror has a "day/night" selection switch that tilts the mirror inside its glass housing without tilting the exterior glass housing itself. The switch tilts the mirror upward, about five degrees, to divert the majority of the light striking the mirror up on to the headliner of the car. The light that you see when the mirror is on the "night" setting is actually bouncing off the glass housing (a good reason to keep it clean). The percentage of light reflected into your eyes in the night position, is very small compared to the amount that would normally be reflected into your eyes in its normal position.

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.

Roll Bar

The purpose of the roll bar is to protect driver and passengers from injury if the car rolls over onto its roof. A series of tubes that are welded together into a contoured shape, and then bolted directly to the frame members, or rails. Since frame members are located differently on different types of cars, a roll bar is very unique to an individual car, and must be designed for a specific car.

Although a roll bar is a very nice feature, it is not always practical, because there isn't a place to mount it. Roll bars are usually put on convertibles as an aftermarket add-on piece. A convertible provides no protection if it overturns.

Some cars have built-in "targa" roll bars. These are roll bars that are covered up by body work; they appear to be part of the body. Targa roll bars are generally flat and wide, instead of round like normal roll bars. Because they are wider, they are able to hold up the overturned car. They also look nice, because they look like a body panel. They do reduce rear visibility because of their greater width. Some targa roll bars are purely cosmetic, because they have no frame inside. This type of roll bar affords you about as much protection as the windshield, and so is not really a roll bar.

Most cars don't come with roll bars, but all race cars have roll bars. Roll bars themselves are relatively inexpensive, but they usually require quite a bit of expensive installation work. Some roll bars provide better protection than others.

If you have a tendency to exceed the speed limit along winding roads or go off roading, you really ought to have a roll bar.

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.

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.

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.

Chassis Cross Member

The chassis cross member is usually a heavy gauge piece of sheet metal that is bent into a convoluted channel shape. It is mounted onto the bottom of the chassis, and keeps the transmission firmly secured at the end where the drive shaft begins. On some cars, the cross member is removable. On other cars, it is part of the body shell.

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.

Transmission Tunnel

The transmission tunnel is a cone-shaped formation in the front of the floor pan. Its shape duplicates the transmission, but it is a little bit bigger and provides about two inches of clearance around the transmission. You won't find the transmission tunnel in front wheel drive cars, because the transmission is on the side of the engine completely under the hood. Only rear-wheel drive cars have transmission tunnels.

A manual transmission tunnel has a hole in it to allow the shift linkage to be worked from inside the car. The shifter linkage goes through the transmission tunnel. A rubber boot on the shifter linkage stops dirt, dust and exhaust fumes from entering the passenger compartment. The rubber boot is mounted onto the transmission tunnel and fastened securely around the gearshift linkage. This arrangement is not necessary with an automatic transmission, because the shift linkage does not usually go through the transmission tunnel. The shift linkage in automatic transmission usually goes in front of the firewall from the base of the steering column.

Rear End Tunnel

The rear end tunnel is a tube with a pumpkin shaped indentation in the center which provides clearance for the drive shaft and the housing of the differential. It allows the rear end to travel up and down with suspension motion; it clears the differential housing by a maximum of three or four inches when the suspension is fully compressed. The rear end tunnel often forms the front of the trunk floor. It is attached to the wheel wells on each side as well as the floor pan and the trunk floor.

Springs

Springs all have one thing in common; they are made of specially formulated steel which is tempered to prevent it from loosing the shape it is bent into when "sprung." For this reason, a spring will compress or extend and then return almost entirely to it original shape. There are two kinds of springs, leaf springs and coil springs.

Springs have life spans that are determined by the number of cycles they can withstand over a certain period of time. Occasionally a spring will break on a car while it is being driven. This doesn't usually lead to a collision, but if a spring breaks while you are driving , the car will suddenly lurch downward--you've got yourself a low-rider! The bottom of the car might be damaged, or you might lose your muffler!

Leaf springs are made of individual springs, or plates. If you break one plate of your leaf-spring, it won't be noticeable, but your car might begin to lean to one side or the other.

Coil springs, if they break, will suddenly drop the front or rear end of your car and impair driving under the normal conditions of full suspension travel.

Usually the springs surround the shock absorbers, because space can be saved by putting the shock absorber inside the spring. The spring on a MacPherson strut suspension rotates along with the strut body itself; it pivots on a bearing mounted to the wheel well.

Some springs have adjustment dials mounted between them and their mounting points. This allows the mechanic to increase the spring tension and the ride height, you desire. This type of spring is usually used only in high performance cars, because it allows the raising and lowering of suspension system's height. The suspension system is lowered for competitive events and then raised afterwards. This way, the car can be driven normally and deal with road hazards such as speed bumps.

Nuts and Bolts

Nuts are hexagon shaped metal objects with a threaded hole through them so that they can be attached to bolts. Bolts are cylindrical objects with "threads" on the outside of them which enable them to be threaded into nuts. The hexagon shaped end classifies a "bolt". A "bolt" without an end is classified as a "lug" or "stud."

Most bolts have what is termed as a "right-handed" thread. This is a spiraling thread. If you were inserting a right-handed threaded bolt into a threaded hole, you would turn it clockwise. Some bolts have "left-handed" threads. When inserting this type of bolt, you turn it counter clockwise.

There are many "grades" of nuts and bolts. Grades depend on the quality of the materials and the tolerances observed during the manufacture of the nuts and bolts. The ends of bolts and the faces of nuts are almost always marked with symbols denoting their quality standards. Unfortunately, in recent years it has become apparent through various government investigations, that unscrupulous individuals have been importing nuts and bolts with symbols printed on them that falsely denote a higher quality bolt. In other words, these individuals import and sell lead with gold stamped on it. This doesn't sound particularly dangerous, but in the cases of certain airplane and amusement park incidents, it has been proven that such a business deal, in conjunction with an innocuous object such as a nut or a bolt, can lead to tragedy.

Nuts and bolts are often separated by washers. Washers have many shapes and sizes, but serve one purpose. This purpose is to give the nut and the bolt a firm hardened surface for bedding against. The parts that you put together with nuts and bolts are usually not as strong as the nuts and bolts themselves. The washers allow the nuts and bolts to be fully tightened down, providing a wider area to spread out the force of the tightening. Washers keep the nuts and bolts from digging into the material when they are tightened. Washers shaped like a broken section of a coil are called "lock washers." They are designed to prevent the nut from rattling loose.

"Allen" bolts have socket heads, or a recessed hexagon shaped hole in the top. You need Allen keys or wrenches to tighten or loosen the Allen bolts.

Glove Box

The glove box, or glove compartment, is a small storage cabinet in the dashboard of an automobile. It is used to store small parts which fall off the interior, and usually a few forgotten parking tickets. The smart motorist also keeps the following in the glove box: a flashlight, an air pressure gauge, and a few paper towels.

Hood Release

The hood release is a small lever which is usually mounted under the dash. It is connected to the hood latch by a cable. The hood latch has a safety feature which requires a second latch to be released before the hood will open. This is to prevent accidental opening while driving.

Visor

The visor is a flat sunshade, usually movable. It is attached to the interior of the car at the top of the windshield. Visors protect the eyes of the driver and passengers from the sun's glare.

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Automotive Emergencies

First Aid for Your Car

Everyone knows that it is important to have a basic knowledge of first aid in case of an accidental injury. First aid is used to keep the body functioning as comfortably as possible until the victim can be taken to a hospital to see a doctor. If a person were to have an accident at home, first aid is a short-term necessity, but if he is picnicking or camping in the wilderness, first aid would be needed to keep the victim functioning for a much longer length of time.

Try to think of the car as a victim of an accident when a breakdown occurs. This, of course, is not a living, breathing body, so it is easy to just shut off the motor and let the car sit until a tow truck arrives to take it off to the hospital (garage) to be taken care of by a doctor (mechanic). Unfortunately, it is not in the nature of a car to break down while idling in the drive-way or backing out into the street (although it sometimes happens). The greatest problems with cars usually occur while in the middle of an intersection, driving through traffic, or on a long trip many miles from home. Since we can't place a sling on the car's wheel or bandage the battery while we tote it off to the nearest garage for emergency care, it is important that we have some basic knowledge of car repair to keep it going until we can get it to a mechanic for professional care. Anyone can repair many of the breakdowns that a car encounters well enough to drive it to a garage. Some repairs will even solve the problem altogether. In either case, a little basic knowledge of car repair can keep the driver from being stranded.

There are some breakdowns, however, that can't be repaired by the driver. Even so, just knowing the symptoms of the car breakdown can save money, because a mechanic that thinks you know what you're talking about is not so apt to overcharge you.

Safety Rules for Automobile Self-help

When working on a car, be prepared in advance to have grease on your hands and you probably will break a fingernail. In addition to these minor inconveniences, there is always a risk in working on a car. Use common sense when making inspections and repairs. Know how to fix an element before you begin, and then work efficiently. Below are some common sense rules to follow while working on a car:

1. Gasoline fumes and hydrogen gas are both explosive, and both gasoline and oil are flammable. Do not smoke while making repairs or even when raising the hood to diagnose the problem. Keep a small fire extinguisher nearby while working on the car, particularly if the work is being done under the hood.

2. Engine exhaust contains carbon monoxide - a poisonous gas. Do not run the engine in a closed area unless there is ample ventilation. If you begin to feel sleepy while working on a car, move away from the vehicle into the fresh air immediately. By the same token, if you can smell the exhaust while driving, open the windows at once.

3. The car battery contains sulfuric acid, which can burn, and it also emits hydrogen gas, which may explode. Wear gloves while working around a battery and do not smoke near it.

4. Car batteries can give electrical shocks and are a fire hazard. Disconnect the battery while working on the fuel line or electrical system. It is only necessary to remove the ground cable, which is easily identified by a black mark or a minus (-) sign on the battery casing at the terminal.

5. It is easy to get a spark or electrical volt, creating a fire hazard when jump starting a car. Be sure to connect the positive (+) terminal of the helping car to the positive terminal of the disabled car, and the negative (-) terminal to the engine frame before turning on either engine. Also, do not touch the positive cable to the end of any other cable or metal part while jump starting the car.

6. Radiator hoses, exhaust pipes, manifolds and mufflers can be very hot to the touch. Allow time for these parts to cool off before working on the car. If there is some reason that you can't wait, wear heavy gloves and be very careful. DO NOT remove the radiator cap in one turn. Turn it slowly to half off and allow the steam to escape. Always use gloves or a rag. When the steam has escaped, turn the cap off fully. Always keep your face turned away from the radiator cap.

7. Loose clothing can easily be pulled into moving machinery parts. A loose shirt cuff, necktie, dangling jewelry, frilled blouses, or long hair can all be pulled into a moving part while making repairs. Be sure to remove such hazards. Caps without brims are considered safer than those with brims, and it is advisable to wear a sturdy pair of shoes or boots to protect the feet.

8. The jack may collapse while holding up the car. Do not - under any circumstances - crawl under a car that is jacked up, unless you have a jack stand, which is made for that purpose. Be sure the jack stand is rated to support the weight of the car. Do not use metal drums, buckets, bricks, concrete blocks, or wooden assemblies in the place of the jack stand. All of these may crumble or collapse.

9. Slipping on oil, gasoline or other leaking fluids can cause serious injuries. To prevent slipping by the person working on the car, or by anyone else, wipe up all spills immediately. Be particularly careful when wiping up flammable or chemical fluids.

10. The car must be stabilized before fixing a flat tire, so that it will not jump the jack or roll. Try to stop the car on level ground to change a tire. If the car has an automatic transmission, put the gearshift into

"park"; if the transmission is manual, shift into reverse. Before jacking up the car, place a brick, stone, 2 x 4, or whatever is within reach, in front of the front wheel and in back of the rear wheel that will stay on the ground. This will stabilize the car and prevent rolling. Be careful when jacking up a car on roads that allow semi truck traffic. The force of the air current produced by large vehicles speeding past, may be enough to topple a car which is up on a jack.

11. When confronted with a serious car problem on a car which is still under warranty, call a tow truck. Any attempts to repair a major part could void the warranty.

12. A car problem should not be worked on unless you have specific knowledge on what is wrong and how to fix it. Car first aid is for emergency and basic repairs only. Major problems should be taken to a mechanic. Otherwise, you may find that you have created even more problems than you had to start with, besides a higher repair bill for straightening out your mistakes.

13. Gasoline, brake fluid, and certain cleaning fluids used in repairing an automobile need special precautions to prevent fire. Fuel, thinner, and other combustibles should always be kept in closed containers designed for the purpose; these should also be well marked and stored safely.

Smoking and unshielded flames should always be avoided while working on a car. As a further protection against fire, oil and grease rags should also be kept in containers; use care, however, that spontaneous combustion does not occur.

14. There are many precautions that should be observed when using tools.

Files should never be used without a handle, because there is always the danger of running the point into the palm of the hand. Files should also not be used as levers or hammers. Files are made with hard temper and are quite brittle, so if hammered, small pieces may fly off and cause severe wounds or loss of eyesight.

Hammers or sledges should be checked to see that the head is attached securely so that it doesn't fly off when the tool is used. When the head of a chisel is mushroomed, it should be thrown away or reground to prevent bits of steel from flying off and causing damage. A shield or helmet should always be worn when grinding.

Pull on the handle of a wrench, rather than pushing on it to prevent the danger of skinning the knuckles. When the jaws of the wrench become worn or sprung, the tool should be disposed of.

DO NOT point an air gun in the direction of anyone, because the high pressure can blow dirt particles at such high speed that they will puncture the skin and/or get in the eyes.

Emergency Stops

A sudden emergency, such as loss in steering control, does not give the driver time to consult a manual or even to ask questions. The driver will need to know what to do immediately in such situations, and may gain some knowledge by studying the emergency measures listed below:

1. A tire suddenly blows out: Steer the car as straight as possible, but do not slam on the brakes. Apply even, gentle pressure to the brake pedal. Then pull off the road slowly onto the shoulder. Try to park the car on level ground.

2. The brakes give out: If you have time, quickly pump the brake pedal; this may tighten up the brake and provide some stopping power. If there is not time for this, apply the parking brake slowly but firmly. Another method that can be used if there is time and pumping doesn't help is to shift down on the gears - from Drive to D-1 and then to D-2. You may even have time to shift into reverse. Do not shift into "park," however. You might turn off the ignition with the car in gear. DO NOT turn the key into the lock position, because this will lock the steering wheel. If none of these procedures work, try to sideswipe guardrails, signposts, or other obstructions that will slow the car. Direct hits may cause serious injury, however, so be careful.

3. Lights go off: If the lights should suddenly go off at night, try the hazard lights immediately. Even directional signals will produce some light. At the same time, brake the car slowly and pull off the road and stop. DO NOT jam on the brakes. You have plenty of time and space in which to brake to a stop safely unless you are on a hair-pin curve on the side of a mountain.

4. Steering locks or gives out: Apply the brakes gently. Do not slam on the brakes, because it may cause the car to swerve. Turn on the hazard lights and blow the horn to warn other drivers of the danger. Get off the road as soon as possible.

5. Accelerator sticks: Turn off the engine, shift to neutral, and pull off the road. Power steering and brakes will become manual, so more effort is necessary to turn and stop. You may now try pulling the pedal up with you foot or hand. Stuck pedals are usually due to broken springs or a blockage in the throttle linkage. Sometimes, an item such as a floor mat may be pressing on the pedal. If you cannot find the solution to the problem, call a tow truck. DO NOT drive the car if you can't solve the problem.

6. Hood flies up: Look under the space below the hood or stick your head out of the window to see. Gently apply the brakes; do not slam them on. Use signals to turn off the road. The hood latch is probably broken. If you can't tie the hood down with wire, rope, or a necktie, call a tow truck for help. If the hood latch was not completely latched, you may be able to close it down and drive on. If you can't see, don't drive.

7. Car drops into deep water: If the windows are electric, open them immediately and hang on tightly to the steering wheel, dash, car seat, door handles or whatever is stable for a handhold. Wait until the car fills up with water and then swim through the windows. If the windows are crank operated, wait until the car is almost filled with water; then crank the windows down to escape. There will be enough air between the water and the bottom of the car roof to supply your breathing needs. The windows are always the best means of escape, because the doors have too much water pressure against them to be opened.

8. Fire in car: Pull off to the side of the road immediately and get out of the car! If it is just a small fire, you may be able to smother it with a blanket, dirt or a coat. DO NOT use water! If the fire is within the fuel system, move at least 500 feet away from the car, because it will likely explode.

9. Head-on crash: If the seat belts are not fastened, throw your body across the front seat or the floor. Try to get as low in the car as possible - below the windows and the windshield.

10. Electric power cable: If you're in the car and a power cable, is on your car, stay in the car until help arrives.

11. Bee in the car: Gently brake the car to a stop on the shoulder of the road. Don't slam on the brakes; the car behind you might run into you and cause worse problems than a bee sting. After stopping, roll down

the windows and coax the bee out of the car.

12. Sudden window fogging: If the fogging problem is outside the car, turn on the windshield wipers. If it's inside the car, wipe the glass with your hand and brake gently to pull the car off the road. Turn on the defroster and wait until you have clear vision before continuing to drive.

13. Car skids: DO NOT slam on the brakes! In fact, stay off the brakes completely. Ease off the gas and steer the car in the direction that you want the "front" of the car to go.

14. Wheels fall into low shoulder: Brake gently to slow the car when the wheels go off the road. Don't jerk the steering wheel. Ride on the shoulder until the car can be turned onto the road. This prevents skidding.

15. Engine quits: Shift the car into neutral gear and coast onto the shoulder of the road, braking gently. Cars with power brakes and power steering will need more effort than normal.

16. Whatever the circumstances, buckle up for safety!

When The Car Doesn't Work

BEFORE a car needs repairs, the owner should check the car's manual to see if maintenance is needed. Failure to care for the car, and ignoring the initial warning signs (funny noises, problems that "fix themselves", etc) will produce more extensive and costly damage in the long run.

I. Starting Problems

Problems encountered in starting are usually due to the condition of the battery (clicking noises, no sound or slow grinding). These problems can often be solved by jump starting or charging the battery. If there is no response after trying these cures, it will probably be necessary to get experienced help or have your car inspected and serviced by a professional.

II. Moving Problems

1. Problems with the engine hesitating, cutting out, being weak, or having difficulty with the idling should all be carefully inspected by an experienced mechanic. Overheating may be due to a need for additional coolant in the radiator or a need to unload excess weight (as when pulling a trailer). Turn off all accessories; i.e., the air conditioner. If this doesn't help, get professional help.

2. Transmission problems should always be inspected for repair or adjustment by a professional mechanic. If the car is driveable, drive slowly and carefully to the nearest service facility. If in doubt about driving the car, call a tow truck.

III. Stopping Problems: When the brakes fail to hold, or if they squeal, grab or drag, they should be inspected and cared for at a specialized brake shop. When the problem is due to worn tires, the tires should be replaced at once before damaging other, more expensive elements of the car.

Tips on Tires

There may be instructions for using the jack pasted on the underside of the trunk lid, so when changing a tire, look there first. If it is possible, the jack base should be supported with a wide, flat board or plywood. Don't use brick or concrete for this, because they are apt to crumble. Do not get under the car after lifting it with the jack for any reason!

Slide the spare tire into the wheel well, match lugs and lug holes, and lift the wheel up onto the lugs. If the spare tire is smooth or for emergency use only, drive slowly and have the tire replaced as soon as possible.

How to Change A Tire

Drive off the road and turn on the hazard lights. Make sure to chock the good wheels in front and back, and have the car shifted into park or neutral with the parking brake on. Try to stop the car on a level surface. There should be a jack, lug wrench, chock for the wheels, rubber hammer, and penetrating oil in the trunk of the car.

Pry the hubcap off with a screwdriver or the end of the lug wrench (or the jack handle). Some hubcaps require a special wrench which is usually in the glove compartment. Loosen the nuts on the wheel before jacking up the car. Push down counterclockwise on the lug wrench; use your foot, if it is necessary. Spray any rusted nuts with penetrating oil, then wait a few minutes before loosening. Chock the good wheel, and position the jack at the wheel to be changed.

Bumper jack lifts will fit the slot in the bumper; scissors and side-lift jacks will be inserted into pads under the side of the car. Position the jack as directed in the car's owner manual. Some cars have diagrams where the tire is stored. Jack up the car until the wheel is just lifted from the ground. Remove nuts, put on the spare wheel, and replace the nuts so that they are screwed securely by hand. Then tighten the nuts with the lug wrench in a criss-cross pattern. Don't over tighten. Let the jack down by flipping the lever or by turning the scissors down slowly. Turn the wheel nuts tight with the wrench in a criss-cross pattern.

Replace the hub cap so that the valve stem of the tire slips through the hole or slit in the hubcap. Tap the hub cap lightly with a rubber hammer or hit it solidly with the hand. Check to make sure it is securely fitted.

When a tire has a slow leak, an aerosol flat-tire fixer can be used. Follow the directions on the can; then drive to a service station as soon as possible for tire repair.

Tires can squeal due to low air pressure or worn tires. Check the air pressure or, if tires are badly worn, have them replaced.

Tires may wear rapidly due to poor alignment, low air pressure, or worn front-end components. Check the air pressure. If this is not the cause of the problem, take the car in for professional care.

Tires may wobble from many causes. First check the tire air pressure, loose wheel nuts, and worn tires. Have the problem corrected, if this is the source. Tire wobbling may also be due to poor alignment, missing balance weights, bent wheel rims, or worn steering linkage. If you can't correct the problems yourself, have the car checked by an experienced or professional mechanic.

Other Problems

1. Anytime that smoke, steam, fluids or odors are escaping from the car (other than those caused from a cold engine, cold atmosphere or odors from diesel engines and catalytic converters), the car should be checked by someone with repair experience or by a professional mechanic. These problems could be caused by the electrical wiring or by defective components and should be corrected immediately.

2. Any noises such as squealing, hissing, clunking, whirring, and clicking, coming from the front, back, or under the hood, should be inspected and repaired by an experienced repairman.

3. Windshield wiper problems are often due to a blown fuse or a need for new wiper. If the problem is from some other cause, such as wiring or burned-out motor, it should be repaired by a competent repairman.

4. When lights, either headlights (bright and dim), taillights, signal lights, flashers, etc., are out or constantly on, check the fuses. Other defects may be in the wiring or defective elements. Have the problem corrected immediately.

Miscellaneous Emergencies

1. The driver is locked out of the car.

Button locks: Use a wire or a coat hanger. Straighten the wire and make a small loop or fishhook shape at one end. Slip the wire through the crack of the window or down through the top crack of the door. You may slip the wire past the weather-stripping of the door. Jiggle the wire around so that the hook will loop around the button lock and then try to lift up the lock. Have a lot of patience.

If you are unable to pull up the lock for some reason, call a police station and tell them the circumstances. A service station may also help to unlock the door. The police call is free - a service station will probably charge about $25.00

NOTE: The weather-stripping around the window often costs more than the locksmith or tow truck driver's fee.

2. Car is stuck

(a) on ice: When moving the car, keep a steady rate of speed to prevent getting stuck again. Drive slowly. The car may skid some, but as long as it is moving, chances of getting to solid ground are at the maximum.

To get off an ice patch, try kitty litter, sand, dirt, or floor mats for friction. Sprinkle the abrasives (front or back) for about fifteen feet. Put the sack of sand or kitty litter back into the trunk and don't stop for anything until the car is on solid ground. Try not to spin the wheels, but if no abrasive material is available, try letting some air out of the tires to gain some friction.

(b) in snow: There are many ways to free a car from the snow. Try rocking the car back and forth by shifting quickly from drive (or first gear) to reverse. Work out a rhythm to the rocking. After rocking for a few minutes, shift into neutral and increase engine speed to let the transmission cool. Once the car is free, keep it moving. Keep the wheels as straight as possible while rocking. If the wheels heat up, let them cool before continuing. Heated tires will sink deeper into the snow. Don't spin the wheels; this will heat up the wheels and also cause ice to form under the wheels. Put a manual transmission into second gear to rock it.

You may be able to shovel enough snow away from the wheels to get some traction. If there is no shovel, use the base of the jack or fold over the floor mat in the place of the shovel.

Car chains probably can't be mounted at this time, but they may be used to provide traction. Tie the chains to the bumper so that the car will pull them along until you are on solid ground. Strap chains are handy for traction on ice, snow, and sometimes on mud. They can be mounted without jacking up the car.

Put several bags of sand in the trunk of the car for added traction. Even if the weight of the sand doesn't help, you will have sand to spread under the tires when the car is stuck.

(c) in mud: Being stuck in mud is worse than being stuck in either ice or snow, because mud clings to the undercarriage of the car until there is no way to get any traction. Spinning the wheels only drives them deeper. When stuck in the mud, use the same methods as getting out of snow or ice. If these methods don't work, call a tow truck.

(d) in sand: Spinning the wheels in sand drives only drives them down deeper. The undercarriage is hung up once the car is sunk to axle level. At this point, a tow truck will be needed. If the car is not up to the hubs in the sand, try letting a little bit of air out of the tires to increase the friction.

3. Blizzard Conditions. When the car can't be moved during blizzard conditions, don't panic. Below are several survival tips that may help to weather the storm.

(a) If the trouble is just starting, look for shelter: a house, barn, store, or service station nearby.

(b) If you can't see a place of shelter, stay in the car. DO NOT wander around, looking for shelter and get lost in the storm.

(c) Run the engine and the heater for ten minutes every half hour. Open the windows a little bit while the engine is running. Engine idle consumes about one gallon of gasoline per hour. Five gallons of fuel is enough for one day with this method. Don't race the motor and waste fuel.

(d) Open the door once in a while so that it does not become snow packed. When opening the door, check to make sure the exhaust pipe is not blocked by snow.

(e) Blow the horn and flash the lights while the engine is running. Don't run down the battery in the meantime.

(f) Stretch arms and legs frequently inside the car.

(g) Use anything available to keep warm: rip out car carpeting for blankets, use floor mats, linings from the trunk, or car seat covers. If the situation becomes really bad, rip the upholstery from the rear seats and roof of the car.

(h) If you absolutely must drive in hazardous conditions, carry food, water and extra clothing in the car in case of emergencies.

4. When the car breaks down on a Federal Interstate, the driver should lift the hood of the car, turn on the emergency signals, and wait for help. This is also true when the car runs out of gas. The person stopping may consent to send a tow truck or may even offer you a ride to the next service station. If a passenger car does not stop, the Highway Patrol will come along eventually and offer help. There are situations, however, that are not as ideal as those on Federal Interstate roads. Drivers sometimes have accidents on isolated roadways - either running out of gas or breakdown of parts. The best advice comes from a patrolman, who says to use your common sense. Be sure to check your gas gauge, tires, and other accessories and parts before taking trips on lonely roads. If your car does have a failure or runs out of gas, it is not always wise to lift the hood, especially if you plan to leave the area. It is probably best to walk to the nearest farm or rural home and ask to use the phone (or ask the homeowner to call for help, if he doesn't want to let you into the house). It would probably be best to lock the car if you plan to walk for any distance or to be away from it for any length of time. If the car breaks down during a storm, such as a blizzard, stay in the car and follow the advice given for blizzard conditions (#3 above). Hitchhiking is illegal, but a policeman will not arrest you if your car has broken down and you are walking in search of help. It is, however, a poor means of travel except in an emergency.

Periodic Care for The Car

If the car owner has periodic maintenance done on the car, it will avoid many of the problems which might otherwise occur. Checkups can be carried out at regular intervals. Below is a checklist that may help in minimizing car problems:

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 1. Every time the car is filled with gasoline, either the driver or
     the service attendant should:
     (a) Check the engine oil
     (b) Check the transmission-fluid level
     (c) Check the power-steering-fluid level
     (d) Check the drive belts
     (e) Check the tires to see if they need air or are badly worn

  2. Monthly maintenance with the engine cold includes:

     (a) Check the level of the coolant in the radiator (not the
        reservoir tank)

     (b) Check the level of the fluid in the master cylinder

  3. Monthly maintenance with the tires cold includes:

     (a) Check tire's air pressure

     (b) Look for tire wear and damage

  4. Monthly maintenance at night with a friend includes:
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     (a) Check headlights (both dim and bright)
     (b) Check taillights
     (c) Check directional signal lights
     (d) Check brake lights

5. 3,000-mile maintenance includes:

     (a) Change oil and oil filters
     (b) Car lubrication
     (c) Check air cleaner and replace, if necessary

 6. 12,000-mile maintenance includes:

     (a) Check exhaust system for leaks
     (b) Check wheel alignment
     (c) Lubricate locks and hinges
     (d) Change spark plugs
     (e) Repack wheel bearings
     (f) Drain and replace antifreeze
     (g) Replace windshield wiper blades
     (h) Get a general engine tune-up
     (i) Bleed and refill brake-fluid system

7. Every 24,000 miles, in addition to the 12,000-mile maintenance:

     (a) Tune up engine, and replace PCV valve
     (b) Replace spark plugs on cars using unleaded fuel
     (c) Change transmission filter
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Emergency Equipment

A car's trunk will only hold a certain amount of equipment. Because of the limited space in the trunk, the following list contains the minimum essentials for safety and emergency repairs. Several of the smaller items listed may be carried in the glove compartment for easier access and so they won't get lost under heavier equipment:

- 1. Flashlight
- 2. Spare tire
- 3. Jack
- 4. Four-way lug wrench
- 5. Water pump belt
- 6. Tire pressure gauge
- 7. Inexpensive wrench-and-socket set

- 8. Utility knife
- 9. Both Standard and Phillips screwdrivers
- 10. Battery-jumper cables
- 11. Pliers
- 12. Fuses
- 13. Hose clamps
- 14. One quart of motor oil
- 15. One dollar's worth of nickels, of dimes, and of quarters
- 16. Six road flares or a set of reflective warning triangles
- 17. 1 gallon plastic jug of water
- 18. Aerosol flat tire fixer
- 19. Small fire extinguisher
- 20. Rags or paper towels
- 21. 50 to 200 pounds of sand (in snowy or cold weather)

- Visit The Service Department To Submit Your Problem Or Question

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The Engine System (An Overview)

The Engine System

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".

The Piston, Rings, and Wrist Pin

The piston converts the potential energy of the fuel, into the kinetic energy that turns the crankshaft. The piston is a cylindrical shaped hollow part that moves up and down inside the engine's cylinder. It has grooves around its perimeter near the top where rings are placed. The piston fits snugly in the cylinder. The piston rings are used to ensure a snug "air tight" fit.

The piston requires four strokes (two up and two down) to do its job. The first is the intake stroke. This is a downward stroke to fill the cylinder with a fuel and air mixture. The second is an upward stroke to compress the mixture. Right before the piston reaches its maximum height in the cylinder, the spark plug fires and ignites the fuel. This action causes the piston to make its third stroke (downward). The third stroke is the power stroke; it is this stroke that powers the engine. On the fourth stroke, the burned gases are sent out through the exhaust system.

The wrist pin connects the piston to the connecting rod. The connecting rod comes up through the bottom of the piston. The wrist pin is inserted into a hole (about half way up) that goes through the side of the piston, where it is attached to the connecting rod.

Pistons are made of aluminum, because it is light and a good heat conductor. Pistons perform several functions. Pistons transmit the driving force of combustion to the crankshaft. This causes the crankshaft to rotate. The piston also acts as a moveable gas-tight plug that keeps the combustion in the cylinder. The piston acts as a bearing for the small end of the connecting-rod. Its toughest job is to get rid of some of the heat from combustion, and send it elsewhere.

The piston head or "crown" is the top surface against which the explosive force is exerted. It may be flat, concave, convex or any one of a great variety of shapes to promote turbulence or help control combustion. In some, a narrow groove is cut into the piston above the top ring to serve as a "heat dam" to reduce the amount of heat reaching the top ring.

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.

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.

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.

Valves

The valve's job is to open and close the valve ports. If the ports were always open, the fuel exploded in the combustion chamber would leave through the ports. The explosion has to be kept in the combustion chamber to push the piston down. The valves are set up to open and close at exactly the right moment. One lets the fuel mixture in and closes. After the fuel explodes and pushes the piston down, the other valve lets the exhaust out.

Valve Guides

The valves are usually held in an upright position by the valve stem. The valve stem is the long straight side of the valve, like the stem of a flower. Holes are bored in the cylinder head for the valve stems. Worn valve guides allow oil to enter the combustion chamber and cause blue smoke in the exhaust.

Valve Springs

The valve springs keep the valves closed tightly against their seats until the valve is opened by the cam. After the cam turns (releasing pressure), the valve springs close the valves.

Valve Seals

The valve seal is a unit that goes over the end of the valve stem. It keeps excess oil from getting between the valve guide and the valve stem.

Camshaft

The camshaft is a round shaft with "lobes" (specially formed bumps) which is driven by the timing belt or timing chain. It, directly or through "lifters" and "pushrods" opens and closes the fuel and exhaust valves. The camshaft turns at one-half of the crankshaft speed. It is supported by bearings located in the front and rear of the crankcase.

Rocker arms

Rocker arms are used to transmit force from cam to valve. Riding on a cam on the camshaft, rocker arms direct the upward motion of the lobe of the cam into an opening motion of the valve stem.

Push Rods

Push Rods attach the valve lifter to the rocker arm. Through their centers, oil is pumped to lubricate the valves and rocker arms.

Flywheel

The flywheel is a fairly large wheel that is connected to the crankshaft. It provides the momentum to keep the crankshaft turning without the application of power. It does this by storing some of the energy generated during the power stroke. Then it uses some of this energy to drive the crankshaft, connecting rods and pistons during the three idle strokes of the 4-stroke cycle. This makes for a smooth engine speed. The flywheel forms one surface of the clutch and is the base for the ring gear.

Horsepower

Horsepower is a unit of power for measuring the rate at which a device can perform mechanical work. Its abbreviation is hp. One horsepower was defined as the amount of power needed to lift 33,000 pounds one foot in one minute.

Oil Weights

Oil weight, or viscosity, refers to how thick or thin the oil Is. The temperature requirements set for oil by the Society of Automotive Engineers (SAE) is 0 degrees F (low) and 210 degrees F (high).

Oils meeting the SAE's low temperature requirements have a "W" after the viscosity rating (example: 10W), and oils that meet the high ratings have no letter (example SAE 30). An oil is rated for viscosity by heating it to a specified temperature, and then allowing it to flow out of a specifically sized hole. Its viscosity rating is determined by the length of time it takes to flow out of the hole. If it flows quickly, it gets a low rating. If it flows slowly, it gets a high rating.

Engines need oil that is thin enough for cold starts, and thick enough when the engine is hot. Since oil gets thinner when heated, and thicker when cooled, most of us use what are called multi-grade, or multi-viscosity oils. These oils meet SAE specifications for the low temperature requirements of a light oil and the high temperature requirements of a heavy oil. You will hear them referred to as multi-viscosity, all-season and all-weather oils. When choosing oil, always follow the manufacturer's recommendation.

Gaskets

Gaskets and seals are needed in your engine to make the machined joints snug, and to prevent fluids and gasses (oil, gasoline, coolant, fuel vapor, exhaust, etc.) from leaking.

The cylinder head has to keep the water in the cooling system at the same time as it contains the combustion pressure. Gaskets made of steel, copper and asbestos are used between the cylinder head and engine block. Because the engine expands and contracts with heating and cooling, it is easy for joints to leak, so the gaskets have to be soft and "springy" enough to adapt to expansion and contraction. They also have to make up for any irregularities in the connecting parts.

Four-stroke Piston Cycle

In 1876, a German engineer named Dr. Otto produced an engine, that worked, using the four-stroke, or Otto cycle. "Four-stroke" refers to the number of piston strokes required to complete a cycle (a cycle being a sequence of constantly repeated operations). It takes two complete revolutions of the crankshaft to complete the cycle.

The first stroke is the intake stroke. The piston moves down the cylinder and creates a partial vacuum in the cylinder. A mixture of air and fuel is forced through the inlet valve into the cylinder by atmospheric pressure, now greater than the pressure in the cylinder. During this stroke, the exhaust valve stays closed.

The second stroke is the compression stroke. The piston moves up in the cylinder with both valves closed. The air and fuel mixture is compressed and the pressure rises.

The third stroke is the power stroke. Near the end of the compression stroke, the air and fuel mixture is ignited by an electric spark from the spark plug. The combustion that occurs causes a rise in temperature and enough pressure to force the piston down again.

Finally, on the fourth stroke, or exhaust stroke, the piston moves up again and forces the burned gases out of the cylinder and into the exhaust system. This cycle repeats itself the entire time the engine is running.

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.

Overhead Camshaft (OHC)

Some engines have the camshaft mounted above, or over, the cylinder head instead of inside the block (OHC "overhead camshaft" engines). This arrangement has the advantage of eliminating the added weight of the rocker arms and push rods; this weight can sometimes make the valves "float" when you are moving at high speeds. The rocker arm setup is operated by the camshaft lobe rubbing directly on the rocker. Stem to rocker clearance is maintained with a hydraulic valve lash adjuster for "zero" clearance.

The overhead camshaft is also something that we think of as a relatively new development, but it's not. In 1898 the Wilkinson Motor Car Company introduced the same feature on a car.

Double Overhead Camshaft(DOHC)

The double overhead cam shaft (DOHC) is the same as the overhead camshaft, except that there are two camshafts instead of one.

Overhead Valve (OHV)

In an overhead valve (OHV) engine, the valves are mounted in the cylinder head, above the combustion chamber. Usually this type of engine has the camshaft mounted in the cylinder block, and the valves are opened and closed by push rods.

Multivalve Engines

All engines have more than one valve; "multivalve" refers to the fact that this type of engine has more than one exhaust or intake valve per cylinder.

Timing

Timing refers to the delivery of the ignition spark, or the opening and closing of the engine valves, depending on the piston's position, for the power stroke. The timing chain is driven by a sprocket on the crankshaft and also drives the camshaft sprocket.

Vacuum System (Importance of)

Engines run on a vacuum system. A vacuum exists in an area where the pressure is lower than the atmosphere outside of it. Reducing the pressure inside of something causes suction. For example, when you drink soda through a straw, the atmospheric pressure in the air pushes down on your soda and pushes it up into your mouth. The same principal applies to your engine. When the piston travels down in the cylinder it lowers the atmospheric pressure in the cylinder and forms a vacuum. This vacuum is used to draw in the air and fuel mixture for combustion. The vacuum created in your engine not only pulls the fuel into the combustion chamber, it also serves many other functions. The running engine causes the carburetor and the intake manifold to produce "vacuum power," which is harnessed for the operation of several other devices.

Vacuum is used in the ignition-distributor vacuum-advance mechanism. At part throttle, the vacuum causes the spark to give thinner mixtures more time to burn.

The positive crankcase ventilating system (PCV) uses the vacuum to remove vapor and exhaust gases from the crankcase.

The vapor recovery system uses the vacuum to trap fuel from the carburetor float bowl and fuel tank in a canister. Starting the engine causes the vacuum port in the canister to pull fresh air into the canister to clean out the trapped fuel vapor.

Vacuum from the intake manifold creates the heated air system that helps to warm up your carburetor when it's cold.

The EGR valve (exhaust-gas recirculation system) works, because of vacuum, to reduce pollutants produced by the engine.

Many air conditioning systems use the vacuum from the intake manifold to open and close air-conditioner doors to produce the heated air and cooled air required inside your vehicle.

Intake manifold vacuum also is used for the braking effort in power brakes. When you push the brake pedal down, a valve lets the vacuum into one section of the power-brake unit. The atmospheric pressure moves a piston or diaphragm to provide the braking action.

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.

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.

Main Bearings

The crankshaft is held in place by a series of main bearings. The largest number of main bearings a crankshaft can have is one more than the number of cylinders, but it can have one less bearing than the number of cylinders.

Not only do the bearings support the crankshaft, but one bearing must control the forward-backward movement of the crankshaft. This bearing rubs against a ground surface of the main journal, and is called the "thrust bearing."

Connecting Rod

The connecting rod links the piston to the crankshaft. The upper end has a hole in it for the piston wrist pin and the lower end (big end) attaches to the crankshaft.

Connecting rods are usually made of alloy steel, although some are made of aluminum.

Connecting Rod Bearings

Connecting rod bearings are inserts that fit into the connecting rod's lower end and ride on the journals of the crankshaft.

Oil Pump

The oil pump is used to force pressurized oil to the various parts of the engine.

Gear and rotary pumps are the most common types of pumps. The gear pump consists of a driven spur gear and a driving gear that is attached to a shaft driven by the camshaft. The two gears are the same size and fit snugly in the pump body. Oil is carried from the inlet to the delivery side of the pump by the opposite teeth of both gears. Here it is forced into the delivery pipe. It can't flow back, because the space between the meshing gear teeth is too tight.

The rotary pump is driven by the camshaft. The inner rotor is shaped like a cross with rounded points that fit into the star shape of the outer rotor. The inner rotor is driven by a shaft turned by the camshaft. When it turns, its rounded points "walk" around the star shaped outer rotor and force the oil out to the delivery pipe.

Piston Motion/Bicycle

The pistons in your engine's cylinder are similar to your legs when you ride a bicycle. Think of your legs as pistons; they go up and down on the pedals, providing power. The pedals are like the connecting rods; they are "attached" to your legs. The pedals are attached to the bicycle crank, which is like the crank shaft, because it turns the wheels.

To reverse this, the pistons (legs) are attached to the connecting rods (pedals) which are attached to the crankshaft (bicycle crank). The power from the combustion in the cylinders powers the piston to push the connecting rods to turn the crankshaft.

The bicycle played a large part in the process of inventing the automobile; in fact, in 1896, the first car that Henry Ford produced was even called a "Quadricycle."

Engine Placement

Mid-engine sports coupes have the engine mounted in front of the rear axle. Passenger space is limited to two people. Concentrating the weight in the center of the car improves handling.

The conventional sports coupe's engine is in the front of the car, driving either the front or rear wheels. This layout reduces production costs, but luggage space and rear seat room are sacrificed for the sporty styling.

Vans have engines located in either the front or the rear. Contemporary sedans have the engine in the front driving the front or rear axle.

Cylinder

A cylinder is a round hole through the block, bored to receive a piston. All automobile engines, whether water-cooled or air-cooled, four cycle or two cycle, have more than one cylinder. These multiple cylinders are arranged in-line, opposed, or in a V. Engines for other purposes, such as aviation, are arranged in other assorted forms.

The first four cylinder engine with a sliding transmission was in the 1907 Buick.

Rotary Engine

One alternative to conventional automobile power is the rotary (or Wankel) engine. Although it is widely known that Felix Wankel built a rotary engine in 1955, it is also a fact that Elwood Haynes made one in 1893!

Dispensing with separate cylinders, pistons, valves and crankshaft, the rotary engine applies power directly to the transmission. Its construction allows it to provide the power of a conventional engine that is twice its size and weight and that has twice as many parts. The Wankel burns as much as 20% more fuel than the conventional engine and is potentially a high polluter, but its small size allows the addition of emission-control parts more conveniently than does the piston engine. The basic unit of the rotary engine is a large combustion chamber in the form of a pinched oval (called an epitrochoid). Within this chamber all four functions of a piston take place simultaneously in the three pockets that are formed between the rotor and the chamber wall. Just as the addition of cylinders increases the horsepower of a piston-powered engine, so the addition of combustion chambers increases the power of a rotary engine. Larger cars may eventually use rotaries with three or four rotors.

Combustion Chamber

The combustion chamber is where the air-fuel mixture is burned. The location of the combustion chamber is the area between the top of the piston at what is known as TDC (top dead center) and the cylinder head. TDC is the piston's position when it has reached the top of the cylinder, and the center line of the connecting rod is parallel to the cylinder walls.

The two most commonly used types of combustion chamber are the hemispherical and the wedge shape combustion chambers.

The hemispherical type is so named because it resembles a hemisphere. It is compact and allows high compression with a minimum of detonation. The valves are placed on two planes, enabling the use of larger valves. This improves "breathing" in the combustion chamber. This type of chamber loses a little less heat than other types. Because the hemispherical combustion chamber is so efficient, it is often used, even though it costs more to produce.

The wedge type combustion chamber resembles a wedge in shape. It is part of the cylinder head. It is also very efficient, and more easily and cheaply produced than the hemispherical type.

Intake Stroke

The first stroke is the intake stroke. The piston moves down the cylinder and creates a partial vacuum in the cylinder. A mixture of air and fuel is forced through the inlet valve into the cylinder by atmospheric pressure, now greater than the pressure in the cylinder. During this stroke, the exhaust valve stays closed.

Compression Stroke

The second stroke is the compression stroke. The piston moves up in the cylinder with both valves closed. The air and fuel mixture is compressed and the pressure rises.

Power Stroke

The third stroke is the power stroke. Near the end of the compression stroke, the air and fuel mixture is ignited by an electric spark from the spark plug. The combustion that occurs causes a rise in temperature and enough pressure to force the piston down again.

Exhaust Stroke

On the fourth stroke, or exhaust stroke, the piston moves up again and forces the burned gases out of the cylinder and into the exhaust system.

Valve Lifter (Tappet)

The valve lifter is the unit that makes contact with the valve stem and the camshaft. It rides on the camshaft. When the cam lobes push it upwards, it opens the valve.

The engine oil comes into the lifter body under pressure. It passes through a little opening at the bottom of an inner piston to a cavity underneath the piston. The oil forces the piston upward until it contacts the push rod. When the cam raises the valve lifter, the pressure is placed on the inner piston which tries to push the oil back through the little opening. It can't do this, because the opening is sealed by a small check valve.

When the cam goes upward, the lifter solidifies and lifts the valve. Then, when the cam goes down, the lifter is pushed down by the push rod. It adjusts automatically to remove clearances.

Lifter Body

The valve lifter body houses the valve lifter mechanism. The valve lifter is the unit that makes contact with the valve stem and the camshaft. It rides on the camshaft. When the cam lobes push it upwards, it opens the valve.

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.

Wankel Rotor

The rotor within a rotary engine consists of three basic parts. One is the rotor itself which has cavities in it that serve as compression chambers. The second part consists of seals; these are strips of metal mounted at each point of the rotor. The third principal component of the rotor is the ring gear. The ring gear engages the fixed gear that is mounted to the side of the engine block. Since the fixed gear and the ring gear are engaged as the rotor rotates, a flip-flopping motion of the rotor (much like a hula-hoop) is caused as it goes around the fixed gear.

Within the rotor is the eccentric shaft that turns independently of both the rotor and the fixed gear. This serves basically the same purpose as the crankshaft of an engine, and it works in much the same way. As the rotor is flipped around the fixed gear, it turns the eccentric shaft at half the rotor's rotating speed. Due to the imperfect nature of the seals on the rotor as compared to the rings on a piston engine, rotary engines tend to pollute more than piston engines. However, with the development of new seal technology, improvements are being made in this area.

Oil Seals

Oil seals are rubber and metal composite items. They are generally mounted at the end of shafts. They are used to keep fluids, such as oil, transmission fluid, and power steering fluid inside the object they are sealing. These seals flex to hold a tight fit around the shaft that comes out of the housing, and don't allow any fluid to pass. Oil seals are common points of leakage and can usually be replaced fairly inexpensively. However, the placement of some seals make them very difficult to access, which makes for a hefty labor charge!

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.

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.

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 Passages

Within the engine is a variety of pathways for oil to be sent to moving parts. These pathways are designed to deliver the same pressure of fresh lubricating oil to all parts. If the pathways become clogged, the affected parts will lock together. This usually destroys parts that are not lubricated, and often ruins the entire engine.

The oil passages are cleverly drilled into the connecting parts of the engine, which allows the highly mobile ones (like the pistons) to have ample lubrication. Originating at the oil pump, they flow through all of the major components of the engine. In the case of the pistons and rods, the passages are designed to open each time the holes in the crankshaft and rods align.

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.

Serpentine Belts

A recent development is the serpentine belt, so named because they wind around all of the pulleys driven by the crankshaft pulley. This design saves space, but if it breaks, everything it drives comes to a stop.

Cutaway of the V-8 Engine

This diagram shows the flow of fuel and exhaust within a V8 engine. It shows the timing chain (driven by the crankshaft) drives the camshaft, which opens the valves. Fuel enters the cylinders via the intake manifold. The spark-caused explosions force the pistons down. Rotation of the crank forces the pistons back up, which expels the exhaust.

The Engine's Lubrication System

This animation shows the route taken by the oil within an engine. The oil pump draws oil from the oil pan, then forces it through the filter, into the crankshaft passage, through the connecting rods to the pistons and rings. Oil is pushed through the lifters and pushrods, and covers the rocker arms. It then flows back down into the pan to complete the cycle.

Autom

Menu for /auto101/maps/auto101_buttons.map

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/auto101.html

/tips.html

/sec_inquiry.html

/home.html

- [Visit The Service Department To Submit Your Problem Or Question]

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Automotive Facts

Automobiles in History

In the annuals of history, the automobile flashed onto the scene like a meteor, changing the entire economy and the national way-of-life. No one was really prepared for it. Generations of horse-drawn road transportation had created a complex system of industries on which the automobile had a damaging effect; everybody from horse doctors and harness-makers to blacksmiths. The continuing changes and the reasons for them are obvious to us, but probably were not so obvious to automotive pioneers. It was, after all, a learn-as-you-go process with no precedents. For every inventor who made a fortune, hundreds had their dreams crumble. Automobiles have ended the isolation of rural communities and set an example of industrial efficiency for the world to copy. It has also spoiled the cities and small towns as neighborhoods are obliterated by highways smashing through; it has polluted the environment, and caused shortages in natural resources. Yet the car itself is still the object of endless fascination.

Automobiles in History and Politics

In 1905, President Theodore Roosevelt said he had ridden in a car only twice in his life and that was quite enough. His chauffeur had been stopped by a policeman on his second ride, going at the outrageous speed of ten mile per hour. Roosevelt declared he would never ride in a car again. He later became the first President to own a car and the first to drive one. The nation`s first speeder, by the way, was arrested in 1899 by a New York policeman riding a bicycle. The speeder was whizzing along at an amazing twelve miles per hour!

In 1907, five years before becoming President of the United States, Woodrow Wilson warned the American citizens that the motorcar would "spread socialist feelings in this country." He, like Roosevelt, was forced to eat his words and think twice before he condemned anything again. In 1919, he bought a Model T Ford.

In 1908, a U.S. Army study predicted that the automobile was unsuited for war. During World War I, however, the Allies commandeered all the taxis in Paris to rush their troops to the front lines, halting the German Army at the Marne. Meanwhile, in spite of their predictions, the Army was buying some cars for the brass, refusing to pay the state of New York a $2.00 license fee on the grounds that the U.S. Government was immune from taxation.

Hiram Johnson was the first political candidate to put his campaign on motorized wheels in 1910. He drove his way right into the governor's mansion in California by covering the state in a car.

Nearly every member of the Russian royal family had a Rolls-Royce. Czar Nicholas II had a matched pair of Rolls-Royce Silver Ghosts. Prince Feliks Yussupov, the Czar's nephew, owned a Silver Ghost which became part of history.

Grigori Yefimovich Novykh, known as "Rasputin," arrived in St. Petersburg from Siberia about 1906. Rasputin means "debauched," an appropriate name for one who believes that salvation can only be gained by sinning. In spite of his amorality, Rasputin claimed to be a holy man with the power to heal. By superstition of the times and manipulation, he was able to accomplish improved health for several of the afflicted who came to him for help. Czarina Alexandra Feodorovna, whose son had hemophilia, in desperation to save the royal heir, sent for Rasputin after the court physicians had failed to help him. Rasputin held some emotional and mystic sessions with the boy and convinced Alexandra that he had cured him. Alexandra then turned to him more and more for advice concerning personal and even public matters. Using his hold over the Czarina, he gained influence over Czar Nicholas' decisions on affairs of state.

Prince Yussupov was alarmed by Rasputin's meddling and conspired with four government officials who felt the same to do away with Rasputin. On December 29, 1916, these conspirators lured him to Moika Palace and fed him wine and cakes laced with cyanide. The poison either had no effect or took longer than the party could stand, so Yussupov shot him several times to shorten his suffering. They carried the body of Rasputin, bleeding but still alive, to Yussupov's Rolls-Royce, first wrapping him so that he would not stain the upholstery. Driving to the banks of the frozen Neva River, they dragged him from the car and dropped him through a hole in the ice. Rasputin went out in grand style: sitting on the back seat of a Rolls-Royce, which was driven by a prince of the realm.

A year and a half later, the entire royal family was dead, murdered during the Communist Revolution. Lenin, the father of Communism, owned the very symbol of Capitalism, a Rolls-Royce. The fate of Yussupov's Rolls-Royce is unknown, but Lenin's is in the Moscow museum. That makes two Rolls-Royce automobiles in Russia at the present time, since the British Ambassador drives one. If you are interested in owning one of the grandest of the grand, the makers of Rolls have an elongated Silver Spur limousine on sale for only $185,000.

Another automobile which played a major part in history is the Mercedes, which really doesn't seem to be a good token for political leaders.

Germany's Kaiser Wilhelm had a chauffeur-driven Mercedes with an imperial eagle on the hood; World War I took away not only his handsome automobile, but also his empire. One war later, Adolph Hitler rode to defeat in a Mercedes limousine. Hitler had been so proud of his country's automobile that in 1939, when Nazi Germany and the Soviet Union signed their pact of non aggression, which neither nation honored, he gave a supercharged sports Mercedes roadster with a rumble seat to his good friend, Joseph Stalin. After Stalin died, his son sold the Mercedes to a Swede who later sold it to a man in Arizona. The Arizonan later offered it for the sale price of $775,000 but said he could be talked down to a measly $700,000.

Shortly after Hitler killed himself (and then swam to South America), the chancellor of the new German Federal Republic, Mercedes-borne Konrad Adenauer, watched his country split in half. Emperor Hirohito of Japan also owned a red and black Mercedes before he came in last during WWII.

The Mercedes is especially popular among the political elite in Africa, which the Swahili call "wabenzi," or men of "Mercedes-Benz." The Central African Republic's Emperor, Jean-Bedel Bokassa, was one such wabenzi, who had his country and his entire Mercedes fleet taken in a 1979 coup. Six years later, the wabenzi of Nigeria, President Alhaji Shihu Shagari, lost his office and impressive car in the same way.

A group of middle-aged women in Togo fared much better than the men. Some decades ago, these ladies made night visits into Ghana to smuggle that country's fine cloth into Togo. Subsequently, they gained control over Togo's entire textile market, branching out into legal commercial enterprises and becoming millionaires many times over. They drive around Togo in their Mercedes limousines to check up on real estate holdings, restaurants, grocery stores, and various other ventures. When the Togolese President discovered that he did not have enough VIP vehicles to receive his visitors while hosting a conference of the African heads of state, he sent out a call for help to the "Mercedes Ladies." In a few hours, a whole procession of gleaming Mercedes automobiles drove up to assist the President.

Clyde Champion Barrow, of Bonnie and Clyde fame, wrote a letter to Henry Ford in 1934, one month before Clyde and the cigar-smoking, gun-toting Bonnie were killed in a shoot-out with the police. Clyde stopped running from the federal authorities long enough to write what a "dandy car" Ford made. He wrote that "...For sustained speed and freedom from trouble the Ford has got every other car skinned and even if my business hasn't been strictly legal it don't hurt anything to tell you what a fine car you got..." In 1947, the very car that Clyde had so much affection for was sold at auction. It had been wrecked during the shoot-out and was bullet-ridden. Even so, it brought $175,000.

When Gerald Ford became Vice President in 1973, he stated, "I am a Ford, not a Lincoln." Once he became President, he found himself to be a Ford in a Lincoln, since the Lincoln was the official automobile for the President, a tradition started by Calvin Coolidge in 1924. This tradition was upheld until Ronald Reagan expressed a fondness for the Cadillac.

Automobiles, like wine, seem to become more costly with maturity and age. An Orlando auction in 1981 brought $350,000 for a 1936 Packard that had been purchased for about $2,000 when new. A 1936 Mercedes brought $421,000 in Los Angeles in 1979. One auto lover in Kansas has given 30,000 hours of labor to fine-tune and plate his 1920 Pierce Arrow with silver and gold. This automobile is insured with Lloyd's of London for $1,000,000!

Automobiles in Art and Literature

Cars have frequently played a major role in literature. They are even used at times to comment on the state of humanity. Carl Sandburg wrote "Portrait of A Motorcar" in 1918 and almost twenty years later, made the automobile the center of his long prose poem, "The People, Yes." Joyce Carol Oates, in 1979, wrote a provocative poem entitled "F---"; for Ford, of course.

In 1919, Sinclair Lewis wrote whimsically of his adventures in a Model T. Six years later, F. Scott Fitzgerald wrote his masterpiece, "The Great Gatsby," portraying the cynicism of post-World War I by the use of Gatsby's cream-colored Rolls-Royce. In 1962, William Faulkner wrote humorously about human frailties against the backdrop of an early Winton Flyer automobile in his literary classic, "The Reivers." Some poets and novelists were drawn to the car culture, but others were depressed by it. Either way, the automobile was the hub of human commentary for a long list of writers.

Even more than writers, composers of popular music are attracted to cars. They jumped in almost as soon as the first car drove past and have never gotten off. Many of the songs are sexually oriented. Titles include "In My Merry Oldsmobile," "On The Back Seat of A Henry Ford," "Tumble in A Rumble Seat," "Keep Away from The Fellow Who Owns an Automobile," up to the contemporary songs such as "Maybelline," "Mustang Sally," "Little Deuce Coupe," "Pull up to The Bumper," and "Little Red Corvette." Trucking songs, such as "King of The Road," "On the Road Again," and others too numerous to mention are immensely popular.

The Los Angeles Music Center and Museum of Contemporary Art commissioned several playwrights to create original ten-minute scripts to be acted out in automobiles. The film industry has relied heavily on the automobile, ranging from the humorous "The Long, Long Trailer" and "It's a Mad, Mad, Mad, Mad World" to "Bonnie and

Clyde" and hundreds of chase scenes. Television made the automobile the very star of the show in "My Mother, The Car" and "The Knight Rider," in which "Kit" is smarter than any of the rest of the cast.

Artists followed Toulouse-Lautrec's lead from his 1896 lithograph, "The Motorist," to take up brushes and portray the essence of the automobile. Some used their brushes in cartoon fashion to show it as a toy of the idle rich. Some saw it as a symbol of mankind's dynamism and vitality. Andy Warhol, who saw art in a Campbell soup can, painted a series devoted to gruesome car wrecks. Other artists see the automobile as a graceful, flowing form of man-made beauty, an art in itself.

Those Women Drivers!

The first "chauffeuse," or woman driver to appear in public was Miss Daisy Post, a niece of Mrs. Frederick Vanderbilt; she was soon joined by Mrs. Herman Oelrichs and Mrs. William Vanderbilt.

A Mrs. Stuyvesant Fish, with Miss Greta Pomeroy as her passenger, decided to drive the "machine" around the grounds. She meant to stay close to the drives and sidewalks, but instead, ran into a stone wall. The wall fell down and the car proceeded, tearing out a clump of choice shrubbery and finally smashing into the steps of the house. At this point, the car finally stopped and the whole side of the automobile gave way and fell off. Mrs. Fish may have been the originator of the male expression, "woman driver." Of course, many male drivers fared no better than Mrs. Fish on their first try - and many did worse. There were many instances recorded of panic-stricken men losing control of their vehicles and shouting, "Whoa! Whoa!"

Miss Anne Rainsford French of Washington, D.C., whose father was a noted physician in the capital city, was awarded her "Steam Engineeer's License, Locomobile Class," on March 22, 1900. She was one of the earliest licensed women drivers in the United States. Mrs. John Howell Phillips of Chicago is said to have been licensed two months prior to Miss French, however. In the same year, 13-year-old Jeanette Lindstrom received license No. 322 and it was claimed that she had already been driving for two years.

Mrs. Mary Landon was the entire office staff of the Haynes-Apperson Automobile Company. In 1899, she read the instruction sheet put out with each of the vehicles and proceeded to drive one of the firm's automobiles across town to the factory. Upon her arrival there, Elmer Apperson exclaimed, "Well, I'll be damned!"

Mrs. Newton J. Cuneo of New York was the only woman driver in the first Glidden Tour in 1905. She was driving smoothly along when another car stalled in front of her on a narrow bridge. Unable to apply the brakes in time, she rear-ended the other car and tipped her own into the creek.

In 1909, Mrs. Alice Ramsey and three women companions (Nettie Powell, Margaret Atwood, and Miss Hermine Johns) drove a Maxwell touring car from New York City to San Francisco in fifty-three days. They proved themselves capable of keeping their car in operation, changing tires and finding their way on unmarked roads. Their biggest problem was that each had only one suitcase for the entire journey. The Maxwell Company hired an advance man, John D. Murphy, to precede the ladies and make necessary hotel accommodations and check on the gasoline supply for their extra-large twenty-gallon tank.

The ladies added a new dimension to motoring. Dusters, scarves, veils, hats, and gauntlet-style gloves were a must of the female driver. Before windshield wipers became standard equipment, goggles had to be part of the attire. Some wore large face-covering bonnets, like bee-keepers hats, with a glass window to see through, or they carried tiny hand-windshields, which they held in front of their faces to keep dust and bugs out of their eyes.

Queen Victoria, of England, had died in 1901, and gradually the symbols of her moralistic influence began to fade. Equal rights became a reality, and the automobile played an influencing role in the change. The status of the weaker sex was improved, and the slogan of the Pullman auto - made in New York, Pennsylvania - had a special meaning for women: "Tailored for Her Majesty, the American Woman."

Wake! For the Car that scatters into flights The Hens before it in a flapping Fright, Drives straight up to your Door, and bids you Come Out for a Morning Hour of Sheer Delight.

We are no other than a Moving Row Of Automobile Cranks that come and go. And what with Goggles and Talc-windowed Veils, In Motoring Get-up, we're a Holy Show! Carolyn Wells, 1906

How Cars Are Assembled

Ford's revolutionary concept of the assembly line to make cars included a rope which pulled a line of chassis along a track, at which stood fifty workers, each fixing their own allotted part to each chassis as it moved by. Assembly time for a chassis dropped from twelve to one and a half hours. In less than ten years, the price of a Model T dropped from $850 to $250. Ford sold 1.8 million Model T cars. In 1951, Ford led the way in using automatic equipment to produce engine blocks.

The urge to save labor has continued to inspire new developments, with robots replacing workers, cutting out tedious tasks and guaranteeing greater accuracy. On the Fiat Uno, 30 of the 2700 welds are done by hand. Only specialized crafts, such as electrical wiring, now remain in human hands.

In a typical car assembly in the 1980s, the first stage was sheet steel arriving at the press shop. In areas as large as three football stadiums, robot cranes supplied rolled sheets of steel to giant stamping machines, which cut the pieces of metal to make up the car body. Then robots built the underbody or floorpan, making numerous welds and creating a complex shape with spaces for wheel arches, boot wells and spare wheels.

In the next stage, large jigs positioned the body sides and roof to be welded into place automatically. In the meantime, the doors had been made on nearby assembly lines in a process that involved several different pressings to create an outer skin clinched over an inner frame. Finally, lasers checked every car body for the smallest flaw, distortion or irregularity.

The car, now largely assembled, was cleaned in a degreasing tank, rinsed and coated with phosphate to make it more receptive to the paint. After further rinses, base primer coat was applied, in several layers. These primer coats were sprayed on electrostatically, using an electric field to attract the paint. The last layers, usually three, were glossy acrylic paint. The paintwork on most mass-produced cars is 0.1mm thick; although on a Rolls-Royce, there are 22 layers of paint, giving a thickness of 0.2mm. Special wax was then applied to protect against water, snow, grit and salt. This was injected into hollow sections such as pillars and sills.

The next stage, the trim, fitted out the interior. The car was wired with its electrical system. Robots fitted underfelt, carpets, seats and other fittings. Windscreen and some other windows were often glued to the car to make a better fit and reduce wind resistance and noise. Robots applied the glue to the edge of the glass and then put it in place on the car with sucker grips.

Finally, the car was hoisted up, and a jacking system brought the engine, complete with clutch and gearbox, into position. The fuel tank was mounted at the rear end of the car. Next came suspension, steering, radiator and battery, and then the wheels and tires. When water, antifreeze, oil and gasoline were added, the car was ready to run. Inspectors examined it at the gate before its final road tests. When the car was given it final checks, it was ready for the dealer.

Facts about Rubbish

Every year Americans throw away 250 million tons of rubbish. New York alone generates almost 10 million tons a year. It has been estimated that America's garbage could provide as much energy as 100 million tons of coal. Unfortunately, most of it is buried and never used. Recycling garbage can produce electricity, saving millions of tons of coal. Rubbish can also be burned by factories instead of coal or oil, but it must be treated first.

For our purposes, rubbish dumped in the ground could be used as a source of fuel. As garbage begins to rot, it produces methane gas, which is the same as the natural gas found in pockets under the earth's crust. Each ton of refuse can produce up to 14,000 cubic feet (or 400 cubic meters) of methane. Left alone, the gas will find its way to the surface and escape, sometimes causing explosions. But it can be tapped very cheaply and used to generate heat or electricity. Some plants use the gas on site to generate electricity by burning it in simple gas engines. This allows all the gas to be used, rather than trying to match output to the fluctuating demands of a factory. In the future, gas production in rubbish may be used to fuel our automobiles as an oil substitute.

We should also be interested in metal waste, which could be sorted out and reused after processing for car parts.

A Few Facts about Oil

When oil was struck in the Forties Field under the North Sea in 1969, it led to the discovery of at least 350 million tons of oil. However, by the year 2020, the world's known oil reserves are due to run out. By then, new oil fields will need to be found, probably in more and more inaccessible places. Prospectors looking for oil look for sedimentary basins which could be oil-bearing, magnetic surveys and gravity surveys are often used. All rocks are magnetic, but the magnetism varies slightly from one rock to another, giving geologists clues to the structure and type of rocks that lie underground. Other clues include the density of the rock.

When the production wells have been drilled and lined with casing, a perforating gun is lowered down them to drive explosive charges through the casing and cement and into the rock beyond to allow the oil to get into the wells. As oil is extracted, pressure may be maintained by injecting water or gas into the reservoir rock to displace the oil towards the production wells.

Even with the help of modern techniques, however, such as electrical and mechanical pumps, it is seldom possible to extract more than 30% to 50% of the oil in a field. Perhaps a means will be found to get all the oil out of a "dig." If so, millions more gallons would be available out of the wells which have previously been drained "dry."

Lighting City Streets

Every day, at dusk and dawn, millions of street lights are turned on and off throughout the world. Most lights are controlled by time switches, which operate a group of lights in nearby streets. The earliest time switches worked by clockwork and had to be wound up and adjusted every week.

Many modern time switches now have an electric clock with a rotating dial, containing levers and tappets, which turn the lights on and off at the chosen times. Since the sun rises and sets at different times during the year, street lights must also go on and off at different times, so these dials also alter the switching times according to the season of the year. This is arranged in the time switch by a mechanical device which adjusts the "On" and "Off" tappets month by month to follow the changes in the hours of daylight.

Recently, engineers have developed a photoelectric control unit called a "pecu," which operates a switch in the electrical supply to the lights. At dawn, light falling on a photocell causes electrons to flow from one atom to another, conducting electricity to the switch and turning it off. When darkness falls, the electrons become immobile, the current stops, and the lights are turned on. The exact time that the lights go on and off will also depend upon weather conditions.

Seat Belt Protection

A driver or passenger travelling in a car is moving at the same speed as the car. If the car suddenly stops, the body of the rider inside will keep moving forward at the same speed. This demonstrates inertia - the tendency of a moving object to keep moving, or of a stationary object to remain at rest. An inertia-reel seat belt works on the same principle. Its mechanism includes a pendulum, which hangs vertically under ordinary driving conditions. If the car should suddenly stop, however, it swings forward, and a locking lever resting on the pendulum is released. The lever engages a toothed ratchet that locks the shaft around which the belt is wound. The locked seat belt then prevents the body from being flung forward.

When the seat belt is fastened, it winds out from the reel against slight tension from a spring. This keeps it taut during normal traveling, but allows enough free movement for a driver to reach forward as necessary. If the driver tugs on the belt abruptly while winding it out, the locking mechanism will engage and stop the action of the spring. Slackening the belt releases the spring and the locking lever.

Tires on Racing Cars

Car tires are more than just cushions for the wheels. They also give the car a good grip on slippery roads and keep it from sliding about when braking and cornering. The tread patterns running all around the tire have thin cuts in the rubber to sponge up surface water, and zigzag channels to pump the water out behind as the car rolls forward. On a wet road, a tire has to move more than one gallon (5 liters) of water a second to give needed grip.

On perfectly dry roads, the treads are not needed. A smooth tire gives the greatest possible area of contact with the road, but if smooth tires are used on wet roads, the film of water builds up in front of the tires and underneath them and actually lifts them off the road surface, a condition known as "hydroplaning." In this situation, the driver will lose control of the car.

Most cars have to function in all types of weather, so their tires must have tread, but racing cars make very few outings a year. If the track is dry, they run on smooth tires, called "slicks," to get the best grip on the roads. The extra wide tires and wheels give more grip than the average car, but in wet weather, the racer must change to treaded tires.

Breath Tests

When someone blows into a breath-test bag, any alcohol in his breath is turned into acetic acid (vinegar), changing the color of the crystals in the blowing tube. The more crystals that change color, the more alcohol is in the body. The first breath-alcohol test was developed by an American doctor, Rolla N. Harger, who called it a "drunkometer."

The breath-alcohol tests used by the police today, however, are usually electronic, and much more accurate than the inflatable plastic bag type. They use the alcohol blown in through the tube as fuel to produce electric current. The more alcohol the breath contains, the stronger the current. If it lights up a green light, the driver is below the legal limit and has passed the test. An amber light means the alcohol level is near the limit, a red light is above the limit, and in both cases the driver has failed the breath test and needs further testing. These tests are used to judge a driver's ability to drive. A high intake of alcohol dulls the nervous system and slows up coordination.

The best advice concerning these are the familiar "If you drink, don't drive; if you drive, don't drink!"

Did You Know?

By 1898, American motorists had formed about fifty clubs across the country. In 1902, the biggest and most enduring of these clubs was founded - the American Automobile Association.

In 1900, the nation's total hard-road surface was under 40,000 miles. The first mile of concrete roadway was laid in 1908, at which time Kansas had 273 miles of macadam and gravel roads; Delaware had 66; Nebraska, 23; and Oklahoma had none.

In 1906, the Stanley Steamer clocked an unheard of speed of 127.6 miles an hour on the sands of Ormond Beach, Florida.

On June 27, 1980, a time when the great international question of the day was whether or not fifty-three American hostages held in Iran by terrorists would get out alive, the top U.S. official in the hostages had plans to get out. Maryland's Motor Vehicle Bureau received a letter from Tehran, asking that the official's driver's license be renewed before it expired. He perhaps dreamed of driving freely down a New England highway when he was released and didn't want expiration of his driver's license to come between him and his dream.

A New Jersey couple tried to swap their fourteen-month-old son for a '77 Corvette. When the police arrived, the couple were just attaching their license plates on the car for which they had traded their son. The infant was found crawling happily on the floor of the showroom.

According to the United States Census Bureau, we spent $856 million to wash our cars in 1982. This was not to smooth dents in fenders or even to touch up paint jobs; it was just to run through the neighbor- hood car wash. Now something new has come on the scene for a soiled car: it is called "detailing." These shops started in California and are spreading across the country. They wash the car, massage it with lotions and creams, blow-dry it, and wipe it gently with chamois for a mere $145 for the eight-hour beauty treatment.

Mrs. Selma Ghelberg applied for and received a personalized license plate in Mount Vernon, New York. Her son had established "No Name" as his CB "handle," and Mrs. Ghelberg therefore asked for a NO NAME tag. Mrs. Ghelberg immediately began to receive dunning notices for unpaid parking and speeding tickets. She had always obeyed the law and had never received a ticket, so she took the notices in and explained her situation at the police station. The police were very skeptical, but since Mrs. Ghelberg was so adamant about her innocence, they agreed to investigate.

The investigation revealed that when a policeman wrote a ticket with the offender's name entered illegibly, the clerk punched "No Name" into the computer. The computer in Albany automatically sent a response that NO NAME was registered to Mrs. Ghelberg, and the police issued her another ticket. The irony of this dilemma was that our poor Mrs. Ghelberg worked for the New York State Department of Motor Vehicles!

Some Interesting Slogans from Pioneer Cars

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Ariel:                 "Look for the Oval Front"
Bates:                 "Buy a Bates and Keep Your Dates"
Black Motor Buggy:     "Get There!"
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Brush:	"Everyman's Car"
Commonwealth:	"The Car With the Foundation"
Dragon:	"The Motor That Motes"
Elmore:	"The Car That Has No Valves"
Firestone Columbus:	"The Car Complete"
Fuller:	"Fuller Cars Do Things"
Gasmobile:	"The Finest Gasoline Touring Carriage Built in America"
Henry:	"Built to Sell on its Merits"
Lancamobile:	"Automobilism Effectually Realized"
Lexington:	"Built to Stay Young"
Lozier:	"The Choice of Men Who Know"
Marmon:	"The Easiest Riding Car in the World"
Metz:	"No Clutch to Slip--No Gears to Strip"
Oakland:	"The Car with a Conscience"
Owen-Magnetic:	"Banishing the Commonplace"
Paige-Detroit:	"Highest Grade Small Car in the World"
Parry:	"In the Long Run a Parry"
Pilot:	"The Car Ahead"
Pope-Toledo:	"The Quiet Mile-a-Minute Car"
Pungs-Finch:	"Stands Alone in Its Class"
Roamer:	"America's Smartest Car"
Santos-Dumont:	"This One Flies But Never Falters"
Severin:	"Faithful to the End of the Road"
Union:	"In Union there is Strength"
Walter:	"The Car of a Hundred Reasons"
Waverly Electric:	"No Dirt, No Odor, No Grease, No Bother"

Automotive Developments 1600-1894

No matter how well automobiles run, people complained about this or that and wanted continual improvements made. Pioneer drivers fretted about pesky details such as the buttoning down of side-curtains in a sudden storm; the stoking of a Clark charcoal auto heater; the frustration of a broken drive-chain wrapped around a rear axle and the feeble flicker of the carbide lamp on the dark country roads. Something had to be done to stop all the complaining!

1600 - The Dutch employed wind power to propel sail-mounted carriages which raced along at 20 mph and held scores of passengers. It is quite probable that both speed and load capacity were exaggerated. Later, small carriages were equipped with wind-mills, the mill vanes geared to the wheels. These were probably the first land vehicles to be propelled by anything other than animal or human muscle power, but people complained because the vehicles depended on the whim of a breeze.

1680 - Sir Isaac Newton conceived of a vehicle propelled by a "rear-wardly directed jet of steam." This idea didn't evolve for use in the automobile, but it was later used in rocket thrust.

1698 - Thomas Savery invented the first steam engine in Britain. It was crude, inefficient, and even dangerous, since it blew up quite often.

1711 - Thomas Newcomen, an English blacksmith, improved upon Savery's engine.

1769 - James Watt, a Scottish instrument maker, patented a steam engine that became widely used in British mines, mills, and factories.
Nicholas Joseph Cugnot, an officer financed by the French government, built a steam-propelled, 3-wheeled artillery wagon, which raced along at 3 mph. In a demonstration, it went out of control and ran into a wall. Most automotive historians trace the beginning of the true automobile back to Cugnot's cannon.

1801 - Richard Trevithick, an engineer in Cornwall, built an experimental road steamer. Two years later, he improved on his invention, which was demonstrated in London and proved itself to have sustained, reliable performance at its maximum speed of 12 mph.

1804 - American road steamers were built by Apollo Kinsley in Connecticut, Nathan Read in Massachusetts, and Oliver Evans in Pennsylvania. Evans' vehicle was 30 feet long and weighed 15 tons. Evans had applied for a patent on a "Steam Land Carriage" in 1792. He was commissioned in 1805 by the city's board of health to build a versatile steam-driven dredge. He added the idea that the machine also travel on land under its own power. A series of belts and gears transmitted the power of the boat's engine to the wagon wheels. On its first run, it clanked slowly along on huge iron wheels, frightening onlookers on its way to the Schuylkill River where its energy was diverted from the land wheels to a paddlewheel in the stern.

1830s- Britain was providing a network of passenger and freight services which were steam-powered in a handful of cities.

1831 - Michael Faraday discovered the principles of the induction coil.

1839 - The first electrically-powered road vehicle is believed to have been built in Scotland by Robert Anderson, but it and others built in Britain in the next several years were mostly unsuccessful. Around 1880, longer-lasting batteries were developed, but these were cumbersome and bulky and needed frequent recharging. Electric cabs, however, appeared on the streets of London in the late 1800s.

1845 - A Scot called Thomson patented a type of pneumatic tire, but John Boyd Dunlop is usually given credit for their development.

1850 - A method of obtaining liquid hydrocarbons from coal and shale was patented by James Young, a Scotsman. This "coal oil" took the pressure off the dwindling numbers of whales which until that time had been a prime source of oil for lamps.

1859 - On August 27, an ex-railroad conductor, Edwin L. Drake, made a revolutionary discovery with a 69-foot well at Titusville, Pennsylvania. "Rock oil" had previously been collected from ground seepage pools and used for medicinal and other limited purposes. With Drake's discovery on Oil Creek leading the way, great volumes of petroleum became available in the United States. It provided kerosene for millions of lamps, paraffin for candles and candy, hoof and harness oils, lubricants for ships and mills, a "miracle" salve called Vasoline, and many by-products to make varnishes, lacquer, oilcloth and patent leather. One of the waste products of the distilling process was an explosive, inflammable substance called "gasolene."

1860 - Etienne Lenoir built and patented the first commercially satisfactory gas engine. Two years later, he constructed a crude vehicle on which to test his engine. Although it was crude, it worked, but ran so slowly (about 1 mph), he became discouraged and stopped his efforts. Lenoir's engine used an electric spark plug system.

1864 - In Vienna, Austria, Siegfried Marcus built a one-cylinder engine that used a primitive carburetor and a magneto arrangement to create small explosions that applied alternating pressures against the piston within the cylinder.

1872 - George Brayton of Boston patented a gasoline engine.

1874 - H. J. Lawson invented the first so-called safety bicycle, a chain-driven device with two medium-sized wheels of equal diameter.

1875 - Siegfried Marcus built his second gasoline-powered vehicle, which is preserved in the Technical Museum in Vienna; Marcus mysteriously washed his hands of the whole idea, deciding it to be a waste of time.

1876 - In Deutz, Germany, Eugene Langen and Nikolaus August Otto improved upon Marcus' engine and introduced the first workable 4-stroke internal combustion gas engine after many years of experimental work. Gottlieb Daimler, an employee of Langen and Otto, was involved in the engine's design.

1879 - George B. Selden, an attorney in Rochester, New York (who, at the time, had never built a motor vehicle), applied for and finally received U.S. patent No. 549,160 (1885)). As a result, claims against automobile manufacturers clouded the industrial scene for years.

1883 - In Bad Cannstatt, Germany, Wilhelm Daimler succeeded in producing a more efficient, 4-stroke, gasoline-fueled engine which was granted a patent. (Earlier "gas" engines had been fueled by hydrogen or turpentine vapors or by coal gas.) Daimler's first engine was mounted on a sturdy bicycle and operated well on a test run in 1885. This is the prototype of the modern motorcycle.

1885 - Carl Benz successfully tested his first gasoline engine motor vehicle at Mannheim, Germany; a 1-hp, 1-cylinder engine; a refinement of the 4-stroke engine which was designed by Otto. This 3-wheeler had all the essential elements characteristic of the modern automobile: electrical ignition, differential, mechanical valves, carburetor, a water cooling system, oil and grease cups for lubrication, and a braking system. He received a patent for his "carriage with gas engine" in 1886. It had a tubular steel chassis and an open wooden two-seater body. The single front wheel steered by means of a tiller, and the two large rear wheels were driven by chains. The single-cylinder engine was mounted horizontally over the rear axle. At 250 to 300 rpm, it produced about 1/2 horsepower and drove the car at about 8 to 10 mph (13-16 kph).

1887 - Building on his experience with the motorcycle, Daimler built and installed his vertical single-cylinder engine into a 4-wheeled, converted carriage with encouraging results. It had an increased horsepower of 900 rpm (as compared to Benz's 300 rpm) and was the first high-speed internal combustion engine, developing one and one-half horsepower.

1888 - John Boyd Dunlop introduced pneumatic bicycle tires for the safety bicycles.

1892 - The Harris motor wagon, built in Baltimore, operated successfully before Duryea brothers' cars. It was a sightseeing bus rather than a conventional auto and ran on hard rubber tires. Maybach introduced the first float-type carburetor at this time.

1893 - Charles E. and J. Frank Duryea introduced what has been recognized as America's first successful internal combustion horseless carriage at Springfield, Massachusetts. This vehicle, called a "buggyaut" by its producers, was a well-worn, high-wheeled carriage with a small, one-cylinder gasoline engine mounted on its back.

1894 - Vacheron introduced the steering wheel.
The Michelin brothers produced a pneumatic tire for cars.
Edgar and Elmer Apperson celebrated the 4th of July in Kokomo, Indiana, by unveiling a car they had built, based on plans conceived by Elwood G. Haynes.

Automotive Developments 1895-1907

1895 - The Duryea brothers established the Duryea Motor Wagon Company which was the first firm in America organized to make gas cars commercially.
Charles R. Black had a Benz-type auto in Indianapolis and John Lambert had operated a gas-mobile in Ohio. Ransom E. Olds had also constructed a workable gas-burning automobile.
Lancaster introduced a propeller shaft transmission.
Mors and Daimler built a multi-cylinder (V4) engine (four in line).

1896 - Henry J. Ford built an internal combustion engine from plans he read in a magazine. He mounted it to a bicycle-wheeled, tiller-steered two-seater, which had neither brakes nor reverse gear and was so noisy it was condemned as a public nuisance.
Alexander Winton, a bicycle builder in Cleveland, Ohio, produced his first experimental car. Years later, he formed the Winton Motor Carriage Company, and started to sell two-seaters (one seat faced frontwards and the other faced the back).
In England, the "Red Flag Act" was repealed. This was celebrated by the first Emancipation Run from London to Brighton, about 60 miles (96 km), which is still held annually as a reliability trial for Veteran cars. (Veteran cars are those built before 1918; "Vintage" cars were built between 1918 and 1930.)

1897 - Thomas B. Jeffery built his first experimental Rambler in a machine shop of his Chicago bicycle factory.

1898 - Ford built a second motorcar which was a vast improvement over his first. He persuaded a few people to back him in producing it commercially, but the enterprise failed after only one year.

Pioneer designers experimented with seating arrangements as they did with all other details on the first cars. One of the most impractical was a two-seater in which lady passengers sat in the front seat to serve as windbreakers (and presumably bugcatchers as well), while the gentlemen steered from the rear. The ladies didn't help the driver's vision much either.

1899 - Camille Jenatzy, of France, drove a Jeantaud electric a record of sixty miles an hour on April 29. The high speeds, however, burned out both the specially fabricated batteries and French interest in electric cars.
The Studebaker name had been applied to vehicles as early as 1852 when the products were wagons, buggies, and carriages. In 1899, the firm entered the auto industry as a body-maker. Three years later, it produced its first car, an electric runabout.
The first Baker Electric was manufactured by the Baker Motor Vehicle Company of Cleveland, Ohio.
The Akron Police Department acquired a brand-new motorized wagon to speed up the business of hauling lawbreakers off to jail.

B. F. Goodrich pioneered pneumatic tires for automobiles.
Freelan O. Stanley demonstrated the power of the Stanley Steamer by driving one up Mr. Washington in New Hampshire. The following year, John Brisben Walker drove another to the top of Pikes Peak.

The U.S. Post Office Department bought its first motor vehicle on an experimental basis. In Milwaukee, the Johnson Service Company built 8 custom steamers to fulfill postal contracts there.

Other innovations in 1899 were the honeycomb radiator, gate gearchange, and floor-mounted accelerator (Daimler); and the universal joint for shaft drive to sprung rear axles (Renault).

1901 - Ransom E. Olds became the first mass-producer of gasoline automobiles with the completion of 425 curved-dash Oldsmobiles in a single year. Olds instituted a system of contracting with several machine shops to make required parts for him to his design specifications - transmissions from one shop, steering gear from another shop, carburetors from another, etc.
The first changes from tillers to steering wheels were made at about the turn of the century.

By the early 1900s, induction coils were being used to produce electrical discharges in low pressure gases, leading to the discovery of x-rays and cathode rays.

1902 - The American Automobile Association was organized in Chicago on March 4, symbolizing the broad interest in the new mode of transportation.

The one-cylinder, 3-hp, tiller-steered model Olds with bicycle type wheels and a curved dashboard sold 2,500 automobiles by introducing quantity production to the industry.
Thomas B. Jeffery and his son, Charles T., began manufacturing one-cylinder Ramblers for public sale in Kenosha, Wisconsin.
The first horseless carriage in Minnesota was an electric six-seater (three rows of seats) with high wheels and friction brakes applied to the surface of the rear tires. It had an unusual bare bulb headlight.

David Dunbar Buick, a successful manufacturer of enamel bath-tubs and other plumbing fixtures, ventured into the automobile business. He produced his first car with the help of Walter L. Marr, but his company was not successful until William Durant bought it and reorganized it.

1903 - The Ford Motor Company was established in Detroit with the Model A, a small, light-weight, powered by a 2-cylinder, 8-hp engine which sold for $850.

The invention of demountable rims helped the tire situation somewhat. It was no longer necessary to change tires at the scene of a flat tire; mounted spares made it possible to make a reasonably fast switch-over, but road conditions made it common practice for a driver to limp home on flats or a bare rim even after using a couple of spare ties.

Two Frenchmen, Georges Bouton and Count Albert de Dion, led to the development of lightweight, high speed engines. Their 1903 "Polulaire" produced 8 hp at 1500 rpm, with a cubic capacity of 846 cm3 (52 in3) and a weight of only 40 lb (18 kg). To handle the requirements of this high speed air cooled engine, Bouton designed an ignition system that bore many similarities to the modern contact breaker ignition.

The Mercedes Company (formerly Daimler) made a braking system with internally-expanding shoes inside a brake drum.

1904 - Ford added the Model B, a 4-cylinder, selling for $2,000.

Carl Graham Fisher and James A. Allison organized the Prest-O-Lite Company and introduced a new system of acetylene gas head-lights.

1905 - Electric cars and trucks were efficient for in-city driving, but drivers had to be alert to get back to garages before the batteries ran down.

1906 - The Stanley Steamer, nicknamed the "Flying Teapot," clocked a remarkable 127.6 miles per hour in Ormand Beach, Florida.
Ford added the Model K, which made that year and that car model important milestones in automotive history. Ford's Model K had a 40-horsepower engine and could push its 2,000-pound weight up to 60 mph. It was a dismal failure to the company at $2,800 per car, but turned out to be the making of the Ford Company.
In this year, cars began to abandon their carriage look and to assume a motor-age appearance.

The "Coyote," produced in California, introduced a power plant very different from those of the past: a V-8 engine.
A very frail front bumper was the beginning of many important safety devices.

The first driver's license was issued in Denver, Colorado, for a cost of $1.00. Other cities required engineers' permits to operate steamers which were classed as mobile boilers.
The Waltham (Mass.) Manufacturing Company introduced the Orient buckboard for postal delivery. It had a mail case with pigeon-hole compartments directly in front of the driver.

1907 - In Seattle, Washington, John McLean, a representative of the Standard Oil Company of California, opened what is claimed to be the first service station in America. It consisted of an old hot-water tank and a hose under a rough wooden canopy. The gas was delivered into the tank by gravity.

The Automobile Gasoline Company and the Oriental Oil Company opened stations in St. Louis, Missouri, and Dallas, Texas. The former is credited with the first chain of automobile service stations.

Within five years, Memphis, Tennessee, could boast a thirteen-pump outlet, complete with a ladies' restroom and a maid who served ice water to the customers. The pumps, however, were in the backyard, not on the street, and the super-service was ahead of its time.

1908 - The Ford Model T was unveiled for the first time. It was powered by a 4-cylinder, 20 hp engine, had two forward speeds and a reverse controlled by pedals. It was also equipped with a throttle mounted on the steering column, and got about thirty miles to a gallon of gasoline. If the purchaser requested it, he could have extra-cost options of headlights, speedometer, and a spare tire. Buyers could choose their cars in red, green, or baby blue. Later, it could be purchased in any color the buyer desired, "as-long-as-it's-black."

The automobiles of this year had air-cooled motors, since there were no water-filled radiators to freeze in the winter time; the passengers were usually air-cooled as well because there were usually no roofs over them.

C. Harold Wills developed the use of vanadium steel for Ford. Charles Y. Knight was perfecting his sleeve-valve engine. The Fisher brothers founded a company which gained rapid fame as a producer of closed auto bodies. The Fisher Body Company was established by brothers Fred and Charles (there were five other brothers).

Charles Frank Kettering of the Dayton Engineering Laboratories Company helped bring about innovations in the electric starter and ethyl gasoline.

Harvey S. Firestone, B. F. Goodrich, Arthur W. Grant, and many others struggled to overcome tire deficiencies.

The first brakes were based on those used on the horse-drawn vehicles and on bicycles. A solid block of wood, leather or metal was forced against the wheel rims by a hand-operated lever, or a contracting band of friction material acted upon the propeller shaft in conjunction with externally-contracting brakes fitted to drums on the rear wheels. In 1908, Herbert Frood patented the asbestos brake linings in England. These were much more effective than the cotton based linings then in use.

The coil and distributor ignition was introduced, comprised of a battery, contact breaker, induction coil and spark plugs.

Automotive Developments 1908-1929

1909 - William A. Besserdich and his brother-in-law, Otto Zachow, were young blacksmiths in Clintonville, Wisconsin, when they built America's first successful four-wheel-drive motor car. Their "Badger Four Wheel Drive Auto Company" was formed on

January 9th; later the "Badger" and "Auto" dropped from the title. The firm finally switched from cars to trucks.

Dayton Engineering Laboratories Company (Delco) was founded. Charles F. Kettering, a genius of the automotive industry, was one of Delco's founders.

1910 - The Fisher Body Company received an order from Cadillac for first quality production of closed bodies - 150 units. Curb-side pumps began to appear about this time, though they were forbidden by law in some communities. Custom-made ambulances made an appearance in the first decade of 1900 and played a major role in World War I.

1911 - By this time, the automobile industry had, for the first time, securities listed on the New York Stock Exchange. The Buick Motor Company, the Olds Motor Works, the Cadillac Automobile Company and the Oakland Motor Car Company had already achieved success and had been combined with other firms by William Crapo Durant into the General Motors Company. Durant, having lost control of the company, moved into building and selling a new auto, designed by and named for Louis Chevrolet, a French race driver. Another manufacturer-promoter, Benjamin Briscoe, had brought some 130 different companies together to form the United States Motor Car Corporation. This ambitious combination ran into financial difficulties and was doomed to receivership in 1912.

The first production four-wheel-drive automobile, built by FWD Corporation, rolled out of Clintonville, Wisc. It was first used as a demonstrator, and when the firm shifted entirely to truck manufacturing, it was used for nearly 35 years to haul mail to and from the post office.

First four-wheel braking was employed by the Italian company of Isotta-Franchini.

Other innovations were an improved electric starter, the dynamo, and a car telephone.

1912 - Edward G. Budd, a young Philadelphia engineer, is credited with the concept of the all-steel auto body. In 1912, he convinced the Oakland and Hupmobile people to try his all-steel body frames, and the next year received his first large contract from John and Horace Dodge.

Charles F. Kettering introduced his greatest contribution to the automotive industry, the electric self-starter.
Henry M. Leland introduced the self-starter in his 1912

Cadillac.

1913 - Dr. William M. Burton improved production of anti-knock additives for gasolines, but not the firing of the larger kerosene molecules mixed in with gasoline.
Henry Ford`s first moving assembly line revolutionized auto production.

The Gulf Oil Company was the first U.S. petroleum firm to distribute free road maps.

1914 - Horace and John Dodge were wealthy manufacturers of components for Olds Motor Works, then for Ford Motor Company, before they introduced their own automobile. The first Dodge was delivered to them on November 14, 1914.

Cleveland, Ohio, installed the nation's first traffic lights.
At about this time, the International Harvester Auto-Wagon, a high-wheeled, hard-tired pioneer version of the pickup truck, appeared.

Most pioneer motorists stored their cars in the winter months, due to clogged roads and operating difficulties. Anti-freeze, winter oils, efficient heaters and other cold weather needs were still to come.

1915 - Ernest Holmes Company of Chattanooga, Tennessee, was one of the pioneers in the field of auto rescue, although the mechanism of the wrecker was pretty complicated.

1916 - Studebaker instituted the "pay-as-you-ride" slogan and sold automobiles on time payments.

1917 - From 1910 to 1917, company crews from B. F. Goodrich erected thousands of signs on some 110,000 miles of U.S. roads. These were guide posts - round metal signs on twelve-foot poles, each of which gave the name of the nearest town, the next large city and the ultimate destination of the route.

1918 - A German named Lankensperger took out a British patent on a system of steering in which the steering wheels are separately pivoted at the ends of the shaft.

1919 - The U.S. Army started its first transcontinental truck convoy. Second in command of the caravan was a Lieutenant Colonel, Dwight D. Eisenhower.

1920 - Jonathan Dixon Maxwell's popular automobile succumbed in the mid-20s. It had spring-suspension wheels (unusual for the times).

Hydraulic braking was introduced.
By this time, mass production methods were well-established, and this led to the availability of a wide range of cheap, reliable and comfortable cars which found a ready market in the affluent '20s.

1921 - The U.S. Bureau of Public Roads was created right after WWI. In 1921, a second Federal Highway Act more clearly defined the aid program to develop a gigantic national road system.
The Kahn-Wadsworth Bill made possible the distribution of more than 25,000 surplus army trucks and other equipment to the state highway departments for road-building purposes.

1923 - Tetraethyl lead was discovered.

1924 - Walter P. Chrysler, the head of the Maxwell Motor Corporation, introduced an auto bearing his name. Fred Zeder was one its key designers. The Chrysler was so successful it brought about the death of the Maxwell.

A California innkeeper erected the first "Motel" sign outside his establishment.

General Motors and Standard Oil Company of New Jersey formed Ethyl Gasoline Corporation to make and sell the new additive, tetraethyl lead.

1926 - The first "Burma Shave" jingles were posted in Minnesota.

1927 - The first drive-up mail box was installed in Houston, Texas.

1929 - The short-lived Ruxton was an unusual front-wheel-drive luxury automobile manufactured by New Era Motors of New York from 1929 to 1931. Although it did not fare well, it marked a new beginning in the automotive age.

History of Major Automotive Developments

1920-1940 - The main components of the cars were well designed and efficient, and a variety of accessories were introduced, such as reversing lights, radios, automatic chokes, windshield wipers, and chrome-plated trim.

Since World War II, most commercial vehicles are fitted with the magnetic speedometer, which was originally developed in the 1920s.

Tires, until the 1920s, were of narrow cross-section and ran at relatively high air pressures. As technology improved tires and they were made wider, they operated at lower pressures. The tire alone would not provide much comfort, however. Between the wheel and the body of the car it is necessary to have springs. Some carriages had had the body suspended by straps from the chassis ends, but the semi-elliptical multi-leaf spring was an early development. Leaf springs are still widely used on cars, especially on the rear axles. Early "shocks" were of the friction type, often consisting of a simple pivoted arm attached to the axle so that its movement turned friction discs like a clutch.

Between WWI and WWII, several very high quality cars were built, and some of these represented such an exceptionally high standard of craftsmanship and durability that, owing to changing economic circumstances, it is unlikely that cars of comparable quality will ever be built again. These include such classics as the Bugatti "Royale," Hispano-Suiza, Rolls-Royce "Phantom III," Bentley 8 litre, and the Delage.
In America the trend was to power and luxury, while European manufacturers concentrated on small, low-priced cars like the Austin 7 in England, and the Italian Fiat 500.

In Germany the KDF, which was to become better known as the Volkswagen, was designed by Ferinand Porsche with the backing of Adolf Hitler. KDF stands for "Kraft durch Freude," that is, "strength through joy". Its basic shape still remains today and over 12 million have been sold.

In 1939, Connecticut instituted "vanity tags" for a premium fee.

1940-1960 - During WWII the production of private cars was severely restricted as raw materials were diverted to military uses. Factories were used to make military vehicles, ammunition and air-craft components. When car production began again, the first models were almost the same as pre-war designs, and it took a few years for the plants to re-tool enough to produce any really new designs.

Power brakes were gradually introduced on road vehicles from the 1940s on.

Shock absorbers became hydraulic and telescopic, consisting of a piston inside a sealed cylinder, one attached to the chassis and the other to the axle.

Many new models had powerful high compression engines, along with independent front suspension. In styling, they became much longer, lower and more elaborate. Lightweight chassis-less bodies were adopted, and the use of curved glass for the windshields and rear windows improved driving visibility a great deal.

Development of transistors during the 1950s led to the introduction of semiconductor ignition systems, which use electronic switching systems to control the ignition coil. There was a large, sometimes excessive, use of chrome plating, and styling became one of the major preoccupations of the industry, with newer models being introduced yearly that were often mechanical images of those they replaced.

The tubeless tire was introduced by the Goodrich Company in 1948.

Power steering, air conditioning, twin headlamps, and wrap-around windshields were originated in the States during the early 1950s.

Glass fiber reinforced resins, light and corrosion free, were used on the bodywork of the 1953 Chevrolet Corvette, and for the roof panel of the 1955 Citroen DS19.

Advances in technology allowed the use of higher compression ratios in fuel. Overhead valve and overhead camshaft designs, with improved fuel systems (including fuel injection) along with better ignition system performance contributed to engine power outputs for a given cubic capacity being increased. The resultant increase in power to weight ratio that was possible improved the acceleration, speed, road holding and braking of cars of that time.

Disc brakes, less prone to failure from overheating than drum brakes, at last became widely accepted, over half a century after Lanchester's original design was patented.
Further improvements in roadholding and braking resulted from the introduction of radial-ply tires in 1953. Due to their higher cost, these tires were at first used only on expensive high performance cars, but they are now widely used on all kinds of cars.
The introduction of new plastic materials for interior trim was a great asset for the stylists, and a wide range of color schemes became available to match the body colors.
The once universal oil pressure gauges and ammeters were often

replaced by simple warning lights, which are cheaper and less complicated; they are also less informative.

1960 - Car design in the 1960s was greatly influenced by the new interest in safety and pollution control. Mechanical improvements brought higher speeds, better road-holding, braking and acceleration, but many countries began to introduce laws which restricted the maximum speed of vehicles. Cars had to be built to comply with the strict new safety and anti-pollution laws of the United States, which were gradually adopted by many other countries.
In addition to improved performance, cars became even more comfortable and easier to drive.
Heating and ventilating equipment became standard on even the small cheap cars where it had previously been available, if at all, as an extra.

Automatic transmission, power brakes and power steering gained widespread acceptance. The electrical system, which had a more and more heavy load to handle, was improved by the introduction of the alternator to replace the dynamo, and the use of circuit breakers instead of fuses.

One important development in engine design was the invention of the wankel engine, which has a single three-lobed driving rotor instead of the conventional pistons and crankshaft. The first one was made in 1957 by Felix Wankel of Germany, and in 1964, the NSU company brought out the Wankel-engined "Spyder," and a few years later, the R080. The prototype Mercedes C111 and several Japanese Mazda cars also have had Wankel engines, that are light, compact, powerful and smooth running.

1973 - The United Stated passed the Clean Air Act (which was amended several times since), with the immediate result of forcing cars to install positive crankcase ventilation.

1974 - The nation-wide 55-mph speed-limit became "permanent" in America.

1975 - The catalytic converter was adopted for most 1975 American cars and many imports as a means to fight fuel consumption. Computers play an important role in car construction now, as in everything else. The purchasing department is in charge of making sure that the glass, rubber, steel and everything else is on hand in the required amounts, and computers keep track of it all. The computer also schedules the construction of each car, and prints a sticker which goes on it, specifying the trim, optional accessories, and even where the car is to be shipped when it is finished.

In this age of the computer, it is only natural for automobile manufacturers to install on-board computers into the cars. It is, after all, the only practical method of monitoring all the engine variables at once. The on-board computer receives its information from the various sensors located near or on the engine and processes the signals to adjust the fuel mixture, timing and other elements. The process is continuous as long as the engine is running.

The modern electro-mechanical carburetor is controlled by the computer as well. The fuel mixture is controlled by an oxygen feedback solenoid, located within the carburetor. The computer can control the speed of the car and determine when something is wrong. When the engine is cold, the computer operates from some predetermined values and the fuel mixture is fixed at full rich.

The car will let us know about any unacceptable feedback, from the seat belts being unfastened to the key being left in the lock.

Indy 500 Racing Facts

Interested in car racing? Here are a few facts concerning the Indy 500 Race:

The Indianapolis 500 is the original 500-mile auto race, predating any other existing 500 by nearly fifty years. It's not only the most famous race in America, but is the most celebrated around the world. The Indy 500 was first run in 1911.

The distance around one lap of the Indianapolis course is two and one-half miles per lap.

It takes a driver forty seconds to negotiate one full lap at a speed of exactly 225 miles per hour.

Traditionally, thirty-three cars start in the 500.

The Speedway was nicknamed "The Brickyard," because the track was once paved with bricks.

For more than fifty years, the winning driver has pulled into Victory Lane and taken a drink of milk.

The Indianapolis Motor Speedway is not located in Indianapolis. It's in Speedway, Indiana, a community incorporated in 1926, with its own town board, police and fire departments, schools systems, and water company.

An effective Indy pit stop (to pump forty gallons of fuel, change four wheels, and many any minor adjustment) takes about fifteen seconds.

Indy cars do not run on gasoline. Since 1964, they've used methanol, a wood-based alcohol.

If an Indy Car engine were installed in the average riding lawn mower, it could cut a half-acre lawn in about 5.6 seconds.

The winning time at the 1990 Indy was more than four hours faster than the 1911 Indy's winning time of six hours, forty-two minutes.

At 200 miles per hour, an Indy driver can cover the length of a football field in less than one second.

While eight different drivers named Jones have driven in at least one 500 race (none of which are related), no starting field has ever included a driver named Smith.

Buddy Lazier was eliminated after only one lap in the 1991 Indy and received $162,690 in prize money. Ernie Ansterberg, on the other hand, pulled out after two laps in 1924 and was awarded the hefty sum of $5.25.

At 224 miles per hour, an Indy Car is traveling about 100 miles faster than an average Air Force fighter jet at takeoff.

Indianapolis 500 Results

YEAR	DRIVER	ENGINE	CYLINDERS	MPH AVERAGE
1911	Ray Harroun	Marmon Wasp	6	74.69
1912	Joe Dawson	National	4	78.72
1913	Jules Goux	Peugeot	4	97.933
1914	Rene Thomas	Delage	4	82,47
1915	Ralph DePalma	Mercedes	4	89.84
1916	Dario Resta	Peugeot	4	84.00*(1)
1919	Howard Wilcox	Peugeot	4	88.05
1920	Gaston Chevrolet	Monroe	4	88.62
1921	Gaston Miltono	Frontenac	4	89.62
1922	Jimmy Murphy	Miller	8	94.48
1923	Tommy Milton	Miller	8	90.95
1924	L.L. Corum	Dusenberg	8	98.23
1925	Peter Depaolo	Duesenberg	8	101.13
1926	Frank Lockhart	Miller	8	95.904*(2)
1927	George Souders	Duesenberg	8	97.545
1928	Louis Meyer	Miller	8	100.448
1931	Louis Schneider	Miller	8	96.629
1932	Fred Frame	Miller	8	104.144
1933	Louis Meyer	Miller	8	104.162
1934	William Cummings	Offenhauser	4	104.863
1935	Kelly Petillo	Offenhauser	4	106.240
1936	Louis Meyer	Offenhauser	4	109.069
1937	Wilbur Shaw	Offenhauser	4	113.580
1938	Floyd Roberts	Offenhauser	4	117.200
1939	Wilbur Shaw	Masurati	8	115035
1940	Wilbur Shaw	Maserati	8	114.277
1941	Floyd Davis	Offenhauser	4	115.117
1942-1945	Race not held (due to WWII)			
1946	George Robson	Thorne/Sparks	6	114.820
1947	Mauri Rose	Offenhauser	4	116.338

1948 Mauri Rose	Offenhauser	4	119.814
1949 Bill Holland	Offenhauser	4	121.320
1950 Johnnie Parsons	Offenhauser	4	124.002*(3)
1951 Lee Wallard	Offenhauser	4	126.244
1952 Troy Ruttman	Offenhauser	4	128.922
1953 Bill Vukovich	Offenhauser	4	128.740
1954 Bill Vukovich	Offenhauser	4	130.840
1955 Bob Sweikert	Offenhauser	4	128.209
1956 Pat Flaherty	Offenhauser	4	128.490
1957 Sam Hanks	Offenhauser	4	135.601
1958 Jim Bryan	Offenhauser	4	133.791
1959 Rodger Ward	Offenhauser	4	135.857
1960 Jim Rathmann	Offenhauser	4	138.767
1961 A.J. Foyt	Offenhauser	4	139.130
1962 Rodger Ward	Offenhauser	4	140.293
1963 Parnelli Jones	Offenhauser	4	143.137
1964 A.J. Foyt	Offenhauser	4	147.350
1965 Jimmy Clark	Ford	8	150.686
1966 Graham Hill	Ford	8	144.317
1967 A.J. Foyt	Ford	8	151.207
1968 Bobby Unser	Offenhauser	4	152.882
1969 Mario Andretti	Hawk-Ford	8	156.867
1970 Al Unser	Colt Ford	8	155.749
1971 Al Unser	Colt-Ford	8	157.735
1972 Mark Donahue	Offenhauser	4	162.962*(4)
1973 Gordon Johncock	Offenhauser	4	159.036
1974 Johnny Rutherford	Offenhauser	4	158.589
1975 Bobby Unser Meyer	Drake	4	149.213*(5)
1976 Johnny Rutherford	Offenhauser	4	148.725*(6)
1977 A.J. Foyt	Coyote-Foyt	4	161.331
1978 Al Unser	Cosworth	8	161.363
1979 Rick Mears	Cosworth	8	158.889
1980 Johnny Rutherford	Chaparral	8	142.862
1981 Bobby Unser	Offenhauser	4	139.029
1982 Gordon Johncock	Cosworth	8	162.029
1983 Tom Sneva	Cosworth	8	162.117
1984 Rick Mears	Cosworth	8	162.962
1985 Danny Sullivan	Cosworth	8	152.982
1986 Bobby Rahal	Cosworth	8	170.722
1987 Al Unser	Cosworth	8	162.175
1988 Rick Mears	Chevy	8	144.809
1989 E. Fittipaldi	Chevy	8	144.809
1990 Arie Luyendyk	Chevy	8	185.984
1991 Rick Mears	Chevy	8	176.457
1992 Al Unser Jr.	Chevy	8	134.447

* Due to rain, the race was shortened to:
(1) 300 miles.
(2) 400 miles.

(3) 345 miles.
(1) 332.5 miles.
(4) 435 miles.
(5) 255 miles.

The race record, as of 1992, belongs to Arie Luyendyk. He averaged 185.984 MPH in 1990.

- Visit The Service Department To Submit Your Problem Or Question

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The Fuel System (Overview)

The Fuel System

The purpose of the fuel system is to provide a mixture of fuel and air to the engine of the car. The air-fuel mixture must be in proportion to the speed and load placed on the engine. Major parts of the system include: fuel tank and cap, emission controls, fuel line, fuel pump, fuel filter, carburetor, and intake manifold as well as the fuel gauge, which indicates the amount of fuel in the tank.

Engine Fuel

Engine fuel is mainly made up of hydrogen and carbon, mixed so that it will burn with oxygen present, and will free its heat energy into mechanical energy. Liquid fuels are ideal for internal combustion engines, because they can be economically produced, have a high heat value per pound, an ideal rate of burning, and can be easily handled and stored. The most common engine fuels are gasoline, kerosene and Diesel fuel oil.

Gasoline has many advantages and is used to a greater extent than any other fuel in internal combustion engines having spark ignition. It has a better burning rate than other fuels, and, because it vaporizes easily, it gives quick starting in cold weather, smooth acceleration and maximum power.

Diesel fuel oil ranks next to gasoline in quantity used. It can be produced as cheaply as gasoline, but its use is limited to Diesel type engines. The use of kerosene as a fuel is usually limited to farm tractors, marine and stationary engines, all which operate at a fairly constant speed. Its traits are such that it cannot be properly mixed with air and controlled in variable speed engines.

Octane Rating

A gasoline's ability to resist detonation is called its "octane" or anti-knock rating. Gasoline from asphaltic base crude oil produces less knock than one from paraffinic base crude. Cracked gas has less tendency to knock than straight run gas. All marketed gasolines are a blend of straight run and cracked gasolines, so unless their blending is controlled, the anti-knock qualities will vary.

A mixture of iso-octane, which has a very high anti-knock rating, and heptane, which makes a pronounced knock, is used as a reference fuel to establish an anti-knock standard. The anti-knock value or octane number is represented by the percentage of volume of iso-octane that must be mixed with normal heptane in order to duplicate the knocking of the gasoline which is being tested. These ratings range from 50 in third grade gasolines to 110 in aviational fuels. The rating of 100 means a fuel having an anti-knock value equal to that of iso-octane. If the octane rating of a gasoline is naturally low, the fuel will detonate as it burns and power will be applied to the pistons in hammer-like blows. The ideal power is that which pushes steadily on the pistons, rather than hammer against them. The octane rating of a gasoline can be raised by treating it with a chemical which is not a fuel. The best chemical known is tetra-ethyl lead compound, which is added to the gasoline.

Tetra-ethyl lead is a liquid which mixes thoroughly with gasoline and vaporizes completely. Ethylene dibromide prevents the tetra-ethyl lead from forming lead oxide deposits on spark plugs and on valve seats and stems. Red dye is added to identify an ethyl treated gasoline and to warn against its being used as anything but an engine fuel. In 1975, it became illegal to use a leaded gasoline except in cars built prior to this time. With the addition of the catalytic converter, it is undesirable to burn leaded fuel, because leaded fuel will clog the converter and increase the back-pressure of the exhaust.

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 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.

Fuel Pump

The fuel pump has three functions: to deliver enough fuel to supply the requirements of an engine under all operating conditions, to maintain enough pressure in the line between the carburetor and the pump to keep the fuel from boiling, and to prevent vapor lock. Excessive pressure can hold the carburetor float needle off its seat, causing high gasoline level in the float chamber. This will result in high gasoline consumption. The pump generally delivers a minimum of ten gallons of gasoline per hour at top engine speeds, under an operating pressure of from about 2 1/2 to 7 pounds. Highest pressure occurs at idling speed and the lowest at top speed. Although fuel pumps all work to produce the same effect, there are various types that may operate somewhat differently.

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.

Electric Fuel Pump

Electric fuel pumps have been used for many years on trucks, buses and heavy equipment, and they have also been used as replacements for mechanically operated fuel pumps on automobiles, but only recently have they become part of a car's original equipment. The replacement types usually use a diaphragm arrangement like the mechanical pumps, except that it is actuated by an electrical solenoid.

The electrically driven turbine type of pump, first used on the Buick Riviera, was a great departure from the usual fuel pump design. It uses a small turbine wheel driven by a constant speed electric motor. The entire unit is located in the fuel tank and submerged in the fuel itself. This pump operates continuously when the engine is running. It keeps up a constant pressure which is capable of supplying the maximum fuel demands of the engine. When less fuel is required, the pump does not deliver at full potential, because the turbine is not a positive displacement type like the mechanical pump. Consequently, the turbine will run without pumping fuel and so, needs no means of varying fuel delivery rate like its mechanical counterpart. Since the fuel can flow past the spinning turbine blades, there is no need for pump inlet and outlet valves nor is there any need to vary its speed.

A relay for the electric fuel pump is used to complete the circuit to the fuel pump. This cuts off current to the fuel pump in the event of an accident.

Vacuum Pump

Several fuel pumps have a vacuum booster section that operates the windshield wipers at an almost constant speed. The fuel section then functions in the same way as ordinary fuel pumps. One difference is that the rotation of the camshaft eccentric in the vacuum pump also operates the vacuum booster section by actuating the pump arm, which pushes a link and the bellows diaphragm assembly upward, expelling air in the upper chamber through its exhaust valve out into the intake manifold. On the return stroke of the pump arm, the diaphragm spring moves the bellows diaphragm down, producing a suction in the vacuum chamber. The suction opens the intake valve of the vacuum section and draws air through the inlet pipe from the windshield wipers.

When the wipers are not operating, the intake manifold suction (vacuum) holds the diaphragm up against the diaphragm spring pressure so that the diaphragm does not function with every stroke of the pump arm. When the vacuum is greater than the suction produced by the pump, the air flows from the windshield wiper through the inlet valve and vacuum chamber of the pump and out the exhaust valve outlet to the manifold, leaving the vacuum section inoperative. With high suction in the intake manifold, the operation of the wiper will be the same as if the pump were not installed. When the suction is low, as when the engine is accelerated or operating at high speed, the suction of the pump is greater than that in the manifold and the vacuum section operates the wipers at a constant speed. Some pumps have the vacuum section located in the bottom of the pump instead of in the top, but the operation is basically the same.

Air Cleaners

Air cleaners are made to separate dust and other particles in the incoming air before it enters the carburetor. Thousands of cubic feet of air are drawn from within the car hood and passed through the engine cylinders, so it is important that the air is clean.

When driving on dirt or other dusty roads, dust particles are drawn through the radiator and find their way into the engine if it is not filtered and cleaned. Dust and other foreign materials in the engine will cause excessive wear and operating problems.

Fuel Gauges

Cars are equipped with fuel gauges which are operated along with the vehicle's electrical system. There are two types: the thermostatic type and the balancing coil type. The thermostatic type is made of a standing unit, located in the fuel tank, and the gauge itself (registering unit), which is located on the instrument panel. The fuel gauge used in some cars and trucks is of the electrically operated balanced coil type. These have a dash unit and a tank unit. The dash unit has two coils, spaced about 90 degrees apart, with an armature and integral pointer at the intersections of the coil axis. The dial has a scale in fractions between "Empty" and "Full". The tank unit has a housing, which encloses a rheostat, and a sliding brush which contacts the rheostat. The brush is actuated by the float arm. The movement of the float arm is controlled by the height of the fuel in the supply tank. The height of the fuel (called variations in resistance) changes the value of the dash unit coil so that the pointer indicates the amount of fuel available. A calibrated friction brake is included in the tank unit to prevent the wave motions of the fuel from fluctuating the pointer on the dash unit. Current from the battery passes through the limiting coil to the common connection between the two coils, which is the lower terminal on the dash unit. The current is then offered two paths, one through the operating coil of the dash unit and the other over the wire to the tank unit. When the tank is low or empty, the sliding brush cuts out all resistance in the tank unit. Most of the current will pass through the tank unit circuit because of the low resistance and only a small portion through the operating coil to the dash unit. As a result, this coil is not magnetized enough to move the dash unit pointer, which is then held at the "Empty" position by the limiting coil.

If the tank is partly full or full, the float rises on the surface of the fuel and moves the sliding brush over the rheostat, putting resistance in the tank unit circuit. More current will then pass through the operating coil to give a magnetic pull on the pointer, which overcomes some of the pull of the limiting coil. When the tank is full, the tank unit circuit contains the maximum resistance to the flow of the current. The operating coil will then receive its maximum current and exert pull of the pointer to give a "Full" reading. As the tank empties, the operating coil loses some of its magnetic pull and the limiting coil will still have about the same pull so that the pointer is pulled toward the lower reading. Variations in battery voltage will not cause an error in the gauge reading because its operation only depends on the difference in magnetic effect between the two coils.

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.

Ram Induction Manifolds

The ram induction manifold system consists of twin air cleaners, twin four-barrel carburetors and two manifolds containing eight long tubes of equal length (four for each manifold).

This system was designed by the Chrysler Company to increase power output by in the middle speed range (1800-3600 rpm). Each manifold supplies one bank of cylinders and is carefully calculated to harness the natural supercharging effect of a ram induction system. By taking advantage of the pulsations in the air intake column caused by the valves opening and closing, sonic impulses help pack more mixture into the combustion chambers.

In the Chrysler system, the air-fuel mixture from each carburetor flows into a chamber directly below the carburetor, then passes through the long individual intake branches to the opposite cylinder bank. The right-hand carburetor supplies the air-fuel mixtures for the left-hand cylinder bank, and the left-hand carburetor supplies the right cylinder bank. The passages between the manifolds are interconnected with a pressure equalizer tube to maintain balance of the engine pulsations.

Manifold Heat Control

Most engines have automatically operated heat controls which use the exhaust gases of the engine to heat the incoming fuel-air charge during starting and warm-up. This improves vaporization and mixture distribution. When the engine is cold, all of the exhaust gas is deflected to and around the intake manifold "hot spot". As the engine warms up, the thermostatic spring is heated and loses tension. This allows the counterweight to change the position of the heat control valve gradually so that, at higher driving speeds with a thoroughly warmed engine, the exhaust gases are passed directly to the exhaust pipe and muffler.

In the ram induction system, there is a heat control chamber in each manifold to operate the automatic choke and to heat the fuel mixture after warm-up. A heat control valve in each exhaust manifold will by-pass the exhaust gas through an elbow to the intake manifold heat control chamber. Heat outlet pipes then carry the gas down to the "Y" connector under the heat control valve.

Heat control is regulated by a coiled thermostatic spring mounted on the exhaust manifold. A counterweight is mounted on the other end of the heat control valve shaft and this counterweight, in conjunction with the thermostatic spring, operates to close and open the heat control valve.

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.

Supercharger

A supercharger is a compressor. Hence, a supercharged engine has a higher overall compression than a nonsupercharrged engine having the same combustion chamber volume and piston displacement and will burn more fuel. Unfortunately, the increase in power is not proportional to the increase in fuel consumption. There are two general models of superchargers, the Rootes type and the centrifugal type. The Rootes "blower" has two rotors, while the centrifugal uses an impeller rotating at high speed inside a housing.

Superchargers can be placed between the throttle body of the carburetor or fuel injection system and the manifold; or at the air inlet before the throttle body. Racing cars usually have it located between the throttle body and the manifold. This design has the advantage that the fuel can be supplied through the throttle body without modification to any part of the system. If the supercharger is placed in front of the throttle body, fuel must be supplied under sufficient pressure to overcome the added air pressure created by the supercharger. The advantage of a supercharger over a turbocharger is that there is no lag time of boost; the moment the accelerator pedal is depressed, the boost is increased.

Turbocharger

A turbocharger, or supercharger, can boost engine power up to 40%. The idea is to force the delivery of more air-fuel mixture to the cylinders and get more power from the engine. A turbocharger is a supercharger that operates on exhaust gas from the engine.

Although turbochargers and superchargers perform the same function, the turbocharger is driven by exhaust gases, while the supercharger is driven by belts and gears. The turbocharger has a turbine and a compressor, and requires less power to be driven than a supercharger. The pressure of the hot exhaust gases cause the turbine to spin. Since the turbine is mounted on the same shaft as the compressor, the compressor is forced to spin at the same time, drawing 50% more air into the cylinders than is drawn in without the turbocharger. This creates more power when the air-fuel mixture explodes.

A turbocharged engine's compression ratio must be lowered by using a lower compression piston, since an excessive amount of pressure will wear on the piston, connecting rods, and crankshaft, and destroy the engine. All of these parts then, as well as the transmission, must be strengthened on a turbocharged engine or it will be torn apart by the increased horsepower.

Breathers

The breather is the positive crankcase ventilation system directing atmospheric pressure to the crankcase. The atmospheric pressure then pushes the blowby gases to a low pressure area. The air that is directed into the crankcase must first be filtered; if it is not, the dust and sand particles will destroy the engine parts. When there is too much blowby, it is routed back through the crankcase breather element. It then enters the carburetor or throttle body with the incoming fresh air to be burned in the cylinders. In addition, the breather helps to keep the regular air filter cleaner for a longer period of time, since blowby contains oil vapor from the crankcase.

Float Circuit

Fuel in the carburetor must be maintained at a certain level under all operating conditions; this is the function of the float circuit. The needed fuel level is maintained by the float. When its attached lever forces the needle valve closed, the flow of fuel from the pump is stopped. As soon as fuel is discharged from the float bowl, the float drops. The needle valve opens and fuel flows into the bowl again. In this way, the fuel is level to the opening of the main discharge nozzle. The float level must be set with a high degree of accuracy. If the level is too low, not enough fuel will be supplied to the system and the engine will stall on turns; if the level is too high, too much fuel will flow from the nozzle.

Metering Rod

A metering rod varies the size of the carburetor jet opening. Fuel from the float bowl is metered through the jet and the metering rod within it. The fuel is forced from the jet to the nozzle extending into the venturi. As the throttle valve is opened, its linkage raises the metering rod from the jet. The rod has several steps, or tapers, on the lower end. As it is raised in the jet, it makes the opening of the jet greater in size. This allows more fuel to flow through the jet to the discharge nozzle. The metering must keep pace with the slightest change in the throttle valve position so that the correct air-fuel mixture is obtained in spite of engine speed.

Choke Valve

Chokes perform the fuel mixture adjustments necessary to start a cold engine. When the fuel-air mixture is too cold, the engine won't start properly, or will stall out periodically. The choke when engaged (closed) the choke causes the fuel air mixture to be increased, or "enriched". The choke is a special valve placed at the mouth of the carburetor so that it partially blocks off the entering air. When the choke plate closes, the vacuum below it increases, drawing more fuel from the fuel bowl. The rich fuel mixture burns even at lower temperatures, allowing the engine to warm up.

The manual choke is a knob on the dash, usually the push-pull type, which extends from the choke on the carburetor to the instrument panel. The driver closes the choke when starting the engine. The main thing to know about a manual choke is to push it back in when the engine has reached normal operating temperature. The trouble with the manual choke is that the driver often forgets to open it fully. This results in a rich fuel mixture which causes carbon to form in the combustion chambers and on the spark plugs. To correct this problem, the automatic choke was developed.

The automatic choke relies on engine heat. The choke valve is run by a thermostat which is controlled by exhaust heat. When the engine is cold, the valve will be closed for starting. As the engine warms, the exhaust heat will gradually open the choke valve. An automatic choke depends on a thermostatic coil spring unwinding as heat is supplied. As the engine warms up, manifold heat is transmitted to the choke housing. The heat causes the bimetal spring to relax, opening the valve.

An electric heating coil in the automatic choke shortens the length of time that the choke valve is closed. As the spring unwinds, it causes the choke valve in the carburetor air horn to open. This lets more air pass into the carburetor. The coil is mounted in a well in the exhaust crossover passage of the intake manifold. Movement of the bimetal spring is relayed to the choke valve shaft by means of linkage and levers.

Fuel Injection

The carburetor, despite all it advances: air bleeds, correction jets, acceleration pumps, emulsion tubes, choke mechanisms, etc., is still a compromise. The limitations of carburetor design is helping to push the industry toward fuel injection.

Direct fuel injection means that the fuel is sprayed directly into the combustion chamber. The fuel injected nozzle is located in the combustion chamber.

Throttle Body injection systems locate the injector(s) within the air intake cavity, or "throttle body". Multi-point systems use one injector per cylinder, and usually locate the injectors at the mouth of the intake port.

The fuel injector is an electromechanical device that sprays and atomizes the fuel. The fuel injector is nothing more than a solenoid through which gasoline is metered. When electric current is applied to the injector coil, a magnetic field is created, which causes the armature to move upward. This action pulls a spring-loaded ball or "pintle valve" off its seat. Then, fuel under pressure can flow out of the injector nozzle. The shape of the pintle valve causes the fuel to be sprayed in a cone-shaped pattern. When the injector is de-energized, the spring pushes the ball onto its seat, stopping the flow of fuel.

Mechanical Fuel Injection

Mechanical fuel injection is the oldest of the fuel injection systems. It uses a throttle linkage and a governor. It is now used mainly on diesel engines. Hydraulic fuel injection is used by some of the imports. Hydraulic pressure is applied to a fuel distributor as a switching device to route fuel to a specific injector. The fuel from the tank is carried under pressure to the fuel injector(s) by an electric fuel pump, which is located in or near the fuel tank. All excess is returned to the fuel tank.

Electronic Fuel Injection

The principle of electronic fuel injection is very simple. Injectors are opened not by the pressure of the fuel in the delivery lines, but by solenoids operated by an electronic control unit. Since the fuel has no resistance to overcome, other than insignificant friction losses, the pump pressure can be set at very low values, consistent with the limits of obtaining full atomization with the type of injectors used. The amount of fuel to be injected is determined by the control unit on the basis of information fed into it about the engine's operating conditions. This information will include manifold pressure, accelerator enrichment, cold-start requirements, idling conditions, outside temperature and barometric pressure. The systems work with constant pressure and with "variable timed" or "continuous flow" injection. Compared with mechanical injection systems, the electronic fuel injection has an impressive set of advantages. It has fewer moving parts, no need for ultra-precise machining standards, quieter operation, less power loss, a low electrical requirement, no need for special pump drives, no critical fuel filtration requirements, no surges or pulsations in the fuel line and finally, the clincher for many car makers, lower cost.

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.

Idle Circuit

The fuel delivery in a carburetor tends to lag behind the motion of the throttle. The basic carburetor operates when the throttle valve is fully open or partially open, but not when it's closed. No driver wants the engine to stop every time the foot leaves the accelerator; such a car would be tiring and stressful to drive, even in the best of road conditions, let alone in a traffic situation. To keep the engine running smoothly and evenly when no power is needed, the idle circuit was added inside the carburetor. The idle jet admits fuel on the engine side of the throttle valve. Additional air is mixed with this fuel through an air bleed. The result is an entirely separate carburetor circuit which operates only when the throttle valve is closed.

Venturi

"Barrel" is a popular term for the carburetor throat. There is one venturi in each throat. A two-barrel carburetor has a primary venturi for part-load running and a secondary venturi for full-throttle; a four-barrel carburetor has two primary and two secondary venturis. The venturi tube is important in carburetion. A "venturi" is a tube with a restricted section. When liquid or air passes through the venturi tube, the speed of flow is increased at the restriction, and air pressure is decreased, creating an "increase in vacuum" (a reduction in ambient pressure). This causes fuel to be drawn into the barrel. The venturi action is used to keep the correct air-fuel ratio throughout the range of speeds and loads of the engine.

Cetane Rating (Ether)

The delay between the time the fuel is injected into the cylinder and ignition is expressed as a cetane number. Usually, this is between 30 and 60. Fuels that ignite rapidly have high cetane ratings, while slow-to-ignite fuels have lower cetane ratings. A fuel with a better ignition quality would help combustion more than a lower cetane fuel during starting and idling conditions when compression temperatures are cooler. Ether, with a very high cetane rating of 85-96, is often used for starting diesel engines in cold weather. The lower the temperature of the surrounding air, the greater the need for fuel that will ignite rapidly. When the cetane number is too low, it may cause difficult starting, engine knock, and puffs of white exhaust smoke, especially during engine warm-up and light load operation. If these conditions continue, harmful engine deposits will accumulate in the combustion chamber.

Pressurized cans of starter fluid are available in emergencies, but are not desirable, because they tend to dry out the cylinders, and are dangerous if used improperly. There are also liquid forms of starter fluid available which can be added to the gasoline.

Fuel Additives

Tetraethyl lead was used in some gasolines to reduce or prevent knocking. However, in 1975, it became illegal to use leaded gasoline except in cars built prior to this time. Methyl Tertiary Butyl Ether (MTBE) is used in unleaded fuel to increase the octane. Gasoline exposed to heat and air oxidizes and leaves a gummy film. Detergents are now added to gasoline to prevent this. The detergents keep the carburetor passages and fuel injectors free from deposits, which could cause hard starting and problems in driving.

Deposits also restrict the flow of fuel and cause a rough idle, hesitation of acceleration, surging, stalling, and lack of power.

Alcohol is frequently used as an additive to commercial gasoline, because it will absorb any condensed moisture which may collect in the fuel system. Water will not pass through the filters in the fuel line, so, when any water collects, it will prevent the free passage of fuel. It also tends to attack and corrode the zinc die castings of which many carburetors and fuel pumps are made. This corrosion will not only destroy parts, but also clog the system and prevent the flow of fuel. By using alcohol in gasoline, any water present will be absorbed and pass through the fuel filter and carburetor jets into the combustion chamber. Alcohol additives are often purchased and added separately into the gas tank to prevent gas-line freeze and vapor lock.

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.

Diesel Fuel

Diesel fuels vary from highly volatile jet fuels and kerosene, to the heavier furnace oil. Automotive diesel engines are capable of burning a wide range of fuel between these two extremes. How well a diesel engine performs with different types of fuel is dependent upon engine operating conditions and the fuel characteristics. The classification of commercially available fuel oils has been set up by the American Society for Testing Materials. Grade 1D fuels range from kerosene to what is known as intermediate distillates. Grades 2D and 4D each have progressively higher boiling points and contain more impurities. The fuels known as high-grade fuels, kerosene, and 1D fuels, contribute a minimum of engine deposits and corrosion and have less impurities. Refining the fuels removes the impurities, but it also lowers the heat value. Therefore, the higher grade fuels develop slightly less power than the same quantity of low-grade fuels. This is more than offset by the cost of maintenance repairs in using low-grade fuel.

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.

Diaphragm

A diaphragm is a flexible partition or wall separating two cavities. 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.

Outlet and Inlet Valves

The intake (or inlet) valve permits a fluid or gas to enter a chamber and seals against its exit. The outlet valve works just the opposite; permitting the pressurized fuel to flow out into the fuel lines to the carburetor.

A check valve above the fuel pump in the fuel line keeps the fuel from flowing back into the fuel tank when the engine is shut down. If this valve were not there, fuel starvation on start-up might occur, since it takes longer for the electric fuel pump to get up pressure in the fuel line than it does for a positive displacement mechanical pump.

Pump Arm and Operating Lever

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.

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.

Pintle Valve

The pintle valve is a spring-loaded ball inside the injector of a fuel-injection system. The injector coil creates a magnetic field, which causes the armature to move upward. This action pulls the pintle valve off its seat. Then, fuel under pressure can flow out of the injector nozzle. The contour of the ball or pintle valve causes the fuel to be sprayed in a cone-shaped pattern. When the injector is de-energized, the spring pushes the ball onto its seat, stopping the flow of fuel.

Variations in Resistance

The height of the fuel in a tank causes the sending unit to send variations in resistance, which changes the current to the dash unit coil so the pointer indicates the amount of fuel available.

Calibrated Friction Brake

A calibrated friction brake is included in the fuel tank unit. This prevents the wave motions of the fuel from fluctuating the pointer on the dash unit, so that the fuel reading will correctly correspond to the amount of fuel available in the tank.

Limiting Coil and Operating Coil

Current from the battery passes through the limiting coil to the common connection of two coils at the lower terminal on the dash unit. The current is then offered a choice of two paths, one through the operating coil of the dash unit and the other over to the tank sending unit.

When the fuel tank is low or empty, the sliding brush cuts out all resistance in the tank unit. Most of the current will then pass through the tank unit circuit because of the low resistance, and only a small portion will pass through the operating coil to the dash unit. As a result, this coil is not magnetized enough to move the dash unit pointer, which is then held at the "Empty" position by the limiting coil.

When the tank is partly full or full, the float of the tank unit will rise to the surface of the fuel and move the sliding brush over the rheostat, putting resistance in the tank unit circuit. More current will then pass through the operating coil to give a magnetic pull on the pointer, which overcomes some of the pull of the limiting coil. When the tank is full, the tank unit circuit contains the maximum resistance to the flow of the current. The operating coil will then receive its maximum current and exert pull of the pointer to give a "Full" reading.

As the tank empties, the operating coil loses some of its magnetic pull and the limiting coil will still have about the same pull so that the pointer is pulled toward the lower reading.

Vapor Lock

Vapor lock is a condition in which fuel boils in the fuel system, forming bubbles which retard or stop flow of fuel to the carburetor.

Gaskets

Gaskets compensate for small irregularities between two surfaces. They are used to prevent fluids and gasses from leaking. In the case of a cylinder head gasket, the combustion pressure is kept in the cylinder, and engine coolant is kept within the passages of the water jacket. The most common cause of gasket failure is overtightening of the bolts that hold the gasket between the metal surfaces. To prevent this, some manufacturers have incorporated a metal washer in the bolt holes of the gasket, which limits the amount of force that can be applied. Some gaskets must be installed in a specific manner, while others do not. Head gaskets require the mechanic to "torque" the head bolts to specific tightness, and also require the bolts to be tightened in a specific order.

Engine Valves

A valve is a device for controlling flow through an opening. The internal combustion engine, which is basically an air pump, depends on the efficient sealing of the valves in order to produce compression. The timing of when the valves open, and the duration of their opening, affects engine operation. The cam dictates these two factors. The following terms describe the major components associated with the valves.

"Valve clearance" is the gap between the end of the valve stem and valve lifter or rocker arm to compensate for expansion due to heat. Engines with hydraulic lifters often do not need valve clearance adjustments because the lifters automatically take up the slack.

The "valve face" is the part of the valve which mates with and rests upon some seating surface. The "valve head" is the portion of a valve upon which the valve face is machined.

The "valve lock" (also called the key, keeper, or washer) is a device which holds the valve spring in place on the valve stem.

"Valve overlap" is an interval which is expressed in degrees where both valves (intake and exhaust) in each cylinder are open at the same time.

The "valve seat" is the part of the cylinder head upon which the valve face rests. These are precision ground to mate with the valve face and thereby seal the cylinder.

The "valve spring" is attached to the valve to return it to its seat after lift is released.

The "valve stem" is the longest portion of the valve which passes through the valve guide.

The "valve guide" is the sleeve through which the valve stem passes. It is pressed or threaded into the cylinder head, and is self lubricated by the composition of its materials. Older cars depend on the lead in "Regular" gas to lubricate the guides.

The "valve timing" refers to the relative position of a valve (either open or closed) to the piston in its travel, in crankshaft degrees.

The "valve train" is the complete set of mechanisms used to transmit the rotating motion of the engine crankshaft to the reciprocating valve stem, causing the valves to open.

Heat Exchanger

The "heat exchanger" is a device that uses exhaust heat to aid in fuel evaporation. It usually is built into the intake manifold as an area where the hot exhaust gasses and fuel-air mixture come close to each other.

Barrel

"Barrel" is a popular term for a carburetor throat. There is one venturi in each throat. A dual (or "two-barrel") carburetor has a primary venturi for part-load running and a secondary venturi for full-throttle; a four-barrel carburetor has two primary and two secondary venturis.

Methanol and Ethanol

Methanol and ethanol are two forms of alcohol fuel 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. However, it requires less air for combustion, which compensates for the high caloric values.

Ethanol is the most common fuel additive; it's an alcohol made from vegetable matter. Some areas require the addition of oxygenates in gasoline, because they reduce carbon monoxide emissions by as much as 39%. They also raise the octane level of the gasoline.

Baffle Plates

"Baffle plates" are sometimes welded to the sides and bottom of the inside of the fuel tank for reinforcement and to prevent the fuel from surging and splashing. Baffle plates are notched or perforated so that the fuel can still flow from one section to another.

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.

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.

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.

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.

Lever Return Spring

A return spring, or restoring spring, is a coil spring that moves something, such as a valve or diaphragm back to its normal position and holds it there.

Diaphragm Return Spring

The diaphragm return spring is a stiff coil spring that pushes the diaphragm upward, flexing it in an upward direction.

Turbocharger Impeller

The impeller is a wheel like device with a series of curved fins or vanes. As the impeller whirls, the air is drawn in at the center and thrown off at the rim; the air is then forced into the passage at increased pressure. The impeller shaft connects the impeller with the turbine.

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 Rail

The fuel rail is a fuel line that connects all of the injectors in a multipoint fuel injected system. It is usually 3/4" in diameter and allows a constant fuel supply to each of the injectors, which act independently. The fuel rail is filled with pressurized fuel from the fuel pump.

Diesel Fuel Pump

Diesel fuel pumps are designed to inject a specific amount of fuel at a very specific time. They control the injectors by the pressure waves of the fuel that they pump. They are usually linked to the crankshaft or the camshaft through a series of gears. These gears allow the fuel pump to be driven directly by the crankshaft of the engine. However, some are belt driven and some are chain driven. The diesel fuel pump has mechanisms in it which allows more or less fuel to be pumped. If less fuel is pumped into the cylinders, this slows the engine. Pumping more fuel increases the speed of the engine. Consequently, the fuel pump regulates the speed of the diesel engine.

Diesel Fuel Injector

The diesel fuel injector is a pressure valve, but it has specific components that allow it to disperse the diesel fuel in set patterns, depending on the design of the valve. Diesel fuel injectors receive the pressurized impulse from the diesel fuel pump, and allow the fuel to enter the combustion chamber when it is needed. If the diesel fuel injectors get clogged, engine performance suffers.

Glow Plugs and Control

Glow plugs are used to warm the fuel mixture within the precombustion chamber in a diesel engine. A glow plug is an electric resistance wire within a small housing that is raised to a certain temperature when the engine is started (or "cold"). The fuel plug gets the fuel mixture up to the proper ignition temperature. Once the engine is warmed up, the glow plug control senses the temperature difference and turns off the glow plugs until they are needed again.

Precombustion Chamber

The precombustion chamber of a diesel engine is a small cavity, much like the combustion chamber, only it is contained within a small area. It allows a preignition state to exist. Once the fuel in the precombustion chamber ignites, it can then ignite the fuel- air mixture in the combustion chamber itself. In cold weather, the precombustion chamber enables diesel engines to start more readily, since the glow plug can easily warm the small volume within it. Under normal operating conditions, the precombustion chamber allows a lean mixture to be used, because it concentrates and ignites it within the precombustion chamber before it disperses into the combustion chamber.

Air as Fuel

The substance your car burns the most of is air. Fuel is mixed with the air at ratios of around 14.6:1. For every gallon of gas you burn, you burn many, many cubic feet of air. The number of molecules of air entering the combustion chamber each time the intake valve opens will vary with the temperature of the air. Cold air is much more dense (the molecules are packed together) than warm air, so cars often perform better in cool weather. If more air gets into the chamber, more power is produced. For this reason, engines running at high altitudes or in especially hot climates have to be specially tuned to get enough air to run properly. If the air is compressed by a turbocharger or supercharger, more of it can be packed into the cylinders. The result is the production of greater power when this air is ignited.

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.

Electric Car Controls

Operation is much like driving a car with an automatic transmission; there is an accelerator that controls forward movement, and a brake that when applied, slows the vehicle and at the same time recharges the batteries. A button is pressed for reverse. The GM Impact uses alternating current (AC) motors and a converter for utlizing the battery's power, which is DC. The car's main power source is a special battery pack. The main obstacle of battery power is its power to weight ratio. Lead batteries weighing the same as a full tank of gasoline have much less usable energy for the car to draw from. Also, as batterys lose their power, the performance drops gradually, which could be dangerous in traffic. There are many different battery types being developed, but the majority of designs use either nickel cadmium or lead-acid. Each has its advantages and disadvantages. Depending on their design and cost, the batteries can take anywhere from 20 minutes to ten hours to recharge. They provide ranges from 30 to 100 miles on a single charge.

Another important part of the electric car is the electronic control system. The energy management control, which encompasses both acceleration and deceleration, controls and monitors the power flow, and alerts the driver of a drop in power.

Hybrid Electric Cars

Volvo has explored building "hybrid" electric cars. The turbine hybrid gives you the best of both worlds; the option of running pure electric for urban driving, or turning on the gas-powered turbine engine in hybrid mode for cruising. The hybrid mode helps to overcome the limited range and performance of a pure electric car. Volvo has a test car that can top 100 mph in hybrid mode, runs up to 415 miles without refueling, and gets 45 mpg at a constant 55 mph.

American Electric Cars

A large number of American firms are developing electric cars. General Motors has taken the lead with an electric car that is slated for mass production in the mid 1990's, the Impact.

The Impact can go from 0-60 in 8 seconds, has a range of about 80 miles per charge, and only requires about 3 hours to recharge on any 220v circuit. Little routine maintenance is required, and the cost will be competitive with conventional gas-powered cars.

GM IMPACT SPECIFICATIONS

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^hDimensions^f
Wheelbase                95.0 IN.
Length                   163.0 IN.
Width                    68.2 IN.
Height                   47.5 IN.
Curb Weight              2200 LBS.
Aerodynamic
drag coefficient         0.19
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^hPerformance^f
Motor speed at 60 mph    9500 rpm
Top Speed                Electronically limited to 75 MPH

^hGeneral Data:^f
Motors (2)               AC induction
Horsepower               114 BHP (57 BHP each motor)
Torque                   94 total LB-FT
Electronic Control Type  Dual MOSFET inverters
Maximum current          159 AMPS RMS to each motor
Frequency range          0-500 HZ
Battery charger          Computer-controlled, integral
                         with dual inverter package
Batteries                32, 1O VOLT Delco-Remy recombinant
                         lead-acid batteries, wired in series
Capacity                 42.5 AMP-HOUR, 13.6 KWH
Drivetrain               Front-wheel drive, one motor per wheel
Tires                    Low-rolling resistance radials
Tire size                P 165/65 R-14
Wheels                   14 X 4 IN. forged aluminum
Steering                 Rack-and-pinion
Suspension               Two control arms per wheel, coil
                         springs, gas pressure shock absorbers
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Solar Cells

Some electric cars are equipped with solar cells located on the roof of the car, similar to a sunroof. These cells are used to collect sunlight and convert it into energy. The solar cell is used to augment the existing recharging system.

Electric Landspeed Lady

Camille Jenatzy, of France, drove a Jeantaud electric a record of sixty miles an hour on April 29, 1899. The high speed, however, burned out both the specially fabricated batteries and French interest in electric cars.

Battery Powered Electric Cars

The electric car, scheduled for mass production in the mid 1990's, offers many advantages over traditional gas powered autos of today. The most obvious advantage is exhaust free operation. As smog levels continue to increase at an alarming rate, the need to lower emission levels becomes more and more important. With the advent of electric cars, a dramatic reduction in the nitrogen oxides (NOx), and nonmethane organic gases such as carbon monoxide and hyrocarbons is possible. These gases are major contributors to the deterioration of the ozone layer. Also, the reduction of particulates (tiny particles of dust, soot, smoke, and other matter floating in the air) would be cut to almost zero.

What is the government doing?

In 1990 the Clean Air Act Amendments were created. These amendments included specific provisions for alternative fuel vehicles. Auto makers in California will be required to sell 150,000 alternative fuel vehicles annually, starting in 1996. Also, fleet vehicles in the nation's most polluted cities will be required to begin using alternative fuel vehicles beginning in 1998. Many states have also passed legislation to promote the use of alternative fuel vehicles. Sales tax rebates and mandates requiring the sale of electric cars to account for a certain percentage of total car sales annually, just to name a few.

Autom

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Automotive History

Why Is It Called An "Automobile"?

First let us consider the name, "automobile." Now, a "car" could have been called anything and, sometimes, it is. Oliver Evans applied for a U.S. patent in Philadelphia in 1792 on a steam land carriage, which he called the "oruktor amphibolos!" We could have been strapped with that name forever, if it weren't for more reasonable individuals working on the same concept.

Martini was a 14th Century Italian painter, who had been trained in engineering. He designed (on paper) a man-propelled carriage, mounted on four wheels. Each wheel was powered by a hand-turned capstan arrangement. Gearing was also provided to transmit the rotation of each capstan to the wheel below. It may have looked good on paper, but the four turners of the capstans couldn't have kept it up for long before they fell over with exhaustion. It is lucky for us that Martini did not name his invention after himself, as many inventors do. If he had, and the word had survived to the present, it might be a little confusing. If we were offered a "Martini," we might not know whether to drive it or drink it! (Representatives of MADD and SADD would probably tell us to park it!) We could be reading headlines like: ORUKTOR ACCIDENT TAKES THREE LIVES or UNITED MARTINI WORKERS ON STRIKE.

The really historical (and fortunate) aspect of Martini's design is the name that he gave it: "automobile," from the Greek word, "auto," (self) and the Latin word, "mobils," (moving). "Car," on the other hand, comes from an ancient Celtic word, "carrus," meaning cart or wagon.

George B. Selden, an attorney in Rochester, New York, applied for, and finally received, a patent for a "road machine" in 1879. The Duryea brothers (1895) called their products "motor wagons." In 1896, Henry Ford introduced an experimental car labeled the "Quadricycle." Newspapers used words like autometon, motor-vique, oleo locomotive, autokenetic, buggyaut, motor carriage, autobaine, automotor horse, diamote, motorig, mocole, and, of course, the horseless carriage. In 1895, H. H. Kohlsaat, publisher of the Chicago Times-Herald, offered a $500.00 prize for the best name for the motorized vehicles of the day. The judges picked "motorcycle" as the winner. "Quadricycle" was a favorite, as was "petrocar." The word "automobile" wasn't even in the running! But in 1897, The New York Times prophesied, "...the new mechanical wagon with the awful name -- automobile...has come to stay..."

Many of the words that are associated with automobiles are derived from the French; i.e, garage, chauffeur, limousine, and chassis are just some examples.

Where Did The Idea Come From?

No one person can be credited for the invention of the automobile that you are driving today. It has developed bit by bit from the ideas, imagination, fantasy, and tinkering of hundreds of individuals through hundreds of years.

In the 13th-century, the English philosopher-scientist, Roger Bacon, said that "cars can be made so that without animals they will move with unbelievable rapidity." Oh, Roger, if you only knew! Bacon was positive that these vehicles had existed in ancient times, but he didn't know what propelled them.

The Greeks apparently had their own Olympic assembly line. In the "Iliad," Haephestus (the Roman "Vulcan"), was the god of fire and invention. When he had time off from making thunder bolts and beautiful jewelry for the vain goddesses, he built three-wheeled vehicles, which moved from place to place under their own power. Homer says they were "self-moved, obedient to the gods," and would Homer lie? The really remarkable thing about this is that even as far back as the Homeric era (8th-9th (?) century B.C.), man had already imagined automobiles.

The motorized vehicle is, indeed, a prime example of creeping development; i.e., invention through slow accumulation of bits and pieces over a time so long that it is hard to pin down its origin. Thomas Russell Ybarra, in this century, wrote rhyming doggerel which pointed to the automobile as a Roman invention. Those who care to can point to two 15th-century Italians: Francesco di Giorgio Martini (whose concept has been presented in another section) and Leonardi Da Vinci. Da Vinci conceived an armor-plated war vehicle, the propulsion system of which is much like that of Martini's. This particular concept of Da Vinci did not contribute anything of value, not even a name, as did Martini's.

The important thing to remember is the automobile is not some recent idea that popped up in the 19th-century, or the 18th, or even the 14th. It is a creation that has charmed imagination and inventiveness before man was able to conceive how to make it go. Perhaps that is why Homer placed it in the hands of the gods.

Ups and Downs in Automotive Progress

As early as 1600, the Dutch, no strangers to wind power, had built a wind-powered, sail-mounted carriage. These carriages were reported to hold several passengers and move at speeds as high as twenty miles per hour. These tests were abandoned in favor of small windmills built onto the carriage, with mill vanes geared to the wheels. In either case, whether equipped with sails or windmills, they never caught on; mostly because they could not move except on the whim of a breeze. However, they were probably the first real land vehicles to move under power, other than that of animal or human muscle. While the Dutch dreamed in terms of the wind, others were thinking of other means of propulsion. In the 1700s, a Frenchman, Jacques de Vaucanson (no relation to the Roman god, Vulcan), built a vehicle which was powered by an engine based on the workings of a clock. What he neglected to calculate was that any clock which was capable of moving a vehicle with passengers would have to outweigh the load it was carrying. Even winding such a clock motor would take great time and greater effort than it was worth.

Inventors in England, France, Germany and other countries worked on the idea of a compressed-air engine, but they were unable to find the solution to self-propulsion in this means. However, in their efforts, they contributed significant individual elements to the picture; elements like valves, pistons, cylinders, and connecting rods, and an emerging idea of how each of these elements related to the other. The first invention that can truly and logically be called an "automobile" was a heavy, three-wheeled, steam-driven, clumsy vehicle built in 1769 by Captain Nicolas-Joseph Cugnot, a French Army engineer. (Cugat was actually born in Switzerland, but the French don't want to hear about it.) This mechanism was slow, ponderous, and only moved by fits and starts. In tests, it carried four passengers at a slow pace - a little over two miles per hour - and had to stop every twenty minutes to build a fresh head of steam. It was, however, a self-powered, steerable, wheeled, people transporter, thereby demonstrating that the idea of mobilization was workable. Unhappily, Cugot's superiors were not men of vision and failed to appreciate the potential of his creation. To show him how they really felt, they disallowed him any funds for further development and transferred him to other duties. Since they had paid good money for this contraption, however, they preserved the vehicle, and it can still be seen in the Paris museum, where it is displayed with proper national pride.

In the meantime, Great Britain, who believed themselves to be the masters of steam, had begun to believe that they could put this same steam on wheels. It was probably natural that they believed this; Thomas Savery, an English engineer, had given the world its first steam engine in 1698. This engine was crude (by our standards), inefficient, and blew up at intervals. Thomas Newcomen, an English blacksmith in 1711, turned out a better, less dangerous version of the engine. Then, in 1679, James Watt, a Scottish instrument maker, had patented a truly improved steam engine that became widely used in British mills, mines, and factories. Sir Isaac Newton, in 1680, conceived of the idea of a carriage propelled by a "rearwardly directed jet of steam." (It didn't amount to much at the time, but Sir Isaac's concept has become the means of rearwardly directed jets to provide the thrust for rockets to probe space.) Then, in 1801, an engineer in Cornwall, Richard Trevithick, built a road steamer, which was first tested in a Christmas Eve snowfall. Two years later, he built an improved model with drive wheels ten feet in diameter, which proved to be capable of sustained, reliable performance at speeds up to twelve miles per hour.

Others were also working on steam propulsion in Germany, Denmark, Sweden, France, and the United States. The Evans vehicle, the "oruktor amphibolos" referred to earlier, was thirty feet long and weighed fifteen tons. It was really intended for dredging the harbor and was the world's first amphibious conveyance. On it first run in 1804, it clanked along on huge iron wheels, frightening Philadelphia onlookers out of their skivvies, before entering the Schuylkill River, where its propulsive energy was converted to a stern paddle wheel. Another American inventor, Richard Dudgeon, was experimenting with steam-mobiles. One was destroyed in a fire in 1858 in the famous Crystal Palace in New York City; another, built about ten years later, was banned from the streets by the civic leaders. Britain actually was where the steamers made their greatest impact. By the 1830s, they had set up a limited network which provided both passenger and freight service to a handful of cities. The public was awed, amused, and sometimes bitter. Some complained that the road steamers were noisy, which they were; and some complained that they were dangerous, which was occasionally true. But, as is natural, the loudest complaints came from vested interests, horse-drawn vehicles and railroads, who were afraid of losing business. Because of the pressure, in 1865, the British Parliament adopted the "Red Flag Act," which limited steamers to a speed of four miles an hour on the open road and to two miles an hour in the city. It required a crew of three men: one walking sixty yards ahead, with a red flag by day and a lantern at night, to warn of the vehicle's approach. Stymied by these restrictions, several British engineers turned their thoughts and attention to electricity as a promising alternative to steam. One can imagine that the automobile may have progressed very differently if not for these restrictions.

It takes courage to effect revolutionary changes of any kind, and there were some formidable tinkerers in the horse-drawn carriage, nineteenth century; men like William Murdock, William Henry James, William Symington, Sir Goldsworthy Gurney and Walter Hancock, Charles Dallery, Etienne Lenoir, Amedee Bollee-Pere, Siegfried Marcus, Thomas Blanchard, William Janes, Nathan Read, Apollos Kinsey, Sylvester Roper, Carl Benz, and Gottlieb Daimler.

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.

Get A Horse!

The proud owner of a new horseless carriage often loaded his family into the machine while the neighbors ogled with envy. Invariably, the budding driver would over-dramatize the ritual of donning his gloves, checking his equipment, and cranking the engine into sputtering, back-firing action, while onlookers held their ears. With heads held high, the driver and passengers would then begin their baptismal trek into the country, beaming with arrogant satisfaction. They would take the way which would lead them past the "right people," of course. If ever there was a "thrill of a lifetime," this was it. But such were the ways of life in those days that such joyous beginnings didn't always have a happy ending.

Somewhere along the way, the tiny engine would start to cough and sputter. The driver would assure his frightened passengers that there was nothing to worry about, but the mechanical hiccuping continued. The driver's assurances would waiver, and when the motor finally died, the ego-deflated owner suffered the pangs of the damned. When no amount of tinkering, kicking, or cursing would revive the engine, the humiliating trip to the nearest farm would have to take place. The farmer would probably be glad to add to the driver's mental anguish by making remarks about "them new-fangled contraptions," but with some degree of stability, he would harness his team and hitch it to the front of the horseless carriage.

Now gone were the proud airs; mother and daughter blushed with shame as they were towed back homeward past their snickering neighbors. Young sons usually enjoyed the experience, but father was ready to explode. The team of horses, as slow, expensive, and old-fashioned as they were, got the final horse laugh. It seems right, somehow, that the term "horse-power" has continued to be a measurement of the automobile's mechanical muscle. The animal has certainly contributed so much to civilization that it needs some lasting remembrance with the vehicle which unceremoniously dumped it from public favor. The horse was not just replaced, he was caught up in a competitive situation which saw him maligned by copyrighters, ridiculed by a new strain of high-powered merchants, called auto dealers, and he was even attacked by health authorities, who saw the motor car as an end of manure heaps, disease-toting flies, and assorted other pollution.

Anyone who has ever walked down-wind of a livery stable knows that the horse had an aromatic drawback. It was also easy for the sly advertiser to win over a public, who was plagued with a need for sticky flypaper, insect traps, and foul-smelling sprays. No one envisioned that the motor car would be all health and happiness, either, but the economic argument was hammered home by automobile publicists. They pointed out that each horse in the U.S. required the production of five acres of land and twenty man-days of work per year. Ransom E. Olds, writing in "Scientific American" before 1900, took an swing at the horse when he advertised a new steam carriage: "It never kicks or bites, never tires on long runs, and never sweats in hot weather. It does not require care in the stable and eats only while on the road." William A. White, a famed editor and horse-lover, wrote, "...he makes no claim to speed, but his carburetor always works, and while he has but two cylinders, he brings his guests back in one piece at home rather than downtown at the undertaker's to be assembled by total strangers..."

Stories of runaways, overturned buggies and other accidents due to horses were widely exaggerated and overdramatized. Of 476 equine accidents, analyzed by a prominent magazine, only two were reportedly caused because the horses involved were frightened by automobiles. This statistical whitewash was to refute the common complaint that motor cars were scaring otherwise good, tame horses. The anti-horse faction, always looking for new ammunition, made the most of a vicious heat wave which hit New York City in July of 1911. About 1,200 horses dropped dead of heat exposure, and it was quickly pointed out that motor cars and trucks continued to function without difficulty or detriment to the health of the populace. The once overwhelming notes of rebuttal began to flag, and in spite of the fact that there were 25,000,000 horses in the country in 1912, Dobbin was definitely "out," and the "Betsy" was "in."

This transition from a centuries-old form of land transportation to one of automobiles was not easy, and it did not just happen in a day or two. The horse was, after all, an important part of the economy. Feed and veterinary bills amounted to millions of dollars each year. The Chicago Times reported that horseshoes in 1915 required enough iron to build 60,000 motor cars. Harness makers, buggy-whip companies, carriage builders, livery stable operators, blacksmiths, an army of street cleaners, wheelwrights and even hitching-post manufacturers were all affected by the technological development of automobiles. These companies had to either re-tool and adapt to the industry or face the realities of a declining business.

The coming of WWI spurred the production of motor vehicles, and also upped the need for horses and mules. After the signing of Armistice, however, the final turning point came. From then on, it was really downhill for the horse - not into oblivion, fortunately, but to a minor role of race tracks, rodeos, show rings, riding clubs, and Wild West movies. The horse retired to greener pastures (or to the glue factory) and became only a legend in transportation and agriculture.

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.

Internal-Combustion Inventors

Lenoir and Marcus had shown the feasibility of the internal-combustion engines, but both lacked faith in their own enterprises and abandoned their efforts. Closest to the mark in the judgment of historians is another pair of inventors who had faith in the future of the motorcar as well as in themselves. They worked doggedly (and unbeknownst to each other) to find the missing pieces of a puzzle that had been plaguing automotive inventors through the years: how to propel the horseless carriage.

Carl Freidrich Benz and Gottlich Wilhelm Daimler worked separately (and at almost the same moment) in Germany; each designing and building the world's first commercially successful cars. These are, for all intents and purposes, the direct linear antecedents of the modern automobile.

Benz's first creation was not very impressive, either in design nor in initial road test. It was a fragile, carriage-like three-wheeler with tubular framework, mounted on a Benz-designed, one-horsepower, one-cylinder engine. The engine was a refinement of the four-stroke engine designed by Nikolaus Otto (another German), who had refined his from Lenoir's two-stroke engine. Even though Benz's creation was awkward and frail, it incorporated some essential elements that would characterize the modern vehicle: electrical ignition, differential, mechanical valves, carburetor, engine cooling system, oil and grease cups for lubrication, and a braking system. He obtained a patent on a "carriage with gasoline engine" in 1886.

About seventy-five miles from Carl Benz, Daimler worked diligently to design a better internal-combustion engine. He was satisfied that he had succeeded in 1833, when he took out a patent on what he believed was a more efficient, four-stroke, gasoline-fueled engine. He first mounted his engine on a sturdy bicycle, a two-wheeler, which ran satisfactorily on its test run in 1885. This was the prototype of the modern motorcycle. In 1887, Daimler, encouraged by this success and by experience, installed his engine in a four-wheeled, two-passenger vehicle. The engine had only a few more horsepower than Benz's, but it was lighter and ran at a much higher speed - 900 rpm as compared to Benz's 300 rpm. It was the first example of a high-speed, internal- combustion engine.

Daimler and Benz argued heatedly concerning each other's claim to fame and prestige. Daimler insisted that he had successfully tested his engine on a bicycle before Benz had patented his tricycle and had, in any case, been the first to patent a four-wheeled car. Benz conceded that Daimler invented the motorcycle, but he insisted his tricycle was the first motorcar. These claims are still argued to this day by people who care; historians give both men a lot of credit: Daimler for his high-speed engine; Benz for the features of water cooling, electric ignition and differential gears. Benz and Daimler continued separately and competitively, to develop improved engines and refined vehicles to put them in. When Gottlich died in 1900, his company removed his name from the car he had created and affixed "Mercedes," for Mercedes Jellinck, the daughter of an influential distributor who lived in France. In 1926, when Carl Benz was 82 (he lived three more years), the companies merged into one firm. These two inventive giants, who worked so hard and lived less than seventy-five miles apart, never met one another, but they poised the world for entry into the Automobile Age. Just as the 19th-century was making its way into the 20th, the world was little inclined to be led in the direction of automobiles - except for those who had money enough to indulge their fancies, and in France, where motorcar production was beginning to assume some significant economical measures.

The wide boulevards of Paris, and the fine paved roads radiating out of the French capital, were ideal settings for rich sportsmen to show off their noisy toys. By 1895, there were so many self-propelled vehicles puttering around the city that the French Academy coined a new word to the French language to describe them. The word was "automobile."

One of the first vehicles to be officially designated an automobile was a car which is now considered to be the real prototype of modern cars. It was a Daimler-powered vehicle built in 1892 by the Parisian carriage-making firm, Panhard and Levassor. The "Panhard" marked the appearance of the automobile's classic design: engine in front, supplying power to a gearbox behind it; gearbox connected by chain drive to the rear drive wheels. It had four forward speeds and a reverse, and an 1894 model made headlines when it covered a 750-mile distance from Paris to Rouen in forty-eight hours at an average speed of fifteen miles per hour.

Is It A Car? Is It A Plane? No, It's A Bicycle!

Although the first automobiles were called "horseless carriages," and they were, indeed, little more than motorized versions of horse-drawn vehicles, the automobile owes much more to the bicycle than it does to the buggy. It has been explained in a prior chapter that Daimler tested his high-speed engine on a bicycle and developed the world's first motorcycle. Bicyclists, too, generated the first movement for good roads and set the stage for motoring in America.

Automotive advancement in America was hampered by the need of roads. Bicyclists, however, generated a national good roads movement in the early 1890s, which culminated with the establishment of the U.S. Office of Road Inquiry under the Department of Agriculture in 1893. This later evolved into the Bureau of Public Roads.

In fact, the American bicycle industry of the 1890s is really a sponsor of the automobile industry. Many pioneers in automotives were men who were experienced in manufacturing bicycles. Charles and Frank Duryea introduced the first successful American internal- combustion engine in 1893. Charles was a skilled bicycle mechanic. Alexander Winston, a bicycle manufacturer, made the first American high-performance car in 1897, a twelve-horsepower model that tested out at 33.7 miles per hour. Henry Ford, a tinkerer, used many bicycle parts, including a saddle, on his first "quadricyle" in 1896. There were twenty-seven American bicycle manufacturers in 1890, and many of these played significant roles in the development of the automobile. The Pope Manufacturing Company opened a motor-carriage department in 1897 to produce Columbia cars, using the popularity of their Columbia bicycles as a sales incentive. Another manufacturer, Rambler bicycles, was so successful with their Rambler automobiles that they concentrated solely on the cars and stopped producing bicycles altogether.

The first car manufacturers were dependent on the bicycle firms for many of the parts they needed: lightweight tubing, gears, chain drives, ball and roller bearings, wire wheels, pneumatic tires, tools, and sometimes, even the space in which they needed to work. The first car dealers were also recruited and converted from the bicycle dealers. The best place to buy a really fine car at the turn of the century was at the local bicycle shop.

America! America!

The greatest legend in the American automobile development is the common belief that the car is an American institution. The American car inventors were really Johnny-come-latelys, when it came to producing the automobile, but once they got going, they made up for all the centuries of lost time.

Although the automobile was becoming an increasingly familiar sight in Europe in the 1890s, it was considered a freakish contraption in the United States. Roads were poor and few. Americans finally became receptive to the idea of the automobile when they realized that, with a car, they could go where they wanted to go without having to use the railroad.

Detroit is not the original forge where the U.S. auto industry took shape: Hartford, Cleveland, and at least a dozen other places have better credentials. Many men and hundreds of hours of creating, designing, and hard work went into the creation of American cars. Several crude, experimental motorized buggies had been built in the U.S. before the Duryea brothers built the first successful, internal-combustion car in 1892-93.

A carriage maker in Flint, Michigan, William C. Durant designed a motorcar and went on to organize Buick, General Motors, and Chevrolet. George M. Pierce made bird cages, bicycles and finally, automobiles--Pierce-Arrows. Charles W. Nash made the Nash. In 1954 the Nash Kelvinator Corp. merged with the Hudson Motor Car Company to become the American Motors Corporation.

Car designers came from all areas and occupations. Some succeeded, but most failed. Then, along came the son of a Michigan farmer. His name was Henry Ford.

In 1879, Henry Ford was sixteen years old when he got a job in Detroit. In his spare time he built an internal-combustion engine from plans he found in a magazine. It was a bicycle-wheeled, tiller-steered two-seater, without brakes or reverse gear. It was so noisy that it was condemned by the public as a nuisance.

In 1898, he built an improved vehicle, but it failed in a year. Finally he produced an automobile that was bigger, more powerful, and much faster. A well-known bicycle rider drove the car in a race and won. The publicity got Ford financial backing.

The first popular car was a roadster, the "Oldsmobile," designed as an economy car by Ransom E. Olds. This car had two seats and a one-cylinder, three-horsepower engine.

In 1900, only 8,000 cars were registered in the U.S. Olds introduced quantity production, and became a very rich man. The car sold for $650, about half the price of competitors. Sales zoomed from 425 in

1901, to 6,500 in 1905.

Henry Ford founded the Ford Motor Company in 1903. Ford first brought out the Model A: a small, two cylinder car with an eight- horsepower engine, which sold for $850. The next year, the Model B Ford was added, a four-cylinder, which sold for $2,000. In 1906, Ford added the Model K, an important milestone. In 1906, New York held two auto shows. In Madison Square Garden, there were 220 exhibits; the 69th Regiment Armory show had 205 exhibitors. Ford's Model K, introduced at Madison Square Garden, was big, heavy, expensive and a mistake. It could go 60 mph with its six-cylinder, 40-horsepower engine. It sold for $2,800, $2,000 more than a Cadillac. Ford lost money on every one sold, so he concentrated on a light, simple, rugged model that could be sold inexpensively; what he termed "the universal automobile."

The new design was called the Model T. Adapted from the model N, it was solidly constructed, and easy to operate and repair. Its chassis was high to provide good clearance. A four-cylinder engine produced 20-horsepower in two forward speeds and a reverse. In 1909, the least expensive Model T got about thirty miles to the gallon. Customers responded to the advantages of the Model T, and new, plants were constructed. Production increased from 10,000 in 1909 to 78,000 in 1912. In 1913, Ford found a better, faster way to build cars.

In 1914, Ford opened the world's first auto assembly line. Production jumped to 472,000; a car could be turned out in 93 minutes. In 1924, when half of the cars in the world were Fords, the Model T sold for $290 and profits piled up. The last "tin lizzy" (the 15,007,003rd) rolled off the production line in 1927. It was truly the "universal car," in every corner of the world.

The eighteen-year supremacy of the Ford caused the disappearance of many of the smaller car companies and the emergence of others. One of the consolidators was the General Motors Corporation. William C. Durant bought out the Buick Motor Company in 1904. He incorporated General Motors in 1908 and merged Buick, Cadillac, Oldsmobile and Oakland (Pontiac) into a single corporation. Ford's monopoly ended after WWI; other manufacturers began to make cheaper, more attractive cars. In 1916, the Chevrolet Motor Company put out a four-cylinder model that eventually passed the Ford as the best-selling car in America.

Another strong competitor of the Model T was a tough four-cylinder Dodge manufactured by John and Horace Dodge. By 1924, they assembled 1,000 cars per day. Four years later the company was purchased for what was then a world's record price of $175,000,000 by Walter P. Chrysler, of the Chrysler Corporation. In 1928 the Chrysler Corporation started selling Dodges, DeSotos Plymouths, and Chryslers.

By 1928, competition had forced new standard equipment. The self- starter was invented in 1911, resulting in more drivers. The car had gone from a wooden, open vehicle to a steel, fully enclosed year-round sedan. The modern automobile was mechanically "complete" by 1929, when 4,587,400 cars were sold in the United States. All the major mechanical developments since then have been improvements or refinements of existing systems.

Henry Ford did not create the automobile nor the automobile industry. When he built his first internal-combustion engine from magazine plans in 1896 and mounted it in a carriage, others had already built better motor vehicles than his crude attempt. Those others must yield the stage to Henry Ford in one aspect; it was he who captained the manufacturing revolution. He jacked up the world and slid four wheels under it. He said he would democratize the automobile and when he was through, just about everyone would have a car. He kept his word. Life would never be the same again.

Name It and It's Yours

By 1911 the automobile industry had come into its own. Securities of automotive companies were listed in the New York Stock Exchange. The Ford Motor Company had been formed, and by 1908 had introduced the historic Model T. The Buick Motor Company, the Olds Motor Works, the Cadillac Automobile Company and the Oakland Motor Car Company had already achieved individual success - and had been combined with other firms by William Crapo Durant into the General Motors Company. Durant then lost control of the organization and moved on to another career, building and selling a new automobile, which had been designed by and named for Louis Chevrolet, a French race driver. Another promoter, Benjamin Briscoe, had brought together some 130 companies to create the United States Motor Car Corporation. This ambitious merger soon ran into financial difficulties and ran into receivership in 1912. Michigan, and especially Detroit, were now established as centers of automobile production. The general public took to motorized vehicles like moths to a flame. While the heads of companies were inventing, merging, maneuvering, suing, counter-suing, promoting, failing, or amassing fantastic wealth, curious Americans from Oregon to Maine were interested enough to open their wallets. Dealerships were set up in livery stables, blacksmith shops and general stores in the largest cities and in the smaller towns. Some of the mechanically-minded individuals assembled their own vehicles, while others turned to their favorite source of supply for anything - the Sears, Roebuck catalog - to order a motor buggy "so safe that a child could run it."

Many of those who contributed to the automotive industry have faded from memory and into historic oblivion (or those whose ideas were stolen, into oblivion itself). Others have been engraved into automobile history on nameplates. Walter Chrysler, Louis Chevrolet, David Dunbar Buick, Ransom E. Olds, Henry Ford, John and Horace Dodge, The White, Mack, and Duesenberg brothers have not been forgotten. John Mohler Studebaker, John North Willys, Harry Stutz, William Crapo Durant, Edwin Ross Thomas, Francis and Freelan Stanley, Johathan Dixon Maxwell, Charles W. Nash, James Ward Packard, Thomas B. Jeffery, E. L. Cord, George N. Pierce, Albert Augustus Pope, Howard C. Marmon and others like them have a niche in the automotive annuals because their names graced the automobiles and radiator caps of their era.

Only an avid hobbyist or automotive historian is familiar with the pioneers like H. Bartol Brazier of Philadelphia; J. L. Cato of San Francisco; Dan J. Piscorski of St. Louis, Missouri; W. H. Kiblinger of Auburn, Indiana; Percy L. Klock of New York; F. J. Fanning of Chicago; C. Clarence Holden of Comanche, Texas; or J. A. Moncrieff of Pawtucket, Rhode Island. They had cars named for them as well, but for some reason, the vehicles failed to catch on and their creators were ground into the oils of automotive history by more popular models.

In 1904, Graham Fisher and James A. Allison organized the Prest-O- Lite Company and introduced a new system of acetylene gas headlights. In 1908, the year of the Model T, C. Harold Wills developed the use of vanadium steel for Ford. At the same time, Charles Y. Knight was perfecting his sleeve-valve engine, and the Fischer brothers founded a company which was to gain fame as a producer of closed auto bodies. Scientific experimentation of Charles Franklin Kettering of the Dayton Engineering Laboratories Company helped bring about such innovations as the electric starter and ethyl gasoline. Harvey S. Firestone, B. F. Goodrich, Arthur W. Grand and others worked with rubber to overcome deficiencies in tire construction. Edward G. Budd, a young Philadelphia engineer, is credited with the idea for all-steel bodies for automobiles. Before this time, many of the manufacturers had been carriage makers and used the same techniques and designs they had previously used for horse-drawn vehicles. The heat of early-day motors caused wood to warp and weakened the glue which held it together. Rough roads made joints give way so that the automobile creaked and groaned. Budd left a good job to pursue his idea with his own company; in 1912, he finally convinced the Oakland and Hupmobile people to try his all-steel body frames, and the next year he received his first large contract from John and Horace Dodge.

Arthur O. Smith, the son of a Milwaukee blacksmith and bicycle parts manufacturer, shifted his interests from bicycles to the new-fangled horseless carriage. He sold his first pressed steel frames to the Peerless Motor Company early in the 20th century and when other auto builders became interested, he offered a house and lot to a foreman who could increase his production to twelve frames per day. It was then that he was visited by Henry Ford. Ford ordered 10,000 Model T frames for delivery in four months; a challenge that was accepted, and by 1921, the A. O. Smith Corporation was capable of producing Ford's first order in a single day.

Hundreds of ideas have come from unknown mechanics who achieved neither fame nor pay for their contributions. The automobile, as it progressed, was a product of many hands, of revolutionary concepts, and of simple, almost unnoticed upgrading. In the end, the one who received the most for these challenges and changes was the motorist, whose interest, money, and enthusiasm have forced the auto-moguls to upgrade, perfect, and add to previous achievements in order to stay in the competition.

The Cadillac is named after the man who, in the 1700's, founded Detroit. His name was Antoine de la Mothe Cadillac.

Animal Names

Some of the cars that have been named after animals are:

Badger	Colt	Eagle	Hawk
Barracuda	Cougar	Falcon	Honey Bee
Beaver	Coyote	Fox	Hornet
Black Crow	Cricket	Golden Eagle	Impala
Bobcat	Crow	Great Eagle	Jack Rabbit
Kangaroo	Panther		Stingray
Lark	Pinto		Wasp
Lion	Rabbit		Whippet
Lynx	Road Runner		Wildcat
Marlin	Seven Little Buffaloes		Wolf
Mustang	Silver Hawk		Wolverine

Star Names

Comet	Jetstar	Star
Eclipse	Meteor	Starfire
Flying Cloud	Moon	Sun
Galaxie	Nova	Sunset
Golden Rocket	Satellite	Vega

Hero and Mythology Names

Ajax	Centaur	Hercules
Apollo	Cressida	Mercury
Ariel	Croesus	Minerva
Argo	Diana	Nike
Argonaut	Die Valkyrie	Olympian
Atlas	Electra	Pan
Aurora	Excalibur	Sphynx
Ben Hur	Goethe	Vulcan

State Names

California	Maryland	Oregon
Carolina	Michigan	Pennsylvania
Illinois	New Yorker	Texan
Indiana	Ohio	Virginian

The Social Impact of The Automobile

Once the world climbed into the driver's seat and stepped on the gas, it hardly ever looked back. Art Buchwald wrote, "Americans are broad- minded people. They'll accept the fact that a person can be an alcoholic, a dope fiend, a wife beater, and even a newspaperman, but if a man doesn't drive there's something wrong with him." Automobiles became more than just toys for the rich, they became a part of day-to-day living in, from, and to the work place. And it is in America that the long ride has been the zippiest, the zestiest, and the zaniest, because it is in America that automobiles started a social revolution almost as revolutionary as that of the motorized industry itself.

One of the first social changes cars brought about was in mating habits. It didn't take young people in America long to realize that there was a lot more they could accomplish in a backseat than on the front porch. Besides, it would be more private and a good deal more comfortable. Motorized courtship had been established even before the Model T offered a love nest within everyone's price range. Gus Edwards' popular "In My Merry Oldsmobile" contained two very provocative lines: "You can go as far as you like with me, In our merry Oldsmobile." Ford's Model T just gave the merry Oldsmobile an enormous amount of company at prices the common person could afford. In 1944, John Steinbeck noted in "Cannery Row": "Most of the babies of the era were conceived in the Model T Ford, and not a few were born in them." And it wasn't just in America.

A survey of 6,000 British girls by the London "Woman" revealed that half of them regularly make love in parked cars. In Los Angeles, a business called "Tail Dating" became popular. The motorist paid a fee to receive a bumper sticker in popular day-glo colors. If one driver spots another car on the road with a driver that sparks his or her interest, and also sports the bumper sticker, the license number can be phoned in to "Tail Dating" to set up a meeting. The automobile manufacturers had no qualms about using sex appeal to sell their product. In 1924, a Jordan firm named one of its models the "Playboy." Its ad campaign showed a handsome cowboy and a beautiful girl driving "somewhere West of Laramie." A Brewster used the same tactics when they produced a heart-shaped radiator grille. Some car companies turned out models with seats that folded down to become a double bed. Things haven't really changed much, except the fold-down seat has become a more comfortable van with all the luxuries of a motel.

Automobiles opened up the possibility of farm children going to town schools, where they were provided with better facilities and greater educational choices. It also gave farm communities the ability to shop at will, rather than once or twice a year. Town was within shopping range and there were also clubs, theaters, and numerous other activities that the average farm family had previously been denied. If one got tired of it, he could always get back to the quiet of the country.

The feminists' movement, which had been dragging its feet ever since the 1820s, had a rapid growth from the automobile. In 1898, Genevra Delphine Mudge drove a Waverly Electric in New York to become the nation's first known female motorist. The following year she became the country's first female racing driver by competing in a Locomobile in a New York race meet. She skidded into five people standing on the sidelines, knocking them down, but not seriously hurting them. She's now only a footnote in automotive history as the first American woman to have an automobile accident. It was also in 1898 that Chicago began requiring licenses in order to drive, and one of the first to be licensed was a woman. The Women's Motoring Club of New York was chartered before Henry Ford had even begun to produce the Model T. In 1909, the president, Alice Ramsey, and three members left New York in an open-bodied Maxwell-Briscoe and drove to San Francisco in 59 days. Women were not a real part of the automotive scene, however, until

Henry Leland produced a self-starter in a 1912 Cadillac. Eliminating the physical strain of hand-cranking, he removed a large physical bar from women drivers and, perhaps, men as well, since he was prompted to this creation because his friend died of injuries he had received from the kickback of a hand crank.

The automobile gave America a new look and something new to look at as well. Escaping railroad schedules and the fixed routes of public transportation, Americans could go wherever and whenever they wanted and stay or leave at will. They took advantage of this opportunity by the thousands. Overcrowded hotels and stage stops developed into road-side cabins and then courts and finally, into motels for the convenience of the motorist who was on his way to someplace else and only needed a stopover to rest for the night.

Businesses looked around and saw the multitude on cars on the roads and followed after them. First there were a smattering of service stations; then they spread across the country like insects as more and more people owned wheels. Every junction of the road had a gas station, and eventually they were on each corner of the junction. The speed of the vehicles picked up sharply and station owners were soon watching them fly by to the next stop, so they started building eye-catching structures, and because man does not live on gasoline alone, they erected diners and cabins and assorted other roadside businesses, which now provide everything from swimming pools and paper, disposable swim suits to breath sprays.

Some salute the car for improving the American breed by providing such extended mating territories. This may be argued, but the car surely did alter the pattern of movement. People began to leave the beaten path, which had previously been unknown. The car introduced a country to itself, enabling travelers to discover and to understand regional differences and common values.

The placid beauty of the open road and the changing scenery began to be spoiled by old tires, food wrappings, pop and beer bottles (and then cans), by bodies of animals who could not outrun the charging vehicle, by deserted service buildings and finally, by road signs designed to catch the motorist`s eye several miles ahead of his arrival, so that he had time to consider stopping before he had already sped past.

One advertising man instituted the now famous Burma Shave jingles, which were spaced out to match the speed of the traffic. Tourist cabins were upgraded into more lavish courts, and then into motels. Diners began to improve and highway food chains made an appearance with some control over menu and sanitary conditions.

Unfortunately, the lure of money brings all kinds of money makers, some of them not so desirable: beer joints, hot dog stands, "wild animal" shows, fortune tellers, souvenir shops, and now automobile scrap heaps lining the edges of every town and city. Signs became bigger and some were lighted in flashing neon.

People trying to get out of the congestion of the city fled in droves to the suburbs. Somehow they envied the farmer who could come in and shop and return to the solitude of the country. They breathed the fresh air and cooked on open grills, and talked about the country life, encouraging more people to move into the suburbs, all bringing their outdoor grills, lawn mowers, automobiles, boats, trailers, and other paraphrenalia, until there was eventually as many people in the suburbs as there were in the city. Then the "suburbanites" demanded some of the advantages of the city. They needed churches, schools, fire departments, markets, drugstores, hardware stores and gasoline stations, until there was soon as much congestion and stress as they had left behind. Shopping malls sprang up everywhere, serving everything from french fries to wedding gowns, and electric rails swept the population into the city in the morning and back to the suburbs in the evening. They finally began to realize that they had not escaped the city at all; they had merely moved to the "residential area."

Oh, Henry!

There being more people and, therefore, more money in the cities, it is natural that the first effects of the automobile should be felt there. In 1899, the Akron police threw away their horse-drawn paddy wagons and replaced them with motorized versions. In the same year, an enterprising citizen in Boston opened "a stable for renting, sale, storage, and repair of motor vehicles" - the country's first garage. Curbs along the city streets began to furnish hand-cranked gasoline pumps, bringing an end to the dangerous practice of open containers in hardware stores, and the nation's first regular service station opened in Pittsburgh in 1913, an all night drive-in that began slowly but soon picked up a lot of business.

The first automobile showroom opened in New York City in 1900 and these were soon found in all city centers all over the country. The used car lot followed shortly after for those who would surrender the class and gloss of a new car for a much smaller price.

It had been the custom for companies to display their goods on the cash-on-the-barrelhead basis, unless it was a major purchase, such as a piano, which could be bought on an installment plan. In 1911, the Studebaker Company offered automobiles on a deferred payment plan. This was soon followed (in some cases, reluctantly) by other car companies. In less than ten years, 50% of all cars sold in America were bought on time payments. Other businesses, seeing the powerful draw this had on consumers, also started selling their merchandise on the installment plan (what the Britishers term "the never-never"), putting almost all of America "on the books."

Cities now had to face the problem of traffic and traffic jams, as more and more people became car owners. Traffic policemen were soon organized, and in 1914, Cleveland installed the first traffic light, and soon there became a need for traffic management. There is always someone standing in the wings, waiting to find a way to make a buck. As the load of traffic became heavier and parking space limited, parking garages were built to care for the overflow; then the unadorned parking lot was installed. In 1935, city officials discovered that there was money to be made in this, and came up with parking meters.

The Great Depression of 1929 gave the nation a thorough understanding of just how important the automobile had become. People began to realize that cars were not just a convenience that would take them from here to there a little faster: they were a fixation, part of the body and soul of everyday life. No matter how poor and needy those in the depression became, they would not give up their cars. If forced to choose between gasoline and beans, the average man may decide the gasoline was more important. Replacement parts were scavenged and repairs were improvised from whatever could be found. Will Rogers said that Americans would be the first people to go to the poor house in an automobile.

In 1924, an innkeeper in California put up a flashing sign that was to spread across the nation. He combined hotel and motor to coin the word, "motel." At the same time, in Florida, businesses began to bow to the motorists needs by establishing curb service dining with bell hops, so that the driver would not even need to leave his car. They coined the word, "drive-in." The government (always the last to act) installed curbside mailboxes, equipped with chutes angled out to receive letters. These were first put up in Houston in 1927. In Camden, New Jersey, on June 6, 1933, the first drive-in movie was shown in a field large enough to hold 500 cars on a 40 x 50 foot screen. At their peak, there were more than 4,000 drive-in movies across America.

Thanks to drive-ins, we now have the privilege of sitting in our cars to do everything. We can draw money from the bank account, have our prescriptions filled, pay utility bills, have clothes cleaned, have film developed, return library books, or buy a bottle of wine. Dallas has a drive-through pawn shop, where you can sell whatever is worth anything to drive straight to the gas station and fill up. There are some drive-through supermarkets. In some cities, church-goers can pick up their drive-through breakfasts and continue down the road to attend drive-in worship services. There are at least two cities that furnish drive-through funeral parlors. The automobile has become an inbred necessity to life in America, thanks to Henry Ford's assembly lines and his "universal automobile."

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.

Drive It Or Park It!

By the 1970s, it was clear that the thrill had disappeared for some of us. At last America's love affair with the automobile was cooling and it was now just a marriage of convenience. Some would still say that nothing has changed; that America still loves the automobile, in spite of social observers who might say that love of a machine is a sickness. It's just that the automobile can now be seen for what it was intended to be in the first place: something to get us from point A to point B in a faster, more comfortable way. We understand now that the car is just another mechanical appliance. We also understand the price we pay in having that appliance for convenience: we must cope with inflated prices from car companies, petroleum producers, and special interest lobbies; we must also cope with an environment which has been degraded, as well as with product unreliability that drains our pockets and consumes our time.

The numbers of cars are awesome in size. There are about 130,000,000 passenger cars on the streets and highways of the country. There are 40,000,000 other types of vehicles who vie with the automobiles for almost 4,000,000 miles of roadway. Consider Belgium, Denmark, France, Great Britain, Holland, Italy, Norway, Sweden, Switzerland, and West Germany - whose combined populations are about 40,000,000 more than that of the United States, and where automobiles are as available and affordable as they are in America; they also had cars before we did. In spite of this, there are 29,000,000 fewer cars in those countries combined than in the United States. America owns about 40% of all the motor vehicles in the world. Four of every ten American families own two or more vehicles.

Once every seven minutes, someone somewhere in New York, tired of fighting or nursing their cars, abandons it on the city's streets. Illegal parking plagues the world. Paris police say that 1/3 of all cars on that city's streets at any given time are parked illegally. Japan will not even register a car unless the owner can prove that he has bought or rented a parking space to put it in. Washington, New York, Philadelphia, and other American cities are so frustrated and overcome by parking tickets that they hire collection agencies to try to collect some of them. Chicago has $500,000,000 worth of unpaid tickets and writes another 4,000,000 every year. Then there are the staggering amounts paid for policemen, administration, judges, besides the enormous sum paid to keep the highways in good condition. The car may not use any oats while it is parked, but it creates huge problems for society.

Casper, Wyoming, with a population of 1,000, has 729 vehicles. Los Angeles has 3,040 cars per square mile. Larger cities have cramped living space into cubicles to build mass-transport highways and ramps that clog the air with pollution from the exhaust pipes. 2/3 of Los Angeles is taken up with streets, ramps, freeways, parking facilities and garages. This is not to mention that many of the houses include garage attachments. Automobile density is worsening each day. The U.S. Government has imposed a Clean Air act to eliminate some of the smog and lethal gases, but catalytic converters, while suppressing some emissions, are substituting others which cause cancer, according to Swiss research.

Besides the 44,175 people killed in automobile accidents in 1984, 1,600,000 other received injuries, 150,000 of them permanent. During nine years of war in Viet Nam, the total American dead was only about 2,000 greater than the number killed on the highway in 1983, and the wounded was less than 1/10 of those disabled in automobile accidents that year. More Americans have died in automobile accidents than have been killed in all the wars that America ever fought, making the love of the automobile a dark romance, to say the least. What does it cost to run the automobile? Well, in spite of "falling" gas prices and increased fuel efficiency, a study released by Hertz Corporation in 1985 says that the average cost is 45.67 cents per mile for a compact and 59.77 cents for a standard-sized car. If you drive 10,000 miles a year, and include depreciation, insurance, licensing, repairs, accessories, gas and oil, the total comes to over $4,500 per year for a compact and almost $6,000 for a standard. (And that was in 1985!) You can see then that driving a car is not just a "free-wheeling" lark, but has become a big bite out of the old pocketbook.

Some economists state that one worker in every five (others say seven or six) workers in the U.S. labor force is employed by some activity related to automobiles. The modern car is made up of some 14,000 parts. These parts are fashioned out of steel, glass, rubber, chrome, and aluminum, among countless other elements.

Important Automobirthdays

1903 Debut of the enclosed car and glass windshield.

1904 Steering wheels replaced tillers.

1908 The first rumble seat. It was part of a Packard two-seater called the "Honeymoon car."

1909 Introduction of the compressed air self-starter. It never worked well.

1912 The electric self-starter we use today was perfected by Samuel Kettering.

1914 Henry Ford started paying his employees a daily minimum wage of five dollars. He thought that his employees should be able to afford the cars they built.

1916 Something for women; cars would feature vanity cases, clocks, crystal flower vases, telephones to "instruct" the driver and smelling salts.

1917 Car heaters started to appear on several models.

1920 The pneumatic tire was introduced allowing the new possibility of flat tires.

1922 The Wills-St. Clair featured a back-up light.

1925 The first rental car: the Hertz "Drivurself."

1926 Shock-proof" glass on Stutz and Rickenbacher models.

1927 The year of the chrome trim.

1930 The first front-wheel drive cars offered to the public were the Gardner, the Cord and the Auburn.

1931 Sun visors for the interior of the car became available.

1933 The billboards first announcing mileage appeared in displays due to concern for fuel economy.

1937 Batteries were moved to a new position, under the hood, and the first automatic transmission (as we know it) appeared on an Oldsmobile.

1938 Buick made turn signals available.

Believe it or Not...

Since horses were quite frightened of cars, they were a great worry for the first drivers. Uriah Smith, the founder of the Horsey Horseless Carriage Company in Battle Creek, Michigan had a solution. His motor car came with a wooden, life-sized horse head on the front. No mention was made of the fact that this did nothing to quiet the noise of the engine.

The 1955 Dodge Custom Royal LaFemme was equipped with a matching rain cape, boot, umbrella and purse.

But Wait...There's More!

The Ford Model T (introduced in 1908) sold for about $290 without extras. Because it was so simple, it lent itself to becoming the most adaptable car in history. Some of the aftermarket extras included tool chests, rubber hood silencers, tire-patching kits flower vases and clamp-on dash lights.

A farmer could reasonably afford a set of tractor wheels to fit a model T. If he needed to use his car in the fields, he could mount the tractor wheels and hitch up his plow, or whatever.

The car made an excellent power plant. If you jacked up the rear wheel and removed the tire, you could attach a belt from the wheel to your buzz saw to cut wood.

Model T's were used to generate electricity, pump water, grind feed, shear sheep, shred corn, churn butter and grind sausage.

The Model T was the first snowmobile in the 20's. A special undercarriage was developed, the front wheels were moved to the rear, and each double set of wheels was fitted with steel caterpillar treads. After steel sled runners were attached to the front axle, the snowmobile was ready for the farmers and woodsmen in the deep northern snows.

The Ferocious FAAS Organization

In rural Pennsylvania at the turn of the century, a group of farmers formed the "Farmers' Anti-Automobile Society," (or FAAS as we would know it today) to set down some rules for car owners.

Automobiles traveling at night must send up a rocket (Roman candle) every mile, wait ten minutes (for the road to clear) and then proceed (with caution) while blowing the horn.

If a driver sees horses coming, he must pull over to the side of the road, stop and cover his car with a camouflage cover.

If a horse refuses to pass a car on the road, the driver must dismantle the car and hide the pieces in the bushes.

FAAS members, as well as members of the community were also encouraged to spend Sundays to chase automobiles, shout and shoot at drivers, as well as threaten them with arrest.

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The Brake System (An Overview)

The Brake System

The braking system is the most important system in your car. If your brakes fail, the result can be disastrous. Brakes are actually 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 thousands of pounds of pressure on each of the four brakes. In modern systems, the master cylinder is power-assisted by the engine. All newer cars have dual systems, with two wheels' brakes operated by each subsystem. That way, if one subsystem fails, the other can provide reasonably adequate braking power. Safety systems like this make modern brakes more complex, but also much safer than earlier braking systems.

The brake system is composed of the following basic components: The "master cylinder" which is located under the hood, and is directly connected to the brake pedal, converts your foot's mechanical pressure into hydraulic pressure. Steel "brake lines" and flexible "brake hoses" connect the master cylinder to the "slave cylinders" located at each wheel. Brake fluid, specially designed to work in extreme conditions, fills the system. "Shoes" and "pads" are pushed by the slave cylinders to contact the "drums" and "rotors" thus causing drag, which (hopefully) slows the car.

In recent years, brakes have changed greatly in design. Disc brakes, used for years for front wheel applications, are fast replacing drum brakes on the rear wheels of modern cars. This is generally due to their simpler design, lighter weight and better braking performance. The greatest advantage of disc brakes is that they provide significantly better resistance to "brake fade" compared to drum type braking systems. Brake fade is a temporary condition caused by high temperatures generated by repeated hard braking. It occurs when the pads or shoes "glaze" due to the great pressure and heat of hard use. Once they cool, the condition subsides. Disc brakes allow greater air ventilation (cooling) compared to drum brakes. Drum brakes are not internally ventilated because if they were, water could accumulate in them. Disc brakes can rapidly fling off any water that they are exposed to, and so they can be well ventilated.

"Boosters" are present in "power brake" systems, and use the engine's energy to add pressure to the master cylinder. "Anti-lock" (ABS) systems, originally developed for aircraft braking systems, use computer controlled valves to limit the pressure delivered to each slave cylinder. If a wheel locks up, steering input cannot affect the car's direction. With ABS, no matter how hard the pedal is pressed, each wheel is prevented from locking up. This prevents skidding (and allows the driver to steer while panic-braking).

As impressive as these advances are, the basic process of converting a vehicle's momentum into (wasted) heat energy has not changed since the days of the horse and buggy. To stop a horse drawn carriage, the driver would pull on a lever which would rub on the wheel. But today, with the advent of regenerating brakes on electric vehicles, new ways of recapturing this lost energy are being developed. In these types of electric cars, when you step on the brakes, the motor switches into "generator mode", and stores the car's momentum as chemical energy in the battery, to be used again when the light turns green!

Disc Brakes

Disc brakes use a clamping action to produce friction between the "rotor" and the "pads" mounted in the "caliper" attached to the suspension members. Inside the calipers, pistons press against the pads due to pressure generated in the master cylinder. The pads then rub against the rotor, slowing the vehicle. Disc brakes work using much the same basic principle as the brakes on a bicycle; as the caliper pinches the wheel with pads on both sides, it slows the bicycle. Disc brakes offer higher performance braking, simpler design, lighter weight, and better resistance to water interference than drum brakes.

Disc brakes, like many automotive innovations, were originally developed for auto racing, but are now standard equipment on virtually every car made. On most cars, the front brakes are of the disc type, and the rear brakes are of the "drum" type. Drum brakes use two semi-circular shoes to press outward against the inner surfaces of a steel drum. Older cars often had drum brakes on all four wheels, and many new cars now have 4-wheel disc brakes.

Because disc brakes can fling off water more easily than drum brakes, they work much better in wet conditions. This is not to say that water does not affect them, it definitely does. If you splash through a puddle and then try to apply the brakes, your brakes may not work at all for a few seconds! Disc brakes also 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 cars in the early seventies.

Brake Pedal

The brake pedal, in case you're one of those people who don't use it, is located on the left side of the accelerator pedal. In cars with manual transmissions, it is between the accelerator and clutch pedals. The brake pedal is connected to the master cylinder via a pushrod. The brake pedal is solidly mounted to the firewall, and works as a force-multiplying lever. Stepping on the brake pedal pushes a piston within the master cylinder, thereby pressurizing the hydraulic brake lines. The hydraulic pressure pushes the brake shoes and pads against the brake drums and rotors, thus slowing the wheels. If the car's engine quits while driving, the power assist (booster) fails. In this event, the brake pedal's mechanical leverage allows the driver to generate sufficient pressure to stop the car, although in a longer distance. It is a good idea to test the difference between power assisted and manual braking in a safe area.

The brake pedal gives feedback to the driver which can be beneficial to good maintenence, and therefore potentially save your life. If the pedal pulses when pressed, the usual culprit is a warped rotor, which is potentially destructive to the caliper. If the pedal squishes down when pressure is applied, a dangerous leak is likely present (even if fluid does not drip out anywhere). Your brake pedal should not move more than a small amount when you press it, no matter how hard it is pressed. It should not feel sponge-like: a spongy pedal spells trouble in the braking system. With the car parked and the engine running, press the brake pedal firmly and hold the pressure. If the pedal sinks slowly, a leak is present.

A good rule of thumb is this: ANY changes in the "feel" of your brake pedal should be a cause for serious concern. Remember, with brakes, there is NO excuse for poor maintenance.

Brake Drums

The brake drum is a heavy flat-topped cylinder, which is sandwiched between the wheel rim and the wheel hub. The inside surface of the drum is acted upon by the linings of the brake shoes. When the brakes are applied, the brake shoes are forced into contact with the inside surface of the brake drums to slow the rotation of the wheels.

The drums are usually covered with fins on their outer surfaces to increase cooling. They are not cooled internally, because water could enter through the air vent cooling holes and braking would then be greatly impaired.

Drum brakes are found on the rear wheels of most older cars, but they are increasingly being fazed out in favor of rear disc brakes. Drum brakes were standard equipment on all four wheels of most cars until the early 70's.

Brake Calipers

The caliper works like a C-clamp to pinch the pads onto the rotor. It straddles the rotor and contains the hydraulic "slave cylinder" or "wheel cylinder" piston(s). One caliper is mounted to the suspension members on each wheel. The caliper is usually mounted onto the spindle, allowing it to deliver the torsional force of the wheel to the chassis via the control arms. Brake hoses connect the caliper to the brake lines leading to the master cylinder. A "bleeder valve" is located on each caliper to allow air bubbles to be purged from the system.

"Floating caliper" disc brakes, the most common variety, allow the caliper to move from side to side slightly when the brakes are applied. This is because only one pad moves (in relation to the caliper). Some calipers contain two or four seperate pistons. These calipers are fixed in place; i.e., there is no lateral movement like the floating caliper, the pistons take up the slack on each side of the rotor. These are called "dual cylinder" or "dual piston" calipers, and are standard equipment on many performance cars.

Wheel (Slave) Cylinders

Wheel cylinders, also called the "slave" cylinders, are cylinders in which movable piston(s) convert hydraulic brake fluid pressure into mechanical force. Hydraulic pressure against the piston(s) within the wheel cylinder forces the brake shoes or pads against the machined surfaces of the drum or rotor. There is one cylinder (or more in some systems) for each wheel. Drum brake wheel cylinders are usually made up of a cylindrical casting, an internal compression spring, two pistons, two rubber cups or seals, and two rubber boots to prevent entry of dirt and water. This type of wheel cylinder is fitted with push rods that extend from the outer side of each piston through a rubber boot, where they bear against the brake shoes.

In disc brakes, the wheel cylinder is built into the caliper. All wheel cylinders have bleeder screws (or bleeder valves) to allow the system to be purged of air bubbles.

As the brake pedal is depressed, it moves pistons within the master cylinder, pressurizing the brake fluid in the brake lines and slave cylinders at each wheel. The fluid pressure causes the wheel cylinders' pistons to move, which forces the shoes or pads against the brake drums or rotors. Drum brakes use return springs to pull the pistons back away from the drum when the pressure is released. On disc brakes, the calipers' piston seals are designed to retract the piston slightly, thus allowing the pads to clear the rotor and thereby reduce rolling friction.

Parking (Emergency) Brakes

The parking brake (sometimes called the emergency brake) is a cable-activated system used to hold the brakes continuously in the applied position. The parking brake activates the brakes on the rear wheels. Instead of hydraulic pressure, a cable (mechanical) linkage is used to engage the brake shoes or discs. When the parking-brake pedal is pressed (or, in many cars, a hand lever is pulled), a steel cable draws the brake shoes or pads firmly against the drums or rotors. The release lever or button slackens the cables and disengages the brake shoes. The parking brake is self adjusting on most systems. An automatic adjuster compensates for lining (brake shoe) wear. On many cars, the parking brake is used to re-adjust the brake shoes as they wear in, or when the shoes are replaced. In these systems, the adjustment is made by repeatedly applying the parking brake while backing up.

The parking brake can be useful while driving up hills: If you're driving a manual transmission car, and you pull up to a stop on an incline, you might notice that you don't have enough feet to operate the clutch, brake, and gas at the same time. In other words, you will likely roll backwards slightly while getting started again. If a someone pulls up right behind you, this can be a problem. Your parking brake is useful in this situation: Apply the parking brake after you stop. When you want to go, release the clutch while pressing the gas, and release the parking brake. This keeps you from having to quickly switch your left foot from the brake to the clutch, or your right foot from the brake to the gas pedal. A little practice, and you'll be able to do it smoothly. Also, remember if you pull up behind someone who is stopped on a hill, give them extra room to roll back a little. Especially if it's a truck.

Some cars have no parking brake release! They automatically release the parking brake when the car is placed in drive or reverse.

Remember, it's a good idea to test the parking brake periodically and keep it in good condition. It may save your life if the main braking system fails!

Drum Brakes

Drum brakes are an older design, but are still in use, although many cars now use 4-wheel disc brakes. One advantage of drum brakes is that they can easily be set up to be mechanically activated by a pull cable (for use as parking brakes). Drum brakes are usually quite sufficient for rear brakes because most of the car's weight transfers to the front wheels during hard braking. The reduced weight on the rear wheels makes the higher performance of disc brakes somewhat unnecessary.

The working parts of a drum brake are contained inside the brake drum. The drum is attached to the hub of the wheel and revolves with it. Inside the drum are a pair of curved brake shoes that are held close to the drum by retractor springs. The shoes and actuator linkages are mounted to the backing plate behind the drum. When the brake pedal is pressed, fluid is pressurized in the wheel cylinders. Pistons in the wheel cylinders then push outwards against both shoes, overcoming the retractor spring tension and pressing the shoes against the drum. The friction of the shoes against the drum slows the wheel. When pressure is removed from the brake pedal, the retractor springs force the shoes back to their normal (released) position. As the linings of the shoes wear down and become thinner, the "self adjuster" keeps them close to the drum without touching until applied.

Brake Pads and Brake Shoes

Brake pads and brake shoes are composed of a friction lining material mounted onto metal backing plates. Brake linings are designed to have a specific coefficient of friction. The linings contact the drums and discs, create drag, and thereby retard the speed of the vehicle. The lining material is designed to wear down faster than the rotors and drums they rub against, so that they are the only part that usually has to be replaced. When worn out pads and shoes are replaced, the drums and rotors are re-machined (a small amount of metal is removed from their surfaces) so that the brake shoes and pads will "break in" properly.

Because of intense friction and heat produced in braking, brake linings were first composed of heat-resistant asbestos compound. When it was discovered that breathing dust containing asbestos fibers can cause serious bodily harm, asbestos pads were replaced with other types. There are now three basic types of materials used in brake linings: (1) non-asbestos organic, which is usually made from filler materials and high temperature resins; (2) metallic; and (3) semi-metallic, which are composed of finely powdered iron or copper, graphite, and small amounts of inorganic filler and friction modifiers. The first and third types of brake lining are used for conventional brake service. Under extreme braking conditions (sports cars, ambulances, police cars), the metallic type of linings are used, because they provide more constant frictional characteristics (reduced brake fade) than the other two. Organic pads and shoes wear down the rotors and drums less than semi-metallic or metallic pads, but also wear down quicker themselves, requiring more frequent replacement.

Most pads and shoes have "wear indicators" built into them, or into the hardware which holds them in place. The wear indicators cause a squealing noise when the linings wear down to a the level of the indicator. Mechanical wear indicators (small metal tabs) allow the driver to know when their brakes are needing replacement before serious damage occurs. When the pads or shoes wear out completely (past the wear indicators) and the backing plates contact the drums or discs for extended periods of time, the damage which results can require replacement of the rotor or drum, which is MUCH more expensive than the shoes and/or pads! Some advanced braking systems have electronic wear indicators built into the linings, which allow the driver to be warned by a light on the dash.

Master Cylinder

The master cylinder displaces hydraulic pressure to the rest of the brake system. It holds THE most important fluid in your car, the brake fluid. It actually controls two seperate subsystems which are jointly activated by the brake pedal. This is done so that in case a major leak occurs in one system, the other will still function. The two systems may be supplied by seperate fluid reservoirs, or they may be supplied by a common reservoir. Some brake subsystems are divided front/rear and some are diagonally separated. When you press the brake pedal, a push rod connected to the pedal moves the "primary piston" forward inside the master cylinder. The primary piston activates one of the two subsystems. 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 brake pedal retracts, the pistons allow fluid from the reservoir(s) to refill the chamber if needed.

Electronic sensors within the master cylinder are used to monitor the level of the fluid in the reservoirs, and to alert the driver if a pressure imbalance develops between the two systems. If the brake light comes on, the fluid level in the reservoir(s) should be checked. If the level is low, more fluid should be added, and the leak should be found and repaired as soon as possible. BE SURE TO USE THE RIGHT BRAKE FLUID FOR YOUR VEHICLE. Use of improper brake fluid can "contaminate the system". If this occurs, ALL of the seals in the brake system will need replacement, and that is usually a VERY expensive operation.

Brake Warning System

The brake warning system has been required standard equipment since 1970, and is connected to the master cylinder. It monitors differences in pressure in the brake lines of the two hydraulic sub-systems, and alerts the driver with a light if an imbalance occurs. When you turn the key to the Ignition position, the brake warning light on the dash comes on during a "self-test". You should not drive a car if the warning light does not come on during the startup self test.

The brake system is divided into two sub-systems to increase safety. A pressure differential switch, connected to the warning light, is positioned between the two. If a major leak occurs, and therefore pressure in one of the lines is sharply reduced, pressure from the other side forces a piston to move, activating the pressure differential switch and turns on the dashboard warning light.

There are two types of pressure differential switches; mechanical or hydraulic. Mechanical switches are activated by excessive brake travel. Hydraulic switches are activated by a difference in pressure between the front and rear system. When pressure in one of the lines is sharply reduced, pressure from the other side forces a piston to move. A plunger pin then drops into a groove in the piston, activating a switch that turns on a dashboard warning light.

The brake warning light is also connected to the brake fluid level sensors in the master cylinder reservoir(s). If the brake warning light comes on, the fluid level should be checked. If the level is low, more fluid should be added, and the leak should be found and repaired as soon as possible. BE SURE TO USE THE RIGHT FLUID.

NEVER IGNORE THE BRAKE WARNING LAMP, AND ALWAYS NOTE WETHER IT WORKS DURING THE STARTING SELF-TEST.

Power Brakes

Power brakes (also called "power assisted" brakes) are designed to use the power of the engine and/or battery to enhance braking power. The four most common types of power brakes are: vacuum suspended; air suspended; hydraulic booster, and electro-hydraulic booster. Most cars use vacuum suspended units (vacuum boosters), which employ a vacuum-powered booster device to provide added thrust to the foot pressure applied.

In a vacuum booster type system, pressure on the brake pedal pushes forward a pushrod connected to the pistons within the master cylinder. At the same time, the pushrod opens the vacuum-control valve so that it closes the vacuum port and seals off the forward half of the booster unit. The engine vacuum line then creates a low-pressure vacuum chamber. Atmospheric pressure in the control chamber then pushes against the diaphragm. The pressure on the diaphragm forces it forward, supplying pressure on the master cylinder pistons.

Hydraulic booster systems usually tap into the power steering pump's pressure, and use this power to augment pressure to the master cylinder. Electro-hydraulic booster systems use an electric motor to pressurize a hydraulic system which augments pressure to the master cylinder. This allows the vehicle to have power assisted brakes even if the engine quits.

You may wish to compare the difference between power and non-assisted braking in a safe area; while driving slowly, turn the ignition key off (don't turn it into the locked position, because the steering wheel will lock, which is highly unsafe.) As the car coasts along, press the brakes hard. The force of your foot is now the only thing stopping the car. The safe driver is always ready to apply the total force needed to stop their vehicle, even if the engine quits (thereby removing the power assist).

Anti-lock Brake Systems (ABS)

Originally developed for aircraft, ABS basically works by limiting the pressure to any wheel which decelerates too rapidly. This allows maximum stopping force to be applied without brake lockup (skidding). If standard brakes are applied too hard, the wheels "lock" or skid, which prevents them from giving directional control. If directional control (steering) is lost, the vehicle skids in a straight line wherever it is going. ABS allows the driver to steer during hard braking, which allows you to control the car much better. In the old days, drivers had to know how to "pump" the brakes or sense the lockup and release foot pressure in order to prevent skidding. This meant that if only one wheel lost traction and started to skid, the driver would have to reduce braking force to prevent a skid. The advantage of ABS is that the brakes on the wheels with good traction can be used to the fullest possible amount, even if other wheels lose traction.

In operation, the wheelspeed sensors at each wheel send electronic pulse signals to the control unit. If wheel lockup (rapid deceleration) is detected during brake application, the computer signals the valve unit to limit the hydraulic pressure to the wheel cylinder. This is usually accomplished by diverting the fluid into a small reservoir. The fluid is later pumped out of the reservoir and returned to the main fluid reservoir when the brakes are not being applied.

The anti-lock brake system tests itself every time the vehicle is started and every time the brakes are applied. The system evaluates its own signals. If a defect is detected, the system then turns off, leaving normal braking unaffected.

Caliper Piston Seals

The caliper piston seals are designed to keep the fluid pressure behind the pistons, and to retract the pistons enough to allow the brake pads to just barely clear the rotor, thus reducing rolling resistance. The seals should NEVER leak. If a leak is detected, it must be repaired immediately, because the fluid which escapes can defeat braking power by getting on the disc, and the pressure loss can affect brake safety.

Push Rods

A push rod is a connecting link in an operating mechanism which transfers mechanical force in only one direction. Two examples are; the push rod between the valve lifter and rocker arm on an overhead valve engine, and another is the push rods which apply pressure to the brake shoes from the slave cylinder pistons.

Rotors (Discs)

The rotor (also called the disc) is clamped by the brake pads in order to slow the vehicle. The rotor is a heavy circular steel plate attached to the wheel providing a two-sided braking surface. Pressurized fluid in the brake lines flows into one or more "slave" cylinders in each caliper. The fluid pressure is exerted against the slave pistons, which force the brake pads against the surface of the disc. As the pads clamp onto the rotor, intense heat is generated, which can in extreme conditions actually cause the rotor to glow red hot! The rotor often has a series of radial vents built into it which allow it to be cooled by ambient air. Ventilation ducts directed to the disc allow the intense heat that is generated by the brake to be transferred to the air quickly.

The surfaces of the rotor are "turned" (re-machined) whenever the brake pads are replaced in order to remove the "glazed" surface which forms on the rotors. The turning process also "trues" the disc (makes it perfectly flat) which eliminates the pulsations which are experienced when the rotor is warped. Warped rotors give a slight tugging when the brakes are applied, and send a pulsing sensation back through the brake pedal. Rotors have "minimum thickness" which means if the rotor has been turned several times, it may become too thin to resurface, and therefore require replacement.

Semi metallic brake pads give better performance, longer replacement intervals and reduced "fade", but they also wear down the rotor more quickly than organic (non-metallic) pads.

Parking Brake (Emergency Brake)

When the parking brake lever (or in some cars a pedal) is applied, it pulls a cable which connect to the manual actuators inside the rear brakes. This lever is the only thing between you and the hospital if your hydraulic brakes fail, so it is a good thing to practice using it, and to maintain it diligently. This lever or pedal is known as the emergency brake, for just that reason.

Brake Booster

The brake booster is a vacuum powered or hydraulic device that is attached to the master cylinder in what are referred to as "power brake" systems. Brake 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. The function of the brake booster is to add to the power delivered to the brake system by your foot. "Vacuum boosters" tap into the vacuum created by the engine, and use the difference between atmospheric pressure and the vacuum created by the engine to assist braking.

In hydraulic booster systems, the booster is supplied with hydraulic power, usually drawn from the power steering pump. Some brake boosters use electric motors to generate the hydraulic power, allowing them to remain effective even without the engine running.

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. These hoses are used to connect the calipers to the metal brake lines, allowing the caliper to move when the wheel turns or goes up and down. The entire hydraulic system is filled with brake fluid, which is pressurized by the movement of the master cylinder's pistons. This fluid is very important. Always use only the recommended fluid.

When you remove a wheel, these hoses are easily visible. If the hoses appear cracked or brittle, they should be replaced immediately. Close inspection of the brake hoses is a good way to prevent catastrophe!

Brake Fluid

Brake fluid is a special liquid for use in hydraulic brake systems, which must meet highly exact performance specifications. It is designed to be impervious to wide temperature changes and to not suffer any significant changes in important physical characteristics such as compressibility over the operating temperature range. The fluid is designed to not boil, even when exposed to the extreme temperatures of the brakes.

Different types of brake fluid are used in different systems, and should NEVER be mixed. Most cars use "DOT 3" or "DOT 4" brake fluid. Some newer cars use silicone brake fluids. These should NEVER be mixed together, because the seals in each car are designed to work with only their specific fluid types. For example, the mixing of "Silicone" brake fluid and conventional glycol based DOT 3 or DOT 4 fluids should be avoided, as the two fluid types are not miscible (they will not mix together). DOT 3 brake fluids and DOT 4 brake fluids can be mixed.

One of the WORST things that can happen to your car is if the brake fluid becomes contaminated, because the seals are designed to work with only pure brake fluid. "System contamination" means that all of the piston seals and hoses are deteriorating, and therefore must be replaced, a MAJOR expense. So, be VERY careful what you put in the master cylinder reservoir!

It should be noted that brake fluid is highly corrosive to paint, and care should be used not to get it on your car's finish.

The brake fluid in your car should be changed every ______ to prevent corrosion of the braking system components.

Brake Lines

Brake lines are small steel tubes with special internal coatings to prevent rust and corrosion. These tubes connect to the master cylinder, and then run under the car to each of the wheels. At the wheel, a "brake hose" connects the brake line to the caliper or wheel cylinder. As the brake pedal is pressed, the master cylinder forces the brake fluid throughout the brake lines and into the wheel (or brake) cylinders. This pressure causes the slave cylinder pistons to move, forcing the shoes and pads against the drums and rotors to slow the vehicle.

Return Springs

The return springs force the brake shoes slightly back (inward) away from the drum when the brake is released. These springs, along with the other brake hardware, should be replaced every other time the brake shoes are replaced.

Backing Plate

The backing plate is a round, stamped steel disc, used to keep water out of the drum/rotor, and in drum brakes as a mount for the wheel cylinder. It is bolted to the end of the rear axle housing for drum brakes and to the spindle in disc brakes. The backing plate is the foundation for the wheel cylinder and brake shoe assembly. Some backing plates have air scoops built in to allow better cooling of the brakes.

Anchor Pins and Shoe Retainers

The anchor pin is a strong metal pin mounted to the backing plate, which prevents the shoes from turning along with the wheel when the brakes are applied. Shoe retainers are small spring clips of various designs used to hold the brake shoes against the backing plate. These pins insure shoe alignment and prevent them from rattling.

Brake Adjusters

Brake adjusters are a type of device that adjusts the drum-to-lining clearance as the shoes' linings wear down. All modern cars have "automatic adjusters" which automatically adjust the clearance. The three main types of adjustment systems are; cable, link, and lever. Some systems can operate (adjust themselves) only when braking in reverse, usually when the parking brake is engaged. Others adjust when braking in the forward direction. Still others operate when braking in either direction. Older cars used adjusters, but they had to be manually adjusted at regular intervals.

Vacuum Valve (Vacuum Control Valve)

The vacuum control valve allows vacuum from the engine into one side of the booster diaphragm, and keeps normal atmospheric pressure on the other side. As the pressure from the pedal reaches a certain level, the valve closes, allowing the vacuum to build up in the front half of the booster. The pressure of the diaphragm pushes against the pushrod, and transfers to the master cylinder.

Vacuum from the Engine

Engine intake manifold vacuum is used for augmenting the foot's braking power in vacuum assisted power brakes. This vacuum is created by the pistons as they draw downward, sucking air into the cylinders. When you push the brake pedal down, the vacuum control valve lets the engine draw a vacuum in the front section of the booster unit. The atmospheric pressure on the other side of the diaphragm provides significant additional braking force.

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. If the cap's seal becomes distorted, it usually indicates a brake fluid contamination problem.

Master Cylinder Pistons

Two closely fitted pistons are located inside the master cylinder. The inner part of the piston is pressed against a rubber primary cup that prevents fluid from leaking past the piston. The outer end of the piston is pressed against a rubber secondary cup. This prevents the fluid from getting out of the master cylinder. The inner piston also has several little bleeder ports; these pass through the through the head to the base of the primary cup. Both of the piston assemblies are in the cylinder, and are kept there by a stop plate (or snap ring) in the end of the cylinder. A push rod, connected to the brake linkage, applies pressure to the pistons.

Booster Air Inlet Filter

As the vacuum booster engages, the air chamber in the front of the booster is allowed to fill with air from the passenger compartment through the booster air inlet filter. The normal air pressure around us pushes the diaphragm of the booster after passing through the filter. This filter keeps the inside of the booster from getting airborne debris inside of it.

Bleeder Valves

Since the brake system is filled with fluid, it must be occasionally "bled". (the old fluid is released in order to install new fluid). This is also done to remove any air bubbles that have gotten into the system (usually when any of the brake parts are changed). All hydraulic brakes have bleeder valves on or near the slave cylinders. These valves are opened while the brake pedal is pressed, causing the brake fluid to flow out as well as any air bubbles present. When the brake fluid comes out without any air bubbles, the mechanic seals the bleeder valve and tops off the brake fluid reservoir. Bleeder valves can also be found on the side of the master cylinder. These are used for the same purpose; getting air bubbles out of the master cylinder assembly. If you have air bubbles in your fluid, your pedal will feel softer than normal, and braking power will be reduced, so it is a good idea to have your brakes bled and the fluid changed according to your owner's manual.

Balance Valve

The balance valve allows the mechanic to adjust the maximum brake pressure to the rear wheels of the car. This is done because the rear wheels don't have as much weight on them during the braking action of the car, and may lock up during use. During braking, most of the weight of the car shifts to the front wheels. If this happens without a proportioning valve, or balance valve acting on the system, the rear brakes tend to lock up. The balance valve allows you to decrease pressure to the rear wheels in all situations where the brakes are used. This valve is not needed on ABS systems, because each wheel is prevented from locking individually.

Brake Cooling Ducts

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

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The Cooling System (Overview)

The Cooling System

The purpose of the engine's cooling system is to remove excess heat from the engine, to keep the engine operating at its most efficient temperature, and to get the engine up to the correct temperature as soon as possible after starting. Ideally, the cooling system keeps the engine running at its most efficient temperature no matter what the operating conditions are.

As fuel is burned in the engine, about one-third of the energy in the fuel is converted into power. Another third goes out the exhaust pipe unused, and the remaining third becomes heat energy.

A cooling system of some kind is necessary in any internal combustion engine. If no cooling system were provided, parts would melt from the heat of the burning fuel, and the pistons would expand so much they could not move in the cylinders (called "seize").

The cooling system of a water-cooled engine consists of: the engine's water jacket, a thermostat, a water pump, a radiator and radiator cap, a cooling fan (electric or belt-driven), hoses, the heater core, and usually an expansion (overflow) tank.

Fuel burning engines produce enormous amounts of heat; temperatures can reach up to 4,000 degrees F when the air-fuel mixture burns. However, normal operating temperature is about 2,000 degrees F. The cooling system removes about one-third of the heat produced in the combustion chamber.

The exhaust system takes away much of the heat, but parts of the engine, such as the cylinder walls, pistons, and cylinder head, absorb large amounts of the heat. If a part of the engine gets too hot, the oil film fails to protect it. This lack of lubrication can ruin the engine.

On the other hand, if an engine runs at too low a temperature, it is inefficient, the oil gets dirty (adding wear and subtracting horsepower), deposits form, and fuel mileage is poor-- not to mention exhaust emissions! For these reasons, the cooling system is designed to stay out of the action until the engine is warmed up.

There are two types of cooling systems; liquid cooling and air cooling. Most auto engines are cooled by the liquid type; air cooling is used more frequently for airplanes, motorcycles and lawnmowers.

Liquid cooled engines have passages for the liquid, or coolant, through the cylinder block and head. The coolant has to have indirect contact with such engine parts as the combustion chamber, the cylinder walls, and the valve seats and guides. Running through the passages in the engine heats the coolant (it absorbs the heat from the engine parts), and going through the radiator cools it. After getting "cool" again in the radiator, the coolant comes back through the engine. This business continues as long as the engine is running, with the coolant absorbing and removing the engine's heat, and the radiator cooling the coolant.

A cooling system pressure tester is used to check the pressure in the cooling system, which allows the mechanic to determine if the system has any slow leaks. The leak can then be found and fixed before it causes a major problem.

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.

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.

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.

Cooling Fans

The reason the coolant goes into the radiator is to allow air to pass through it and cool the coolant. When you are driving fast enough, the air rushes through the grille of the car and passes through the radiator core. If you aren't driving fast enough to push air through the radiator, then the fan will pull the air through.

The fan improves cooling when you are driving at slow speeds, or if the engine is idling. It is usually mounted on the water pump shaft, and is turned by the same belt that drives the water pump and the alternator, although it can be mounted as an independent unit. Most independently mounted fans are electric.

Belt Powered Fans

The fan's activity is not always necessary, and it takes power from the engine to spin. For this reason a thermostatic control, or fan clutch, is often used to reduce drive torque when it isn't needed (variable-speed fan). A different type of fan uses centrifugal force to move its flexible plastic blades, by flattening them when the engine rpm is high (flexible-blade fan). The less angle the blades have, the less power they use. The idea of these units is to save horsepower and reduce the noise the fan makes.

A fan can have from four to six blades to suck the air through the radiator. Often the radiator has a shroud for the fan to keep it from recirculating the same hot air that has collected behind the radiator. Many fans have irregularly spaced blades to reduce resonant noise.

Electric Fans

Front-wheel drive engines mounted transversely usually use electric fans to cool the engine. The radiator is located in the usual place, but an electric motor drives the fan. A thermostatic switch is used to turn the fan on and off at predetermined temperature settings, which it senses. The exception to this is air conditioning. If you turn on the air conditioner, you bypass the thermostatic switch, and the fan runs continuously. If you turn off the air conditioner, the thermostatic switch is re-activated, and goes back to turning the fan on and off, according to its instructions. Many cars have one electric fan for normal cooling and a separate one just for when the air conditioner is on.

There are some really nice features about the electric fan. The nicest feature is that you don't have to keep an eye on the treacherous old fan belt -- there isn't one, so you don't have to worry about its health and fitness. It's also quieter, and less of a power drain on the engine. They also help your engine by continuing to cool it after it's turned off.

V-Belt (Fan Belt)

The fan (drive) belt wedges neatly into the different pulley grooves. The belt uses the tension and friction to turn the auxiliary devices.

The fan belt is usually V-shaped, so it is also called a V-belt. The fan belt friction comes from the sides of the belt and the sides of the pulley grooves to transmit power from one pulley to the other through the belt. Since the sides of the belt are used for transmission of power, the sides have very large surface areas. The reason that the belt does not slip is because of the wedging action of the belt as it curves into the pulley grooves.

Because your belts are so essential to so many parts of your engine, it is a very good idea to periodically check their condition. Check for cracking, splitting, or fraying, especially before summer. Also, check the tightness of the belt and have it adjusted according to your owner's manual specifications. Belts have a tendency to loosen with use. On the other hand, you don't want the belt to be too tight, or it will put too much pressure on the accessory bearings and cause them to die an early death. If a belt is over three years old, have it replaced even if it looks good.

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!

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.

Water (Coolant) Jackets

When our bodies feel cold, we put on a jacket. Our car engines wear permanent jackets for the opposite reason-- to keep cool!

The water jacket is a collection of passages within the block and head. These passages let the coolant circulate around the "hot spots" (valve seats and guides, cylinder walls, combustion chamber, etc.) in order to cool them off.

The engine block is actually manufactured in one piece with the water jackets cast into the block and cylinder head. At normal operating temperature, the water pump forces the coolant through the head gasket openings and on into the water jackets in the cylinder head. It flows around in there, cooling everything off by absorbing the heat. After doing its thing, the coolant flows through the upper hose to the radiator where it releases the heat. Then, the water pump sends it back down into the engine's water jackets to continue the cooling process.

On the sides of the engine are "freeze" or "expansion" plugs, which are sheet metal plugs pressed into a series of holes in the block. These are designed to hold the pressure of the cooling system, but to pop out if the coolant in the block ever freezes.

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.

The Fan Clutch

The fan clutch is a small fluid coupling with a thermostatic device that controls a variable-speed fan. The fan clutch ensures that the fan will rotate at just the right speed to keep the engine from overheating, and reduces drive to the fan when it is no longer needed.

The fan clutch has a fluid coupling partly filled with silicone oil designed for just that purpose. If the temperature of the air passing through the radiator rises, the heat alerts a bimetal coil spring to "uncoil" or expand. When it expands, it allows just a little more oil to enter the fluid coupling, so the fluid coupling starts to rotate the fan. If the air coming through the radiator is cool, the opposite happens; the coil spring contracts, the oil leaves the fluid coupling and the fan slows. Slowing the fan when it is not needed reduces fuel consumption, makes less noise and saves engine power.

Sometimes a flat bimetal strip spring is used instead of a coil spring; it bows out and in when the temperature rises and drops, letting oil in and out of the fluid coupling.

Freeze Plugs (Expansion Plugs)

Freeze plugs (also called "blind" or "expansion core" plugs) are small steel plugs used to seal the holes in the engine block and head made in casting. They expand and flatten as they are driven into place, and make a tight seal. These are designed to hold the pressure of the cooling system, but to pop out if the coolant in the block ever freezes.

If you have a leak in your cooling system, freeze plugs are one of the areas to have checked.

Temperature Sending Units

Since it is critical for you to keep an eye on the temperature of the coolant in your cooling system at all times, your car will have either a gauge or a warning light located on the instrument panel or dashboard (see temperature gauge). The question is, how does the information about your coolant get to the gauge? It gets there, or is sent by the temperature sending unit.

The temperature sending unit is a device that is placed so that it can determine the temperature of the engine coolant. Simply put, its resistance to electricity changes with increases and decreases in the temperature of the coolant. The electric resistance changes control the movement of the indicator needle on the temperature gauge. If you have an indicator light, or lights, these changes will cause the bulb to be connected to the battery if the temperature of your coolant gets too high. If this happens, the light goes on.

There are two types of sending units. One type uses a Bourdon tube instrument, a capillary tube filled with a special gas, and a capsule, or bulb. The other type uses an electric sender receiver.

The Bourdon tube type works by having one end of the tube attached to the gauge fitting, and the free end fastened to the needle indicator. A Bourdon tube is a round, hollow metal tube. Putting pressure on the hollow end causes it to try to straighten, so that the other end moves the needle on the gauge. Because it is placed in an engine water jacket, the pressure from the coolant temperature causes it to move, which, in turn forces the other end to move the gauge needle. When the coolant cools, the lack of pressure allows the needle to swing back to cold on the gauge.

The electric sender receiver type has a bimetal thermostat in the dashboard. This thermostat is linked to the gauge needle, so that when the engine gets warmer and passes more current, the thermostat, getting hotter itself, bends. When the thermostat bends, it moves the gauge needle, which indicates that the coolant temperature is rising. As it cools off, the thermostat "unbends" again, and the needle drops back to the cold indicator.

The Temperature Gauge

Some cars have temperature gauges, and some have indicator lights. The purpose of these temperature viewing devices is one of extreme importance to you while operating your vehicle, because you need to monitor the temperature of your coolant at all times.

The temperature gauge, or indicator light, is installed on the dash or control panel of your car. If this light comes on, it indicates that something has gone terribly wrong in your engine.

A temperature gauge gives you more of a complete picture. It gradually moves from "Cold", when you start your engine, up toward the "Hot" indicator. Usually this type of gauge will have some type of marking (like RED) to show you when you are approaching the danger zone. When your engine is happy, it will usually move up to (and stay put) somewhere in the middle. If it advances into the "red" zone, STOP and let it cool down. Give the engine a rest for half an hour with the hood up. DON'T REMOVE THE RADIATOR CAP UNTIL THE ENGINE COOLS OFF. Don't pour water over the engine, this can crack the block. When the engine has cooled off, check the water level, start the engine, then fill it up with water or antifreeze. When you get to a service station, have the problem fixed as soon as possible.

Temperature increase can sometimes indicate problems not directly involved with the cooling system.

Some vehicles have indicator lights instead of gauges. These are more difficult to monitor, since nothing much happens until there is a problem. Indicator lights are located in the control panel or dashboard. Some cars have a "Cold" indicator light. This will go on when you start the car, and go out when normal operating temperature has been reached. The "Hot" light goes on when the car is overheating. This light is designed to light up at 5 to 10 degrees F below the coolant's boiling point. This light tells you to STOP before the engine is damaged, let it cool down, and have the problem discovered and fixed.

Indicator lights have one other feature, called "prove-out." This means that when you turn the key in the ignition switch, the lights should go on for just a moment to "prove" that they are functioning, and that the bulbs haven't burned out. It is very important for you glance at them each time you start your car to make sure that they are in working order. Suppose your "Hot" indicator light bulb has burned out. If your engine is overheating, it won't be able to tell you. As a result, you'll go driving on your merry way to engine damage city without a clue. Your first clue will be a "knocking" or "pinging" sound during acceleration, and at that point, it's usually too late to prevent serious damage.

Oil Coolers

Engine oil gets quite hot as it removes heat from the cylinder walls, pistons, and other engine parts, so we need to have a way to cool the oil off. Usually this happens when the airstream passes over the oil pan. Also, the cooling system is doing its job of keeping the engine temperature down so that the oil doesn't have too much to contend with. Routinely, the oil loses some heat as it goes through the oil filter and also as the whole engine gives off heat. For all of these reasons, it's unusual for the oil to become overheated.

However, there are some situations when special equipment needs to be added to keep the oil temperature down. Heavy duty engines, and normal duty engines that are carrying heavy loads are often equipped with oil coolers. Also, almost all air-cooled engines have oil coolers.

There are several types of oil coolers. One type fits between the oil filter and engine block. It's a compartment passageway made up of thin disks. The oil is forced through this passage, where engine coolant circulates around it, and cools it off.

A different type of oil cooler "borrows" a small section of the coolant radiator and gets cooled off the same way as the coolant does; forced air from the grille and the fan.

Transmission Fluid Cooler

As it is possible for the transmission fluid in automatic transmissions to overheat, causing reduction in performance and transmission damage, a transmission fluid cooler is a must. Manual transmissions (with the exception of racing car type vehicles) do not generally need transmission fluid coolers.

The transmission fluid cooler is either a "borrowed" section of the engine's coolant radiator, or a separately mounted little tube with fins. The fluid is forced to flow through one of these arrangements, and consequently, cooled.

Tube Type Transmission Fluid Cooler

The tube type of transmission fluid cooler is usually located in the radiator's end cap. Because of its location it is immersed in and cooled by the engine's coolant. Then, when the transmission fluid passes through it, the fluid is cooled. Two metal tubes, called the transmission cooler lines, are attached to the outlet tank of the radiator and carry the fluid between the transmission and the fluid cooler.

Auxiliary Transmission Fluid Cooler

Vehicles that are factory equipped with packages for towing often also come equipped with an auxiliary fluid cooler. This cooler is mounted in front of the radiator and connected with the trans- mission. The auxiliary cooler is like a small engine coolant radiator.

Both types of transmission fluid coolers ask the engine cooling system to do a bigger job; the tube type transfers the heat to the coolant. The auxiliary type, since it is mounted in front of the radiator, warms the air before it passes through the radiator.

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 airstream 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. 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.

Water Pump

Water pumps come in many designs, but most include a rotating impeller, which forces the coolant through the engine block. In most rear wheel drive cars, the fan is installed on the end of the water pump shaft. Many water pumps have a spring-loaded seal to avoid leakage of water around the pump shaft. Modern pumps are fitted with pre-packed ball bearings, which are sealed at each end to eliminate the need for lubrication.

Impeller type water pumps must turn rapidly to be efficient, and worn or loose drive belts can permit slippage which is not easily detected.

Coolant Bypass

The bypass hose allows coolant to recirculate within the engine, without passing through the radiator, as it does when the engine is warmed up and the thermostat opens. The bypass hose connects the thermostat housing and the water pump. The water enters the bypass tube through the bypass valve, when such a valve is fitted.

The bypass valve is sometimes operated thermostatically; it closes off the bypass hose when a certain temperature is reached. This increases the circulation of the coolant within the engine. Many cars don't need a bypass valve, because there is plenty of coolant going through the radiator hoses due to the thermostat.

Coolant (Antifreeze)

Coolant (antifreeze) is a complex chemical liquid that allows the engine to run at higher and lower temperatures than plain water would otherwise allow. It helps prevent freezing in cold climates, so that cars can operate in sub zero temperatures, and boils at a higher temperature than water. This gives the car more flexibility in accommodating temperature ranges. It also serves to lubricate the water pump as it flows through. Some antifreeze compounds are specially formulated for aluminum radiators. Coolant is supposed to be kept somewhere between 20 and 60 percent of the mixture in your car, depending on the car and climactic conditions. Too strong of an antifreeze mixture can cause leaks in your car's cooling system.

Coolant is extremely poisonous and should never be poured out on the ground. Animals are very attracted to it's sweet smell and drink it.

This will kill them. Keep antifreeze in a safe place, where young children will not have access to it; it is poisonous to them as well as animals.

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.

Hose Clamps

The clamps used to secure the ends of radiator hoses come in a variety of designs. Most use a simple one piece design, which has no adjustment when installed. The other major design uses a screw drive to allow a wide size range and greater adjustability. These types are better in some ways, but if they are overtightened, they can cut through the hoses.

- Visit The Service Department To Submit Your Problem Or Question

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Drive Train (An Overview)

Drive Train

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".

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.

Transmission Gears

Most cars have from three to five forward gears, and one reverse gear. The transmission changes the ratio of the engine speed and the wheels by connecting gears in various combinations. If a gear with 10 teeth is driving a gear with 20 teeth, the drive would be said to have a 2:1 ratio.

First gear connects the engine power to the drive wheels via a pair of reduction gear sets, which gives increased power and reduced wheelspeed when the car is beginning to move. This means the engine is turning much faster than the output shaft, typically around a 4:1 ratio. Intermediate speeds are delivered by changing the gear ratio closer to 1:1. Final drive is usually accomplished by directly linking the input and output shafts, giving a 1:1 gear ratio. Using a moveable set of different sized gears, it's possible to get several degrees of torque output. The differential pinion, driven by the drive shaft, turns the ring gear, which acts like a single speed transmission. This further reduces RPM's and increases torque by a set ratio.

Gears work exactly like levers. A small gear driving a larger one gives an increase in torque, and a decrease in speed, and vise-versa.

Transmission gears are heat-treated, high quality steel. They have smooth, hard teeth, cut on precision machinery while red hot. There are many types of gear teeth, but most transmissions use spur and helical gears. Most of the gears are the helical type, because they last longer and are more quiet than spur gears. There has to be enough room (a few thousandths of an inch) between the gear teeth for lubrication, expansion, and any irregularities in size.

Transmission Oil

The transmission needs lubrication to keep all of the gears and shafts running smoothly. This is accomplished by partially filling the transmission housing with thick transmission gear oil. When the gear gears spin, they fling the fluid around and lubricate all of the parts. Oil seals at the front and rear stop the fluid from leaking out of the housing.

Fluid levels should be checked when you change your oil, or if you notice difficulties or differences in shifting. This can indicate that the level of fluid might be low.

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

The clutch allows you to connect and disconnect the engine and the transmission, both starting up and during shifts. Friction plates route the rotation of the engine crankshaft to the gears, and then to the wheels. It takes the rotation up slowly, so that you aren't off to a screeching start. In a manual transmission, you disengage the clutch when you press the pedal down. The pedal works the thrust pad, and it presses levers in the middle of the clutch cover. Doing all this lifts the pressure plate away from the clutch plate. The flywheel (which is turned by the crankshaft from the transmission shaft) gets disconnected.

When you lift the clutch pedal, springs force the pressure plate and clutch plate against the flywheel. The clutch plate friction linings allow it to slide before becoming engaged. The sliding causes a smooth start instead of a jolt.

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.

The Flywheel

The flywheel is a fairly large wheel that is connected to the crankshaft. It provides the momentum to keep the crankshaft turning between piston firings.

The flywheel is the base for the entire clutch attachment. The side of the flywheel that the clutch is attached to is smooth, so that it provides a surface for friction. The clutch assembly is mounted to the flywheel, sandwiching the clutch plate in between. A bearing, called the "pilot bearing" is installed in a hole in the center of the flywheel. This lubricated bearing, either a ball bearing or a bronze bushing, is used to support one end of the clutch shaft, which is also the transmission input shaft. Around the flywheel is the ring gear, which the starter motor turns when the key is turned.

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.

Hydraulic Clutch

Another method used to activate the clutch throw-out fork is the hydraulic clutch. This method is often used when the mechanical design of the car makes it difficult to use levers and cables. It is also used to multiply force, reducing driver fatigue.

With a hydraulic clutch, when you press the clutch pedal, it moves a small cylinder called the "master" cylinder. Pressure is created in the master cylinder which is, in turn, transmitted to the "slave" cylinder. The slave cylinder is attached to the throw-out fork by a small adjustable rod, so when pressure is exerted on the slave cylinder, it operates the fork. Both master and slave cylinders are designed in such an uncomplicated way that they are easy to attach with hydraulic tubing.

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.

Differential Fluids

For lubrication fluid, a very heavy oil, must be used in rear axle housings. Special hypoid oils are used in the differential case. Even another type of fluid, or oil must be used in a positraction type differential.

The oil is circulated by the ring gear, and flung all over all the parts. Special troughs, or gullies are used to bring the oil back to certain spots, like the ring and pinion area and the piston bearings. The fluid is kept in with gaskets and oil seals. The bottom of the housing has a drain plug, and another filler plug is located part way up the housing. The housing must never be filled above this plug.

The housing fluid lubricates some of the outer bearings, but others have lubrication fittings for the injection of wheel bearing grease. A hand gun, not a pressure grease gun must be used to grease these bearings (sparingly). A pressure grease gun could inject grease into the brakes-- greasy brakes are inefficient at best! Finally, some bearings are filled with grease at the factory and are sealed. These never require attention unless they are defective.

Positraction Differentials

A positraction differential is a special traction differential. Its purpose is to improve the way your differential performs under adverse conditions. When one wheel starts to slip, these differentials transfer the torque to the wheel that is not slipping. The car can then continue to go forward. There are several different kinds of positraction differentials, but all of them are based on a friction device to provide resistance to normal differential operation.

A positraction differential provides better traction, which is handy when roads are slippery. It also lends itself to fast acceleration.

One type uses four differential pinions instead of two, with two pinion shafts. It also uses a series of four clutch discs. The differential pinions run into resistance when they try to turn the axle side gears. The resistance gets transferred to the pinion shafts driving the pinions. The shafts are forced to slide up little ramps. This action moves both shafts outward. The pinions cause the clutches to lock.

Other types use cone clutches, or disc clutches under pressure from coil springs. By restricting the differential action, torque is delivered to the slipping wheel.

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 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.

Constant Velocity Joints (CV Joints)

Front wheel drive cars need u-joints which not only allow up and down motion, but steering motion as well. the angle at which they turn requires a different design than the standard U-joint.

Constant velocity, or CV joints are universal joints that are able to transfer torque at large angles efficiently. These joints transfer power very smoothly. They are comprised of four basic parts: 1. The outer section, which has grooves machined on its inner surface, 2. the bearings, which are usually in a "cage", 3. the inner ball, which has grooves on its outer surface for the bearings to ride in, and 4. a rubber boot to protect the unit from dirt and moisture.

A common cause of CV joint failure is cracks in the CV boot. As dirt enters the CV joint, its parts grind themselves until a clicking noise is heard when turning, or until they fail completely. The boots should be replaced as soon as cracking is visible in their rubber folds.

Front Wheel Drive

Many cars use a front drive axle. Most front-wheel drive axles are constructed the same way as rear-wheel drive axles, with one exception. A front-wheel axle assembly must provide a way to turn the wheels as well as drive them.

The clutch or torque converter sends the power on to the transmission input shaft. Next, the power is sent on to the differential by gears or chains (belts). It goes through the differential gears through the axle and CV Joints and finally to the front wheels.

Front wheel drive was not new in the eighties when it became popular. Front wheel drive was introduced by the Pennington Car Company in 1900. Before that, steamers and electric cars had used it for years.

2WD, 4WD and AWD

2-Wheel Drive

The engine, clutch and gearbox are usually mounted on the frame at the front of the vehicle. The rotating motion produced by the crankshaft at the front of the vehicle is transmitted either to the two wheels at the rear (rear wheel drive), or the two wheels at the front (front wheel drive). Some cars are manufactured with rear mounted engines that drive the rear wheels, and front mounted engines that drive the front wheels.

4 Wheel Drive

4-wheel drive vehicles use live front and rear drive axles. When the front drive axle receives power from the transfer case, along with the rear drive axle, the vehicle can function well on off-road terrain (sand, rocks, mud, snow, etc.). A 4-wheel drive vehicle has one drive axle that is automatically in use. The operator of the vehicle has to activate and deactivate the second live drive axle.

All Wheel Drive (AWD)

All-wheel drive vehicles use live front and rear drive axles. When the front drive axle receives power from the transfer case, along with the rear drive axle, the vehicle can function well on off-road terrain (sand, rocks, mud, snow, etc.). A 4-wheel drive vehicle has one drive axle that is automatically in use. The operator of the vehicle has to activate and deactivate the second live drive axle. An all-wheel drive vehicle has both axles live at all times without manually activating or deactivating axles.

Automatic Transmissions

An automatic transmission is much easier to drive than a manual transmission, because you don't have to use a clutch pedal or gearshift lever. An automatic transmission does the work all by itself. The first automatic transmission appeared in 1939.

Automatic transmissions automatically change to higher and lower gears with changes in the car's speed and the load on the engine. These transmissions are also aware of how far down you have pushed the gas pedal, and shift accordingly.

The system is operated by transmission fluid pressure; shift valves control the gear changes. A "governor" controls the shifting of the gears. It's linked to the output shaft and throttle valve and controls the transmission fluid supply, at different pressures, to the shift valve. Here's how it works: the output shaft turns the governor. The faster the car goes, the faster the governor turns. Oil is sent from the pump to the shift valves by centrifugal force from the governor. The shift valves move out, and send the transmission fluid to the gear shifting mechanisms in the transmission. When you slow down, the valves move in, and send the transmission fluid in the opposite direction. This action changes the gears.

By routing the pressure to the clutches and brake bands, the different gears are selected.

Torque Converter

The torque converter is a type of fluid coupling between the engine and the gearbox to even out speed changes. The torque converter also multiplies engine torque.

The torque converter is used as a clutch to send the power (torque) from the engine to the transmission input shaft. It has three parts; an impeller connected to the engine's crankshaft, a turbine to turn the turbine shaft which is connected to the gears, and a stator between the two. The torque converter is filled with transmission fluid that is moved by the impeller blades. The stator's vanes catch the oil thrown off from the impeller, and use it to move the turbine's blades. When the impeller spins above a certain speed, the turbine spins, driven by the impeller.

In some designs, the torque converter locks the impeller and the turbine together when at highway speeds, which increases efficiency.

Brake Bands

A brake band is made of steel, and has a friction lining. One end of the band is attached a servo actuating rod.

A servo actuating rod is a hydraulic piston (a cylinder with a piston inside it) that is open at one end to allow oil to flow in. The piston is normally in the released position because it's kept that way by a spring. However, when pressurized oil is sent to the cylinder, the oil forces the piston forward. This causes the brake band to tighten, and this locks the brake.

Transmission Fluid

Transmission fluid is a special kind of oil used only for transmissions. It circulates through and lubricates the gears. Check your car's owner's manual for the type to use. No other type of oil should ever be used in your transmission.

Automatic Gear shifting

Almost all automatic transmissions use a pair of gear groups called epicyclic, or planetary gears. Each group consists of; an outside "ring" gear, a shared "sun" gear in the center, and a set of "planet gears", which mesh in between the sun and the ring gear. Planet gears are so named because each one turns on its own axis as they orbit the sun gear, like planets do. Each group of planet gears is held in a "planet gear carrier". By clamping the ring gears, the sun gear, and the carriers together in various combinations, and by locking some of them in stationary positions, it is possible to achieve three forward gear ratios, and reverse as well.

Single epicyclic gear sets work like this:

To increase torque: When the ring gear is stopped, and the power is applied to the sun gear, the planet gears are forced to go around the sun gear. This makes the pinion gears revolve more slowly around the inside gears, and drive from the carrier will have lower speed and increased torque.

To reverse the torque's direction: If the planet gear carrier is stopped, and torque is applied to the sun gear, the planet gears are forced to turn by the sun gear. This makes the ring gear revolve, but more slowly than the ring gear, which increases the torque, and in the opposite direction as the sun gear, giving reverse.

If two members of the gear set are locked together, planetary action is stopped and the gear set turns as one unit. When this happens, there are no increases or decreases in torque transmission.

In order to have more than 2 forward speeds, two sets of epicyclic gears are needed. By changing the number of teeth (size) of one set of planetary gears, 4 forward speeds can be produced.

The clutches within the transmission are used to connect the input torque, and the brake bands are used to lock the sun gear or the rear planet carrier. One way bearings serve to allow power flow in certain directions only, working as clutches. All of the clutches and brake bands are powered by hydraulic pressure, and regulated by the logic circuit which is connected to the governor and/or directly to a computer-controlled valve assembly. The transmission senses gas pedal position and drive selector position, and engages the proper clutches and bands for you to "Get out of Dodge".

The details of automatic transmission functions are vast, and different designs are introduced by the many automakers with great regularity. Some common principles shared by virtually all automatics are: fluid clutches, brake bands, one way bearings (one way clutches), and epicyclic gears. This crazy diagram is a simplified version of but one design among many, and if you think it's hard to understand, don't feel bad. It is!

In this type of transmission, to give first gear, the forward drive clutch (C) locks the turbine shaft to the front ring gear. At the same time, the second planet carrier brake band (D) locks the rear planet carrier in place. The power from the turbine shaft flows through the front ring gear, which turns the front carrier, which turns the sun gear. This reduces the RPM's and increases torque one time. The second reduction/multiplication happens when the sun gear turns the rear planet gears, each of which rotate within their stationary carrier. This causes the second ring gear to turn. The second ring gear transfers its torque to the output shaft through the second one-way clutch. (Does your brain hurt yet?)

Second gear is accomplished by engaging the sun gear brake band (B) and the forward-drive clutch (C). This gives one reduction in RPM.

Third gear (Drive) is engaged by locking the reverse-high clutch (A) and the forward-drive clutch (C). This gives a 1:1 (direct) ratio between the input and output shafts.

When reverse is selected, the reverse-high clutch (A) and the second carrier brake band (D) are locked. This reverses the torque direction, and reduces the ratio (twice) for use in backing up the car.

Gears and Gear Ratios

Gears are wheels with teeth that mesh together. This can happen either directly (the wheels touch each other) or indirectly (a chain might be used to make one gear turn the other). Sometimes a screw (worm gear) or a shaft with teeth (a rack) acts in place of one of the wheels. In your car, a gear is a combination of gear wheels that are designed to produce certain speeds.

The gear ratio is dependent on the size of the two gear wheels working together. The larger wheel will always rotate more slowly than the smaller wheel (the smaller wheel has to turn faster to keep up with the larger wheel). This means that the greater the size difference between the two gear wheels, the greater the variance in speed and force between the two wheels. For example, if the smaller gear turns three times for every one turn of the larger wheel, the gear ratio would be 3 to 1 (3:1).

This fundamental principle is at work in the transmission in our autos. The mechanical elements and complexity of manual transmissions and the even more complex automatic transmissions are just a more sophisticated version of a bicycle's derailleur gears. The purpose of all three types of transmissions is to use the relatively stable power output from our engines, or bodies, to the varying power needed to begin and sustain motion.

If you have ever tried to pedal a multi-speed bike uphill in the "wrong" gear, you have felt this principle at work. Our legs tire quickly because too much is demanded from them. We can either stop and walk, or stop and fall over. A better answer is to shift to an easier (lower) gear. "Downshifting" the gear allows the power from our bodies to be leveraged, or multiplied; the pedals will turn faster with less effort. What becomes confusing at this point is that shifting downward INCREASES the gear ratio. It's easier to go uphill at a 10 to 1 (10:1) ratio than it is with a five to one (5:1) ratio. With a 2 to 1 (2:1) gear ratio, the engine turns twice to turn the wheels once. Gear ratios are determined by the number of teeth on them. A gear with 20 teeth meshing with a gear with 60 teeth would yield a 3:1 ratio.

By moving the shift lever, we have increased the number of pedal revolutions needed to turn the rear wheel, but decreased the amount of effort required to turn the wheel.

Both the amount of power and the RPM's (revolutions per minute) needed to turn our bicycle or car wheels are controlled by gears or sprockets of varying sizes.

Throw-Out Bearing

The release lever operating mechanism of the clutch is known as the throw-out bearing. This is a ball bearing, mounted on a sleeve or collar, and it slides back ad forth on a hub. The hub is part of the transmission front bearing retainer.

The factory fills the throw-out bearing with grease, so it doesn't usually need service. Some cars use a graphite type, which is a ring of graphite that presses against a plate attached to the clutch levers.

The sleeve with the throw-out bearing moves in and out by means of a throw-out fork; it rotates on a ball pivot stud.

When you disengage the clutch, the clutch pedal is all of the way down. The throw-out fork forces the throw-out bearing into contact with the pressure plate release levers, which pull the pressure plate from the clutch disc to release it. Once released, the flywheel and pressure plate continue to turn.

Synchronizers (Synchros)

"Synchros" are synchronizers inside the transmission. These are the actual parts that move when you move your gear shift from side to side and back and forth. Their job is to connect the gears of the transmission to the shafts that they ride on and lock them together. This must be done at a gradual rate or the gears will grind. The synchronizer drives a cone shaped metal piece against the gear and starts the gear spinning. It accelerates it to the speed of the output shaft. When the gear reaches the speed of the output shaft, the synchro meshes completely with both of them and directs drive through its splines from the gear to the output shaft or vice versa. Some cars allow you to shift without pressing the clutch. If you shift gears slowly, the synchro will do the entire job and you never have to press the clutch. This comes in handy if you've sprained your left ankle.

Transmission Housing

The transmission housing is metal casting which is shaped to accommodate the gears within the transmission. On one end it has a flange that is bolted on to the back end of the clutch. On the other end, it has a seal where the output shaft protrudes going to the drive shaft.

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.

One-way Clutch Bearings

One-way clutch bearings allow shafts to be driven in only one direction; it allows one shaft to "freewheel" if it is spinning in the opposite direction from the direction at which the clutch is designed to engage. The one-way clutch bearing is designed very much like the roller bearing, but the rollers are allowed to move up small ramps. When the shaft turns in direction that locks the clutch, the rollers roll up small ramps and wedge into cavities. When this happens, the clutch locks and the shaft will drive the gear, or the gear will drive the shaft. These bearings are used extensively in automatic and manual transmissions-- allowing gears to be engaged depending on their direction of rotation.

Governor

The governor is a device that senses the speed of the output shaft and sends signals to the hydraulic control valve assembly telling the transmission that it's time to shift.

Park Locking Ring

When you put your car in "Park", the shift mechanism makes the park locking ring engage with a large metal pin. This prevents the output shaft from turning. This way, your car cannot roll away without permission.

Roller Bearings

Roller bearings are constructed almost the same way as ball bearings, but they have cylindrical shaped bearings instead of spherical shaped bearings. This gives them a greater load bearing area. They are used in wheel bearing applications. They consist of: 1. an inner "race" which is a hardened ring that is slightly tapered on the outside and 2. an outer race, a hardened ring that is slightly tapered on the inside and 3. a set of rollers contained in a cage. These bearings must not be crushed together, (the angle of assembly drives them together) creating friction if they are tightened too far. Roller bearings need to be repacked periodically with fresh grease to insure a long life.

Idler Gears

Idler gears are small gears which are not directly linked to anything. They are used to reduce or increase rotation speeds, and reverse directions of rotation. If three gears are connected in a string, the center gear would be considered an idler gear.

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.

Thrust Bearings

Thrust bearings are similar to ball bearings except that the plates that the balls ride between are designed as flat washers. The balls riding between these washers reduce side-to-side load. These are used inside of the transmission, rear end and many other areas of the car.

Ring Gear

The ring gear is a large gear connected to the differential case. The differential case is turned by a ring gear attached to a pinion gear and shaft. The propeller shaft connects the transmission output shaft to the differential pinion shaft. It is connected to the ring gear pinion shaft.

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.

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.

4 Speed Transmission (Rear Wheel Drive)

In this animation, the red gears and shafts represent the path of the power being transferred within a four speed manual transmission. As the shifter goes through the shift pattern, the shifter forks move the synchronizers, which couple the shafts to the gears. Reverse is accomplished by moving the reverse gear into mesh with its idler gears.

Front Wheel Drive

This animation shows how the power is transferred from the pistons to the wheels in a front wheel drive powertrain. The pistons turn the crankshaft that (via the clutch) drives the transmission, which adjusts the torque and speed of the rotation of the differential, which drives the two driveshafts that deliver the power to each of the wheels of the car.

The Differential (Rear Wheel Drive)

This animation demonstrates how the power from the drive shaft turns the ring gear, which is fastened to the spider gear carrier. As the spider gears turn, they force the drive axle gears to turn as well. But if one wheel wants to go faster (such as when turning), the spider gears turn on their own axles, allowing each drive axle gear to turn at its own rate.

Autom

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The Electrical System (An Overview)

The Electrical System

When the automotive industry was in its infancy, it used electricity only to ignite the fuel inside the engine. By the late 1920's, the electric starter replaced the hand crank, electric headlights made acetylene lamps obsolete and the braying of the electric horn drowned out the squeak of the hand-squeezed air horn. Today, an automobile requires an elaborate electrical system of circuits just to produce, store, and distribute all the electricity it requires simply for everyday operation.

The first major component in the electrical system is the battery. The battery is used to store power for starting, and for running auxiliary devices such as clocks, radios and alarms when the engine is off. The next major component is the starter motor, which is used to start the engine. The third component is a charging device powered by the engine, known as the alternator. It powers the electrical system when the car is running, and restores the charge within the battery. With these basic components, the car maintains its supply of electricity. A device called the voltage regulator keeps the power level stabilized, and the fuse box keeps minor problems from becoming major ones.

Many different auxiliary electrical devices are used in modern cars, such as: radios, cellular phones, rear window defrosters and electric door locks, as well as a vast array of motors powering everything from the moonroof on down.

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.

Starter

The starter converts electricity to mechanical energy in two stages. Turning on the ignition switch releases a small amount of power from the battery to the solenoid above the starter. This creates a magnetic field that pulls the solenoid plunger forward, forcing the attached shift yoke to move the starter drive so that its pinion gear meshes with the engine's crankshaft flywheel. When the plunger completes its travels, it strikes a contact that permits a greater amount of current to flow from the battery to the starter motor. The motor then spins the drive and turns the meshed gears to provide power to the crankshaft, which prepares each cylinder for ignition. After the engine starts, the ignition key is released to break the starting circuit. The solenoid's magnetic field collapses and the return spring pulls the plunger back, automatically shutting off the starter motor and disengaging the starter drive.

When the starter is not in use, the drive unit is retracted so that its pinion is disengaged from the flywheel. As soon as the starter is activated, the forward movement of the solenoid plunger causes the shift yoke to move the drive in the opposite direction and engage the pinion and flywheel. The pinion is locked to its shaft by a clutch that unlocks if the engine starts up and the flywheel begins turning the pinion faster than its normal speed. By allowing the pinion to spin freely for a moment, the clutch protects the motor from damage until the drive is retracted.

Alternator or Generator

The alternating-current generator, or alternator, is the electrical system's chief source of power while the engine is running. Its shaft is driven by the same belt that spins the fan. It converts mechanical energy into alternating-current electricity, which is then channeled through diodes that alter it to direct current for the electrical system and for recharging the battery.

Spark Plug

A spark plug is a device, inserted into the combustion chamber of an engine, containing a side electrode and insulated center electrode spaced to provide a gap for firing an electrical spark to ignite air-fuel mixtures.

The high-voltage burst from the coil via the distributor is received at the spark plug's terminal and conducted down a center electrode protected by a porcelain insulator. At the bottom of the plug, which projects into the cylinder, the voltage must be powerful enough to jump a gap between the center and side electrodes through a thick atmosphere of fuel mixture. When the spark bridges the gap, it ignites the fuel in the cylinder.

Spark Plug Wear

The spark plugs ignite the fuel mixture in the cylinders by means of a burst of high-voltage electricity carried from the distributor. The ability of the spark to ignite the fuel is badly affected if the plugs are damaged or the spark gaps are abnormal. It is therefore important to examine used spark plugs closely and to clean them periodically. The gaps of old and new plugs should also be checked before installing them. There are three basic types of spark plug fouling: "carbon" fouling, "high speed" or "lead" fouling, and "oil/carbon" fouling.

Carbon fouling is caused from low-speed operation or a fuel mixture that is too rich. It causes missing or roughness and creates soft black soot that is easily removed. Lead fouling is caused by tetraethyl lead used in some fuels and by extended high speed operation. Lead compounds which are added to the gasoline have a bad effect on some spark plug insulators. At high temperatures, it is a good conductor and may give good results under light loads, but often fails under full loads and high combustion temperatures. In some cases, it is possible to run the engine at a speed just below the point where missing will occur; then, increase the speed (always keeping below the missing speed) to burn off the lead fouling. Lead fouling appears as a heavy, crusty formation, or as tiny globules.

The third type of fouling is found on engines that are so badly worn that excess oil reaches the combustion chamber past the piston ring, or the valve guides.

In all cases of fouling or wear, it is best to replace the plugs. To avoid having to replace plugs one at a time as they wear out, always replace the entire set, even though only one plug may be bad. Plugs should normally be replaced about every 12,000 miles.

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.

Distributor

The distributor is separated into three sections: the upper, middle, and lower. In the middle section, the corners of the spinning breaker cam strike the breaker arm and separate the points some 160 miles an hour. (standard ignition) High-voltage surges generated by the action of the coil travel to the rotor that whirls inside a circle of high-tension terminals in the distributor cap. At each terminal, current is transferred to wires that lead to the spark plugs. Two other devices - the vacuum advance and the centrifugal advance - precisely coordinate the functions of the points and the rotor assembly as the requirements of the engine vary.

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.

Main Lighting Switch

The main lighting switch (sometimes called the headlight switch) is the heart of the lighting system. It controls the headlights, parking lights, side marker lights, taillights, license plate light, instrument panel lights, and interior lights. Individual switches are provided for special purpose lights such as directional signals, hazard warning flashers, back up lights, and courtesy lights. The main lighting switch may be of either the "push-pull" or "push-pull with rotary contact" types. A typical switch will have three positions: off, parking, and headlamps. Some switches also contain a rheostat to control the brightness of the instrument panel lights. The rheostat is operated by rotating the control knob, separating it from the push-pull action of the main lighting switch.

When the main lighting switch completes the circuit to the headlamps, the low beam lights the way for city driving and for use when meeting oncoming traffic on the highway. When the dimmer switch is actuated, the single filament headlamps go "on," along with the high beam of the two filament headlamps. The next actuation of the dimmer switch returns the headlighting system to low beams only on the two filament lamps. Some cars are equipped with an electronic headlight dimming device, which automatically switches the headlights from high beam to low in response to light from an approaching vehicle or light from the taillight of a vehicle being overtaken. The dimmer switch in the automatic headlamp dimming system is a special override type. It is located in the steering column as part of a combination dimmer, horn, and turn signal switch. The override action occurs when a slight pull toward the driver on the switch lever provides high beam headlights regardless of the amount of light on the sensor-amplifier.

For some years there has been discussion about the advantages of a polarized headlight system. Such a system comprises headlights which produce polarized light in a particular plane. The windscreens of all cars would be fitted with polarizing glass, which would be oriented so that glare from an approaching vehicle would be essentially eliminated, while the forward vision would still be kept at the present levels. The advantages the system appear attractive, but the practical problems of making the transition are very great, since it would not be practical to convert all existing vehicles to this type of lighting. Also, any benefits would only be marginal because glare itself is not a frequent cause of accidents. However, many cars now have refracting or colored glass to cut down on glare.

Due to recent legislation, newer cars in Texas with the dimmer switch mounted on the steering column will have to be refurbished with standard floor-mounted dimmers. Too many Aggies are being found in the ditch with their legs caught in the steering wheel.

Directional Signal Switch

The directional signal switch is installed just below the hub of the steering wheel. A manually controlled lever projecting from the switch permits the driver to signal the direction in which he wants to turn. Moving the switch handle down will light the "turn signal" lamps on the left front and left rear of the car, signaling a left turn. Moving the switch upward will light the turn signal lamps on the right (front and rear), signaling a right turn. With the switch in a position to signal a turn, lights are alternately turned "on" and "off" by a turn signal flasher. Incorporated in the directional signal switch is a "lane change switch mechanism." This feature provides the driver the opportunity to signal a lane change by holding the turn lever against a detent, then releasing it to cancel the signal immediately after the maneuver is completed.

Stoplight Switch

In order to signal a stop, a brake pedal operated "stoplight switch" is provided to operate the vehicle's stop lamps. In addition to lighting the conventional rear lights, the switch also operates the center high-mounted stop lamp, that became mandatory on later models. Cruise control equipped vehicles may also utilize a vacuum release valve. In this case, both the vacuum release valve and the stoplight switch are actuated by movement of the brake pedal.

Horn

The car horn on passenger cars provides the driver with a means of sounding an audible warning signal. The horn electrical circuit generally includes: battery, fuse or fusible link, horn relay, horn(s), steering column wiring harness, horn switch, and body sheet metal. Often, a cadmium plated screw is used to ground the horn to the body of the vehicle. Horns usually are located in the forward part of the engine compartment or in the front fender well. The horn switch is built into the steering wheel or incorporated into the multi-functional switch lever, which includes turn signal and dimmer switch.

Electricity At Rest

The ancient Greeks had a word for it. Records show that as early as 600 BC the attractive properties of amber were known. Thales of Miletus (640-546 BC), one of the "seven wise men" of ancient Greece, is credited with having observed the attraction of amber for small fibrous materials and bits of straw. Amber was used by these people, even as it is now, for ornamental purposes. Just as the precious metals had their names of gold and silver, so amber had its name: "electron." It was later shown that the same effect can be obtained by rubbing a rod of glass or hard rubber with a handkerchief. Many other nonmetallic materials are found to have this property, which is known as "static electricity."

All electrified materials behave either as glass or rubber. Glass has a "positive" charge and hard rubber has a "negative" charge. If you electrify two strips of hard rubber by rubbing them with fur, they will repel each other. Two glass rods will behave the same way. But, if you electrify a rod of rubber and suspend it near an electrified rod of glass, they will attract each other. One of the most important laws of electricity is "Bodies with similar charges repel each other; bodies with opposite charges attract each other." A positive charge is designated with a (+); a negative charge by the sign (-).

Although people have controlled electricity for many years, no one can explain exactly what it is. Many different theories have been given as to the nature of electricity through the years, but the modern one is the "Electron theory." In short, the electron theory proposes that all matter consists of tiny particles called molecules. These molecules are made up of two or more smaller particles called atoms. The atoms are then divided into smaller particles called protons, neutrons, and electrons. These particles are all the same in matter, whether in gas, liquid, or solid. The different properties or characteristics of the matter take form according to the arrangement and numbers of these particles which make up the atom. The proton has a natural positive charge of electricity; the electron has a negative charge; and the neutron has no charge at all, but just adds weight to the matter.

Protons and neutrons form the central core of the atoms about which the electrons rotate. The electrons carry small negative charges of electricity, which neutralize the positive charges of the protons. The simplest atom of all is the hydrogen atom. It consists of one positive proton and one negative electron. Other atoms, such as those forming copper, iron, or silicon, are much more complicated. Copper, for example, has 29 electrons circling about its nucleus in four different orbits. While protons are much smaller than electrons in size, they contain the bulk of the mass of every atom. One proton, for example, weighs nearly two thousand times as much as an electron. The electrons therefore are light particles or objects around a small but relatively heavy nucleus.

It is difficult to conceive the size of the atom. Research by physicists has established that the mass on one electron is about .000,000,000,000,000,000,000,000,000,911 of a gram. If you assume that one proton in a hydrogen atom is the size of a baseball in Kansas City, then the electron would have an orbit which would reach from the Atlantic coast to the Pacific. Along with the extremely small size of electrons and protons, they are separated by relatively vast distances.

Conductors and Insulators

Not all substances are good conductors of electricity. As a general rule, metals are good conductors whereas nonmetals are poor conductors. The poorest of conductors are commonly called "insulators," or "nonconductors." Aluminum, copper, gold, iron, mercury, nickel, platinum, and silver are examples of good conductors. Amber, glass, mica, paper, porcelain, rubber, silk, and sulfur are all nonconductors. The difference between a conductor and an insulator is that in a conductor, there are free electrons, whereas in an insulator, all of the electrons are tightly bound to their respective atoms. In an uncharged body, there are an equal number of positive and negative charges. In metals, a few of the electrons are free to move from atom to atom, so that when a negatively charged rod is brought to the end of the conductor, it repels nearby free electrons in the conductor, causing them to move. They in turn repel free electrons in front of them, giving rise to a flow of electrons all along the conductor. There are a large number of substances that are neither good conductors of electricity nor good insulators. These substances are called "semi-conductors." In them, electrons are capable of being moved only with some difficulty, i.e., with considerable force.

Electricity In Motion (Electrical Current)

When an electric charge is at rest it is spoken of as "static electricity," but when it is in motion, it is referred to as an "electric current." In most cases, an electric current is described as a flow of electric charge along a conductor. To make an electron current flow continuously along a wire, a continuous supply of electrons must be available at one end and a continuous supply of positive charges at the other. This is like the flow of water through a pipe: to obtain a continuous flow, a continuous supply of water must be provided at one end and an opening for its escape into some receptacle at the other. The continuous supply of positive charge at the one end of a wire offers a means of escape for the electrons. If this is not provided, electrons will accumulate at the end of the wire and the repulsion back along the wire will stop the current flow.

The rate at which the free electrons drift from atom to atom determines the amount of electrical current. In order to create a drift of electrons through a circuit, it is necessary to have an electrical pressure, or "voltage." Electric current, then, is the flow of electrons. The more electrons in motion, the stronger the current. In terms of automotive applications, the greater the concentration of electrons at a battery or generator terminal, the higher the pressure between the electrons. The greater this pressure (voltage) is, the greater the flow of electrons.

In modern electric car designs, the drive motors are often used as the brakes also, allowing them to switch over into performing as generators, which charge the batteries with the energy generated.

Electromagnetic Principles

The connection between electricity and magnetism was made by Oersted, a Danish scientist, in 1820. He had frequently demonstrated the nonexistence of a connection between electricity and magnetism. His usual procedure was to place a current-carrying wire at right angles to, and directly over, a compass needle to show that there was no effect of one on the other. One occasion, at the end of his lecture, he placed the wire parallel to the compass needle and saw the needle move to one side. When he reversed the current in the wire, the needle, to his amazement, deviated in the opposite direction. Thus a great discovery concerning electromagnetism was made quite by accident.

There is no actual knowledge as to why some materials have magnetic properties and others have not. The "electron theory" generally is accepted as the best explanation of magnetism. It is also known as the "domain theory."

According to the theory, an electron moving in a fixed circular orbit around the proton creates a magnetic field with the north pole on one side of the orbit and a south pole on the other side. It is assumed that the orbiting electron carries a negative charge of electricity, which is the same as electrical current flowing through a conductor. Current flow, then, is from negative to positive. When a number of magnetized orbiting electrons exist in a material, they interact with each other and form "domains," or groups of atoms having the same magnetic polarity. However, these domains are scattered in random patterns throughout and the material is, in effect, demagnetized. Under the influence of a strong external magnetic field, domains become aligned and the total material is magnetized. The strength of its magnetic field depends on the number of domains that are aligned. In magnetic substances, the domains align themselves in parallel planes and in the same direction when placed in a magnetic field. This arrangement of the electron-created magnets produces a strong magnetic effect.

If you stroke a piece of hardened steel with a magnet, the piece of steel itself will become a magnet. (Steel railroad tracks laid in a north-to-south direction become magnetized because they lie parallel to the magnetic lines of the earth.) Much stronger magnets and magnetic fields can be produced by electrical means. Placing a piece of steel in any strong magnetic field will cause it to become magnetized.

A magnetized field surrounds any conductor carrying an electrical current. The discovery of that fact resulted in the development of much of our electrical equipment. The "field of force" is always at right angles to the conductor. Since the magnetic force is the only force known to attract a compass needle, it is obvious that a flow of electric current produces a magnetic field similar to that produced by a permanent magnet. Not only is the field of force at right angles to the conductor, but the field also forms concentric circles about the conductor. When the current in the conductor increases, the field of force is increased. Doubling the current will double the strength of the field of force.

The Left-Hand Rule (Magnetic Effect)

Oersted's experiment has been interpreted to mean that "around every wire carrying an electric current there is a magnetic field." The direction of this field at every point, like that around a bar magnet, can be mapped by means of a small compass or by iron filings. If a wire is mounted vertically through a hole in a plate of glass or other suitable nonconductor, and then iron filings are sprinkled on the plate, there will be a lining-up of the filings parallel to the magnetic field. The result shows that the magnetic lines of force or "lines of induction" are concentric circles whose planes are at right angles to the current.

The "left-hand rule" used in electromagnetism can always be relied upon to give the direction of the magnetic field due to an electron current in a wire. Derived from experiment, the rule states: "if the current-carrying wire were to be grasped in the left hand, the thumb pointing in the direction of the electron current, negative (-) to positive (+), the fingers will point in the direction of the magnetic induction."

Magnetic Properties of A Solenoid

Shortly after Oersted discovered the magnetic effect of a current-carrying wire, Ampere found that a loop or coil of wire (a single loop or a coil of several turns of wire) acted as a magnet. A coil of wire of this kind is sometimes referred as a "solenoid," or as a "helix." The magnetic lines of force in a solenoid are such that one side or end of the coil acts like a "N" magnetic pole and the other side or end like a "S" magnetic pole. At all points in the region around a coil of wire carrying a current, the direction of the magnetic field, as shown by a compass, can be predicted by the left-hand rule. Inside each loop or turn of wire, the lines point in one direction, whereas outside they point oppositely. Outside the coil, the lines go the same way they do about a permanent bar magnet, whereas inside the coil they go from "S" to "N". Not only does one coil of wire act like a magnet, but two coils will demonstrate the repulsion and attraction of like and unlike poles.

Electronics (Solid State)

Electronics refers to any electrical component, assembly, circuit, or system that uses solid state devices. "Solid state" means that these devices have no moving parts, other than electrons. Examples of solid state devices include semiconductor diodes, transistors, and silicon controlled rectifiers. These and many more have broad application in automotive electronics.

Semiconductors and Diodes

Semiconductors are made from material somewhere between the ranges of conductors and nonconductors. Semiconductors, basically, are designed to do one of three things: (1) stop the flow of electrons, (2) start the flow of electrons, or (3) control the amount of electron flow. A semiconductor diode is a two-element solid state electronic device. It contains what is termed a "P" type material connected to a piece of "N" material. The union of the "P" and "N" materials forms a PN junction with two connections. The "anode" is connected to the P material; the "cathode" is connected to the N material. A diode is, in effect, a one-way valve. It will conduct current in one direction and remain non conductive in the reverse direction. When current flows through the diode, it is said to be "forward biased." When current flow is blocked by the diode, it is "reverse biased." When a diode is reverse biased, there is an extremely small current flow; actually, the current flow is said to be "negligible." When the P and N are fused together to form a diode, it can be placed in a circuit. The P material is connected to the positive side of the battery and the N material is connected to the negative side of the battery. Connected in this manner, current will flow. If connected in the reverse manner, current will not flow.

Transistors and Resistors

A transistor is a solid state device used to switch and/or amplify the flow of electrons in a circuit. A typical automotive switching application would be a transistorized ignition system in which the transistor switches the primary system off and on. An amplifying application could be in a stereo system where a radio signal needed strengthening.

A transistor is a three-element device made of two semiconductor materials. The three elements are called "emitter," "base," and "collector." The outer two elements (collector and emitter) are made of the same material; the other element (base) is different. Each has a conductor attached. The materials used are labeled for their properties: "P" for positive, meaning a lack of electrons. It has "holes" ready to receive electrons. "N" is for negative, which means the materials has a surplus of electrons. The movement of a free electron from atom to atom leaves a hole in the atom it left. This hole is quickly filled by another free electron. As this movement is transmitted throughout the conductor, an electric current is created from the negative to the positive. At the same time, the "hole" has been moved backward in the conductor as one free electron after another takes its place in a sort of chain reaction. "Hole flow" is from positive to negative. Current flow in a transistor, then, may be either electron movement or hole flow, depending on the type of material, and this determines the type of transistor it is as well.

In most 12 volt systems, a resistor is connected in series with the primary circuit of the ignition coil.

During the cranking period, the resistor is cut out of the circuit so that full voltage is applied to the coil. This insures a strong spark during cranking, and quicker starting is provided. The starting circuit is designed so that as long as the starter motor is in use, full battery voltage is applied to the coil. When the starter is not cranking, the resistance wire is cut into the circuit to reduce the voltage applied to the coil. If the engine starts when the ignition switch is turned on, but stops when the switch is released to the run position, it can indicate that a resistor is bad and should be replaced.

At no time should the resistor be bypassed out of the circuit, as that would supply constant battery voltage and burn out the coil. The resistor and resistor wires should always be checked when the breaker points are burned, or when the ignition coil is bad.

Ignition Circuit

An ignition circuit consists of two sub-circuits: the primary, which carries low voltage; and the secondary, which carries high voltage. The primary circuit, controlled by the ignition key, releases 12 volts of electricity from the battery or alternator through the coil to a set of breaker points in the lower part of the distributor, or to the relay in electronic ignition applications. When the points or relay are closed, current flows through the chassis back to the battery, completing the circuit. When the points or relay are open, the flow stops, causing a high-voltage surge to pass from the coil through a rotor in the top of the distributor to the spark plugs. Once the car has started, the voltage regulator protects the battery from being overcharged by the alternator. The condenser absorbs part of the low-voltage current when the points are open.

Computerized and Electronic Ignition

In an electronic ignition, a rotating reluctor and magnetic-pickup coil replace the traditional cam, breaker points and condenser in the distributors of cars equipped for electronic ignition. This system reduces the time between tune-ups. The high spots of the reluctor interrupt the magnetic field of the pickup coil and the permanent magnet. These interruptions, or pulses, are transmitted from the pickup to a nearby electronic control unit. There, the pulses signal a transistor to break the low-voltage sub-circuit and release high voltage from the coil to the spark plugs.

The short-lived electronic ignition system was a transition from the points and condenser system to the computerized ignition system. It came into widespread use in the mid-1970s, but there are still a few engines that use electronic ignition.

Starting Circuit

The starter circuit is activated when the ignition switch is turned on. This opens a second switch in the solenoid, permitting a second flow of electricity from the battery to the starter motor.

The engine cranking circuit is made up of a battery, starting motor, ignition switch, and electrical wiring. When the ignition switch is placed in the "start" position, the solenoid windings are energized and the resulting shift lever movement causes the drive pinion gear to engage the flywheel ring gear, and cranking takes place. When the engine starts, an overrunning clutch (part of the drive assembly) protects the armature from too much speed until the switch is opened. At this time, a return spring causes the pinion gear to disengage from the flywheel.

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.

Distributor Cap

As the rotor rotates inside the cap, it receives the high voltage from the ignition coil, then passes it to the nearest connection, which is a metal projection in the cap, which is connected to a spark plug.

The distributor cap should be checked to see that the sparks have not been arcing from point to point within the cap. The inside of the cap must be clean. The firing points should not be eroded, and the inside of the towers must be clean and free from corrosion.

Distributor Rotor

A distributor rotor is designed to rotate and distribute the high tension current to the towers of the distributor cap. The firing end of the rotor, from which the high tension spark jumps to each of the cap terminals, should not be worn. Any wear will result in resistance to the high tension spark. The rotor with a worn firing end will have to be replaced.

Rotors are mounted on the upper end of the distributor shaft. In this connection, the rotor must have a snug fit on the end of the shaft. On another design, two screws are used to attach the rotor to a plate on the top of the distributor shaft. Built-in locators on the rotor, and holes in the plate, insure correct reassembly. One locator is round; the other is square.

The rotor is driven directly by the camshaft, but is "advanced" (turned) by the centrifugal advance mechanism. Advancing the spark timing allows the engine to run efficiently. A vacuum advance is also fitted on some cars for the same reason.

Condenser

Primary current produces a magnetic field around the coil windings. This does not occur instantly, because it takes time for the current and the magnetic field to reach maximum value. The time element is determined by the resistance of the coil winding or the length of time the distributor contacts are closed. The current does not reach the maximum because the contacts remain closed for such a short time, and more so at higher engine speeds. When the breaker points begin to open, the primary current will continue to flow. This condition in a winding is increased by means of the iron core. Without an ignition condenser, the induced voltage causing this flow of current would create an arc across the contact points and the magnetic energy would be consumed in this arc. As a result, the contact points would be burned and ignition would not occur. The "condenser" prevents the arc by making a place for the current to flow. As a result of condenser action, the magnetic field produced and continued by the current flow will quickly collapse. It is the rapid cutting out of magnetic field that induces high voltage in the secondary windings. So, if the condenser should go bad, the high voltage needed to jump the gap at the spark plugs will not be possible. This could cause a no-start condition or a driving problem.

Breaker Point (Standard) Ignition

The ignition distributor makes and breaks the primary ignition circuit. It also distributes high tension current to the proper spark plug at the correct time. The distributor is driven at one half crankshaft speed on four cycle engines. It is driven by the camshaft.

Distributor construction varies with the manufacturers, but the standard model is made of a housing into which the distributor shaft and centrifugal weight assembly are fitted with bearings. In most cases, these bearings are bronze bushings.

In standard ignition, the contact set is attached to the movable breaker plate. A vacuum advance unit attached to the distributor housing is mounted under the breaker plate. The rotor covers the centrifugal advance mechanism, which consists of a cam actuated by two centrifugal weights. As the breaker cam rotates, each lobe passes under the rubbing block, causing the breaker points to open. Since the points are in series with the primary winding of the ignition coil, current will pass through that circuit when the points close. When the points open, the magnetic field in the coil collapses and a high tension voltage is induced in the secondary windings of the coil by the movement of the magnetic field through the secondary windings.

The design is to provide one lobe on the breaker cam for each cylinder of the engine; i.e., a six cylinder engine will have a six lobe cam in the distributor; and an eight cylinder engine will have an eight lobe cam, so every revolution of the breaker came will produce one spark for each cylinder of the engine. However, on a four cycle engine, each cylinder fires every other revolution so the distributor shaft must revolve at one half crankshaft speed. After the high tension surge is produced in the ignition coil by the opening of the breaker points, the current passes from the coil to the center terminal of the distributor cap. From there, it passes down to the rotor mounted on the distributor shaft and revolves with it. The current passes along the rotor, and jumps the tiny gap to the cap electrode under which the rotor is positioned at that instant. This cap electrode is connected by high tension wiring to the spark plug. As the rotor continues to rotate, it distributes current to each of the cap terminals in turn.

Battery Vents and Vent Plugs

Vent plugs of various designs are used. Generally, the vent plugs are baffled so gas can escape, but electrolyte splashed into the vent will drain into the cell. The plugs may be screw type or push-in type. The push-in type may be a single plug or a gang vent plug (three-plug manifold). Most maintenance-free batteries do not vent plugs. Instead, the gas is vented through baffled passages and small vent holes in the cover. Most conventional batteries have flame arrestor vent plugs. In maintenance-free batteries, the flame arrestors are located at the exits of the baffled passages.

Only distilled water should be added to the battery.

Battery Charging Methods

Battery charging methods vary, based on several considerations: (1) electrical capacity of the battery being serviced; (2) temperature of electrolyte; (3) battery state of charge at start of charging period; and (4) the age and condition of the battery.

When preparing to charge a battery, be aware of all the precautions that should be observed during the charging operation. Be familiar with the manufacturer's battery charger guide, and follow all the step-by-step instructions in the sequence given by the manufacturer. Ideally, use an automatic battery charger that senses battery voltage and automatically shuts off - or almost shuts off - when the battery reaches or approaches the fully charged state. These chargers include temperature sensing and generally sense polarity to help avoid sparks if the charger clamps are connected in reverse.

Battery charging methods include "high rate fast charging", "constant potential charging", "constant current slow charging", and "trickle charging."

"High rate fast charging" provides a high charging rate for a short time. Usually, the intent of a fast charge is to give the battery the "boost" it needs until the vehicle charging system can bring it to a full state of charge.

The fast charging rate should be limited to 60 amperes for 12 volt batteries. Usually, the rate is set at 40 to 60 amperes for 30 minutes. To completely recharge a battery, the high rate fast charger should be adjusted to "slow charge," preferably at the rate of one ampere per positive plate per cell. For a battery with nine plates per cell, 4 (+) and 5 (-), the charging rate would be four amperes.

"Constant Potential Charging," as the name implies, maintains the same voltage on the battery throughout the period of the charge. As a result, the current is automatically reduced as the battery approaches full charge. This features cuts the amount of overcharge the battery can receive, so batteries in good condition will not be damaged by this method of charging. If the battery is badly sulfated, the temperature may rise soon after it is placed on charge. These batteries should be placed on "slow charge."

"Constant current charging" uses a low charging rate for a relatively long time. Charging rates of three to five amperes or one percent of cold cranking rating are typical, as is one ampere per positive plate per cell. Constant current slow charging periods as long as 24 hours may be needed to bring the battery to full charge.

"Trickle charging" is designed to charge batteries at a rate of approximately one ampere. Trickle charges are used primarily for maintaining displays and stocks of batteries in fully charged condition. Common practice is to leave the batteries on a trickle charge during the day and take them off charge during the night. In that way, the danger of severe overcharging is lessened.

Jump Starting An Engine

Jump starting an engine is a very common procedure, which for most cars is safe, but some cars cannot handle the power surges involved. If in doubt, check your owner's manual. Jumper cables are used to transfer power from a good (booster) battery to a discharged battery. The key to safe and effective jump starting is the correct hookup of the jumper cables. The operation is common enough - and relatively safe, provided proper precautions are taken.

First, turn off your ignition to avoid draining any power that may be left in the battery. Park a vehicle that has a fully charged battery of the same voltage near the disabled car so that the two cars do not touch. The jumper cables to be used should not have to reach across either engine, where they might drop accidentally into the fans. Using old gloves or a rag, remove the cell caps from both batteries. Cover the holes with clean rags to contain any splashing acid. Another reason for doing this is that a chemical reactions inside a battery may produce hydrogen gas. Removing the caps allows the gas to escape. CAUTION: In extremely cold weather, look into the cells to be sure the battery fluid is not frozen. If it is, pockets of hydrogen gas may have formed and the gas could explode when the jumper cable is attached. Thaw out the battery before using the jumper.

Attach the ends of one jumper cable to the positive posts of both batteries. Next, attach one end of the second cable to the post of the charged battery. Ground the other end by clipping it to a clean, unpainted part of the disabled car's engine, car frame, or other clean metallic part. Be sure all four cable clips are so positioned that they cannot accidentally contact each other or drop onto moving parts once the engine turns over and begins to run.

CAUTION: Be sure to attach the second cable as directed, not to the ground post of the discharged battery. This is because a few sparks occur when this final connection is broken after the car starts. If the connection is made on the battery itself, the sparks could ignite any hydrogen gas that has accumulated.

Allow the discharged battery to charge up for a few minutes. It can be determined if current is flowing by removing the ground cable temporarily, sparks indicate current. SPARKS CAN IGNITE BATTERY FUMES. DO NOT MAKE SPARKS NEAR THE BATTERY.

With the assisting vehicle's engine running, and all the accessories in both cars turned off, start the disabled car's engine.

Remove the negative (ground) cable from the problem car's engine and then from the post on the booster battery. Disconnect the first cable from the positive posts of the two batteries. Remove the rags from the vent caps on both batteries and dispose of them. Replace the vent caps.

Voltage Regulator

The alternator produces the electricity needed to charge the battery and to operate electrical equipment. Its output, however, continues to rise as its speed increases, so the charging system must be provided with a voltage regulator.

Voltage regulators are in their third phase of development. First, there were electromagnetic voltage regulators, which were used in both dc and alternator charging systems. Then came electronic voltage regulators, which are still used in most late model applications. They are solid state devices, which did away with wire-wound coils, contact points, and bimetallic hinges. They appear to be more reliable, durable, and less affected by temperature change. Now, in some cars, the voltage regulator function has become part of the engine computer control system.

Regardless of the kind, the voltage regulator controls voltage and current output of the alternator by automatically cutting resistance in or out of the field circuit to keep it in a safe value. Varying the resistance alters the amount of current passing through the field. When the battery becomes fully charged, the resistance is cut into the field circuit and the charging rate is decreased.

Electromagnetic regulators, which are used on many dc generator charging systems, consist of three elements: cutout relay, current regulator, and voltage regulator. Others may use a cutout relay and a step-voltage control unit or a cutout relay with a vibrating voltage regulator or a combination of the cutout relay with a current-voltage unit.

In electromagnetic regulators, the voltage regulator unit limits voltage output by controlling the amount of current applied to the rotating field. The field relay on these regulators connects the alternator field windings and voltage regulator windings directly to the battery. The conventional cutout relay unit has been eliminated by the diodes in the alternator. The current regulator has also been eliminated by the current-limiting characteristic of the alternator design.

Basically, in a transistorized or an electronic regulator, the transistor is switched on and off to control the alternator field current. The frequency of switching depends on the alternator speed and accessory load, with the possibility that the on-off cycle may be repeated as often as 7000 times per second. The transistorized units have a voltage limiter adjustment. The electronic units are factory calibrated and sealed. They are also nonadjustable. When the ignition switch is turned off, the solid state relay circuit turns off the output stage, and turns off all current flow through the regulator. With that, there is no current drain on the battery. The field current overprotection stage protects the regulator against damage that could be caused by a "short" in the field circuit.

Voltage regulator units have been replaced by functions with two engine computer modules on some late model Chrysler Corporation applications. The regulator functions are shared by circuits in the power and logic modules in the engine spark control computer. It is claimed that this prevents the possibility of "blowing" computer circuits if a charging system terminal is accidentally grounded. In operation, the field is turned on by a driver in the power module. The logic module also checks battery temperature as a means of determining and controlling alternator output voltage to control the amount of current allowed to pass through the alternator field windings.

The Move to Computers

Ever since the car was first invented, a breaker point ignition has been used to transform battery voltage into 20,000 volts to fire the spark plugs. With government intervention and regulation, a system more advanced than breaker points was needed. This system had to meet emission control levels, gas mileage, and provide a smooth and continuous operation. The answer was found in an on-board computer system. The computer found on modern cars has two components. One is the hardware and the other is the software.

The computer hardware on an automobile uses a Central Processing Unit (CPU), which, when made in an integrated circuit, is referred to as a microprocessor. The integrated circuit (IC) combines transistors, diodes, and capacitors, which are placed on a tiny chip of semiconductor material that is smaller and thinner than an eraser on a pencil. The material used most of the time is silicon. Silicon, like any semiconductor, does not conduct electricity until either voltage, a magnetic field, heat, or light is directed to the semiconductor. A program instructs the microprocessor on what to do.

The computer software on a car carries a program. The program tells the computer what to do, and when to do it in a specific sequence. The program is stored in a permanent memory, which is referred to as Read Only Memory (ROM). The computer knows only what is placed in its memory. General Motors has another variation, which is called the Programmable Read Only Memory (PROM), which can be readily removed and replaced, while the ROM cannot. This makes it less expensive if the memory should become defective. Only the PROM has to be replaced, not the entire microprocessor.

The microprocessor contains a ROM (or PROM) and a RAM. RAM stands for Random Access Memory, which can be accessed without going through a specific sequence. The technician interfaces with the RAM whenever trouble codes are accessed. Not all computerized ignition systems have trouble codes, however.

Some computers have the ability to learn. This is referred to as an adaptive memory. When a value falls outside of a specified limit, due to engine wear, the adaptive memory makes a slight adjustment in the program to compensate. The car must be driven from 20 to 30 miles, as it takes the computer this long to learn. Any time that power is disconnected to the computer, it will have to relearn everything.

Fuses and Circuit Breakers

A fuse block is usually connected between the battery and the main lighting switch. It is generally mounted on the driver's side of the firewall. When a short circuit or overload occurs in a circuit, the fuse burns out and opens that circuit so no further damage will result. Too much current will open a circuit breaker's terminals, indicating there is something wrong in that circuit. The circuit breaker then remains open until the trouble is corrected.

Headlamp Delay Switches

Headlamp delay systems automatically control headlamp "on-off" operation after the ignition switch and main lighting switch have been turned off. The system, controlled by the driver, provides a light-on situation on a time-delay basis, so that the occupants will have the convenience of headlights after leaving the vehicle. The system automatically delays switching off the headlights for a period of time preselected by the driver. The system can also be switched to a light sensitive, automatic on-off control of the headlamps and other exterior lamps. A light sensitive photocell is mounted in an area exposed to outside light. With the main lighting switch off and the automatic control on, the system will turn on the headlamps when natural outside light diminishes.

Fog Lights

Fog lights are gaining popularity again, both in original equipment and later installation. Standard equipment lamps generally are built into the front bumper or suspended below the bumper. Aftermarket fog lights are available in kits that include the lamps, halogen bulbs, impact resistant plastic covers, and a prewired harness with in-line fuse holder and switch. The yellow lenses allow better vision in foggy weather. If driving in patchy fog, do not use high beams, as their light simply bounces straight back, reducing visibility.

Stoplight Switch

In order to signal a stop, a brake-pedal operated stoplight switch is provided to operate the vehicle's stop lights. Besides lighting the rear lamps, the switch also operates the center high-mounted light that became mandatory on later models. Cruise control equipped vehicles usually use a vacuum release valve. In this case, both the vacuum release valve and the stoplight switch are turned on by movement of the brake pedal.

Wires and Cables

Wires and cables are conductors of electricity. Usually, they are made of annealed copper and are used to carry electricity to the various electrical devices and equipment on passenger cars and trucks. Wires and cables must be the right size for the application and must have proper insulation. If the wire or cable is too small in cross section or too long for its size, its resistance will be too great and valuable voltage will be lost. This will then result in poor operation of the electrical device in the connecting circuit.

Wire size and length determines the resistance of the wire. Wire and cable sizes are expressed by a gauge number, which indicates the cross-sectional area of the conductor. The cross-sectional area of the wires is given in metric size or circular mils. The diameter is given in decimals of an inch. A circular mil is a unit of area equal to the area of a circle one mil in diameter. A mil is a length unit equal to .001 inches. The larger the diameter of the wire or cable, the smaller the gauge size number.

Cables are made of several strands of wire. The cross-sectional area is equal to the circular mil area of a single strand times the number of strands. Special gauges are available for measuring the gauge size of wires and cables. Many multi-purpose electrician's pliers feature wire size holes for stripping, cutting, and crimping operations. When comparing cables, consider that the external diameter of insulated wire or cable has nothing to do with its current-carrying capacity. Thick insulation will make a small gauge wire look much larger. It is important that only the size of the metal conductors are compared.

Battery Cables

Battery cables connect the battery to the rest of the starting and charging circuits. A starting motor which is cranking an engine will draw about 200 amps of current, so the battery cables must be of sufficient size to carry such heavy current.

Since the cables are close to the battery and could corrode, it is important that the cables make good electrical contact with the cable clamps. In the same way, clamps must make good electrical contact with the battery posts. Any looseness or corrosion between the cable and its clamp, or between the cable clamp and battery, will result in high resistance and consequent voltage drop.

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 gear box section of the wiper. It is driven by the wiper unit gear assembly.

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.

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.

Digital Speedometer and Odometer

Unlike the analog speedometer, the digital speedometer is operated by a vehicle speed sensor. It puts out electrical pulses to be processed by the computer. The computer turns on segments of a display to form numbers, which is the speed of the car.

The digital odometer chip can be replaced if it is defective without replacing the entire speedometer cluster, but a new odometer will register zero mileage. If the entire cluster has to be replaced, however, the old odometer chip can be transferred to the new cluster, displaying the current mileage, because the chip retains the mileage in its memory.

As far as the instruments of a car, new devices are being considered which allow certain information, for example, the vehicle's speed, to be displayed by creating an image on the windshield. The image would appear to be some distance ahead of the car, so that the driver need not re-focus his eyes to read it. The so-called heads-up display device would therefore allow the driver to be able to monitor his speed and other functions of the car without having to scan downwards from his forward view.

Tachometer and Tach Block

A tachometer is designed to give the speed of a rotating part in revolutions per minute (rpm). For automotive use, the tachometer is made for measuring the speed of the engine.

One lead of the tachometer is connected to the primary terminal of the distributor. The other lead is connected to ground. The control is set for low range to test curb idle and fast idle. The control is set for high range to make tests at speeds above 1200 rpms. A "tach block" is a block with exposed terminals to hook up test equipment or to connect to an electrical circuit.

Power Formulas

The electrical unit for measuring work is called a "joule." One joule is equal to one ampere flowing for one second under the pressure of one volt. An electrical force may exist without work being done. This is the condition that exists between the terminals of a battery when no equipment is connected to them. When a piece of equipment is connected to the terminals of the battery, current will flow and work will be done.

"Power" is the rate of doing that work. The mathematical formula for power can therefore be given as: power = work/time. In the same way, we can find a mathematical formula for electrical power: Electrical power = electrical work/time. A "watt" is an electrical unit of power. The watt is equal to one joule of electrical work per second, giving us the formula:

Watt = joules/seconds = volts x amperes x seconds/seconds.

In an automotive lighting circuit, the current is 8 amperes and the voltage is 12. Therefore, the number of watts being used is: 8 (amps) x 12 (volts) = 96 watts.

The unit for measuring mechanical power is called "horsepower." In experimentation, it has been found that one horsepower is equal to 746 watts.

The first car on the moon was electric, and it took ten years to design. The cost was something around sixty million dollars. It went with the Apollo 15 space crew in 1971.

Distributorless Ignition System

The Distributorless Ignition System (DIS) uses several electronic sensors instead of a distributor. It also uses one coil for every two cylinders. The components in the system are:

- 1. Crankshaft timing sensor
- 2. Camshaft sensor
- 3. DIS Ignition module
- 4. Ignition coil packs

The crankshaft timing sensor consists of a single Hall effect magnetic switch activated by 3 vanes on the crankshaft damper and pulley assembly. This sensor sends a signal that feeds timing and rpm information to the DIS and EEC-IV module.

The camshaft sensor is driven by the camshaft; it provides information on the cylinder position for the ignition coil and fuel system.

The DIS ignition module receives the signal from the crankshaft sensor and the camshaft sensor. It also receives the spark signal from the EEC-IV module. This module's major purpose is to use the information supplied to it to control the ignition coils. The reason it does this is to ensure that they fire in the correct sequence. The DIS module also controls the engine dwell.

The ignition coil pack has multiple ignition coils. The DIS module controls these coils by means of coil leads. The ignition coils fire two spark plugs simultaneously; one on the compression stroke and one on the exhaust stroke.

Armature

An armature is part of an electrical device which includes many current-carrying windings, which rotate within a magnetic field. It is supported in bearings which are set inside end plates. It usually has a ball bearing at the pulley end and a bronze bushing at the other end. If it is turned with a pulley and driven by a V-belt from the crankshaft pulley, it is a generator. If power is fed to the armature it is called a motor.

Oil Gauge

One of your car's most important measuring devices is the oil gauge. It lets you know the pressure in the oil pump; it is a direct indicator of the "survivability" of your engine. If the oil gauge gives very low readings, it means that your oil pressure has dropped. When the oil pressure drops, the oil is not forced into the nooks and crannies that it needs to visit, and your engine soon grinds to a halt.

Some cars don't have oil gauges; instead they have warning (or "idiot") lights that light up when the oil pressure drops below a certain preset threshold. Since the light doesn't come on until the oil pressure is extremely low, it is a good idea to check the light bulb often; it's the only thing standing between you and a "Post Toastie" engine.

Ammeter

The Ammeter tells the driver whether the electrical system is charging, discharging, or staying "level". The gauge should dip when the engine is started, then go up as the alternator re- charges the battery. After a few minutes, it should go to its middle position.

Bimetallic Arm

Bimetallic arms are used in gauges to deflect the needle when the arm experiences a different current. This occurs because different metals expand and contract at different rates. When current flows through them, they warm, and consequently expand. A gauge has current flowing through its bimetallic arm that pushes and moves the indicator needle.

Indicator Needle

The indicator needle is the pointer on your gauge that shows you the gauge's current reading. Examples of indicator needles are those found in your speedometer, temperature gauge, tachometer and oil pressure gauge.

Running Circuit

As your car drives down the road, it goes through a little routine. Once the battery is back up to its optimum level, the car runs solely on the alternator. The energy generated by the alternator is sufficient to operate everything on your car. The alternator supplies energy to your headlights, wipers, distributor, radio, electric windows, etc., while you are driving.

This is accomplished by the belt that drives the alternator. The alternator generates the electricity. The electricity flows through the voltage regulator, which keeps the electricity at a reasonable voltage level for the car to deal with. Next, the electricity travels to the various appliances you are using. One of these is the distributor, which consumes electricity to ignite the spark plugs as the car runs.

Charging Circuit

If the battery hasn't quite gotten "up to snuff" -- or if it's in a "discharge state" (as it is when you first start your car) -- the alternator provides electricity, through the voltage regulator, to charge up the battery. This means that the hardworking alternator has to power your accessories and the distributor at the same time as it charges your battery.

The voltage regulator prevents the alternator from charging the battery above its normal level; this protects the battery.

Grounding Points

Almost everything that is powered electrically in your car is grounded to the frame or the body of the car. These are called "grounding points" and serve to complete the power loop for sending electricity around within the car.

Example: current from the positive wiring from the positive terminal of the battery, or fuse box, travels to a light bulb. Once the current has passed through the filament of the light bulb, it passes through the housing of the light bulb and grounds to the frame. The negative battery terminal is also grounded to the frame, which causes the frame to serve as a gigantic piece of wire.

Battery Terminals

The battery terminals are the points on the battery to which you connect your wires. Some cars have the "post" type that use clamps.

This type is slowly being phased out by the "side-mount" type of terminals which use a bolt to screw into the side of the battery and clamp on the battery wire.

Battery terminals are a problem in many cars, because vapors from battery acid causes corrosion to form on the lead surfaces and copper wiring associated with the battery wires. It is a good idea to clean these periodically, but wash your hands thoroughly after cleaning the terminals because the corrosion on the terminals is also acidic.

Electromagnet

An electromagnet is a magnet made by wrapping a coil of wire around an iron or steel bar. When current is flowing through the coil, the bar becomes magnetized. It remains magnetized as long as the current continues to flow.

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.

Hazard Lights

The hazard warning flasher actuates the hazard warning system. When the control knob is operated, all front and rear turn signal lamps light and flash together. The hazard warning switch control knob generally is mounted on the upper portion of the steering column. The flasher usually is located under the instrument panel on near the fuse block.

Position Sensor

Position sensors give input to the computer about the location of a moving part by varying the resistance in an electrical circuit.

The computer sends a reference current through a circuit (made by a contact needle). The contact needle pivots over a resistor wire known as a "zigzag" wire. When the moving part moves, the needle goes to the left or the right. This alters the circuit's resistance which then changes the current returning to the computer. For example: when the needle moves to the left, the current goes through more of the resistor. The return flow decreases proportionately.

Crankshaft Position Sensor

The crankshaft position sensor is designed to record the rate at which the crankshaft is spinning. This sensor consists of a toothed metal disk mounted on the crankshaft and a stationary detector that covers a magnetic coil that the current passes through. As the metal teeth move past the coil, its magnetic field is disturbed. This causes a stream of pulses in the current. The computer can calculate the crankshaft's speed from the frequency of the pulses.

Knock Sensor

The knock sensor is designed to sense when fuel is burning unevenly and causing "knocking" or irregular vibrations in the engine.

The knock sensor consists of an electric coil that is wound around two ceramic rods with a magnet in the center. Engine vibration makes the ceramic rods vibrate. This disturbs the coils magnetic field and alters the current passing through the coil. This disturbance returns to the computer as a signal pattern that the computer analyzes. The computer then determines whether the vibrations are characteristic of engine knocking.

Oxygen Sensor

The oxygen sensor, inserted into the exhaust manifold, is a hollow tube. This tube is divided into inner and outer compartments by a U-shaped rod coated with platinum. The exhaust gas enters the outer compartment through a series of slits. Air is available to the inner compartment through a vent at the other end. An electrical signal is generated by the platinum in response to the difference in oxygen content on either end of the rod. The strength of the signal lets the computer know how much oxygen is in the exhaust. From this information, the computer can tell how well the fuel is burning.

Engine Speed Sensor

The engine speed sensor sends information to the computer telling it how fast the car is traveling.

The engine speed sensor is designed to record the rate at which the crankshaft is spinning. This sensor consists of a toothed metal disk mounted on the crankshaft and a stationary detector that covers a magnetic coil that the current passes through. As the metal teeth move past the coil, its magnetic field is disturbed. This causes a stream of pulses in the current. The computer can calculate engine speed from the number of rotations of the crankshaft. The number of rotations are reported by the frequency of the pulses from the engine speed sensor.

Airflow Sensor

The airflow sensor measures the air that goes into the engine through the intake manifold.

A small air stream is diverted past two small wire coils. The first wire coil is the temperature measuring coil. This coil measures the air temperature. The second coil is the heating coil. This coil is heated to a fixed level above the normal temperature by the computer. As the diverted air cools the second coil, its resistance decreases. The computer detects the change and boosts the current to the heating coil so that it is restored to the correct temperature and resistance. The amount of current required by the computer to keep the coil at the right temperature indicates the rate of air flow.

Radio

Rock and Roll to cruise by!

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.

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The Emission Control System

Emission Control System

The purpose of the emission control system is just that; it controls the emissions and exhaust from your vehicle. The idea is to turn the harmful gases your car manufactures into harmless ones that don't ruin the environment, or us. Some of the problem gases are:

- hydrocarbons (unburned)
- carbon monoxide
- carbon dioxide
- nitrogen oxides
- sulfur dioxide
- phosphorus
- lead and other metals

To help control these substances, we (along with federal regulations) have made changes in our gasoline to eliminate them. Also, with a push from federal regulations, we have developed ways, varying from state to state, to test emissions, that have caused automotive manufacturers to develop better, safer emission systems.

Although emissions control systems vary between manufacturers and vehicles, they all have the same goal and use many of the same methods. The addition of computers to ignition systems allows the engine to monitor and adjust itself continuously, so it just isn't true that emission controls lower the amount of mileage we get from fuel.

The best news is that emission controls have reduced carbon monoxide and hydrocarbon emissions by about ninety-six percent from pre-control vehicles. That's almost a hundred percent!

The Tailpipe

The tailpipe is a long metal tube attached to the muffler. It sticks out from under the body of your car, at the rear, in order to discharge the exhaust gases from the muffler of your engine into the air outside the car.

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.

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.

The EGR Valve

The Exhaust Gas Recirculation (EGR) valve is used to send some of the exhaust gas back into the cylinders to reduce combustion temperature. Why would we want to do this?

Nitrous oxides (nasty pollutants) form when the combustion temperature gets above 2,500 degrees F. This happens, because at such temperatures, the nitrogen in the air mixes with the oxygen to create nitrous oxides. Did you ever have two friends that were fine by themselves but just awful when they got together? Well, our good friend, the sun, is just like that. When it's sunny, the nitrous oxides from the exhaust get together with the hydrocarbons in the air to form our not-so-good friend, smog. That's when the EGR valve comes in handy.

By recirculating some of the exhaust gas back through the intake manifold to the cylinders, we can lower the combustion temperature. Lowering the combustion temperature lowers the amount of nitrous oxide produced. Consequently, less of it comes out the tail pipe.

There are two types of EGR valves. One operates through the use of a vacuum, and the other operated through the use of pressure. Both types allow the exhaust gas in to lower the combustion temperature when it gets too high.

PCV Valve

The process of combustion forms several gases and vapors; many of them quite corrosive. Some of these gases get past the piston rings and into the crankcase. If left in the crankcase, these substances would cause all kinds of bad things (rust, corrosion, and formation of sludge), so they have to be removed. Back in the old days, they used to be dumped out into the atmosphere through a tube. Once we realized what a problem pollution was in the sixties, the PCV (Positive Crankcase Ventilation) system was developed to take the place of the old "dump tube."

The PCV system uses a hose connected between the engine and the intake manifold to draw these gases out of the engine's crankcase and back into the cylinders to burn with the regular fuel. The only problem to solve is how to keep these gases from going willy-nilly into the manifold and upsetting the required air-fuel ratio. The solution to this problem is the PCV valve.

The PCV valve controls the release of crankcase gases and vapors to the intake manifold. The valve is kept closed by spring action when the engine is at rest. When the engine is running normally, the low vacuum it creates allows the valve to open and release crankcase vapors and gases into the intake manifold for burning. If the engine is idling or you are slowing down, the vacuum level rises and pulls the valve plunger into the valve opening. This partially blocks off the opening so that only a small amount of vapors and gases can be drawn into the intake manifold.

One really comforting feature of the PCV valve is its behavior in the event of a backfire. If your car backfires in the manifold, the pressure makes the spring close the valve completely. With the valve closed, there is no chance that the flame can move into the crankcase and cause an explosion.

The Air Pump

The air pump sends (or pumps) compressed air into the exhaust manifold and in some cases to the catalytic converter. The oxygen in the pressurized air helps to burn quite a bit of any unburned hydrocarbons (fuel) and therby converts the poisonous carbon monoxide into good old carbon dioxide.

A belt from the engine drives the air pump. It has little vanes (thin, flat, curved fins) that draw the air into the compression chamber. Here, the air is compressed and sent off to the exhaust manifold where it speeds up the emissions burning process. Stainless steel nozzles are used to shoot the air into the exhaust manifold, because they will not burn.

Some engines use a pulse air injection system. This system uses pulses of exhaust gas to operate an air pump that delivers air into the exhaust system.

The Exhaust Manifold and Header

The exhaust manifold, usually constructed of cast iron, is a pipe that conducts the exhaust gases from the combustion chambers to the exhaust pipe. It has smooth curves in it for improving the flow of exhaust.

The exhaust manifold is bolted to the cylinder head, and has entrances for the air that is injected into it. It is usually located under the intake manifold.

A header is a different type of manifold; it is made of separate equal-length tubes.

Manifold to Exhaust Pipe Gaskets

There are several types of gaskets that connect the exhaust pipe to the manifold.

One is a flat surface gasket. Another type uses a ball and socket with springs to maintain pressure. This type allows some flexibility without breakage of the seal or the manifold. A third type is the full ball connector type, which also allows a little flexibility.

Exhaust Pipe Hangers

Hangers hold the exhaust system in place. They give the system flexibility and reduce the noise level. The hanger system consists of rubber rings, tubes and clamps.

Catalysts

The materials within a catalytic converter vary between cars. Catalytic converters are designed to do different things, depending on the design of the converter.

Some catalytic converters use what is called an "oxidation " catalyst; this usually consists of ceramic beads coated with platinum to reduce hydrocarbons and carbon monoxide. Through the catalytic action, the hydrocarbons and carbon monoxide are "burned" to create water vapor and carbon dioxide. This type of catalytic converter needs an input of oxygen, so oxygen is usually injected into the cylinder head, or directly into the exhaust header or manifold.

Newer catalytic converters have a two part design. The front half is a "three-way" catalyst, which burns various pollutants, and reduces hydrocarbons, carbon monoxide, and oxides of nitrogen into water, carbon dioxide and nitrogen. These converters require exact fuel air mixtures in order to maintain efficient exhaust reduction. The rear section of these converters is the normal oxidation catalyst that further reduces hydrocarbons and carbon monoxide. Air from the air pump is injected into the center of these converters. Here the air is allowed to mix with the exhaust before it passes into the oxidation catalyst, where it burns off its toxic chemicals and reduces emissions.

Exhaust Pipe

The exhaust pipe is the bent-up or convoluted pipes you will notice underneath your car. Some are shaped to go over the rear axle, allowing the rear axle to move up and down without bumping into the exhaust pipe; some are shaped to bend around under the floor of the car, connecting the catalytic converter with the muffler. Exhaust pipes are usually made out of stainless steel, since the high heat conditions involved with the muffler system will cause rust.

Reverse-flow Muffler

The reverse-flow muffler is oval-shaped and has multiple pipes. Four chambers and a double jacket are used to accomplish muffling of the exhaust noise. Exhaust gases are directed to the third chamber, forced forward to the first chamber, from where they travel the length of the muffler and are exhausted into the tail pipe.

Straight Through Muffler

The straight through muffler has a central tube, perforated with several openings which lead into an outside chamber packed with a sound absorbing (or insulating) material. As the exhaust gases expand from the perforated inner pipe into the outer chamber, they come in contact with the insulator and escape to the atmosphere under constant pressure. Because of this, the expanding chamber tends to equalize or spread the pressure peaks throughout the exhaust from each individual cylinder of the engine.

A V-8 engine requires two exhaust manifolds and either one or two mufflers and often accompanying resonators. If one muffler is used, the exhaust pipe from one manifold meets the other one in the form of a "Y".

Dual Exhaust System

The advantage of a dual exhaust system is that the engine exhausts more freely, thereby lowering the back pressure which is inherent in an exhaust system. With a dual exhaust system, a sizable increase in engine horsepower can be obtained because the "breathing" capacity of the engine is improved, leaving less exhaust gases in the engine at the end of each exhaust stroke. This, in turn, leaves more room for an extra intake of the air-fuel mixture.

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Environment And Environmental 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.

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.

Relays

A relay is an electromagnetic device in which contacts are made and subsequently broken. An example of this would be your car's horn.

By natural law, the farther electrical current travels, the lower its voltage becomes. Your car horn has to be connected to the car battery in order to sound. The shortest distance between two points is a wire connecting your horn to your battery. The only problem with this arrangement is that connecting the two would give you a permanent horn blast when you turned the key in your ignition.

This is an unacceptable arrangement, so a relay is included in the connection. The relay stops the horn from sounding until you activate the relay by pressing the horn. The relay then allows the horn to connect to the battery, or complete the circuit, and it sounds. As soon as you stop pressing the horn, the relay breaks the connection, or circuit, and presto-- no more horn!

Relays, with switches, are used for most of the equipment that depends on the battery for an energy source. This includes headlights, taillights, radio, etc.

In 1922, a Model T was the first car equipped with a radio. In 1927, the first commercially produced car radio came on the scene. A "relay" is any switching device operated by a low current circuit that controls opening and closing of another circuit of high current capacity. The purpose of the "cutout relay" is to prevent the battery from discharging through the generator when the engine is stopped or turning over slowly. A "field relay" connects the alternator field windings and voltage regulator windings directly to the battery.

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.

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.

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 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 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.

Discharge/Suction Service Valves

Discharge and suction service valves allow the air conditioning system to be emptied and filled. These valves also provide places where the system can be checked with pressure gauges.

Note: Some systems use a Schrader valve in place of the discharge and suction valves. This is a spring-loaded valve which looks rather like the valve in a tire.

The Compressor Relay

A capillary tube from a cycling switch lets the switch know what the temperature is in the evaporator. This switch turns the compressor on and off to keep the evaporator temperature at about 32 to 45 degrees F. The relay switch keeps moisture from freezing on the evaporator core.

Electric Air Conditioning Fan

Sometimes an extra electric fan is placed in front of the condenser to provide an extra flow of air during warm weather, or for times when the car has to idle for a long time. You activate and deactivate the air conditioning fan when you turn it on and off at the control panel.

Compressor Belt

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

Heater/AC Blower Motor

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

Air Ducts

The air ducts control the passage of hot or cold air into the interior of the car. They are operated by a control on the dash, either manually or automatically.

Controls

Most air conditioning/heating systems have three possible air settings. One is to recirculate the air that is in the car, a second is to use only air from the outside of the car, and a third is to mix some of the outside air with the air recirculating inside the car.

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.

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.

AC Compressor Drive Ring

Inside the air conditioner's refrigerant compressor is a drive ring made of a friction material that is mounted to both sides of the "swash" or "wobble" plate. As the swash plate rotates, the friction material pushes the ball bearings (mounted to the pistons) back and forth.

The Car and the Environment (Overview)

Most of us know that cars are the number one cause of air pollution, but most of us never do anything about it until someone makes us. This usually happens because of a law. We buy gas that causes less harmful emissions, because that's what's for sale now. Scientists tell us that if we don't do something soon, we will be unable to repair the damage that we are causing to our planet. What are some of the things we can do to help?

1. Buy a fuel-efficient car and keep it that way

Good gas mileage isn't just a way to save money. It's also a way to stop pollution. Since the world just isn't set up for you to start riding a bike everywhere, you're probably going to be using a car. Choose a car that is friendly to the environment when you purchase one. Use the most recent EPA gas Mileage Guide to check fuel-efficiency, and don't get any optional equipment that wastes fuel that you don't need.

2. Keep your car tuned up

A car that is badly tuned releases more pollutants into the air. If you keep track of your gas mileage, you'll know when something is wrong and can have it fixed. A badly tuned car uses almost 10% more gas than a well-tuned car. Other ways to waste gas are:

Idling your car unnecessarily: If you are stopped for longer than a minute, it is more fuel efficient to turn off your engine.

Using dirty fuel filters. Dirty fuel filters waste gas.

Carrying unnecessary weight in your car. The heavier your car is, the more gas it uses.

Air Conditioner Maintenance

In November of 1990, the Clean Air Act was signed into Federal law. This law requires a complete phase out of chlorofluorocarbons (commonly known as CFCs) and other ozone-depleting chemicals (ODCs) by the year 2000, although it might be revised to 1997 or sooner. What does this have to do with your air conditioner?

Your air conditioner uses a CFC based refrigerant, known as R-12, or freon. This law means that there won't be much R-12 left by the year 2000, and what is left will be very expensive, because of a tax that will reach about $5.00 per pound.

Why are they doing this to us? We like our cars to have air conditioning. This is being done because of the terrible damage CFC based refrigerant is doing to the ozone layer. In the U.S., the largest single source of ozone damaging emissions is from our automobile air conditioners. It's been estimated that car air conditioners used over 48,000 metric tons of R-12 in 1989 -- this is 21% of all CFC use in the U.S.

Of course, this causes a big problem for both us and our mechanics. We won't be able to go out and buy a can to "top-off" our systems. The new laws specify that all refrigerant will have to be recaptured and recycled when we have repairs made. Of course, this will take expensive and specialized equipment. Our mechanics will have to make sure that there are no leaks, and fix them if there are, before they can add any R-12 to our air conditioning systems. Naturally, this cost will be passed along to us.

Recovered refrigerant will be recycled. Capturing refrigerants and restoring them for reuse is not only environmentally sound, but mechanically safe. Each molecule of CFC in the atmosphere has a 120 year life that will destroy tens of thousands of ozone molecules. This means that a CFC molecule released in 1991 will still be damaging the ozone layer in 2100.

Gas Ecology

There are many ways that we can reduce pollution by observing good gas ecology -- that is using our cars in fuel efficient ways.

Don't move the car unless you are going somewhere. Plan ahead. Starting the car up just to move it a short distance produces more pollutants than hours of driving on the freeway.

Don't use your heater until the car is warmed up. The engine will warm more quickly, because it won't be losing heat to warm you.

Try to drive within 35-45 miles per hour when possible. Driving at slower speeds reduces engine efficiency and causes more pollutants.

Don't make fast starts or stops. Fast starts can burn more than 50% more gas than regular acceleration (as well as cause 50% more emissions). When a big burst of gas enters the engine, much of the catalytic converter's job is bypassed and the unburned gas comes out the tailpipe or is sent into the converter. Rapid acceleration is only called for in emergency or passing situations. Stopping rapidly also leaves the engine with a lot of unburned gas to deal with. This results in damage to the converter and pollution.

Try not to idle. At bank lines and fast food places with over thirty second waits, turn the engine off, and restart it. It is more fuel efficient, and causes less pollution. The only time that idling is a good thing is after a long, fast run. Idling the engine for a minute or so after one of these helps get rid of any hot spots and fuel vapors.

Keep to steady speeds on the highway. Changing speeds produces more pollution and uses more gas.

Don't use the air conditioner unless you have to. It makes your engine work harder, uses more gas, and causes more pollution.

Most evaporative emissions get into the atmosphere when we put gas in our cars. Make sure your gas cap is the right one, and in good working order. Gas caps don't cost that much, but are very important in anti-pollution.

Since gasoline expands, never overfill your tank. It will wind up leaking out.

Use known brands of gas. Poor quality gas will not save you money. Instead, it will foul your engine and cause it to function badly. Try several different brands and octane ratings to find out which makes you car the happiest, and stay with it.

Fuel Conservation

In addition to the ways mentioned to be "gas-ecological," there are other ways that you can conserve fuel.

Don't drive around the parking lot for hours waiting for a convenient space to "open up." Americans do this all of the time. Just think of the gas that we could save (not to mention pollution) if we all just parked in the first spot we could find, and walked! It would probably save time, too (the reason we're so intent on finding a "close" parking spot in the first place).

Use carpools, vanpools and public transportation. Although this means that you'll have to give up some of your "freedom," it doesn't necessarily mean that in the long run. If you don't do it now, by your own freedom of choice (the pollution situation won't go away on its own) soon regulations may order you to give up your freedom. If this happens, it won't be on your schedule. It will be on the law's schedule. They might order you not to drive on Tuesdays, and it won't be voluntary. You'll be a "lawbreaker" if they catch you, and punished accordingly. Don't wait for that to happen. If we all take some sort of voluntary action now, it won't have to happen.

Use a bicycle, and/or respect those who do

Bicycles are a great means of transportation. Remember when you were too young to drive? You didn't think anything of getting where you needed to go on your bike. It worked just fine. You got exercise, and didn't pollute anything.

We are seeing more and more cyclists on the road these days, but we tend to resent them. We think that they are in our way. They are, but they are also cutting down on pollution. Try to think that if they were in a car, you might not make it through the next light because they would be in front of you. Realize that there aren't many good roads for bicycles and that if there were, the cyclists would be even happier to be on them than you would. Don't think of them as your adversaries. Just be glad they're not in cars.

Think about riding a bicycle yourself. If it wasn't for the danger of short-tempered, mean-spirited drivers, cycling could be a great form of exercise -- with a purpose. It's also great for the environment. There are lots of trips you make that would be ideally suited for a bicycle. If more of us rode them, then better bicycle routes would be demanded by the taxpayers. This would make it better all around for both bicyclists and motorists. More people would bike, and less people would drive. More people would be healthy and feel better, and so would the environment.

Call Ahead

If you aren't sure they have what you want, call stores to find out before you drive there. Don't drive from store-to-store -- call from store-to-store. You can even do price comparisons that way. Call before you "drop-in" on someone to make sure they're home (they'll appreciate that, anyhow). Using your phone can save you hours of driving, parking and walking around.

Use Your Legs

Why is it, that even if we only live a mile from work, we drive anyhow? Sometimes we have too much to carry, or it's raining, or we have to do some errands. This isn't true all of the time. The truth is, we just don't think of walking anymore.

Zillions of people are out walking these days -- it's called "recreational walking," and it's all the rage. To do recreational walking, the rule is, you have to wear special clothes and shoes, and use your "spare" time for it to "count." Right? Wrong. You can walk in any kind of clothes (although you might want to wear your "special" shoes and carry your "work" shoes) and actually save some of your "spare" time for something else. Try to work walking into your regular schedule, lose weight, feel better and help the environment.

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.

Recycling Coolant

Although coolant isn't as bad for the environment as used motor oil, you should still make sure that you dispose of it in the proper manner. It is very toxic, so keep it away from childern and pets. Place it in leak-proof containers and find out where to take it for recycling. Most cities have oil recycling, but not coolant recycling. Write to your local officials if they don't.

Recycling Tires

This is a tough one, but one that is serious enough for several companies to have begun looking for answers. Something like 240 million tires are discarded in the U.S. each year. These tires pose a very serious threat to the environment. Aside from taking up huge amounts of landfill space, they tend to rise to the top. Tires catch on fire very easily, and this can result in a very dangerous situation.

Only about 20% of used tires are suitable for retreading. Some old tires wind up padding docks and swinging in back yards, but until recently, most of them have just been piling up. Recently, entrepreneurs have been trying to find uses for old tires. They are shredding them for fuel, mixing them with highway asphalt and using them to soften airport runways. One company uses the tires for rubber mats, garbage cans and other products.

Since tire disposal costs are skyrocketing, state and city regulations are going to have a big effect on how it's done. Disposal costs range from twenty five to fifty cents a tire. One state has begun to have a surcharge on new tire sales in order to finance disposal.

What can you do right now? Try to make your tires last as long as is safely possible. Buy long-lasting, fuel efficient tires. Check with your dealer about "rolling resistance" and mileage performance before you buy tires. Keep your tires properly inflated, balanced and rotated.

Don't dispose of tires yourself. If they can't be recapped, give them to the dealer where you buy your new tires and request that they be properly disposed of.

Recycling Batteries

Old car batteries contain nasty chemicals that can be hazardous to your health. They should not be thrown away, and there's no need to. The easiest (why take it home with you) way to recycle a battery is to trade it in when you get a new one. Since carrying auto batteries around is a pretty heavy duty job, this is the best way.

If this method doesn't work out for you, for some reason (most people don't buy new batteries until the old ones quit), get your yellow pages. Find "Battery Repairing and Rebuilding" and sell it to someone listed there.

Emissions Testing

Many states require emissions tests on vehicles. This means that you drive to a facility where the test people take a sample of your emissions and run it through some analysis. The results are printed, and you pass or fail depending on the percentage of toxic emissions that turn up in your car's sample.

The only way to "study" or prepare for this test is to take good care of your car, including its emission system. If you use preventative maintenance, and keep your car tuned properly, you will pass. If you tamper with your emissions system, you will not pass. You can have your car checked independently before your emissions test if you want to resolve problems before going to the emissions test station.

One other good thing to do is to save your printouts from the test from year to year. If you compare them, you will be able to monitor your car (if its score is getting worse) and catch any problems before the emissions people catch you.

Autom

* [Visit The Service Department To Submit Your Problem Or Question]

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The Steering/Suspension System (Overview)

The Steering/Suspension System

"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 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.

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!

Coil Springs

Compression type coil springs may be mounted between the lower control arm and spring housing or seat in the frame. Other front suspension systems have the coil springs mounted above the upper control arms, compressed between a pivoting spring seat bolted to the control arm and a spring tower formed in the front end sheet metal. 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 in the frame members and sometimes support the rear coil springs to provide for up-and-down movement of the axle and wheel assembly.

Leaf Springs

Front leaf springs are used with solid axle beams in most truck applications. Corvettes use single-leaf, filament-wound, glass/epoxy front and rear springs mounted transversely; i.e., they are crosswise to the vehicle's centerline. Rear leaf springs are used on trucks and some passenger cars. Single leaf or multi-leaf springs are usually mounted longitudinally over the front axle beam or under the rear axle housing. The spring center bolt fastens the leaves together, and its head locates the spring in the front axle beam or saddle on the rear axle housing. U-bolts clamp the spring firmly in place and keep it from shifting. Eyebolts, brackets, and shackles attach it to the frame at each end. Leaf springs also serve as control arms, locating the rear end in position and transferring force to the chassis.

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 crossmember. The inner ends of the lower control arms are bolted to the crossmember and pivot through a bushing.

Shock Absorber Struts

A strut is a structural piece designed to resist pressure in the direction of its length. On typical "MacPherson Strut" use, the shock absorber is built into the strut. Most shock absorber struts are hydraulic units. Some MacPherson systems used on Ford vehicles are equipped with low-pressure, gas-filled shock struts. They are nonadjustable and nonrefillable. Like the hydraulic shock struts, faulty units must be replaced as an assembly. Another similar front suspension system is called the "hydraulic shock strut." This strut serves as a shock absorber and replaces the upper control arm. The coil spring, however, is located between the lower control arm and the body structure instead of being mounted directly on the strut.

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.

Steering Linkage

The steering linkage is made of interconnected parts which move every time the steering wheel is turned. The rotating movement of the steering column activates mechanisms inside the steering box. Tie rod ends, which join the key parts, pass on the steering wheel's motion no matter what the angle of the linkage or the vibration from the road. In a pitman arm steering setup, 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. The steering arms pick up the motion from the tie rods and cause the steering knuckles to turn the wheels. The steering linkages need regular maintenance for safe operation, such as lubrication and inspection. Faulty steering links can cause tire wear at the least, and complete loss of control of the vehicle at worst. "Popping" noises (when turning the wheels) usually indicate worn out steering linkages.

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.

Manual Recirculating Ball Steering

With the manual recirculating ball steering gear, turning forces are transmitted through ball bearings from a "worm gear" on the steering shaft to a sector gear on the pitman arm shaft. A ball nut assembly is filled with ball bearings, which "roll" along grooves between the worm teeth and grooves inside the ball nut. When the steering wheel is turned, the worm gear on the end of the steering shaft rotates, and movement of the recirculating balls causes the ball nut to move up and down along the worm. Movement of the ball nut is carried to the sector gear by teeth on the side of the ball nut. The sector gear then moves with the ball nut to rotate the pitman arm shaft and activate the steering linkage. The balls recirculate from one end of the ball nut to the other through ball return guides.

Manual Worm and Sector Steering

The manual worm and sector steering gear assembly uses a steering shaft with a three-turn worm gear supported and straddled by ball bearing assemblies. The worm meshes with a 14-tooth sector attached to the top end of the pitman arm shaft. In operation, a turn of the steering wheel causes the worm gear to rotate the sector and the pitman arm shaft. This movement is transmitted to the pitman arm and throughout the steering train to the wheel spindles.

Worm and Tapered Peg Steering

The manual worm and tapered peg steering gear has a three-turn worm gear at the lower end of the steering shaft supported by ball bearing assemblies. The pitman shaft has a lever end with a tapered peg that rides in the worm grooves. When the movement of the steering wheel revolves the worm gear, it causes the tapered peg to follow the worm gear grooves. Movement of the peg moves the lever on the pitman shaft which in turn moves the pitman arm and the steering linkage.

Manual Worm and Roller Steering

The manual worm and roller steering gear is used by various manufacturers. This steering gear has a three-turn worm gear at the lower end of the steering shaft. Instead of a sector or tapered peg on the pitman arm shaft, the gearbox has a roller assembly (usually with two roller teeth) that engages the worm gear. The assembly is mounted on anti-frictional bearings. When the roller teeth follow the worm, the rotary motion is transmitted to the pitman arm shaft, pitman arm and into the steering linkage.

Power Steering

Over the years, power steering has become a standard equipment item on many automobiles. The demand for this system has caused power steering to be installed on over 90% of all domestic new car production. All systems require a power steering pump attached to the engine and driven by a belt, a pressure hose assembly, and a return line. Also, a control valve is incorporated somewhere in the hydraulic circuit. "Power steering" is really "power assisted steering." All systems are constructed so that the car can be steered manually when the engine is not running or if any failure occurs in the power source.

Most power steering pumps contain a flow control valve, which limits fluid flow to the power cylinder to about two gallons per minute, and a relief valve which limits pressure according to system demands.

Power Rack and Pinion

Power rack and pinion steering assemblies are hydraulic/ mechanical unit with an integral piston and rack assembly. An internal rotary valve directs power steering fluid flow and controls pressure to reduce steering effort. The rack and pinion is used to steer the car in the event of power steering failure, or if the engine (which drives the pump) stalls.

When the steering wheel is turned, resistance is created by the weight of the car and tire-to-road friction, causing a torsion bar in the rotary valve to deflect. This changes the position of the valve spool and sleeve, thereby directing fluid under pressure to the proper end of the power cylinder. The difference in pressure on either side of the piston (which is attached to the rack) helps move the rack to reduce turning effort. The fluid in the other end of the power cylinder is forced to the control valve and back to the pump reservoir. When the steering effort stops, the control valve is centered by the twisting force of the torsion bar, pressure is equalized on both sides of the piston, and the front wheels return to a straight ahead position.

Integral Power Steering Gears

A representative of an integral power steering gear is used on certain General Motors rear-wheel drive cars and on American Motors four-wheel drive. This power steering gear uses a recirculating ball system in which steel balls act as rolling threads between the steering worm shaft and the rack piston. The key to its operation is a rotary valve that directs power steering fluid under pressure to either side of the rack piston. The rack piston converts hydraulic power to mechanical force. The rack piston moves up inside the gear when the worm shaft turns right. It moves down when the worm shaft turns left. During these actions, the steel balls recirculate within the rack piston, which is power assisted in movement by hydraulic pressure. (See also Manual Recirculating Ball Steering)

Power Steering Hoses

The power steering hoses are used to transmit hydraulic fluid under pressure from the pump to the power cylinder and to return. Besides this, the hoses must provide the proper amount of expansion to absorb any shock surge and offer enough restriction to the fluid flow to keep the pump cavity full of fluid at all times.

Power steering hoses are specially designed rubber hoses with metal fittings at each end which screw together with your power steering system. They contain power steering fluid at high pressures, and allow the system to circulate the fluids between the pump and the power cylinders.

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.

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.

Tire Types and Markings

Size, shape, materials, and construction are all factors that will govern tires' longevity as well as the ride they furnish. The first and most important rule in choosing tires is to follow the directions and recommendations in the owner's manual. Check out the information embossed on the sidewall as well. This information can help the owner choose a set of tires that will suit both the car and the driver's personal needs. The markings on a tire will give the weight (load), size designation, serial number, tire type, carcass cords, DOT, and profile size. Other markings on the tire will probably be the brand name and the name of the tire.

The "size designation" is a combination of one letter and four numbers and is a three-part code.

The letter denotes the sidewall-to-sidewall width of the tire; the two numbers grouped with the letter refer to the height-to-width ratio; and the numbers following the dash indicate in inches the diameter of the wheel rim the tire will fit. To replace the tire, the own will find the sizes that will fit the car specified in the owner's manual.

As to "tire type," government regulations require that every passenger tire be stamped either "tubeless" or "tube-type," but more than 90% of the passenger cars are tubeless. "Belted" would indicate that a tire has extra strength in its construction. In addition, if the tire were a radial, it would be designated as such - a necessary precaution because radials should not be mixed with other tire types except when the radials are used as the pair on the rear axle.

Bias Ply Tires

There are three general methods of arranging or laying down the tire plies. They may be laid down "on the bias," "on the bias and belted," or "radially."

The standard, and least expensive, tire is a bias ply. In this type of ply, the cord strips are arranged diagonally (i.e., at a bias) to the center line of the tread and alternate plies are reversed to cross at a 30 or 40 degree angle. The result is a uniformly firm body, which will wear satisfactorily at moderate speeds, with sidewalls that can stand curb bruises. In fast driving or hard turning, however, the tread elements squirm together and spring apart, producing heat that weakens the tires.

A veterinarian named John Dunlop in Belfast, Ireland gets credit for inventing the pneumatic tire. In 1888 he tried making better tires for his son's bicycle by using linen-covered sheet rubber. Although he was granted a patent for bicycle and tricycle tires, he sold his idea in 1889. The man he sold it to was named Harvey du Cros, Jr., who started the Dunlop Rubber Company. Dunlop himself was never part of the company.

Tire Rotation

The tire-rotation procedures charted below are not as difficult as they seem. At any given time, only one chart will pertain to any car. First find the number and type of tires you will be rotating. Then read down the column at the left. The top entry on the left is for regular rotation without snow tires. The second and third rows are for snow tire rotation. Remember, if radial tires are used in the front, then the snow tires should be radial also. When storing tires, it is a good idea to record its position on the inner face of each one, using chalk or tape. This will help when remounting the tire.

4 TIRES (Non-radial) Rotation

From:	R-front to:	L-front to:	R-rear to:	L-rear to:	Storage
Routine	L-rear	R-rear	R-front	L-front	
Fall	storage	storage	R-front	L-front	R-L:rear
Spring	L-rear	R-rear	storage	storage	R-L:front

5 Tires (Non-radial) Rotation

From:	R-front	L-front	R-rear	L-rear	Rear Holding	Storage
Routine	L-rear	Rear/H	R-front	L-front	storage	L-R:rear
Fall	Rear/H	storage	R-front	L-front	storage	L-R:rear
Spring	L-front	Rear/H	storage	storage	R-rear	L-R:rear

4 Radial Tires

From:	R-front to:	L-front to:	R-rear to:	L-rear to:	Storage
Routine	R-rear	L-rear	R-front	L-front	
Fall	storage	storage	R-front	L-front	L-R: rear
Spring	R-rear	L-rear	storage	storage	L-R:front

5 Radial Tires

From:	R-front	L-front	R-rear	L-rear	Rear Holding	Storage
Routine	Rear/H	L-rear	R-front	L-front	R-rear	L-R:rear
Fall	Rear/H	storage	R-front	L-front	storage	L-R:rear
Spring	Rear/H	L-rear	storage	storage	R-rear	L-R:front

The tire valve is really an air check that opens under air pressure and closes when pressure is removed. The inner valve or "valve core," acts as a check valve for the air. Positive sealing is provided by the "valve cap," which contains a soft rubber washer or gasket. It is this gasket, pressed against the end of the "valve stem," that seals the air in the tire. The careless practice of operating tires without the valve cap should not be followed, because, without the valve cap in place, there is usually a slow leak of air from the tire, causing the tire to run in an underinflated condition. If air should leak out around the base of the valve, it will be necessary to install a new tire valve assembly. This is easily accomplished with a special lever-type tool.

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.

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.

Worm Gear

A "worm gear" is a shaft with very coarse thread, which is designed to operate or drive another gear or a portion of a gear. The special shape of the gear allows the rotation direction to be turned when the gears engage with minimal friction.

An example is found inside the steering box, where the steering shaft turns a worm gear that is screwed into a large nut. The nut moves back and forth on friction-reducing ball bearings, which are continuously recirculated by dropping into the nut's bored channels and emerging at the opposite side. Power to move the nut comes from pressurized fluid entering from a pump through rotary valves that open in response to the steering wheel. The worm gear engages the cross shaft through a roller or by a tapered pin.

Pitman Shaft and Pitman Arm

A Pitman shaft is a column extending from the steering sector, which attaches to the Pitman arm, which moves the tie rods. Depending on the turn direction, the fluid from a pump moves a piston forward or backward. This action moves a nut, which turns the Pitman shaft and steering linkage. 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.

Steering Arms

The steering arms pick up motion from the relay rods and the tie rods, causing the steering knuckles to turn the wheels. They are not used in rack-and-pinion setups.

Tie Rod Ends

Tie rod ends are utilized in the steering linkage, steering knuckle pivot supports, and various other hinge mechanisms. Ball joints that join the key parts of the steering linkage pass on the steering wheel's motion no matter what the angle of the linkage or the vibration from the road.

Steering Knuckles

The steering knuckle or "spindle" pivots on either a kingpin or on the upper and lower ball joints. The disc brake caliper is attached to the spindle, as well as the tie rod ends and the upper and lower ball joints, or a MacPherson strut bottom clamp maybe attached, instead of an upper ball joint. In rear-wheel drive cars, the front axle (the shaft which supports the wheel bearings) is part of the spindle. Front wheel drive spindles have bearing pockets only.

Ball Bearings

A ball bearing is an antifriction bearing consisting of a hardened inner and outer race with a series of hardened steel balls separating the two. "Sealed" bearings have plastic dust seals and are greased only at the time of manufacture.

Upper and Lower Ball Joints

The upper and lower ball joints allow the spindle to rotate when steered, and move vertically to absorb road bumps at the same time. They are constructed of an inner ball which is bolted to the spindle, and a socket, which is bolted to the control arm. They are lubricated to prevent wear through their grease fittings.

Rotary Valve

The key to the operation of power steering is a "rotary valve" that directs power steering fluid under pressure to either side of the rack piston. The rack piston converts hydraulic power to mechanical force. Friction from the wheel causes a torsion bar in the rotary valve to deflect. This changes the position of the valve spool and sleeve, directing fluid under pressure to the proper end of the power cylinder. The difference in pressure on either side of the piston (which is attached to the rack) helps move the rack to reduce turning effort.

"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.

"Roller" Power Steering Pump

A "roller" steering pump operates much like the vane type. Instead of vanes, however, six rollers on a toothed carrier unit rotate inside of a cam insert to build up fluid pressure.

"Slipper" Power Steering Pump

A "slipper" type steering pump produces hydraulic pressure by means of four to ten spring-loaded slippers in a toothed rotor turning inside of a cam inserted within the pump body.

Tubeless Tires

The tubeless tire is designed so that the air is sealed within the rim of the wheel and the tire casing. When an inner tube is used in the tire casing, the air is contained within the tube, while the casing is mainly used to protect the tube and provide traction. A tubeless tire is composed of a carcass, sidewall, and tread.

Carcass of A Tire

The carcass is the entire tire structure except the sidewall and tread. The carcass is made up of layers of cord materials such as rayon, nylon, polyester, fiber glass, or steel wire strands. The cords are laid parallel in layers and impregnated with rubber to form plies.

The foundation of a tire is a strong but resilient fabric carcass made up of paired plies (or layers) of rubberized fibers called cords. Whatever material the fibers are - nylon, polyester, rayon, fiberglass, or steel strands - they must be identified under the "carcass cords" identification. Polyester does not "flat spot" after standing, as nylon does, causing temporarily bumpy rides; nor does it deteriorate when wet, as rayon can do. Fiberglass, while not as durable as steel, affords a smooth and quiet ride.

Sidewall of A Tire

The sidewall is that portion of the tire between the bead (that part of the tire shaped to fit the rim) and the tread. The sidewall and tread material is applied after the plies are arranged and vulcanized in place.

Tread of A Tire

The "tread" is the portion of the tire that comes in contact with the road. Treads are grooved traction surfaces around the circumference of the tire. The grooves and ribs formed during the manufacturing process are carefully engineered to provide good traction on wet and dry roads, control when cornering, minimum distortion at high speeds, reduced rolling resistance, and increased wear resistance. The sidewall and tread material is applied after the plies have been arranged and vulcanized in place. The tread and tire are designed to place the full width of the tread on the road when the tire is properly inflated. The variety of tread patterns is very broad. In fact, one publisher has produced a tread pattern identification guide that illustrates over 3000 patterns.

Plies of A Tire

The plies are arranged at various angles in different combinations of layers and belts (plies laid circumferentially around the tire). The sidewall and tread material is applied later and vulcanized in place.

Tread Wear Indicators

Tread wear indicators molded into modern tires serve as visual proof that the tire tread is approaching worn-out condition. These 1/2 inch indicators are located in several positions around the circumference of the tire. As long as the tread grooves are at least 1/16 deep, the grooves are unbroken. When tread depth reaches that point, the tread wear indicators will appear as solid strips across the tire. These strips interrupt tread continuity and are clearly visible upon inspection. The tire should be replaced when this occurs.

Belted Tires

There are three general methods of arranging or laying down the tire plies. They may be laid down "on the bias," "on the bias and belted," or "radially."

The body plies of belted-bias tires criss-cross diagonally, like those of bias-ply tires, to ensure strong sidewalls. The added belts are two or more cord strips that are cut on the bias and alternated, in herringbone fashion, around the perimeter of the tire between the body plies and the tread. Belts not only strengthen the tire against impact and puncture damage, but also serve to stiffen the tread so that it has less tendency to squirm on the road.

Radial Tires

There are three general methods of arranging or laying down the tire plies. They may be laid down "on the bias," "on the bias and belted," or "radially."

The body cords of radial tires run at right angles (radially) to the center line of the treads; the belt cords are laid in a herringbone pattern. The radial body cords allow sidewalls to flex so that the tread maintains maximum surface contact with the road during turns, whereas the stiff sidewalls of bias-type tires would lift the edges of the tread. Radials are well suited to high-speed driving, but some may produce noise or roughness at low speeds.

A flat tire used to be expected on every journey in the early days of automobiles. This was because horses were always losing the nails from their shoes all over the road.

Tire Load

The weight, or load, that a tire can support is designated by a letter. Car makers usually suggest the B tire; the C is rare and the stronger D tire is generally recommended only for heavy-duty hauling or for station wagons. Under one of these letters, the specific load-carrying and tire-pressure capacities are spelled out. A tire at the maximum safe air pressure of 32 pounds per square inch can carry up to 1,620 pounds. The total weight of a fully loaded car should not exceed four times the limit of each tire - in this case, 6,480 pounds.

DOT

The "DOT" marking on a tire certifies that the tire meets the minimal performance standards of the U.S. Department of Transportation. The encoded letters and numbers beneath DOT are a tire's serial number. This code provides the name of the manufacturer (a brand name on the sidewall may represent only the distributor), the tire's size, the materials and date of manufacture. For example, the last three digits; 211, would mean the tire was made in the 21st week of 1991.

Profile Size

The percentage ratio of a tire's tread-to-wheel-rim height pertaining to its sidewall-to-sidewall width establishes its "profile size" and series number. Greater tread width gives better traction and stability, so today's trend is away from conventional 83-series toward 78s or 70s for family cars, to 60s and 50s for sports models.

Tire Tread Wear

Excessive or uneven tread wear results from underinflation, rapid stops, fast acceleration, misalignment, and unbalanced conditions. Road surface condition also affects tire life. Gravel roads and rough-finished concrete will wear tires quickly. Smooth concrete and asphalt surfaces aid in promoting maximum tire life. Normal wear causes the tire tread to be reduced evenly and smoothly; but there are several types of abnormal tire wear that should be avoided or corrected.

Abnormal wear includes: (1) spotty wear; (2) overinflation wear; (3) underinflation wear; (4) toe-in wear; (5) toe-out wear; (6) camber wear; and (7) cornering wear.

When considering any tire tread wear condition and what caused it, remember excessive or uneven wear usually results from a combination of conditions. Tires wear at a different rate on all four wheels due to driving conditions, weight of the vehicle, power on the driving wheels, crown of the road, alignment of wheels, overloading the vehicle, tire inflation, and probably most important of all, driving habits of the person behind the steering wheel.

Fast starts, quick stops, high speeds, and fast turns all take their toll on tire life. Safe and conservative driving habits will promote maximum tire life and economy.

Spotty Tread Wear

Spotty wear results from a combination of conditions, including the design of the tire tread. Underinflation and incorrect camber are the main factors, along with toe-in and toe-out wear. Imbalance of the wheel can also cause this problem.

Tire Overinflation

Overinflation causes tires to wear excessively at the center of the tread surface, and there is usually a little wear on the outer edges of the tire. This causes early failure at the center ribs and breaks in the tire sidewall.

Tire Underinflation

Underinflation is characterized by excessive wear on the two tread ribs next to the inner and outer shoulder ribs. In several cases, underinflation also causes spotty wear.

Toe-in and Toe-Out Tread Wear

Important in the ease of steering the car is the correct setting of toe-in. Toe-in is a term used to specify the amount (in fractions of an inch) that the front wheels are closer together in front that at the rear, when measured at hub height. Precision testing equipment and careful measurement and correction will prevent any slipping or scuffing action between the tires and the road.

If toe-in is incorrect, the tires will be dragged along the road, scuffing and featheredging the treadribs. Changes in road or load conditions will affect more than one steering angle, and uneven tread wear patterns will result. Changes in road or load conditions will affect more than one steering angle, and uneven tread wear patterns will result. Also, toe-in will change when other angular adjustments are made. Because of this, front wheel toe-in should be measured first and uneven tread wear patterns corrected last on all wheel alignment jobs.

Toe-out Tread Wear

It is obvious that driving conditions make it impossible to keep the front wheels parallel at all times. Regardless of how accurately the front wheels are positioned for straight ahead driving, they could be out of their correct relative positions on turns. Considering that the outside wheel is approximately five feet farther away from the point about which the car is turning, it must turn at a lesser angle and travel in a greater circle than the inside wheel. This condition is called toe-out turns, which means that each front wheel requires a separate turning radius to keep the inside tire from slipping and scuffing on turns. Toe-out turns is the relationship between the front wheels which allows them to turn about a common center. To accomplish this, the steering arms are designed to angle several degrees inside of the parallel position. The exact amount depends on the tread and wheelbase of the car and on the arrangement of the steering control linkage. Unless toe-out is aligned correctly, the tires will have a scrubbing action on the road surface. This will produce a featheredge on the outer edges of the tread ribs.

Camber Tread Wear

Too much camber (inward or outward tilt of the wheel at the top) will produce wear on one side of the tire tread. If there is too much positive camber, the tread wear will be on the outer ribs. If there camber is negative, the wear will occur on the inner side of the tire tread. If there is excessive wear on both inner and outer areas of the tread, it probably was caused by too much skidding on turns.

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.

Wheel Balance and Unbalance

It is important to check to see that the wheel and tire assemblies are in balance before aligning the vehicle. "Static" balance is the equal distribution of weight around the wheel and tire assembly. "Dynamic" balance is the equal distribution of weight on each side of the vertical centerline of the wheel and tire assembly.

"Unbalance" (or imbalance) exists when the weight is distributed unequally around the horizontal axis of the wheel and tire assembly. Unbalance can exist in the tire, wheel, brake drum or rotor, or even in the hub. It also occurs in any combination of these components. Unbalance can be detected with the aid of special equipment, which usually indicates the proper location for wheel weights to restore the proper balance. Even with regular maintenance, however, uneven tire wear can result from drivers' habits, such as side wear from excessive cornering speeds. To counteract uneven wear that leads to unbalance, the tire industry recommends that tires should be rotated every six to eight thousand miles.

Caster Alignment

Caster is the steering angle that uses the weight and momentum of the car's chassis to lead the front wheel in a straight path. In wheel alignment, caster is the backward tilt or the forward tilt of the steering axis that tends to stabilize steering in a straight direction. It places the weight of the vehicle either ahead of or behind the area of tire-to-road contact. "Positive" caster is the angular amount that the upper ball joint is farther back than the lower joint. "Negative" caster is the condition when the upper ball joint is farther ahead than the lower one. The "caster angle" is the number of degrees (or fraction of a degree) that the steering axis is tilted backward or forward from the vertical axis of the front wheels.

Static Wheel Balance

"Static" balance is the equal distribution of weight around the wheel and tire assembly. If the unbalance of a wheel lies in the plane of wheel rotation, it is known as static (or kinetic) unbalance. This condition causes the wheels to bounce. The wheel lifts off the road, then slams down during each revolution. This will result in flat spots on the tire tread and worn ball joints, tie rod ends, steering gears, and shock absorbers. Bouncing could also set up a heavy vibration in the chassis and affect the steering balance.

Dynamic Wheel Balance

"Dynamic" balance is the equal distribution of weight on each side of the vertical centerline of the wheel and tire assembly. If unbalance lies on either or both sides of a plane of rotation, it is dynamic unbalance. This causes the wheels to bounce, resulting in flat spots on the tire tread and worn ball joints, tie rod ends, steering gears, and shock absorbers. Dynamic unbalance in the front wheels will cause them to wobble as well. Bouncing could also set up a heavy vibration the chassis and affect the steering balance.

Steering Balance

Steering control of a vehicle in motion is maintained by keeping the vehicle's tires in close contact with the road surface. Tire to road contact is influenced by the condition of the tire treads, tire inflation, wheel balance, weight on the wheels, shock absorber action, spring action, and wheel angularity. A balanced condition between these elements will establish a perfect pivot point from which the front wheels can rotate with the least friction. The point on the tread of each front tire is the target of all steering angle adjustments. Anything that tends to increase the area of tire tread contact with the road will increase the rolling resistance, and the car will steer to that side.

Car Weight Balance

One of the preliminary steps in wheel alignment is to check the accuracy of attachment of the wheels to the vehicle. All ball joints, control arm bushings and steering links must be in good condition in order to properly align the wheels. The frame must be checked to see that it is not bent. The axles and wheels must be located properly in relation to the frame or body. This involves making a series of measurements to establish the parallel and right angle relationships between the frame and wheels. The most important part of this car weight balance relationship is a straight, undistorted frame.

rst, an accurate centerline must be established. Then, if straight lines are drawn through the center of both rear axles and both front spindle locations, they must be parallel to each other and form right angles with the centerline of the frame. Next, when the wheels are attached to the front spindles and rear axles, the rear wheels should be parallel to the centerline of the frame. Also, the front wheels in their straight ahead position should be parallel to this line. This is necessary so that each wheel will roll straight and true in relation to the frame centerline.

Wheelbase Balance

Another important factor when locating axles and spindles for wheel balance is the wheelbase measurement. Wheelbase is the distance between the center of the front wheel and center of the rear wheel. This distance (left front to left rear, right front to right rear with wheels in the straight ahead position) must be exactly the same on each side for proper weight balance. Correct wheelbase contributes to the ability of the car's rear wheel to follow directly in line with the front wheels (called "track"). Shorter wheelbases allow sharper turning radiuses, and longer wheelbases give a smoother ride and increased stability.

Tread Width in Wheel Balance

Tread width is a key measurement with respect to weight balance and rear wheel track. Tread width is the distance between the center points of the left tire tread and right tire tread as they come in contact with the road. While the front and rear wheels may have different tread widths, each front wheel must be the same distance from the centerline of the frame and each rear wheel must be the same distance from the centerline. This parallel relationship establishes a balance between the front and rear, and between the right and left. While this balance may not mean true equal weight at these points, it does mean that a balanced distribution of weight and stress has been acquired for the proper setting of front wheel angles.

Rear Wheel Track Alignment

The rear end is secured by a number of control arms, making it possible for the unit to move up and down, but not side to side. These arms can usually be adjusted, allowing the rear end to be aligned with the rest of the car. The growing popularity of front wheel drive and four wheel drive vehicles has sharply increased the need for correct alignment of all four wheels. In fact, some designs require "camber" and "toe-in" adjustments on all four wheels. The four wheel alignment is required so that correct rear wheel track is established.

The front wheels steer the vehicle, but the rear wheels direct it. The rear wheels determine the "thrust line" which, in effect, is the rear rolling direction. When the thrust line is made to agree with the vehicle frame's centerline (by aligning front and rear wheels and centering the steering wheel), correct rear wheel track will be achieved. An out-of-line condition not caused by an accident usually can be traced to a mechanical defect or sag due to stress in the middle or corner of the frame. A frame that is out of line must be straightened before it is possible to get correct steering alignment.

The frame rails must be the same height from the floor on each side at the spring seats, along with the essential parallel and right angle relationships.

Weight Balance on The Springs

The springs control the up-and-down motion of the car and so, the height of the car above the road. If one or more of the springs is collapsed or broken, it causes an unbalanced distribution of weight. This unbalance creates a lopsided appearance, puts an added strain on the related parts, and changes the angularity of the front wheels. This condition may also occur when the load is distributed unequally. In fact, anything that changes the ratio of weight on the springs will have a definite bearing on the alignment angles and on the area of tire-to-road contact. This can wear tires unevenly, making it necessary to replace them prematurely.

Shock Absorbers in Wheel Alignment

The shock absorbers are important in controlling the up-and-down motion of a moving vehicle. Efficient shock absorber action aids wheel alignment by furnishing a dampening effect that protects the springs from sudden overloading or unloading action. If the shock absorbers are not functioning properly, the car will bounce too much and steering angles will change to damaging extents. Sometimes steering angles will check out correctly on the alignment equipment, yet the car will not handle well on the road. This problem could also be caused by faulty springs or shock absorbers, worn parts in the steering gear or front suspension system, driving conditions, or the habits of the driver.

Front Wheel Alignment

The angles involved in front wheel alignment are caster, camber, toe-in, steering axis inclination, and toe-out on turns. They refer to the tilt of the wheels and steering axis. These angles govern the way the front wheels behave while the vehicle is in motion. Balance is a large part of the picture. The goal is a balanced relationship of the steering angles, with due regard for road and load factors involved in each individual case.

Some early cars used a tiller instead of a steering wheel. To turn the wheels, you really had to pay attention.

Turning the tiller to the left turned the car to the right, and vice versa.

Camber Alignment

Camber is the inward or outward tilt of the wheel at the top. It is built into the wheel spindle by forming the spindle with a downward tilt to provide positive camber. Steering axis inclination is the inward tilt of the steering knuckle. It is so interrelated with the camber that they share a common side (vertical axis of the wheel).

Steering Axis Inclination

Steering axis inclination is the inward tilt of the steering knuckle. It is so interrelated with the camber that they share a common side (vertical axis of the wheel). With the steering axis tilted inward (inclined), the end of the spindle will form an arc that is lower in the extreme turn position than in the center or straight ahead position. In normal operation, the weight of the car prevents the spindle from moving up and down. Therefore, the car is forced upward when the front wheels are turned, and the force of gravity tends to straighten the wheels. In this way, the weight of the car helps to provide an automatic steering effect brought about by accurate adjustment of the steering angles.

The combination of the camber tilt and the steering axis inclination forms an important junction that is known as the "included angle." The purpose of this two-angle team is to place the turning point of the wheel at the center of the tire tread contact area to reduce the scuff area to a minimum. The benefits of additional alignment becomes apparent when some of the troubles caused by misalignment are seen; these include: hard steering, wander, pull to one side, and unequal or excessive tire wear.

MacPherson Strut

In MacPherson Struts, the shock absorber is built into the strut. The strut consists of a shock absorber unit, a coil spring, an upper pivot, and a lower clamp. The upper pivot mounts to the fenderwell. The rest of the unit rotates when the steering is used. The lower clamp secures the spindle and the strut together into a solid unit. Most shock absorber struts are hydraulic units. Some use low-pressure, gas to absorb energy. These are usually nonadjustable and nonrefillable. Like the shock absorber, faulty units must be replaced as an assembly.

Wheel Lugs

Wheel lugs are the large bolts that go through the wheel rim and secure it to the wheel hub. They are pressed into the hub from the inboard side so they cannot pull out when tightened. The Lug nuts thread onto the wheel lugs, clamping the wheel rim between the hub and lug nuts. It is extremely important that the wheel lug nuts are securely tightened! If they are not -- your wheel will come off! Over- tightening is also a bad idea; it can prevent you from being able to change a flat tire.

Grease Fittings

Grease fittings are mounted to almost all of the moving parts of the suspension. They are used to add grease to bushings, pivot points, tie rods, ball joints and even universal joints on some cars (not usually). When you have your car's chassis lubricated, the grease fittings are where the grease is put into during the lubrication process.

Grease Cap

A grease cap is a small sheet metal part that is mounted over the wheel bearing, that contains the grease that the wheel bearing has on it. It protects the wheel bearing from dust and dirt. The grease cap is removed in order to unscrew the nut that holds the rotor and the bearings on. These are not used on front wheel drive cars, since their bearings are usually the sealed type.

Wheels

Wheels come in many different designs and usually fall into two categories: stamped sheet metal and machine castings. Some wheels are a combination of the two.

Usually cast alloy wheels are higher priced, but have greater strength than stamped sheet metal wheels. Stamped sheet metal wheels are the most common, because they are less expensive to produce and are adequate for most uses. Some cars have wire wheels which consist of three basic components; inner rings, outer rings, and a series of spokes which connect the two. Cast aluminum wheels are very popular, magnesium wheels are also popular. Both are popular because they are light-weight and strong.

Suspension Computer

The suspension computer allows the suspension system to adapt to changes in road conditions (smooth or bumpy).

A suspension computer works continually to work out the best compromise for the car's stability and comfort. Position sensors at all four wheels determine whether the car is riding smoothly or jouncing up and down on a rough road. The computer adjusts the air shocks in the wheels by giving electronic instructions.

The computer can give instructions directly to each of the air shocks. A position sensor is attached to the suspension system at each wheel. These sensors convert the up and down motion into a signal into an electrical signal that is sent to the suspension computer. The computer signals the compressor to pump more air into each air shock. The air expands a bladder in the shock and increases its stiffness. This helps the shock to resist bumps. When the road is smooth again, the computer signals a valve at the top of the shock to open and let air out of the bladder.

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System Requirements

For either DOS/Windows Versions:

VGA or better

3 1/2 HD disk drive

Hard Disk

Windows:

Version 3.1

4MB Ram suggested

386 machine or better, (256 color mode recommended)

DOS:

512K Ram, 286 machine or better

1MB extended or expanded memory (optional)

Mouse (optional)

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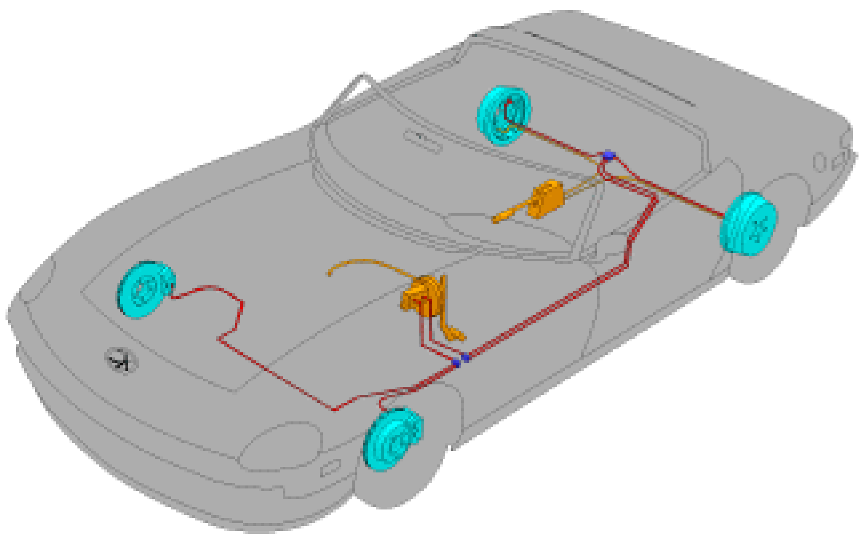
Brake System Overview



Below is an explanation of this system's operation

- Visit The Service Department To Submit Your Problem Or Question
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The Brake System

The braking system is the most important system in your car. If your brakes fail, the result can be disastrous. Brakes are actually 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 thousands of pounds of pressure on each of the four brakes. In modern systems, the master cylinder is power-assisted by the engine. All newer cars have dual systems, with two wheels' brakes operated by each subsystem. That way, if one subsystem fails, the other can provide reasonably adequate braking power. Safety systems like this make modern brakes more complex, but also much safer than earlier braking systems.

The brake system is composed of the following basic components: The "master cylinder" which is located under the hood, and is directly connected to the brake pedal, converts your foot's mechanical pressure into hydraulic pressure. Steel "brake lines" and flexible "brake hoses" connect the master cylinder to the "slave cylinders" located at each wheel. Brake fluid, specially designed to work in extreme conditions, fills the system. "Shoes" and "pads" are pushed by the slave cylinders to contact the "drums" and "rotors" thus causing drag, which (hopefully) slows the car.

In recent years, brakes have changed greatly in design. Disc brakes, used for years for front wheel applications, are fast replacing drum brakes on the rear wheels of modern cars. This is generally due to their simpler design, lighter weight and better braking performance. The greatest advantage of disc brakes is that they provide significantly better resistance to "brake fade" compared to drum type braking systems. Brake fade is a temporary condition caused by high temperatures generated by repeated hard braking. It occurs when the pads or shoes "glaze" due to the great pressure and heat of hard use. Once they cool, the condition subsides. Disc brakes allow greater air ventilation (cooling) compared to drum brakes. Drum brakes are not internally ventilated because if they were, water could accumulate in them. Disc brakes can rapidly fling off any water that they are exposed to, and so they can be well ventilated.

"Boosters" are present in "power brake" systems, and use the engine's energy to add pressure to the master cylinder. "Anti-lock" (ABS) systems, originally developed for aircraft braking systems, use computer controlled valves to limit the pressure delivered to each slave cylinder. If a wheel locks up, steering input cannot affect the car's direction. With ABS, no matter how hard the pedal is pressed, each wheel is prevented from locking up. This prevents skidding (and allows the driver to steer while panic-braking).

As impressive as these advances are, the basic process of converting a vehicle's momentum into (wasted) heat energy has not changed since the days of the horse and buggy. To stop a horse drawn carriage, the driver would pull on a lever which would rub on the wheel. But today, with the advent of regenerating brakes on electric vehicles, new ways of recapturing this lost energy are being developed. In these types of electric cars, when you step on the brakes, the motor switches into "generator mode", and stores the car's momentum as chemical energy in the battery, to be used again when the light turns green!

Disc Brakes

Disc brakes use a clamping action to produce friction between the "rotor" and the "pads" mounted in the "caliper" attached to the suspension members. Inside the calipers, pistons press against the pads due to pressure generated in the master cylinder. The pads then rub against the rotor, slowing the vehicle. Disc brakes work using much the same basic principle as the brakes on a bicycle; as the caliper pinches the wheel with pads on both sides, it slows the bicycle. Disc brakes offer higher performance braking, simpler design, lighter weight, and better resistance to water interference than drum brakes.

Disc brakes, like many automotive innovations, were originally developed for auto racing, but are now standard equipment on virtually every car made. On most cars, the front brakes are of the disc type, and the rear brakes are of the "drum" type. Drum brakes use two semi-circular shoes to press outward against the inner surfaces of a steel drum. Older cars often had drum brakes on all four wheels, and many new cars now have 4-wheel disc brakes.

Because disc brakes can fling off water more easily than drum brakes, they work much better in wet conditions. This is not to say that water does not affect them, it definitely does. If you splash through a puddle and then try to apply the brakes, your brakes may not work at all for a few seconds! Disc brakes also 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 cars in the early seventies.

Brake Drums

The brake drum is a heavy flat-topped cylinder, which is sandwiched between the wheel rim and the wheel hub. The inside surface of the drum is acted upon by the linings of the brake shoes. When the brakes are applied, the brake shoes are forced into contact with the inside surface of the brake drums to slow the rotation of the wheels.

The drums are usually covered with fins on their outer surfaces to increase cooling. They are not cooled internally, because water could enter through the air vent cooling holes and braking would then be greatly impaired.

Drum brakes are found on the rear wheels of most older cars, but they are increasingly being fazed out in favor of rear disc brakes. Drum brakes were standard equipment on all four wheels of most cars until the early 70's.

Brake Calipers

The caliper works like a C-clamp to pinch the pads onto the rotor. It straddles the rotor and contains the hydraulic "slave cylinder" or "wheel cylinder" piston(s). One caliper is mounted to the suspension members on each wheel. The caliper is usually mounted onto the spindle, allowing it to deliver the torsional force of the wheel to the chassis via the control arms. Brake hoses connect the caliper to the brake lines leading to the master cylinder. A "bleeder valve" is located on each caliper to allow air bubbles to be purged from the system.

"Floating caliper" disc brakes, the most common variety, allow the caliper to move from side to side slightly when the brakes are applied. This is because only one pad moves (in relation to the caliper). Some calipers contain two or four seperate pistons. These calipers are fixed in place; i.e., there is no lateral movement like the floating caliper, the pistons take up the slack on each side of the rotor. These are called "dual cylinder" or "dual piston" calipers, and are standard equipment on many performance cars.

Wheel (Slave) Cylinder

Wheel cylinders, also called the "slave" cylinders, are cylinders in which movable piston(s) convert hydraulic brake fluid pressure into mechanical force. Hydraulic pressure against the piston(s) within the wheel cylinder forces the brake shoes or pads against the machined surfaces of the drum or rotor. There is one cylinder (or more in some systems) for each wheel. Drum brake wheel cylinders are usually made up of a cylindrical casting, an internal compression spring, two pistons, two rubber cups or seals, and two rubber boots to prevent entry of dirt and water. This type of wheel cylinder is fitted with push rods that extend from the outer side of each piston through a rubber boot, where they bear against the brake shoes. In disc brakes, the wheel cylinder is built into the caliper. All wheel cylinders have bleeder screws (or bleeder valves) to allow the system to be purged of air bubbles.

As the brake pedal is depressed, it moves pistons within the master cylinder, pressurizing the brake fluid in the brake lines and slave cylinders at each wheel. The fluid pressure causes the wheel cylinders' pistons to move, which forces the shoes or pads against the brake drums or rotors. Drum brakes use return springs to pull the pistons back away from the drum when the pressure is released. On disc brakes, the calipers' piston seals are designed to retract the piston slightly, thus allowing the pads to clear the rotor and thereby reduce rolling friction.

Parking (Emergency) Brakes

The parking brake (sometimes called the emergency brake) is a cable-activated system used to hold the brakes continuously in the applied position. The parking brake activates the brakes on the rear wheels. Instead of hydraulic pressure, a cable (mechanical) linkage is used to engage the brake shoes or discs. When the parking-brake pedal is pressed (or, in many cars, a hand lever is pulled), a steel cable draws the brake shoes or pads firmly against the drums or rotors. The release lever or button slackens the cables and disengages the brake shoes. The parking brake is self adjusting on most systems. An automatic adjuster compensates for lining (brake shoe) wear. On many cars, the parking brake is used to re-adjust the brake shoes as they wear in, or when the shoes are replaced. In these systems, the adjustment is made by repeatedly applying the parking brake while backing up.

The parking brake can be useful while driving up hills: If you're driving a manual transmission car, and you pull up to a stop on an incline, you might notice that you don't have enough feet to operate the clutch, brake, and gas at the same time. In other words, you will likely roll backwards slightly while getting started again. If a someone pulls up right behind you, this can be a problem. Your parking brake is useful in this situation: Apply the parking brake after you stop. When you want to go, release the clutch while pressing the gas, and release the parking brake. This keeps you from having to quickly switch your left foot from the brake to the clutch, or your right foot from the brake to the gas pedal. A little practice, and you'll be able to do it smoothly. Also, remember if you pull up behind someone who is stopped on a hill, give them extra room to roll back a little. Especially if it's a truck.

Some cars have no parking brake release! They automatically release the parking brake when the car is placed in drive or reverse.

Remember, it's a good idea to test the parking brake periodically and keep it in good condition. It may save your life if the main braking system fails!

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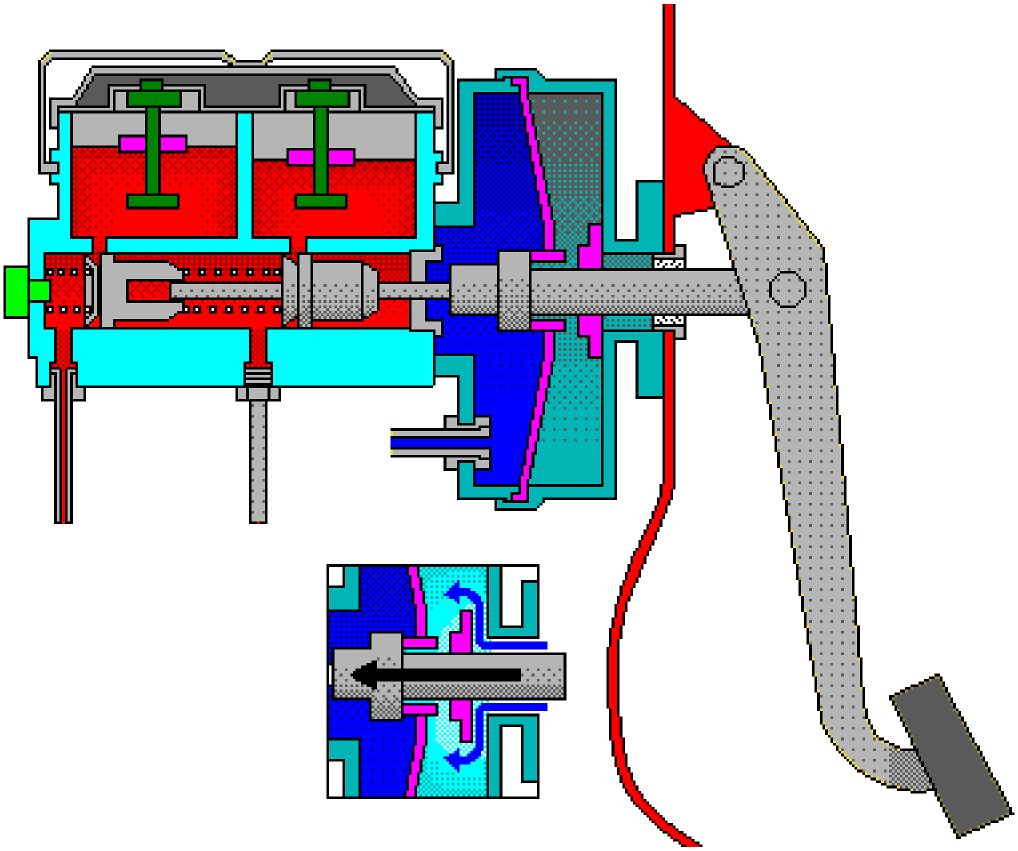
Brake System Operation



Below is an explanation of this system's operation

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Master Cylinder

The master cylinder displaces hydraulic pressure to the rest of the brake system. It holds THE most important fluid in your car, the brake fluid. It actually controls two seperate subsystems which are jointly activated by the brake pedal. This is done so that in case a major leak occurs in one system, the other will still function. The two systems may be supplied by seperate fluid reservoirs, or they may be supplied by a common reservoir. Some brake subsystems are divided front/rear and some are diagonally separated. When you press the brake pedal, a push rod connected to the pedal moves the "primary piston" forward inside the master cylinder. The primary piston activates one of the two subsystems. 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 brake pedal retracts, the pistons allow fluid from the reservoir(s) to refill the chamber if needed.

Electronic sensors within the master cylinder are used to monitor the level of the fluid in the reservoirs, and to alert the driver if a pressure imbalance develops between the two systems. If the brake light comes on, the fluid level in the reservoir(s) should be checked. If the level is low, more fluid should be added, and the leak should be found and repaired as soon as possible. BE SURE TO USE THE RIGHT BRAKE FLUID FOR YOUR VEHICLE. Use of improper brake fluid can "contaminate the system". If this occurs, ALL of the seals in the brake system will need replacement, and that is usually a VERY expensive operation.

Brake Warning System

The brake warning system has been required standard equipment since 1970, and is connected to the master cylinder. It monitors differences in pressure in the brake lines of the two hydraulic sub-systems, and alerts the driver with a light if an imbalance occurs. When you turn the key to the Ignition position, the brake warning light on the dash comes on during a "self-test". You should not drive a car if the warning light does not come on during the startup self test.

The brake system is divided into two sub-systems to increase safety. A pressure differential switch, connected to the warning light, is positioned between the two. If a major leak occurs, and therefore pressure in one of the lines is sharply reduced, pressure from the other side forces a piston to move, activating the pressure differential switch and turns on the dashboard warning light.

There are two types of pressure differential switches; mechanical or hydraulic. Mechanical switches are activated by excessive brake travel. Hydraulic switches are activated by a difference in pressure between the front and rear system. When pressure in one of the lines is sharply reduced, pressure from the other side forces a piston to move. A plunger pin then drops into a groove in the piston, activating a switch that turns on a dashboard warning light.

The brake warning light is also connected to the brake fluid level sensors in the master cylinder reservoir(s). If the brake warning light comes on, the fluid level should be checked. If the level is low, more fluid should be added, and the leak should be found and repaired as soon as possible. BE SURE TO USE THE RIGHT FLUID. NEVER IGNORE THE BRAKE WARNING LAMP, AND ALWAYS NOTE WETHER IT WORKS DURING THE STARTING SELF-TEST.

Power Brakes

Power brakes (also called "power assisted" brakes) are designed to use the power of the engine and/or battery to enhance braking power. The four most common types of power brakes are: vacuum suspended; air suspended; hydraulic booster, and electro-hydraulic booster. Most cars use vacuum suspended units (vacuum boosters), which employ a vacuum-powered booster device to provide added thrust to the foot pressure applied.

In a vacuum booster type system, pressure on the brake pedal pushes forward a pushrod connected to the pistons within the master cylinder. At the same time, the pushrod opens the vacuum-control valve so that it closes the vacuum port and seals off the forward half of the booster unit. The engine vacuum line then creates a low-pressure vacuum chamber. Atmospheric pressure in the control chamber then pushes against the diaphragm. The pressure on the diaphragm forces it forward, supplying pressure on the master cylinder pistons.

Hydraulic booster systems usually tap into the power steering pump's pressure, and use this power to augment pressure to the master cylinder. Electro-hydraulic booster systems use an electric motor to pressurize a hydraulic system which augments pressure to the master cylinder. This allows the vehicle to have power assisted brakes even if the engine quits.

You may wish to compare the difference between power and non-assisted braking in a safe area; while driving slowly, turn the ignition key off (don't turn it into the locked position, because the steering wheel will lock, which is highly unsafe.) As the car coasts along, press the brakes hard. The force of your foot is now the only thing stopping the car. The safe driver is always ready to apply the total force needed to stop their vehicle, even if the engine quits (thereby removing the power assist).

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. If the cap's seal becomes distorted, it usually indicates a brake fluid contamination problem.

Vacuum From The Engine

Engine intake manifold vacuum is used for augmenting the foot's braking power in vacuum assisted power brakes. This vacuum is created by the pistons as they draw downward, sucking air into the cylinders. When you push the brake pedal down, the vacuum control valve lets the engine draw a vacuum in the front section of the booster unit. The atmospheric pressure on the other side of the diaphragm provides significant additional braking force.

Brake Fluid

Brake fluid is a special liquid for use in hydraulic brake systems, which must meet highly exact performance specifications. It is designed to be impervious to wide temperature changes and to not suffer any significant changes in important physical characteristics such as compressibility over the operating temperature range. The fluid is designed to not boil, even when exposed to the extreme temperatures of the brakes.

Different types of brake fluid are used in different systems, and should NEVER be mixed. Most cars use "DOT 3" or "DOT 4" brake fluid. Some newer cars use silicone brake fluids. These should NEVER be mixed together, because the seals in each car are designed to work with only their specific fluid types. For example, the mixing of "Silicone" brake fluid and conventional glycol based DOT 3 or DOT 4 fluids should be avoided, as the two fluid types are not miscible (they will not mix together). DOT 3 brake fluids and DOT 4 brake fluids can be mixed.

One of the WORST things that can happen to your car is if the brake fluid becomes contaminated, because the seals are designed to work with only pure brake fluid. "System contamination" means that all of the piston seals and hoses are deteriorating, and therefore must be replaced, a MAJOR expense. So, be VERY careful what you put in the master cylinder reservoir!

It should be noted that brake fluid is highly corrosive to paint, and care should be used not to get it on your car's finish.

The brake fluid in your car should be changed every (See Owners Manual) to prevent corrosion of the braking system components.

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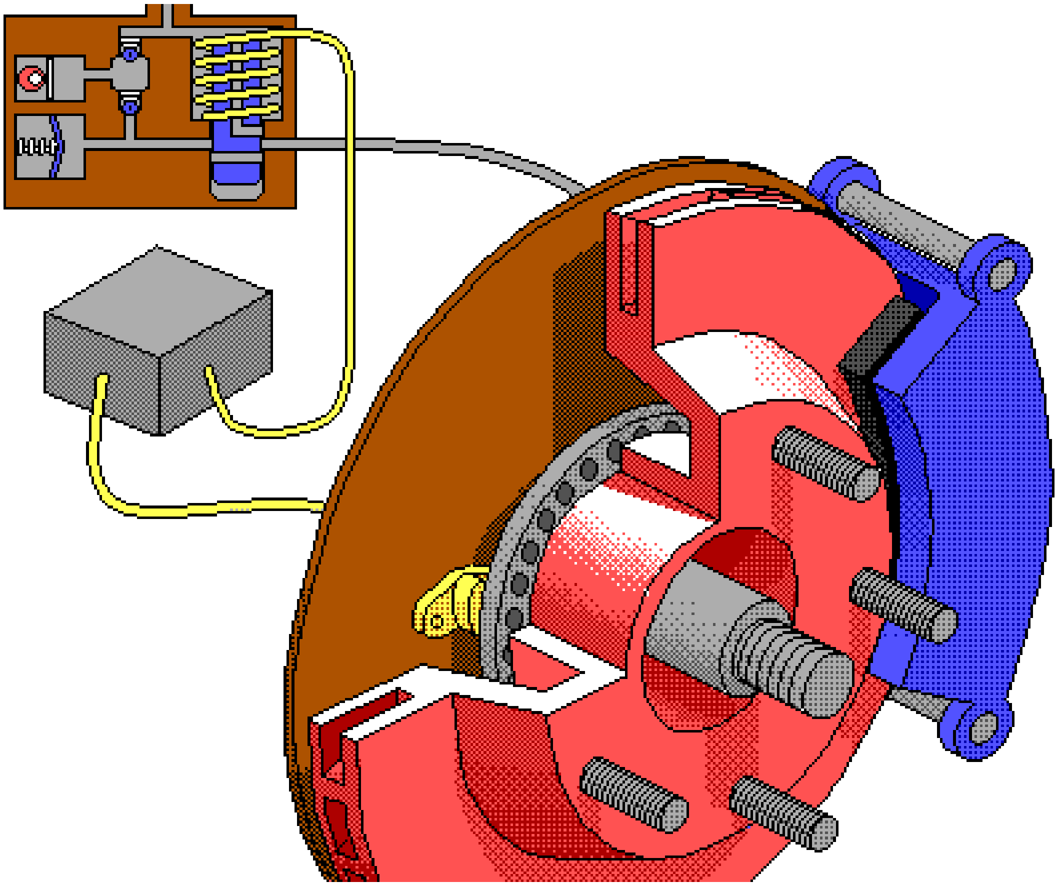
Anti-Lock Braking System



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Anti-lock Brake Systems (ABS)

Originally developed for aircraft, ABS basically works by limiting the pressure to any wheel which decelerates too rapidly. This allows maximum stopping force to be applied without brake lockup (skidding). If standard brakes are applied too hard, the wheels "lock" or skid, which prevents them from giving directional control. If directional control (steering) is lost, the vehicle skids in a straight line wherever it is going. ABS allows the driver to steer during hard braking, which allows you to control the car much better. In the old days, drivers had to know how to "pump" the brakes or sense the lockup and release foot pressure in order to prevent skidding. This meant that if only one wheel lost traction and started to skid, the driver would have to reduce braking force to prevent a skid. The advantage of ABS is that the brakes on the wheels with good traction can be used to the fullest possible amount, even if other wheels lose traction.

In operation, the wheelspeed sensors at each wheel send electronic pulse signals to the control unit. If wheel lockup (rapid deceleration) is detected during brake application, the computer signals the valve unit to limit the hydraulic pressure to the wheel cylinder. This is usually accomplished by diverting the fluid into a small reservoir. The fluid is later pumped out of the reservoir and returned to the main fluid reservoir when the brakes are not being applied.

The anti-lock brake system tests itself every time the vehicle is started and every time the brakes are applied. The system evaluates its own signals. If a defect is detected, the system then turns off, leaving normal braking unaffected.

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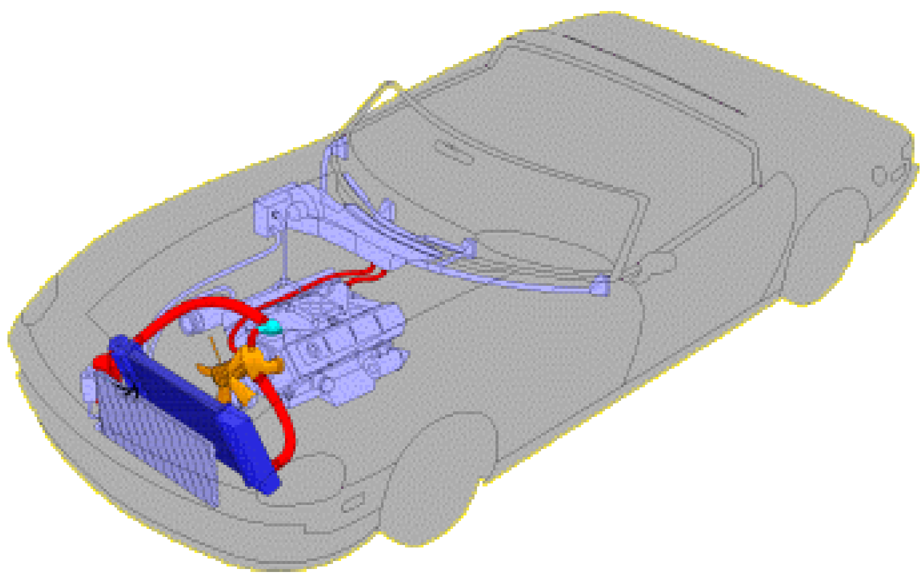
Cooling System Overview



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The Cooling System

The purpose of the engine's cooling system is to remove excess heat from the engine, to keep the engine operating at its most efficient temperature, and to get the engine up to the correct temperature as soon as possible after starting. Ideally, the cooling system keeps the engine running at its most efficient temperature no matter what the operating conditions are.

As fuel is burned in the engine, about one-third of the energy in the fuel is converted into power. Another third goes out the exhaust pipe unused, and the remaining third becomes heat energy.

A cooling system of some kind is necessary in any internal combustion engine. If no cooling system were provided, parts would melt from the heat of the burning fuel, and the pistons would expand so much they could not move in the cylinders (called "seize").

The cooling system of a water-cooled engine consists of: the engine's water jacket, a thermostat, a water pump, a radiator and radiator cap, a cooling fan (electric or belt-driven), hoses, the heater core, and usually an expansion (overflow) tank.

Fuel burning engines produce enormous amounts of heat; temperatures can reach up to 4,000 degrees F when the air-fuel mixture burns. However, normal operating temperature is about 2,000 degrees F. The cooling system removes about one-third of the heat produced in the combustion chamber.

The exhaust system takes away much of the heat, but parts of the engine, such as the cylinder walls, pistons, and cylinder head, absorb large amounts of the heat. If a part of the engine gets too hot, the oil film fails to protect it. This lack of lubrication can ruin the engine.

On the other hand, if an engine runs at too low a temperature, it is inefficient, the oil gets dirty (adding wear and subtracting horsepower), deposits form, and fuel mileage is poor-- not to mention exhaust emissions! For these reasons, the cooling system is designed to stay out of the action until the engine is warmed up.

There are two types of cooling systems; liquid cooling and air cooling. Most auto engines are cooled by the liquid type; air cooling is used more frequently for airplanes, motorcycles and lawnmowers.

Liquid cooled engines have passages for the liquid, or coolant, through the cylinder block and head. The coolant has to have indirect contact with such engine parts as the combustion chamber, the cylinder walls, and the valve seats and guides. Running through the passages in the engine heats the coolant (it absorbs the heat from the engine parts), and going through the radiator cools it. After getting "cool" again in the radiator, the coolant comes back through the engine. This business continues as long as the engine is running, with the coolant absorbing and removing the engine's heat, and the radiator cooling the coolant.

A cooling system pressure tester is used to check the pressure in the cooling system, which allows the mechanic to determine if the system has any slow leaks. The leak can then be found and fixed before it causes a major problem.

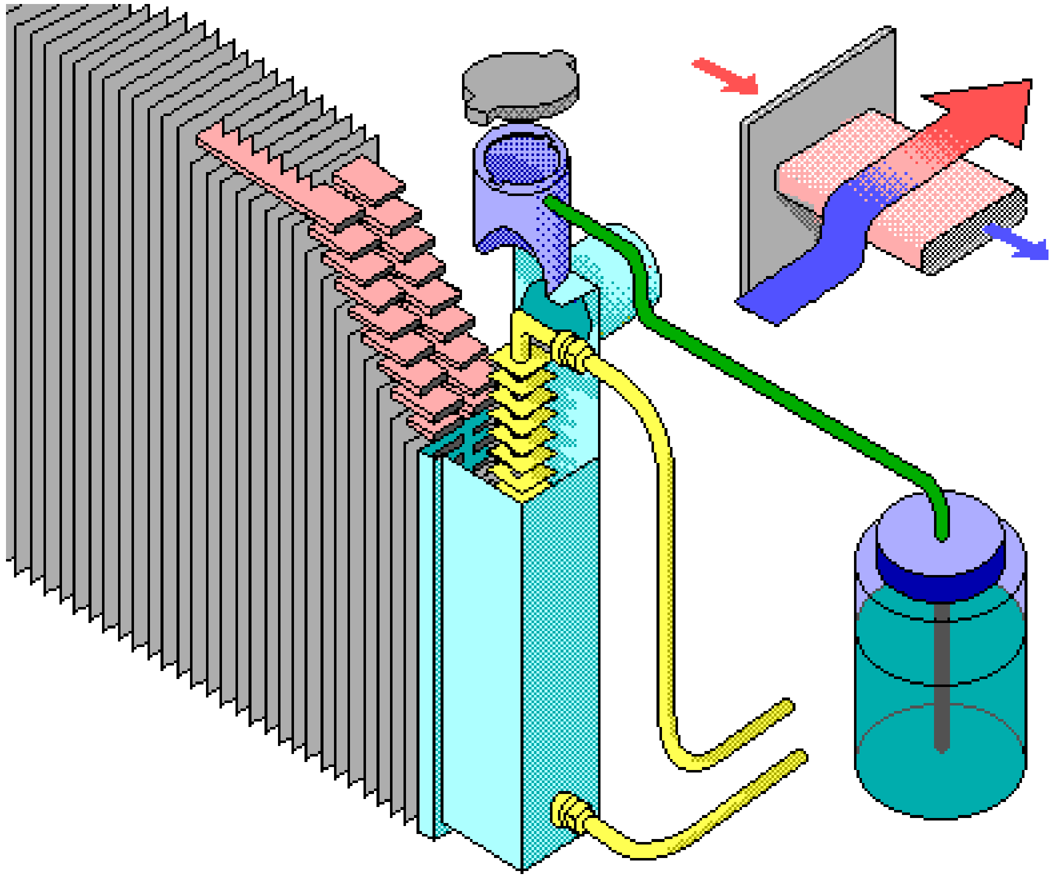
The Heater Core

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.

Cooling System Operation



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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 "endcaps" 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 airstream 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:**

- 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.
- 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!
- 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.
- Check the overflow tank coolant level. If it's empty, the radiator is probably low on coolant.
- 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.
- 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.**
- 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.

Water Pump

Water pumps come in many designs, but most include a rotating impeller, which forces the coolant through the engine block. In most rear wheel drive cars, the fan is installed on the end of the water pump shaft. Many water pumps have a spring-loaded seal to avoid leakage of water around the pump shaft. Modern pumps are fitted with pre-packed ball bearings, which are sealed at each end to eliminate the need for lubrication.

Impeller type water pumps must turn rapidly to be efficient, and worn or loose drive belts can permit slippage which is not easily detected.

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.

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.

Cooling Fans

The reason the coolant goes into the radiator is to allow air to pass through it and cool the coolant. When you are driving fast enough, the air rushes through the grille of the car and passes through the radiator core. If you aren't driving fast enough to push air through the radiator, then the fan will pull the air through.

The fan improves cooling when you are driving at slow speeds, or if the engine is idling. It is usually mounted on the water pump shaft, and is turned by the same belt that drives the water pump and the alternator, although it can be mounted as an independent unit. Most independently mounted fans are electric.

Belt Powered Fans

The fan's activity is not always necessary, and it takes power from the engine to spin. For this reason a thermostatic control, or fan clutch, is often used to reduce drive torque when it isn't needed (variable-speed fan). A different type of fan uses centrifugal force to move its flexible plastic blades, by flattening them when the engine rpm is high (flexible-blade fan). The less angle the blade shave, the less power they use. The idea of these units is to save horsepower and reduce the noise the fan makes.

A fan can have from four to six blades to suck the air through the radiator. Often the radiator has a shroud for the fan to keep it from recirculating the same hot air that has collected behind the radiator. Many fans have irregularly spaced blades to reduce resonant noise.

Electric Fans

Front-wheel drive engines mounted transversely usually use electric fans to cool the engine. The radiator is located in the usual place, but an electric motor drives the fan. A thermostatic switch is used to turn the fan on and off at predetermined temperature settings, which it senses. The exception to this is air conditioning. If you turn on the air conditioner, you bypass the thermostatic switch, and the fan runs continuously. If you turn off the air conditioner, the thermostatic switch is re-activated, and goes back to turning the fan on and off, according to its instructions. Many cars have one electric fan for normal cooling and a separate one just for when the air conditioner is on.

There are some really nice features about the electric fan. The nicest feature is that you don't have to keep an eye on the treacherous old fan belt -- there isn't one, so you don't have to worry about its health and fitness. It's also quieter, and less of a power drain on the engine. They also help your engine by continuing to cool it after it's turned off.

V-Belt (Fan Belt)

The fan (drive) belt wedges neatly into the different pulley grooves. The belt uses the tension and friction to turn the auxiliary devices.

The fan belt is usually V-shaped, so it is also called a V-belt. The fan belt friction comes from the sides of the belt and the sides of the pulley grooves to transmit power from one pulley to the other through the belt. Since the sides of the belt are used for transmission of power, the sides have very large surface areas. The reason that the belt does not slip is because of the wedging action of the belt as it curves into the pulley grooves.

Because your belts are so essential to so many parts of your engine, it is a very good idea to periodically check their condition. Check for cracking, splitting, or fraying, especially before summer. Also, check the tightness of the belt and have it adjusted according to your owner's manual specifications. Belts have a tendency to loosen with use. On the other hand, you don't want the belt to be too tight, or it will put too much pressure on the accessory bearings and cause them to die an early death. If a belt is over three years old, have it replaced even if it looks good.

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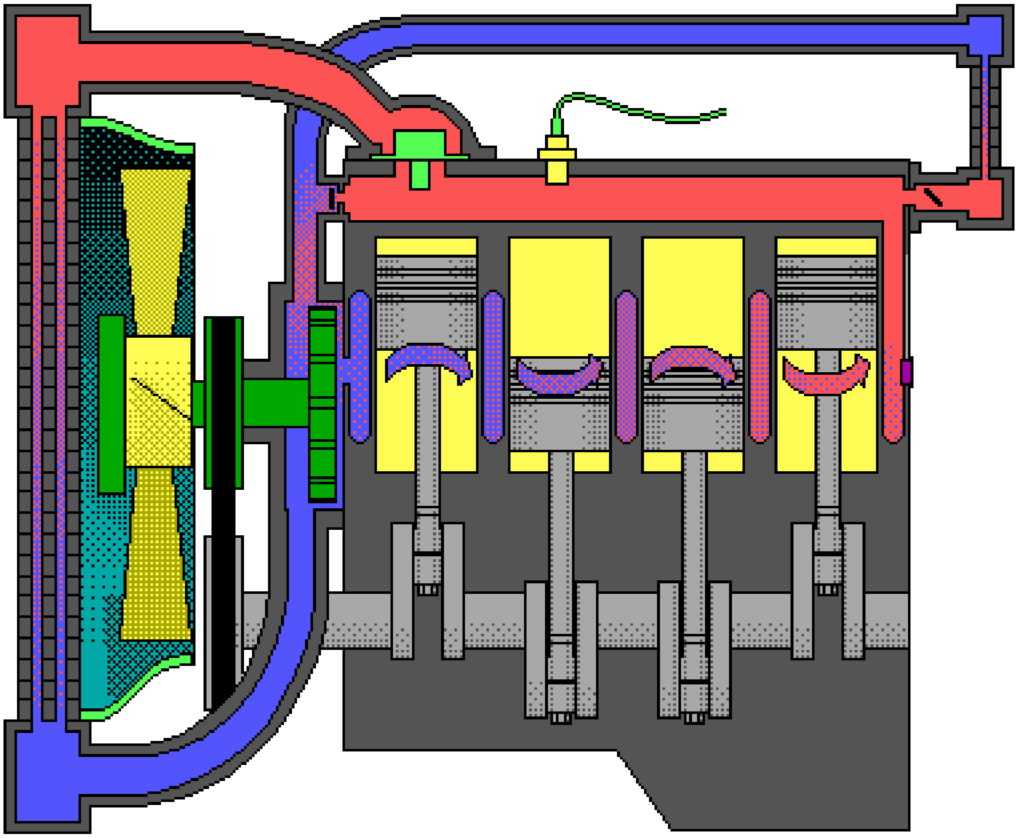
Coolant Flow Radiator And Engine Block



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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.

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.

Water (Coolant) Jackets

When our bodies feel cold, we put on a jacket. Our car engines wear permanent jackets for the opposite reason-- to keep cool!

The water jacket is a collection of passages within the block and head. These passages let the coolant circulate around the "hot spots" (valve seats and guides, cylinder walls, combustion chamber, etc.) in order to cool them off.

The engine block is actually manufactured in one piece with the water jackets cast into the block and cylinder head. At normal operating temperature, the water pump forces the coolant through the head gasket openings and on into the water jackets in the cylinder head. It flows around in there, cooling everything off by absorbing the heat. After doing its thing, the coolant flows through the upper hose to the radiator where it releases the heat. Then, the water pump sends it back down into the engine's water jackets to continue the cooling process.

On the sides of the engine are "freeze" or "expansion" plugs, which are sheet metal plugs pressed into a series of holes in the block. These are designed to hold the pressure of the cooling system, but to pop out if the coolant in the block ever freezes.

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.

The Fan Clutch

The fan clutch is a small fluid coupling with a thermostatic device that controls a variable-speed fan. The fan clutch ensures that the fan will rotate at just the right speed to keep the engine from overheating, and reduces drive to the fan when it is no longer needed.

The fan clutch has a fluid coupling partly filled with silicone oil designed for just that purpose. If the temperature of the air passing through the radiator rises, the heat alerts a bimetal coil spring to "uncoil" or expand. When it expands, it allows just a little more oil to enter the fluid coupling, so the fluid coupling starts to rotate the fan. If the air coming through the radiator is cool, the opposite happens; the coil spring contracts, the oil leaves the fluid coupling and the fan slows. Slowing the fan when it is not needed reduces fuel consumption, makes less noise and saves engine power.

Sometimes a flat bimetal strip spring is used instead of a coil spring; it bows out and in when the temperature rises and drops, letting oil in and out of the fluid coupling.

Freeze Plugs (Expansion Plugs)

Freeze plugs (also called "blind" or "expansion core" plugs) are small steel plugs used to seal the holes in the engine block and head made in casting. They expand and flatten as they are driven into place, and make a tight seal. These are designed to hold the pressure of the cooling system, but to pop out if the coolant in the block ever freezes.

If you have a leak in your cooling system, freeze plugs are one of the areas to have checked.

Temperature Sending Units

Since it is critical for you to keep an eye on the temperature of the coolant in your cooling system at all times, your car will have either a gauge or a warning light located on the instrument panel or dashboard (see temperature gauge). The question is, how does the information about your coolant get to the gauge? It gets there, or is sent by the temperature sending unit.

The temperature sending unit is a device that is placed so that it can determine the temperature of the engine coolant. Simply put, its resistance to electricity changes with increases and decreases in the temperature of the coolant. The electric resistance changes control the movement of the indicator needle on the temperature gauge. If you have an indicator light, or lights, these changes will cause the bulb to be connected to the battery if the temperature of your coolant gets too high. If this happens, the light goes on.

There are two types of sending units. One type uses a Bourdon tube instrument, a capillary tube filled with a special gas, and a capsule, or bulb. The other type uses an electric sender receiver.

The Bourdon tube type works by having one end of the tube attached to the gauge fitting, and the free end fastened to the needle indicator. A Bourdon tube is a round, hollow metal tube. Putting pressure on the hollow end causes it to try to straighten, so that the other end moves the needle on the gauge. Because it is placed in an engine water jacket, the pressure from the coolant temperature causes it to move, which, in turn forces the other end to move the gauge needle. When the coolant cools, the lack of pressure allows the needle to swing back to cold on the gauge.

The electric sender receiver type has a bimetal thermostat in the dashboard. This thermostat is linked to the gauge needle, so that when the engine gets warmer and passes more current, the thermostat, getting hotter itself, bends. When the thermostat bends, it moves the gauge needle, which indicates that the coolant temperature is rising. As it cools off, the thermostat "unbends" again, and the needle drops back to the cold indicator.

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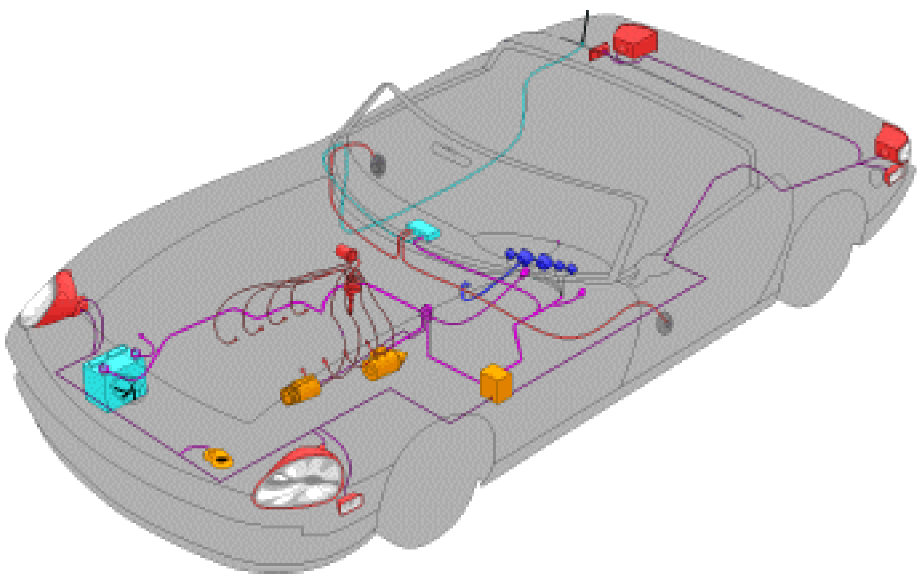
Electrical System Overview



Below is an explanation of this system's operation

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- Click Here For A Detailed Discussion Of The Ignition System

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The Electrical System (An Overview)

When the automotive industry was in its infancy, it used electricity only to ignite the fuel inside the engine. By the late 1920's, the electric starter replaced the hand crank, electric headlights made acetylene lamps obsolete and the braying of the electric horn drowned out the squeak of the hand-squeezed air horn. Today, an automobile requires an elaborate electrical system of circuits just to produce, store, and distribute all the electricity it requires simply for everyday operation.

The first major component in the electrical system is the battery. The battery is used to store power for starting, and for running auxiliary devices such as clocks, radios and alarms when the engine is off. The next major component is the starter motor, which is used to start the engine. The third component is a charging device powered by the engine, known as the alternator. It powers the electrical system when the car is running, and restores the charge within the battery. With these basic components, the car maintains its supply of electricity. A device called the voltage regulator keeps the power level stabilized, and the fuse box keeps minor problems from becoming major ones.

Many different auxiliary electrical devices are used in modern cars, such as: radios, cellular phones, rear window defrosters and electric door locks, as well as a vast array of motors powering everything from the moonroof on down.

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.

Starter

The starter converts electricity to mechanical energy in two stages. Turning on the ignition switch releases a small amount of power from the battery to the solenoid above the starter. This creates a magnetic field that pulls the solenoid plunger forward, forcing the attached shift yoke to move the starter drive so that its pinion gear meshes with the engine's crankshaft flywheel. When the plunger completes its travels, it strikes a contact that permits a greater amount of current to flow from the battery to the starter motor. The motor then spins the drive and turns the meshed gears to provide power to the crankshaft, which prepares each cylinder for ignition. After the engine starts, the ignition key is released to break the starting circuit. The solenoid's magnetic field collapses and the return spring pulls the plunger back, automatically shutting off the starter motor and disengaging the starter drive.

When the starter is not in use, the drive unit is retracted so that its pinion is disengaged from the flywheel. As soon as the starter is activated, the forward movement of the solenoid plunger causes the shift yoke to move the drive in the opposite direction and engage the pinion and flywheel. The pinion is locked to its shaft by a clutch that unlocks if the engine starts up and the flywheel begins turning the pinion faster than its normal speed. By allowing the pinion to spin freely for a moment, the clutch protects the motor from damage until the drive is retracted.

Alternator or Generator

The alternating-current generator, or alternator, is the electrical system's chief source of power while the engine is running. Its shaft is driven by the same belt that spins the fan. It converts mechanical energy into alternating-current electricity, which is then channeled through diodes that alter it to direct current for the electrical system and for recharging the battery.

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.

Main Lighting Switch

The main lighting switch (sometimes called the headlight switch) is the heart of the lighting system. It controls the headlights, parking lights, side marker lights, taillights, license plate light, instrument panel lights, and interior lights. Individual switches are provided for special purpose lights such as directional signals, hazard warning flashers, back up lights, and courtesy lights. The main lighting switch may be of either the "push-pull" or "push-pull with rotary contact" types. A typical switch will have three positions: off, parking, and headlamps. Some switches also contain a rheostat to control the brightness of the instrument panel lights. The rheostat is operated by rotating the control knob, separating it from the push-pull action of the main lighting switch.

When the main lighting switch completes the circuit to the headlamps, the low beam lights the way for city driving and for use when meeting oncoming traffic on the highway. When the dimmer switch is actuated, the single filament headlamps go "on," along with the high beam of the two filament headlamps. The next actuation of the dimmer switch returns the headlighting system to low beams only on the two filament lamps. Some cars are equipped with an electronic headlight dimming device, which automatically switches the headlights from high beam to low in response to light from an approaching vehicle or light from the taillight of a vehicle being overtaken. The dimmer switch in the automatic headlamp dimming system is a special override type. It is located in the steering column as part of a combination dimmer, horn, and turn signal switch. The override action occurs when a slight pull toward the driver on the switch lever provides high beam headlights regardless of the amount of light on the sensor-amplifier.

For some years there has been discussion about the advantages of a polarized headlight system. Such a system comprises headlights which produce polarized light in a particular plane. The windscreens of all cars would be fitted with polarizing glass, which would be oriented so that glare from an approaching vehicle would be essentially eliminated, while the forward vision would still be kept at the present levels. The advantages the system appear attractive, but the practical problems of making the transition are very great, since it would not be practical to convert all existing vehicles to this type of lighting. Also, any benefits would only be marginal because glare itself is not a frequent cause of accidents. However, many cars now have refracting or colored glass to cut down on glare.

Due to recent legislation, newer cars in Texas with the dimmer switch mounted on the steering column will have to be refurbished with standard floor-mounted dimmers. Too many Aggies are being found in the ditch with their legs caught in the steering wheel.

Directional Signal Switch

The directional signal switch is installed just below the hub of the steering wheel. A manually controlled lever projecting from the switch permits the driver to signal the direction in which he wants to turn. Moving the switch handle down will light the "turn signal" lamps on the left front and left rear of the car, signaling a left turn. Moving the switch upward will light the turn signal lamps on the right (front and rear), signaling a right turn. With the switch in a position to signal a turn, lights are alternately turned "on" and "off" by a turn signal flasher. Incorporated in the directional signal switch is a "lane change switch mechanism." This feature provides the driver the opportunity to signal a lane change by holding the turn lever against a detent, then releasing it to cancel the signal immediately after the maneuver is completed.

Stoplight Switch

In order to signal a stop, a brake pedal operated "stoplight switch" is provided to operate the vehicle's stop lamps. In addition to lighting the conventional rear lights, the switch also operates the center high-mounted stop lamp, that became mandatory on later models. Cruise control equipped vehicles may also utilize a vacuum release valve. In this case, both the vacuum release valve and the stoplight switch are actuated by movement of the brake pedal.

Horn

The car horn on passenger cars provides the driver with a means of sounding an audible warning signal. The horn electrical circuit generally includes: battery, fuse or fusible link, horn relay, horn(s), steering column wiring harness, horn switch, and body sheet metal. Often, a cadmium plated screw is used to ground the horn to the body of the vehicle. Horns usually are located in the forward part of the engine compartment or in the front fender well. The horn switch is built into the steering wheel or incorporated into the multi-functional switch lever, which includes turn signal and dimmer switch.

Electricity At Rest

The ancient Greeks had a word for it. Records show that as early as 600 BC the attractive properties of amber were known. Thales of Miletus (640-546 BC), one of the "seven wise men" of ancient Greece, is credited with having observed the attraction of amber for small fibrous materials and bits of straw. Amber was used by these people, even as it is now, for ornamental purposes. Just as the precious metals had their names of gold and silver, so amber had its name: "electron." It was later shown that the same effect can be obtained by rubbing a rod of glass or hard rubber with a handkerchief. Many other nonmetallic materials are found to have this property, which is known as "static electricity."

All electrified materials behave either as glass or rubber. Glass has a "positive" charge and hard rubber has a "negative" charge. If you electrify two strips of hard rubber by rubbing them with fur, they will repel each other. Two glass rods will behave the same way. But, if you electrify a rod of rubber and suspend it near an electrified rod of glass, they will attract each other. One of the most important laws of electricity is "Bodies with similar charges repel each other; bodies with opposite charges attract each other." A positive charge is designated with a (+); a negative charge by the sign (-).

Although people have controlled electricity for many years, no one can explain exactly what it is. Many different theories have been given as to the nature of electricity through the years, but the modern one is the "Electron theory." In short, the electron theory proposes that all matter consists of tiny particles called molecules. These molecules are made up of two or more smaller particles called atoms. The atoms are then divided into smaller particles called protons, neutrons, and electrons. These particles are all the same in matter, whether in gas, liquid, or solid. The different properties or characteristics of the matter take form according to the arrangement and numbers of these particles which make up the atom. The proton has a natural positive charge of electricity; the electron has a negative charge; and the neutron has no charge at all, but just adds weight to the matter.

Protons and neutrons form the central core of the atoms about which the electrons rotate. The electrons carry small negative charges of electricity, which neutralize the positive charges of the protons. The simplest atom of all is the hydrogen atom. It consists of one positive proton and one negative electron. Other atoms, such as those forming copper, iron, or silicon, are much more complicated. Copper, for example, has 29 electrons circling about its nucleus in four different orbits. While protons are much smaller than electrons in size, they contain the bulk of the mass of every atom. One proton, for example, weighs nearly two thousand times as much as an electron. The electrons therefore are light particles or objects around a small but relatively heavy nucleus.

It is difficult to conceive the size of the atom. Research by physicists has established that the mass on one electron is about .000,000,000,000,000,000,000,000,000,911 of a gram. If you assume that one proton in a hydrogen atom is the size of a baseball in Kansas City, then the electron would have an orbit which would reach from the Atlantic coast to the Pacific. Along with the extremely small size of electrons and protons, they are separated by relatively vast distances.

Conductors and Insulators

Not all substances are good conductors of electricity. As a general rule, metals are good conductors whereas nonmetals are poor conductors. The poorest of conductors are commonly called "insulators," or "nonconductors." Aluminum, copper, gold, iron, mercury, nickel, platinum, and silver are examples of good conductors. Amber, glass, mica, paper, porcelain, rubber, silk, and sulfur are all nonconductors. The difference between a conductor and an insulator is that in a conductor, there are free electrons, whereas in an insulator, all of the electrons are tightly bound to their respective atoms. In an uncharged body, there are an equal number of positive and negative charges. In metals, a few of the electrons are free to move from atom to atom, so that when a negatively charged rod is brought to the end of the conductor, it repels nearby free electrons in the conductor, causing them to move. They in turn repel free electrons in front of them, giving rise to a flow of electrons all along the conductor. There are a large number of substances that are neither good conductors of electricity nor good insulators. These substances are called "semi-conductors." In them, electrons are capable of being moved only with some difficulty, i.e., with considerable force.

Electricity In Motion (Electrical Current)

When an electric charge is at rest it is spoken of as "static electricity," but when it is in motion, it is referred to as an "electric current." In most cases, an electric current is described as a flow of electric charge along a conductor. To make an electron current flow continuously along a wire, a continuous supply of electrons must be available at one end and a continuous supply of positive charges at the other. This is like the flow of water through a pipe: to obtain a continuous flow, a continuous supply of water must be provided at one end and an opening for its escape into some receptacle at the other. The continuous supply of positive charge at the one end of a wire offers a means of escape for the electrons. If this is not provided, electrons will accumulate at the end of the wire and the repulsion back along the wire will stop the current flow.

The rate at which the free electrons drift from atom to atom determines the amount of electrical current. In order to create a drift of electrons through a circuit, it is necessary to have an electrical pressure, or "voltage." Electric current, then, is the flow of electrons. The more electrons in motion, the stronger the current. In terms of automotive applications, the greater the concentration of electrons at a battery or generator terminal, the higher the pressure between the electrons. The greater this pressure (voltage) is, the greater the flow of electrons.

In modern electric car designs, the drive motors are often used as the brakes also, allowing them to switch over into performing as generators, which charge the batteries with the energy generated.

Electromagnetic Principles

The connection between electricity and magnetism was made by Oersted, a Danish scientist, in 1820. He had frequently demonstrated the nonexistence of a connection between electricity and magnetism. His usual procedure was to place a current-carrying wire at right angles to, and directly over, a compass needle to show that there was no effect of one on the other. One occasion, at the end of his lecture, he placed the wire parallel to the compass needle and saw the needle move to one side. When he reversed the current in the wire, the needle, to his amazement, deviated in the opposite direction. Thus a great discovery concerning electromagnetism was made quite by accident.

There is no actual knowledge as to why some materials have magnetic properties and others have not. The "electron theory" generally is accepted as the best explanation of magnetism. It is also known as the "domain theory."

According to the theory, an electron moving in a fixed circular orbit around the proton creates a magnetic field with the north pole on one side of the orbit and a south pole on the other side. It is assumed that the orbiting electron carries a negative charge of electricity, which is the same as electrical current flowing through a conductor. Current flow, then, is from negative to positive. When a number of magnetized orbiting electrons exist in a material, they interact with each other and form "domains," or groups of atoms having the same magnetic polarity. However, these domains are scattered in random patterns throughout and the material is, in effect, demagnetized. Under the influence of a strong external magnetic field, domains become aligned and the total material is magnetized. The strength of its magnetic field depends on the number of domains that are aligned. In magnetic substances, the domains align themselves in parallel planes and in the same direction when placed in a magnetic field. This arrangement of the electron-created magnets produces a strong magnetic effect.

If you stroke a piece of hardened steel with a magnet, the piece of steel itself will become a magnet. (Steel railroad tracks laid in a north-to-south direction become magnetized because they lie parallel to the magnetic lines of the earth.) Much stronger magnets and magnetic fields can be produced by electrical means. Placing a piece of steel in any strong magnetic field will cause it to become magnetized.

A magnetized field surrounds any conductor carrying an electrical current. The discovery of that fact resulted in the development of much of our electrical equipment. The "field of force" is always at right angles to the conductor. Since the magnetic force is the only force known to attract a compass needle, it is obvious that a flow of electric current produces a magnetic field similar to that produced by a permanent magnet. Not only is the field of force at right angles to the conductor, but the field also forms concentric circles about the conductor. When the current in the conductor increases, the field of force is increased. Doubling the current will double the strength of the field of force.

The Left-Hand Rule (Magnetic Effect)

Oersted's experiment has been interpreted to mean that "around every wire carrying an electric current there is a magnetic field." The direction of this field at every point, like that around a bar magnet, can be mapped by means of a small compass or by iron filings. If a wire is mounted vertically through a hole in a plate of glass or other suitable nonconductor, and then iron filings are sprinkled on the plate, there will be a lining-up of the filings parallel to the magnetic field. The result shows that the magnetic lines of force or "lines of induction" are concentric circles whose planes are at right angles to the current.

The "left-hand rule" used in electromagnetism can always be relied upon to give the direction of the magnetic field due to an electron current in a wire. Derived from experiment, the rule states: "if the current-carrying wire were to be grasped in the left hand, the thumb pointing in the direction of the electron current, negative (-) to positive (+), the fingers will point in the direction of the magnetic induction."

Magnetic Properties of A Solenoid

Shortly after Oersted discovered the magnetic effect of a current-carrying wire, Ampere found that a loop or coil of wire (a single loop or a coil of several turns of wire) acted as a magnet. A coil of wire of this kind is sometimes referred as a "solenoid," or as a "helix." The magnetic lines of force in a solenoid are such that one side or end of the coil acts like a "N" magnetic pole and the other side or end like a "S" magnetic pole. At all points in the region around a coil of wire carrying a current, the direction of the magnetic field, as shown by a compass, can be predicted by the left-hand rule. Inside each loop or turn of wire, the lines point in one direction, whereas outside they point oppositely. Outside the coil, the lines go the same way they do about a permanent bar magnet, whereas inside the coil they go from "S" to "N". Not only does one coil of wire act like a magnet, but two coils will demonstrate the repulsion and attraction of like and unlike poles.

Electronics (Solid State)

Electronics refers to any electrical component, assembly, circuit, or system that uses solid state devices. "Solid state" means that these devices have no moving parts, other than electrons. Examples of solid state devices include semiconductor diodes, transistors, and silicon controlled rectifiers. These and many more have broad application in automotive electronics.

Semiconductors and Diodes

Semiconductors are made from material somewhere between the ranges of conductors and nonconductors. Semiconductors, basically, are designed to do one of three things: (1) stop the flow of electrons, (2) start the flow of electrons, or (3) control the amount of electron flow. A semiconductor diode is a two-element solid state electronic device. It contains what is termed a "P" type material connected to a piece of "N" material. The union of the "P" and "N" materials forms a PN junction with two connections. The "anode" is connected to the P material; the "cathode" is connected to the N material. A diode is, in effect, a one-way valve. It will conduct current in one direction and remain non conductive in the reverse direction. When current flows through the diode, it is said to be "forward biased." When current flow is blocked by the diode, it is "reverse biased." When a diode is reverse biased, there is an extremely small current flow; actually, the current flow is said to be "negligible." When the P and N are fused together to form a diode, it can be placed in a circuit. The P material is connected to the positive side of the battery and the N material is connected to the negative side of the battery. Connected in this manner, current will flow. If connected in the reverse manner, current will not flow.

Transistors and Resistors

A transistor is a solid state device used to switch and/or amplify the flow of electrons in a circuit. A typical automotive switching application would be a transistorized ignition system in which the transistor switches the primary system off and on. An amplifying application could be in a stereo system where a radio signal needed strengthening.

A transistor is a three-element device made of two semiconductor materials. The three elements are called "emitter," "base," and "collector." The outer two elements (collector and emitter) are made of the same material; the other element (base) is different. Each has a conductor attached. The materials used are labeled for their properties: "P" for positive, meaning a lack of electrons. It has "holes" ready to receive electrons. "N" is for negative, which means the materials has a surplus of electrons. The movement of a free electron from atom to atom leaves a hole in the atom it left. This hole is quickly filled by another free electron. As this movement is transmitted throughout the conductor, an electric current is created from the negative to the positive. At the same time, the "hole" has been moved backward in the conductor as one free electron after another takes its place in a sort of chain reaction. "Hole flow" is from positive to negative. Current flow in a transistor, then, may be either electron movement or hole flow, depending on the type of material, and this determines the type of transistor it is as well.

In most 12 volt systems, a resistor is connected in series with the primary circuit of the ignition coil. During the cranking period, the resistor is cut out of the circuit so that full voltage is applied to the coil. This insures a strong spark during cranking, and quicker starting is provided. The starting circuit is designed so that as long as the starter motor is in use, full battery voltage is applied to the coil. When the starter is not cranking, the resistance wire is cut into the circuit to reduce the voltage applied to the coil. If the engine starts when the ignition switch is turned on, but stops when the switch is released to the run position, it can indicate that a resistor is bad and should be replaced.

At no time should the resistor be bypassed out of the circuit, as that would supply constant battery voltage and burn out the coil. The resistor and resistor wires should always be checked when the breaker points are burned, or when the ignition coil is bad.

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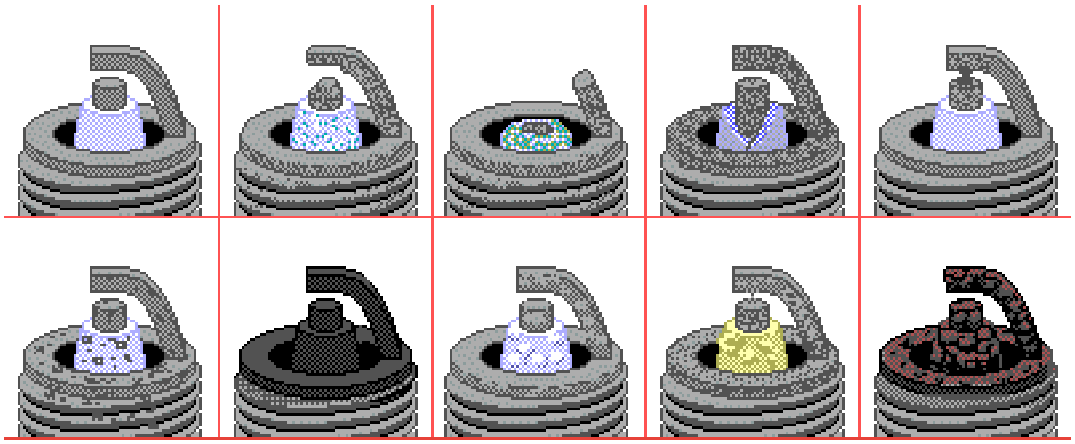
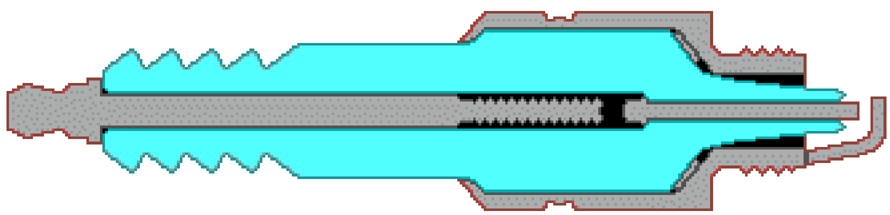
Spark Plugs Do Tell A Story!





Click on the graphic above for a description of each plug's condition.

Below is an overview of spark plug conditions and causes.

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Spark Plugs

A spark plug is a device, inserted into the combustion chamber of an engine, containing a side electrode and insulated center electrode spaced to provide a gap for firing an electrical spark to ignite air-fuel mixtures.

The high-voltage burst from the coil via the distributor is received at the spark plug's terminal and conducted down a center electrode protected by a porcelain insulator. At the bottom of the plug, which projects into the cylinder, the voltage must be powerful enough to jump a gap between the center and side electrodes through a thick atmosphere of fuel mixture. When the spark bridges the gap, it ignites the fuel in the cylinder.

Spark Plug Wear

The spark plugs ignite the fuel mixture in the cylinders by means of a burst of high-voltage electricity carried from the distributor. The ability of the spark to ignite the fuel is badly affected if the plugs are damaged or the spark gaps are abnormal. It is therefore important to examine used spark plugs closely and to clean them periodically. The gaps of old and new plugs should also be checked before installing them. There are three basic types of spark plug fouling: "carbon" fouling, "high speed" or "lead" fouling, and "oil/carbon" fouling.

Carbon fouling is caused from low-speed operation or a fuel mixture that is too rich. It causes missing or roughness and creates soft black soot that is easily removed. Lead fouling is caused by tetraethyl lead used in some fuels and by extended high speed operation. Lead compounds which are added to the gasoline have a bad effect on some spark plug insulators. At high temperatures, it is a good conductor and may give good results under light loads, but often fails under full loads and high combustion temperatures. In some cases, it is possible to run the engine at a speed just below the point where missing will occur; then, increase the speed (always keeping below the missing speed) to burn off the lead fouling. Lead fouling appears as a heavy, crusty formation, or as tiny globules.

The third type of fouling is found on engines that are so badly worn that excess oil reaches the combustion chamber past the piston ring, or the valve guides.

In all cases of fouling or wear, it is best to replace the plugs. To avoid having to replace plugs one at a time as they wear out, always replace the entire set, even though only one plug may be bad. Plugs should normally be replaced about every 12,000 miles.

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.

Ignition Circuit

The distributor is separated into three sections: the upper, middle, and lower. In the middle section, the corners of the spinning breaker cam strike the breaker arm and separate the points some 160 miles an hour. (standard ignition) High-voltage surges generated by the action of the coil travel to the rotor that whirls inside a circle of high-tension terminals in the distributor cap. At each terminal, current is transferred to wires that lead to the spark plugs. Two other devices - the vacuum advance and the centrifugal advance - precisely coordinate the functions of the points and the rotor assembly as the requirements of the engine vary.

An ignition circuit consists of two sub-circuits: the primary, which carries low voltage; and the secondary, which carries high voltage. The primary circuit, controlled by the ignition key, releases 12 volts of electricity from the battery or alternator through the coil to a set of breaker points in the lower part of the distributor, or to the relay in electronic ignition applications. When the points or relay are closed, current flows through the chassis back to the battery, completing the circuit. When the points or relay are open, the flow stops, causing a high-voltage surge to pass from the coil through a rotor in the top of the distributor to the spark plugs. Once the car has started, the voltage regulator protects the battery from being overcharged by the alternator. The condenser absorbs part of the low-voltage current when the points are open.

Computerized and Electronic Ignition

In an electronic ignition, a rotating reluctor and magnetic-pickup coil replace the traditional cam, breaker points and condenser in the distributors of cars equipped for electronic ignition. This system reduces the time between tune-ups. The high spots of the reluctor interrupt the magnetic field of the pickup coil and the permanent magnet. These interruptions, or pulses, are transmitted from the pickup to a nearby electronic control unit. There, the pulses signal a transistor to break the low-voltage sub-circuit and release high voltage from the coil to the spark plugs.

The short-lived electronic ignition system was a transition from the points and condenser system to the computerized ignition system. It came into widespread use in the mid-1970s, but there are still a few engines that use electronic ignition.

Starting Circuit

The starter circuit is activated when the ignition switch is turned on. This opens a second switch in the solenoid, permitting a second flow of electricity from the battery to the starter motor.

The engine cranking circuit is made up of a battery, starting motor, ignition switch, and electrical wiring. When the ignition switch is placed in the "start" position, the solenoid windings are energized and the resulting shift lever movement causes the drive pinion gear to engage the flywheel ring gear, and cranking takes place. When the engine starts, an overrunning clutch (part of the drive assembly) protects the armature from too much speed until the switch is opened. At this time, a return spring causes the pinion gear to disengage from the flywheel.

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.

Distributor Cap

As the rotor rotates inside the cap, it receives the high voltage from the ignition coil, then passes it to the nearest connection, which is a metal projection in the cap, which is connected to a spark plug.

The distributor cap should be checked to see that the sparks have not been arcing from point to point within the cap. The inside of the cap must be clean. The firing points should not be eroded, and the inside of the towers must be clean and free from corrosion.

Distributor Rotor

A distributor rotor is designed to rotate and distribute the high tension current to the towers of the distributor cap. The firing end of the rotor, from which the high tension spark jumps to each of the cap terminals, should not be worn. Any wear will result in resistance to the high tension spark. The rotor with a worn firing end will have to be replaced.

Rotors are mounted on the upper end of the distributor shaft. In this connection, the rotor must have a snug fit on the end of the shaft. On another design, two screws are used to attach the rotor to a plate on the top of the distributor shaft. Built-in locators on the rotor, and holes in the plate, insure correct reassembly. One locator is round; the other is square.

The rotor is driven directly by the camshaft, but is "advanced" (turned) by the centrifugal advance mechanism. Advancing the spark timing allows the engine to run efficiently. A vacuum advance is also fitted on some cars for the same reason.

Condenser

Primary current produces a magnetic field around the coil windings. This does not occur instantly, because it takes time for the current and the magnetic field to reach maximum value. The time element is determined by the resistance of the coil winding or the length of time the distributor contacts are closed. The current does not reach the maximum because the contacts remain closed for such a short time, and more so at higher engine speeds. When the breaker points begin to open, the primary current will continue to flow. This condition in a winding is increased by means of the iron core. Without an ignition condenser, the induced voltage causing this flow of current would create an arc across the contact points and the magnetic energy would be consumed in this arc. As a result, the contact points would be burned and ignition would not occur. The "condenser" prevents the arc by making a place for the current to flow. As a result of condenser action, the magnetic field produced and continued by the current flow will quickly collapse. It is the rapid cutting out of magnetic field that induces high voltage in the secondary windings. So, if the condenser should go bad, the high voltage needed to jump the gap at the spark plugs will not be possible. This could cause a no-start condition or a driving problem.

Breaker Point (Standard) Ignition

The ignition distributor makes and breaks the primary ignition circuit. It also distributes high tension current to the proper spark plug at the correct time. The distributor is driven at one half crankshaft speed on four cycle engines. It is driven by the camshaft. Distributor construction varies with the manufacturers, but the standard model is made of a housing into which the distributor shaft and centrifugal weight assembly are fitted with bearings. In most cases, these bearings are bronze bushings.

In standard ignition, the contact set is attached to the movable breaker plate. A vacuum advance unit attached to the distributor housing is mounted under the breaker plate. The rotor covers the centrifugal advance mechanism, which consists of a cam actuated by two centrifugal weights. As the breaker cam rotates, each lobe passes under the rubbing block, causing the breaker points to open. Since the points are in series with the primary winding of the ignition coil, current will pass through that circuit when the points close. When the points open, the magnetic field in the coil collapses and a high tension voltage is induced in the secondary windings of the coil by the movement of the magnetic field through the secondary windings.

The design is to provide one lobe on the breaker cam for each cylinder of the engine; i.e., a six cylinder engine will have a six lobe cam in the distributor; and an eight cylinder engine will have an eight lobe cam, so every revolution of the breaker came will produce one spark for each cylinder of the engine. However, on a four cycle engine, each cylinder fires every other revolution so the distributor shaft must revolve at one half crankshaft speed. After the high tension surge is produced in the ignition coil by the opening of the breaker points, the current passes from the coil to the center terminal of the distributor cap. From there, it passes down to the rotor mounted on the distributor shaft and revolves with it. The current passes along the rotor, and jumps the tiny gap to the cap electrode under which the rotor is positioned at that instant. This cap electrode is connected by high tension wiring to the spark plug. As the rotor continues to rotate, it distributes current to each of the cap terminals in turn.

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The Ignition System

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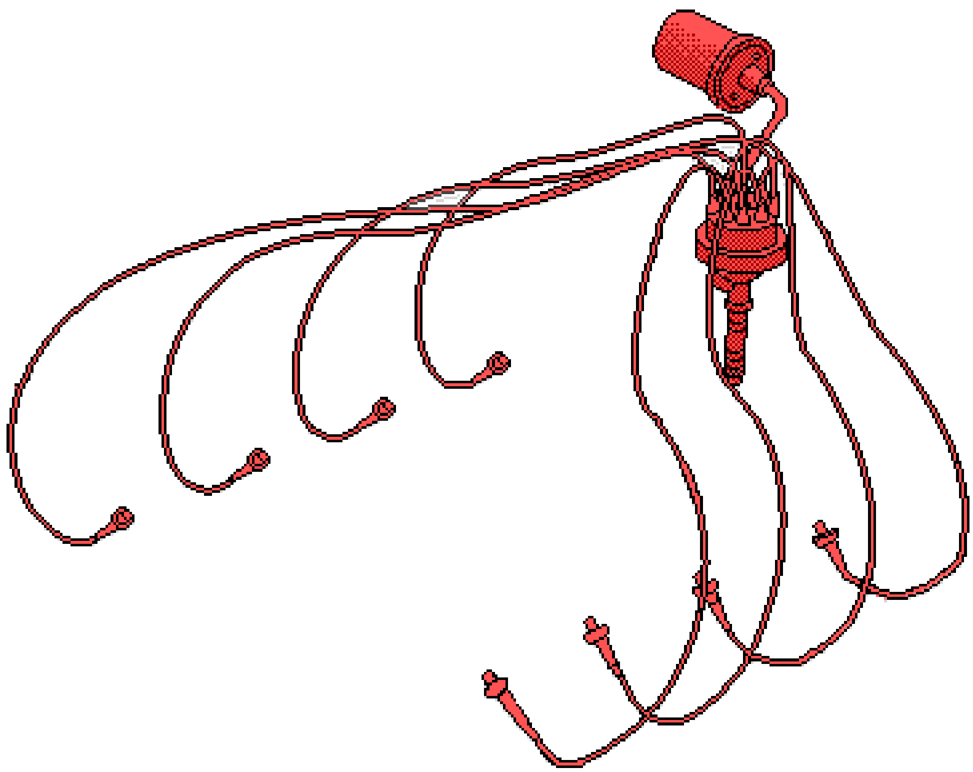

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- Ignition Coil
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- Starting Circuit
- Spark Plug Wires
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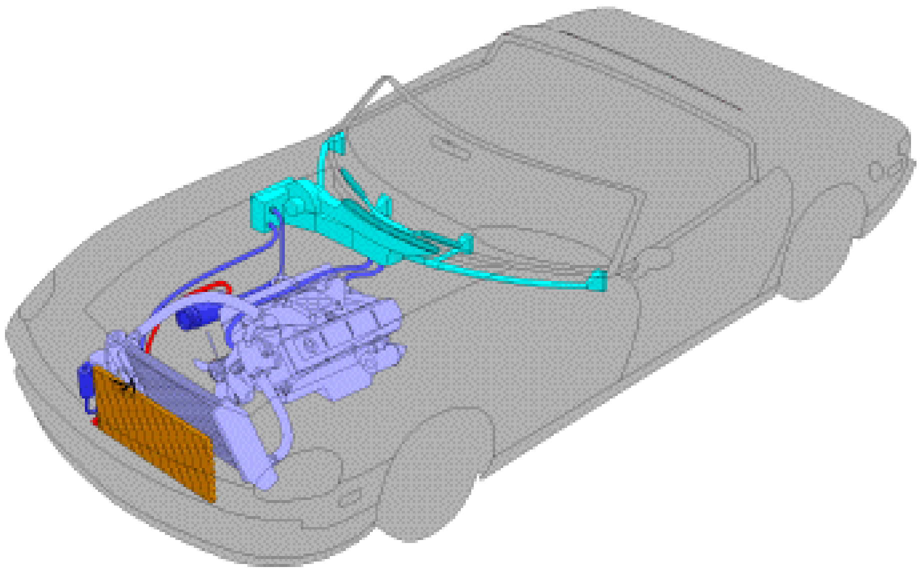
A/C And Heat Systems Overview



Below is an overview of this system's operation

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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.

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.

Relays

A relay is an electromagnetic device in which contacts are made and subsequently broken. An example of this would be your car's horn.

By natural law, the farther electrical current travels, the lower its voltage becomes. Your car horn has to be connected to the car battery in order to sound. The shortest distance between two points is a wire connecting your horn to your battery. The only problem with this arrangement is that connecting the two would give you a permanent horn blast when you turned the key in your ignition.

This is an unacceptable arrangement, so a relay is included in the connection. The relay stops the horn from sounding until you activate the relay by pressing the horn. The relay then allows the horn to connect to the battery, or complete the circuit, and it sounds. As soon as you stop pressing the horn, the relay breaks the connection, or circuit, and presto-- no more horn!

Relays, with switches, are used for most of the equipment that depends on the battery for an energy source. This includes headlights, taillights, radio, etc.

In 1922, a Model T was the first car equipped with a radio. In 1927, the first commercially produced car radio came on the scene.

A "relay" is any switching device operated by a low current circuit that controls opening and closing of another circuit of high current capacity. The purpose of the "cutout relay" is to prevent the battery from discharging through the generator when the engine is stopped or turning over slowly. A "field relay" connects the alternator field windings and voltage regulator windings directly to the battery.

Heater/AC Blower Motor

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

Air Ducts

The air ducts control the passage of hot or cold air into the interior of the car. They are operated by a control on the dash, either manually or automatically.

Controls

Most air conditioning/heating systems have three possible air settings. One is to recirculate the air that is in the car, a second is to use only air from the outside of the car, and a third is to mix some of the outside air with the air recirculating inside the car.

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.

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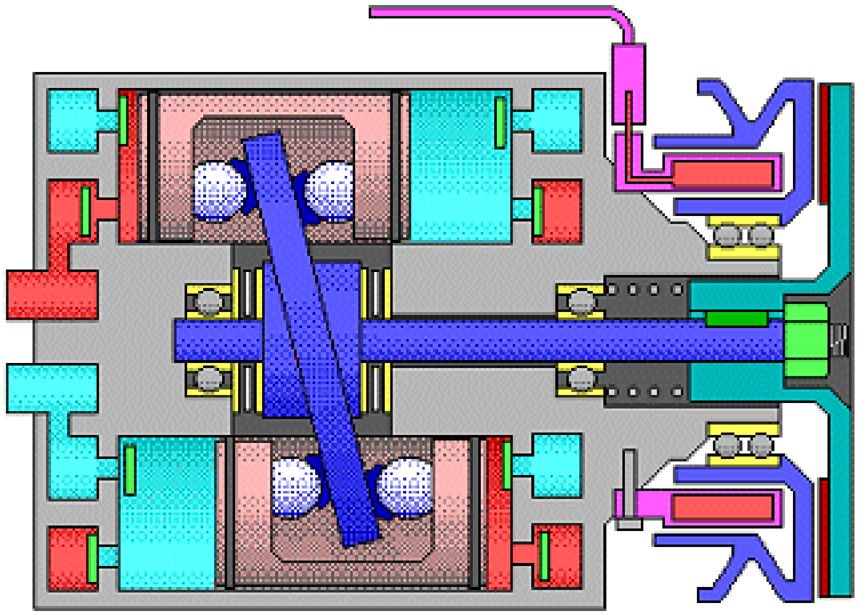
A/C Compressor Operation



Below is an overview of an A/C compressor and its operation

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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.

AC Compressor Drive Ring

Inside the air conditioner's refrigerant compressor is a drive ring made of a friction material that is mounted to both sides of the "swash" or "wobble" plate. As the swash plate rotates, the friction material pushes the ball bearings (mounted to the pistons) back and forth.

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.

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 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 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.

Discharge/Suction Service Valves

Discharge and suction service valves allow the air conditioning system to be emptied and filled. These valves also provide places where the system can be checked with pressure gauges.

Note: Some systems use a Schrader valve in place of the discharge and suction valves. This is a spring-loaded valve which looks rather like the valve in a tire.

The Compressor Relay

A capillary tube from a cycling switch lets the switch know what the temperature is in the evaporator. This switch turns the compressor on and off to keep the evaporator temperature at about 32 to 45 degrees F. The relay switch keeps moisture from freezing on the evaporator core.

Electric Air Conditioning Fan

Sometimes an extra electric fan is placed in front of the condenser to provide an extra flow of air during warm weather, or for times when the car has to idle for a long time. You activate and deactivate the air conditioning fan when you turn it on and off at the control panel.

Compressor Belt

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

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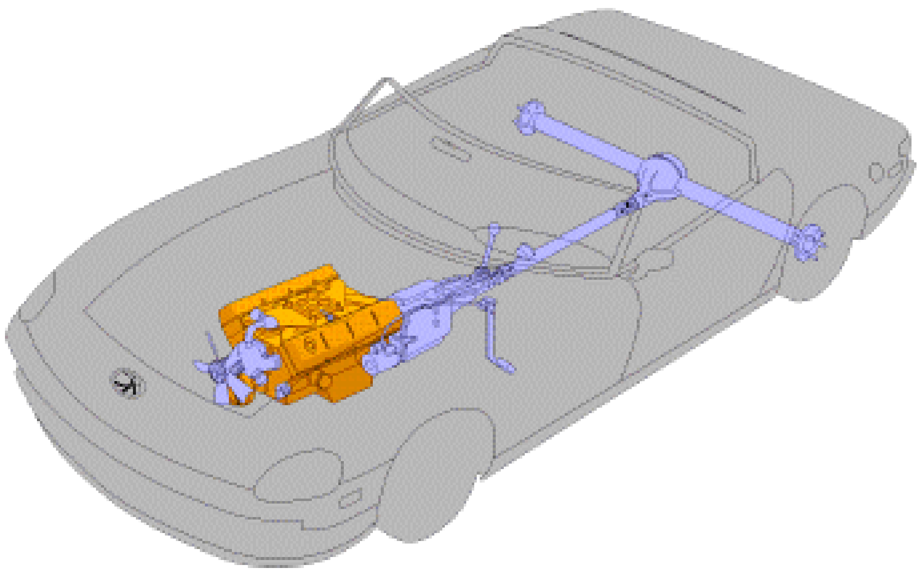
Engine Overview



Below is an overview of this system's operation

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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".

Horsepower

Horsepower is a unit of power for measuring the rate at which a device can perform mechanical work. Its abbreviation is hp. One horsepower was defined as the amount of power needed to lift 33,000 pounds one foot in one minute.

Oil Weights

Oil weight, or viscosity, refers to how thick or thin the oil Is. The temperature requirements set for oil by the Society of Automotive Engineers (SAE) is 0 degrees F (low) and 210 degrees F (high).

Oils meeting the SAE's low temperature requirements have a "W" after the viscosity rating (example: 10W), and oils that meet the high ratings have no letter (example SAE 30). An oil is rated for viscosity by heating it to a specified temperature, and then allowing it to flow out of a specifically sized hole. Its viscosity rating is determined by the length of time it takes to flow out of the hole. If it flows quickly, it gets a low rating. If it flows slowly, it gets a high rating.

Engines need oil that is thin enough for cold starts, and thick enough when the engine is hot. Since oil gets thinner when heated, and thicker when cooled, most of us use what are called multi-grade, or multi-viscosity oils. These oils meet SAE specifications for the low temperature requirements of a light oil and the high temperature requirements of a heavy oil. You will hear them referred to as multi-viscosity, all-season and all-weather oils.

When choosing oil, always follow the manufacturer's recommendation.

Gaskets

Gaskets and seals are needed in your engine to make the machined joints snug, and to prevent fluids and gasses (oil, gasoline, coolant, fuel vapor, exhaust, etc.) from leaking.

The cylinder head has to keep the water in the cooling system at the same time as it contains the combustion pressure. Gaskets made of steel, copper and asbestos are used between the cylinder head and engine block. Because the engine expands and contracts with heating and cooling, it is easy for joints to leak, so the gaskets have to be soft and "springy" enough to adapt to expansion and contraction. They also have to make up for any irregularities in the connecting parts.

Four-stroke Piston Cycle

In 1876, a German engineer named Dr. Otto produced an engine, that worked, using the four-stroke, or Otto cycle. "Four-stroke" refers to the number of piston strokes required to complete a cycle (a cycle being a sequence of constantly repeated operations). It takes two complete revolutions of the crankshaft to complete the cycle.

The first stroke is the intake stroke. The piston moves down the cylinder and creates a partial vacuum in the cylinder. A mixture of air and fuel is forced through the inlet valve into the cylinder by atmospheric pressure, now greater than the pressure in the cylinder. During this stroke, the exhaust valve stays closed.

The second stroke is the compression stroke. The piston moves up in the cylinder with both valves closed. The air and fuel mixture is compressed and the pressure rises.

The third stroke is the power stroke. Near the end of the compression stroke, the air and fuel mixture is ignited by an electric spark from the spark plug. The combustion that occurs causes a rise in temperature and enough pressure to force the piston down again.

Finally, on the fourth stroke, or exhaust stroke, the piston moves up again and forces the burned gases out of the cylinder and into the exhaust system. This cycle repeats itself the entire time the engine is running.

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.

Overhead Camshaft (OHC)

Some engines have the camshaft mounted above, or over, the cylinder head instead of inside the block (OHC "overhead camshaft" engines). This arrangement has the advantage of eliminating the added weight of the rocker arms and push rods; this weight can sometimes make the valves "float" when you are moving at high speeds. The rocker arm setup is operated by the camshaft lobe rubbing directly on the rocker. Stem to rocker clearance is maintained with a hydraulic valve lash adjuster for "zero" clearance.

The overhead camshaft is also something that we think of as a relatively new development, but it's not. In 1898 the Wilkinson Motor Car Company introduced the same feature on a car.

Double Overhead Camshaft(DOHC)

The double overhead cam shaft (DOHC) is the same as the overhead camshaft, except that there are two camshafts instead of one.

Overhead Valve (OHV)

In an overhead valve (OHV) engine, the valves are mounted in the cylinder head, above the combustion chamber. Usually this type of engine has the camshaft mounted in the cylinder block, and the valves are opened and closed by push rods.

Multivalve Engines

All engines have more than one valve; "multivalve" refers to the fact that this type of engine has more than one exhaust or intake valve per cylinder.

Timing

Timing refers to the delivery of the ignition spark, or the opening and closing of the engine valves, depending on the piston's position, for the power stroke. The timing chain is driven by a sprocket on the crankshaft and also drives the camshaft sprocket.

Vacuum System (Importance of)

Engines run on a vacuum system. A vacuum exists in an area where the pressure is lower than the atmosphere outside of it. Reducing the pressure inside of something causes suction. For example, when you drink soda through a straw, the atmospheric pressure in the air pushes down on your soda and pushes it up into your mouth. The same principal applies to your engine. When the piston travels down in the cylinder it lowers the atmospheric pressure in the cylinder and forms a vacuum. This vacuum is used to draw in the air and fuel mixture for combustion. The vacuum created in your engine not only pulls the fuel into the combustion chamber, it also serves many other functions.

The running engine causes the carburetor and the intake manifold to produce "vacuum power," which is harnessed for the operation of several other devices.

Vacuum is used in the ignition-distributor vacuum-advance mechanism. At part throttle, the vacuum causes the spark to give thinner mixtures more time to burn.

The positive crankcase ventilating system (PCV) uses the vacuum to remove vapor and exhaust gases from the crankcase.

The vapor recovery system uses the vacuum to trap fuel from the carburetor float bowl and fuel tank in a canister. Starting the engine causes the vacuum port in the canister to pull fresh air into the canister to clean out the trapped fuel vapor.

Vacuum from the intake manifold creates the heated air system that helps to warm up your carburetor when it's cold.

The EGR valve (exhaust-gas recirculation system) works, because of vacuum, to reduce pollutants produced by the engine.

Many air conditioning systems use the vacuum from the intake manifold to open and close air-conditioner doors to produce the heated air and cooled air required inside your vehicle.

Intake manifold vacuum also is used for the braking effort in power brakes. When you push the brake pedal down, a valve lets the vacuum into one section of the power-brake unit. The atmospheric pressure moves a piston or diaphragm to provide the braking action.

Rotary Engine

One alternative to conventional automobile power is the rotary (or Wankel) engine. Although it is widely known that Felix Wankel built a rotary engine in 1955, it is also a fact that Elwood Haynes made one in 1893!

Dispensing with separate cylinders, pistons, valves and crankshaft, the rotary engine applies power directly to the transmission. Its construction allows it to provide the power of a conventional engine that is twice its size and weight and that has twice as many parts. The Wankel burns as much as 20%% more fuel than the conventional engine and is potentially a high polluter, but its small size allows the addition of emission-control parts more conveniently than does the piston engine. The basic unit of the rotary engine is a large combustion chamber in the form of a pinched oval (called an epitrochoid). Within this chamber all four functions of a piston take place simultaneously in the three pockets that are formed between the rotor and the chamber wall. Just as the addition of cylinders increases the horsepower of a piston-powered engine, so the addition of combustion chambers increases the power of a rotary engine. Larger cars may eventually use rotaries with three or four rotors.

Combustion Chamber

The combustion chamber is where the air-fuel mixture is burned. The location of the combustion chamber is the area between the top of the piston at what is known as TDC (top dead center) and the cylinder head. TDC is the piston's position when it has reached the top of the cylinder, and the center line of the connecting rod is parallel to the cylinder walls.

The two most commonly used types of combustion chamber are the hemispherical and the wedge shape combustion chambers.

The hemispherical type is so named because it resembles a hemisphere. It is compact and allows high compression with a minimum of detonation. The valves are placed on two planes, enabling the use of larger valves. This improves "breathing" in the combustion chamber. This type of chamber loses a little less heat than other types. Because the hemispherical combustion chamber is so efficient, it is often used, even though it costs more to produce.

The wedge type combustion chamber resembles a wedge in shape. It is part of the cylinder head. It is also very efficient, and more easily and cheaply produced than the hemispherical type.

Intake Stroke

The first stroke is the intake stroke. The piston moves down the cylinder and creates a partial vacuum in the cylinder. A mixture of air and fuel is forced through the inlet valve into the cylinder by atmospheric pressure, now greater than the pressure in the cylinder. During this stroke, the exhaust valve stays closed.

Compression Stroke

The second stroke is the compression stroke. The piston moves up in the cylinder with both valves closed. The air and fuel mixture is compressed and the pressure rises.

Power Stroke

The third stroke is the power stroke. Near the end of the compression stroke, the air and fuel mixture is ignited by an electric spark from the spark plug. The combustion that occurs causes a rise in temperature and enough pressure to force the piston down again.

Exhaust Stroke

On the fourth stroke, or exhaust stroke, the piston moves up again and forces the burned gases out of the cylinder and into the exhaust system.

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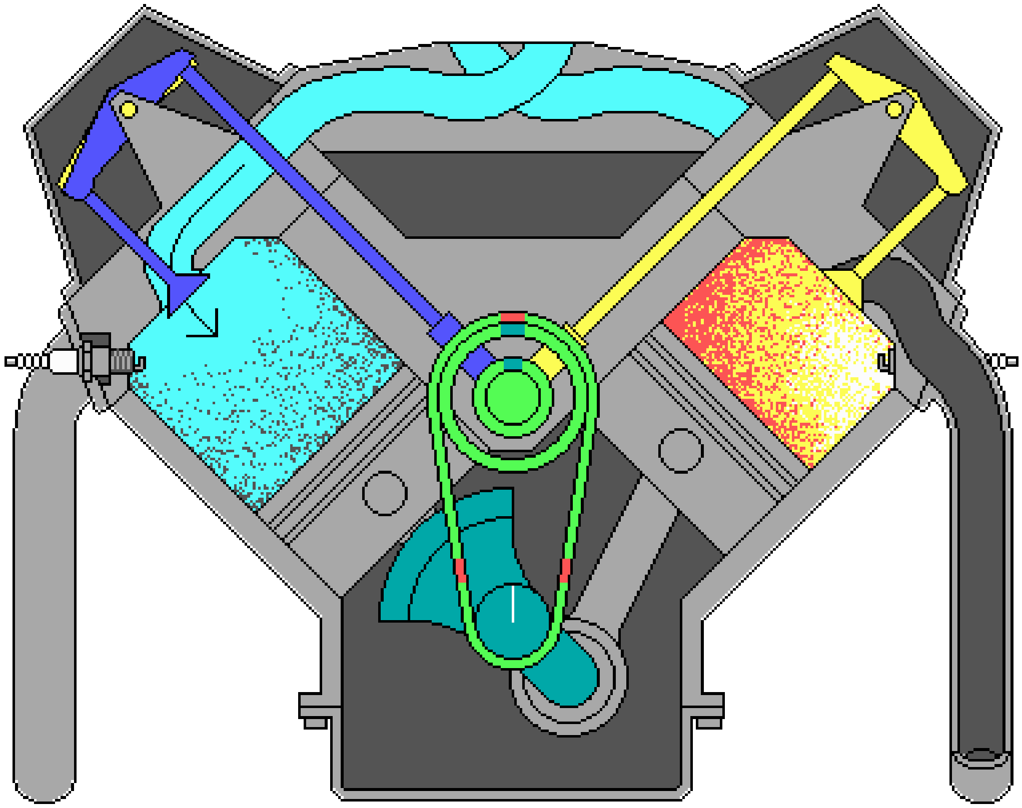
V-8 Engine Operation



Below is an overview of a V-8 engine

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Cutaway of the V-8 Engine

This diagram shows the flow of fuel and exhaust within a V8 engine. It shows the timing chain (driven by the crankshaft) drives the camshaft, which opens the valves. Fuel enters the cylinders via the intake manifold. The spark-caused explosions force the pistons down. Rotation of the crank forces the pistons back up, which expels the exhaust.

The Engine's Lubrication System

This animation shows the route taken by the oil within an engine. The oil pump draws oil from the oil pan, then forces it through the filter, into the crankshaft passage, through the connecting rods to the pistons and rings. Oil is pushed through the lifters and pushrods, and covers the rocker arms. It then flows back down into the pan to complete the cycle.

The Piston, Rings, and Wrist Pin

The piston converts the potential energy of the fuel, into the kinetic energy that turns the crankshaft. The piston is a cylindrical shaped hollow part that moves up and down inside the engine's cylinder. It has grooves around its perimeter near the top where rings are placed. The piston fits snugly in the cylinder. The piston rings are used to ensure a snug "air tight" fit.

The piston requires four strokes (two up and two down) to do its job. The first is the intake stroke. This is a downward stroke to fill the cylinder with a fuel and air mixture. The second is an upward stroke to compress the mixture. Right before the piston reaches its maximum height in the cylinder, the spark plug fires and ignites the fuel. This action causes the piston to make its third stroke (downward). The third stroke is the power stroke; it is this stroke that powers the engine. On the fourth stroke, the burned gases are sent out through the exhaust system.

The wrist pin connects the piston to the connecting rod. The connecting rod comes up through the bottom of the piston. The wrist pin is inserted into a hole (about half way up) that goes through the side of the piston, where it is attached to the connecting rod.

Pistons are made of aluminum, because it is light and a good heat conductor. Pistons perform several functions. Pistons transmit the driving force of combustion to the crankshaft. This causes the crankshaft to rotate. The piston also acts as a moveable gas-tight plug that keeps the combustion in the cylinder. The piston acts as a bearing for the small end of the connecting-rod. Its toughest job isto get rid of some of the heat from combustion, and send it elsewhere.

The piston head or "crown" is the top surface against which the explosive force is exerted. It may be flat, concave, convex or any one of a great variety of shapes to promote turbulence or help control combustion. In some, a narrow groove is cut into the piston above the top ring to serve as a "heat dam" to reduce the amount of heat reaching the top ring.

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.

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.

Push Rods

Push Rods attach the valve lifter to the rocker arm. Through their centers, oil is pumped to lubricate the valves and rocker arms.

Flywheel

The flywheel is a fairly large wheel that is connected to the crankshaft. It provides the momentum to keep the crankshaft turning without the application of power. It does this by storing some of the energy generated during the power stroke. Then it uses some of this energy to drive the crankshaft, connecting rods and pistons during the three idle strokes of the 4-stroke cycle. This makes for a smooth engine speed. The flywheel forms one surface of the clutch and is the base for the ring gear.

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.

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.

Main Bearings

The crankshaft is held in place by a series of main bearings. The largest number of main bearings a crankshaft can have is one more than the number of cylinders, but it can have one less bearing than the number of cylinders.

Not only do the bearings support the crankshaft, but one bearing must control the forward-backward movement of the crankshaft. This bearing rubs against a ground surface of the main journal, and is called the "thrust bearing."

Connecting Rod

The connecting rod links the piston to the crankshaft. The upper end has a hole in it for the piston wrist pin and the lower end (big end) attaches to the crankshaft.

Connecting rods are usually made of alloy steel, although some are made of aluminum.

Connecting Rod Bearings

Connecting rod bearings are inserts that fit into the connecting rod's lower end and ride on the journals of the crankshaft.

Oil Pump

The oil pump is used to force pressurized oil to the various parts of the engine.

Gear and rotary pumps are the most common types of pumps. The gear pump consists of a driven spur gear and a driving gear that is attached to a shaft driven by the camshaft. The two gears are the same size and fit snugly in the pump body. Oil is carried from the inlet to the delivery side of the pump by the opposite teeth of both gears. Here it is forced into the delivery pipe. It can't flow back, because the space between the meshing gear teeth is too tight.

The rotary pump is driven by the camshaft. The inner rotor is shaped like a cross with rounded points that fit into the star shape of the outer rotor. The inner rotor is driven by a shaft turned by the camshaft. When it turns, its rounded points "walk" around the star shaped outer rotor and force the oil out to the delivery pipe.

Piston Motion/Bicycle

The pistons in your engine's cylinder are similar to your legs when you ride a bicycle. Think of your legs as pistons; they go up and down on the pedals, providing power. The pedals are like the connecting rods; they are "attached" to your legs. The pedals are attached to the bicycle crank, which is like the crank shaft, because it turns the wheels.

To reverse this, the pistons (legs) are attached to the connecting rods (pedals) which are attached to the crankshaft (bicycle crank). The power from the combustion in the cylinders powers the piston to push the connecting rods to turn the crankshaft.

The bicycle played a large part in the process of inventing the automobile; in fact, in 1896, the first car that Henry Ford produced was even called a "Quadricycle."

Engine Placement

Mid-engine sports coupes have the engine mounted in front of the rear axle. Passenger space is limited to two people. Concentrating the weight in the center of the car improves handling.

The conventional sports coupe's engine is in the front of the car, driving either the front or rear wheels. This layout reduces production costs, but luggage space and rear seat room are sacrificed for the sporty styling.

Vans have engines located in either the front or the rear. Contemporary sedans have the engine in the front driving the front or rear axle.

Cylinder

A cylinder is a round hole through the block, bored to receive a piston. All automobile engines, whether water-cooled or air-cooled, four cycle or two cycle, have more than one cylinder. These multiple cylinders are arranged in-line, opposed, or in a V. Engines for other purposes, such as aviation, are arranged in other assorted forms.

The first four cylinder engine with a sliding transmission was in the 1907 Buick.

Oil Seals

Oil seals are rubber and metal composite items. They are generally mounted at the end of shafts. They are used to keep fluids, such as oil, transmission fluid, and power steering fluid inside the object they are sealing. These seals flex to hold a tight fit around the shaft that comes out of the housing, and don't allow any fluid to pass. Oil seals are common points of leakage and can usually be replaced fairly inexpensively. However, the placement of some seals make them very difficult to access, which makes for a hefty labor charge!

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.

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.

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 Passages

Within the engine is a variety of pathways for oil to be sent to moving parts. These pathways are designed to deliver the same pressure of fresh lubricating oil to all parts. If the pathways become clogged, the affected parts will lock together. This usually destroys parts that are not lubricated, and often ruins the entire engine.

The oil passages are cleverly drilled into the connecting parts of the engine, which allows the highly mobile ones (like the pistons) to have ample lubrication. Originating at the oil pump, they flow through all of the major components of the engine. In the case of the pistons and rods, the passages are designed to open each time the holes in the crankshaft and rods align.

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.

Serpentine Belts

A recent development is the serpentine belt, so named because they wind around all of the pulleys driven by the crankshaft pulley. This design saves space, but if it breaks, everything it drives comes to a stop.

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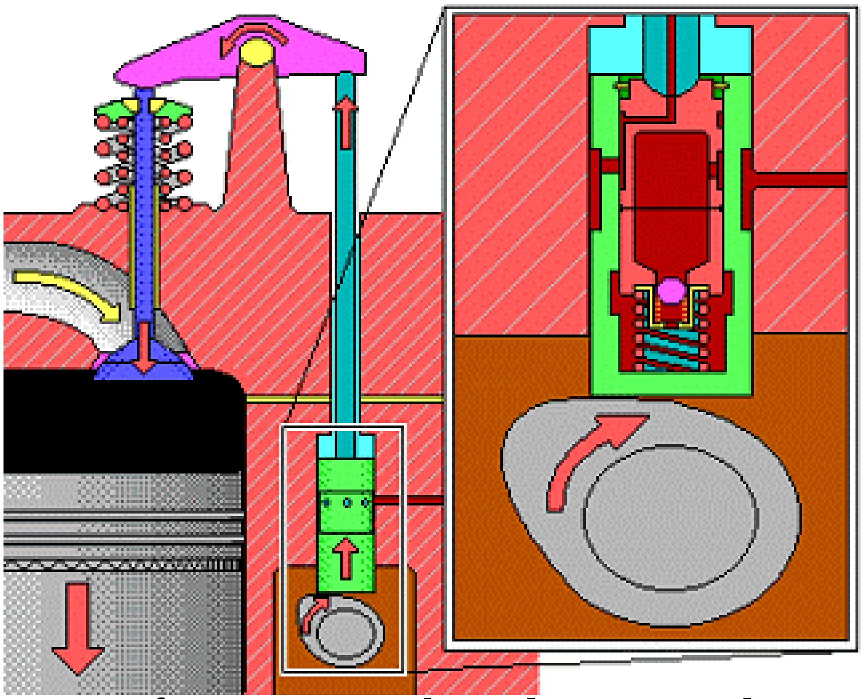
Valve System Operation



Below is information on the valvetrain and camshaft

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Valve Lifter (Tappet)

The valve lifter is the unit that makes contact with the valve stem and the camshaft. It rides on the camshaft. When the cam lobes push it upwards, it opens the valve.

The engine oil comes into the lifter body under pressure. It passes through a little opening at the bottom of an inner piston to a cavity underneath the piston. The oil forces the piston upward until it contacts the push rod. When the cam raises the valve lifter, the pressure is placed on the inner piston which tries to push the oil back through the little opening. It can't do this, because the opening is sealed by a small check valve.

When the cam goes upward, the lifter solidifies and lifts the valve. Then, when the cam goes down, the lifter is pushed down by the push rod. It adjusts automatically to remove clearances.

Lifter Body

The valve lifter body houses the valve lifter mechanism. The valve lifter is the unit that makes contact with the valve stem and the camshaft. It rides on the camshaft. When the cam lobes push it upwards, it opens the valve.

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.

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.

Valves

The valve's job is to open and close the valve ports. If the ports were always open, the fuel exploded in the combustion chamber would leave through the ports. The explosion has to be kept in the combustion chamber to push the piston down. The valves are set up to open and close at exactly the right moment. One lets the fuel mixture in and closes. After the fuel explodes and pushes the piston down, the other valve lets the exhaust out.

Valve Guides

The valves are usually held in an upright position by the valve stem. The valve stem is the long straight side of the valve, like the stem of a flower. Holes are bored in the cylinder head for the valve stems. Worn valve guides allow oil to enter the combustion chamber and cause blue smoke in the exhaust.

Valve Springs

The valve springs keep the valves closed tightly against their seats until the valve is opened by the cam. After the cam turns (releasing pressure), the valve springs close the valves.

Valve Seals

The valve seal is a unit that goes over the end of the valve stem. It keeps excess oil from getting between the valve guide and the valve stem.

Camshaft

The camshaft is a round shaft with "lobes" (specially formed bumps) which is driven by the timing belt or timing chain. It, directly or through "lifters" and "pushrods" opens and closes the fuel and exhaust valves. The camshaft turns at one-half of the crankshaft speed. It is supported by bearings located in the front and rear of the crankcase.

Rocker arms

Rocker arms are used to transmit force from cam to valve. Riding on a cam on the camshaft, rocker arms direct the upward motion of the lobe of the cam into an opening motion of the valve stem.

Push Rods

Push Rods attach the valve lifter to the rocker arm. Through their centers, oil is pumped to lubricate the valves and rocker arms.

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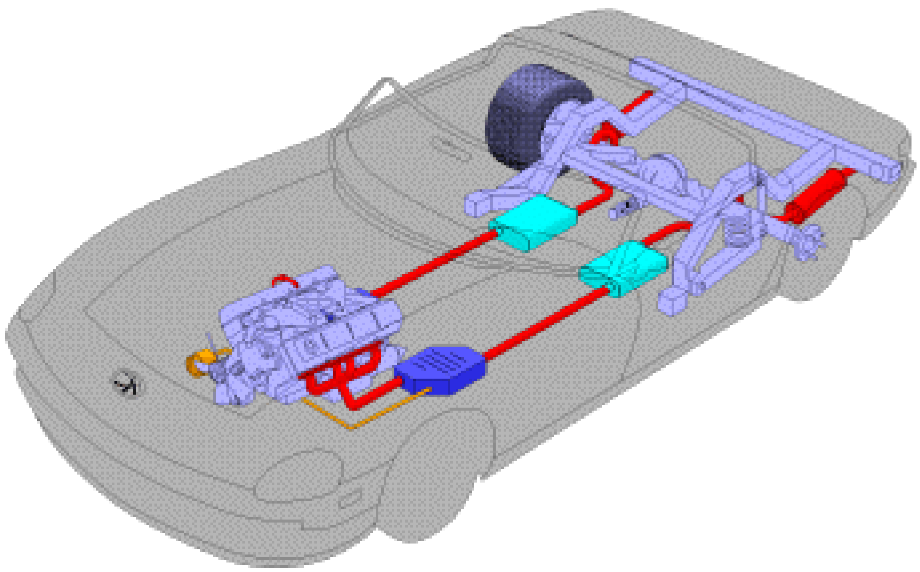
Exhaust/Emissions Systems Overview



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Emissions Testing

Many states require emissions tests on vehicles. This means that you drive to a facility where the test people take a sample of your emissions and run it through some analysis. The results are printed,and you pass or fail depending on the percentage of toxic emissions that turn up in your car's sample.

The only way to "study" or prepare for this test is to take good care of your car, including its emission system. If you use preventative maintenance, and keep your car tuned properly, you will pass. If you tamper with your emissions system, you will not pass. You can have your car checked independently before your emissions test if you want to resolve problems before going to the emissions test station.

One other good thing to do is to save your printouts from the test from year to year. If you compare them, you will be able to monitor your car (if its score is getting worse) and catch any problems before the emissions people catch you.

The Emission Control System

The purpose of the emission control system is just that; it controls the emissions and exhaust from your vehicle. The idea is to turn the harmful gases your car manufactures into harmless ones that don't ruin the environment, or us. Some of the problem gases are:

- hydrocarbons (unburned)
- carbon monoxide
- carbon dioxide
- nitrogen oxides
- sulfur dioxide
- phosphorus
- lead and other metals

To help control these substances, we (along with federal regulations) have made changes in our gasoline to eliminate them. Also, with a push from federal regulations, we have developed ways, varying from state to state, to test emissions, that have caused automotive manufacturers to develop better, safer emission systems.

Although emissions control systems vary between manufacturers and vehicles, they all have the same goal and use many of the same methods. The addition of computers to ignition systems allows the engine to monitor and adjust itself continuously, so it just isn't true that emission controls lower the amount of mileage we get fromfuel.

The best news is that emission controls have reduced carbon monoxide and hydrocarbon emissions by about ninety-six percent from pre-control vehicles. That's almost a hundred percent!

The Tailpipe

The tailpipe is a long metal tube attached to the muffler. It sticks out from under the body of your car, at the rear, in order to discharge the exhaust gases from the muffler of your engine into the air outside the car.

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 ofthe 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.

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, dualbed 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.

The EGR Valve

The Exhaust Gas Recirculation (EGR) valve is used to send some of the exhaust gas back into the cylinders to reduce combustion temperature. Why would we want to do this?

Nitrous oxides (nasty pollutants) form when the combustion temperature gets above 2,500 degrees F. This happens, because at such temperatures, the nitrogen in the air mixes with the oxygen to create nitrous oxides. Did you ever have two friends that were fine by themselves but just awful when they got together? Well, our good friend, the sun, is just like that. When it's sunny, the nitrous oxides from the exhaust get together with the hydrocarbons in the air to form our not-so-good friend, smog. That's when the EGR valve comesin handy.

By recirculating some of the exhaust gas back through the intake manifold to the cylinders, we can lower the combustion temperature. Lowering the combustion temperature lowers the amount of nitrous oxide produced. Consequently, less of it comes out the tail pipe.

There are two types of EGR valves. One operates through the use of a vacuum, and the other operated through the use of pressure. Both types allow the exhaust gas in to lower the combustion temperature when it gets too high.

PCV Valve

The process of combustion forms several gases and vapors; many of them quite corrosive. Some of these gases get past the piston rings and into the crankcase. If left in the crankcase, these substances would cause all kinds of bad things (rust, corrosion, and formation of sludge), so they have to be removed. Back in the old days, they used to be dumped out into the atmosphere through a tube. Once we realized what a problem pollution was in the sixties, the PCV (Positive Crankcase Ventilation) system was developed to take the place of the old "dump tube."

The PCV system uses a hose connected between the engine and the intake manifold to draw these gases out of the engine's crankcase and back into the cylinders to burn with the regular fuel. The only problem to solve is how to keep these gases from going willy-nilly into the manifold and upsetting the required air-fuel ratio. The solution to this problem is the PCV valve.

The PCV valve controls the release of crankcase gases and vapors to the intake manifold. The valve is kept closed by spring action when the engine is at rest. When the engine is running normally, the low vacuum it creates allows the valve to open and release crankcase vapors and gases into the intake manifold for burning. If the engine is idling or you are slowing down, the vacuum level rises and pulls the valve plunger into the valve opening. This partially blocks off the opening so that only a small amount of vapors and gases can be drawn into the intake manifold.

One really comforting feature of the PCV valve is its behavior in the event of a backfire. If your car backfires in the manifold, the pressure makes the spring close the valve completely. With the valve closed, there is no chance that the flame can move into the crankcase and cause an explosion.

The Air Pump

The air pump sends (or pumps) compressed air into the exhaust manifold and in some cases to the catalytic converter. The oxygen in the pressurized air helps to burn quite a bit of any unburned hydrocarbons (fuel) and therby converts the poisonous carbon monoxide into good old carbon dioxide.

A belt from the engine drives the air pump. It has little vanes (thin, flat, curved fins) that draw the air into the compression chamber. Here, the air is compressed and sent off to the exhaust manifold where it speeds up the emissions burning process. Stainless steel nozzles are used to shoot the air into the exhaust manifold, because they will not burn.

Some engines use a pulse air injection system. This system uses pulses of exhaust gas to operate an air pump that delivers air into the exhaust system.

The Exhaust Manifold and Header

The exhaust manifold, usually constructed of cast iron, is a pipe that conducts the exhaust gases from the combustion chambers to the exhaust pipe. It has smooth curves in it for improving the flow of exhaust.

The exhaust manifold is bolted to the cylinder head, and has entrances for the air that is injected into it. It is usually located under the intake manifold.

A header is a different type of manifold; it is made of separate equal-length tubes.

Manifold to Exhaust Pipe Gaskets

There are several types of gaskets that connect the exhaust pipe to the manifold.

One is a flat surface gasket. Another type uses a ball and socket with springs to maintain pressure. This type allows some flexibility without breakage of the seal or the manifold. A third type is the full ball connector type, which also allows a little flexibility.

Exhaust Pipe Hangers

Hangers hold the exhaust system in place. They give the system flexibility and reduce the noise level. The hanger system consists of rubber rings, tubes and clamps.

Catalysts

The materials within a catalytic converter vary between cars. Catalytic converters are designed to do different things, depending on the design of the converter.

Some catalytic converters use what is called an "oxidation" catalyst; this usually consists of ceramic beads coated with platinum to reduce hydrocarbons and carbon monoxide. Through the catalytic action, the hydrocarbons and carbon monoxide are "burned" to creat ewater vapor and carbon dioxide. This type of catalytic converter needs an input of oxygen, so oxygen is usually injected into the cylinder head, or directly into the exhaust header or manifold.

Newer catalytic converters have a two part design. The front half is a "three-way" catalyst, which burns various pollutants, and reduces hydrocarbons, carbon monoxide, and oxides of nitrogen into water, carbon dioxide and nitrogen. These converters require exact fuel air mixtures in order to maintain efficient exhaust reduction. The rear section of these converters is the normal oxidation catalyst that further reduces hydrocarbons and carbon monoxide. Air from the air pump is injected into the center of these converters. Here the air is allowed to mix with the exhaust before it passes into the oxidation catalyst, where it burns off its toxic chemicals and reduces emissions.

Exhaust Pipe

The exhaust pipe is the bent-up or convoluted pipes you will notice underneath your car. Some are shaped to go over the rear axle, allowing the rear axle to move up and down without bumping into the exhaust pipe; some are shaped to bend around under the floor of the car, connecting the catalytic converter with the muffler. Exhaust pipes are usually made out of stainless steel, since the high heat conditions involved with the muffler system will cause rust.

Reverse-flow Muffler

The reverse-flow muffler is oval-shaped and has multiple pipes. Four chambers and a double jacket are used to accomplish muffling of the exhaust noise. Exhaust gases are directed to the third chamber, forced forward to the first chamber, from where they travel the length of the muffler and are exhausted into the tail pipe.

Straight Through Muffler

The straight through muffler has a central tube, perforated with several openings which lead into an outside chamber packed with a sound absorbing (or insulating) material. As the exhaust gases expand from the perforated inner pipe into the outer chamber, they come in contact with the insulator and escape to the atmosphere under constant pressure. Because of this, the expanding chamber tends to equalize or spread the pressure peaks throughout the exhaust from each individual cylinder of the engine.

A V-8 engine requires two exhaust manifolds and either one or two mufflers and often accompanying resonators. If one muffler is used, the exhaust pipe from one manifold meets the other one in the form of a "Y".

Dual Exhaust System

The advantage of a dual exhaust system is that the engine exhausts more freely, thereby lowering the back pressure which is inherent in an exhaust system. With a dual exhaust system, a sizable increase in engine horsepower can be obtained because the "breathing" capacity of the engine is improved, leaving less exhaust gases in the engine at the end of each exhaust stroke. This, in turn, leaves more room for an extra intake of the air-fuel mixture.

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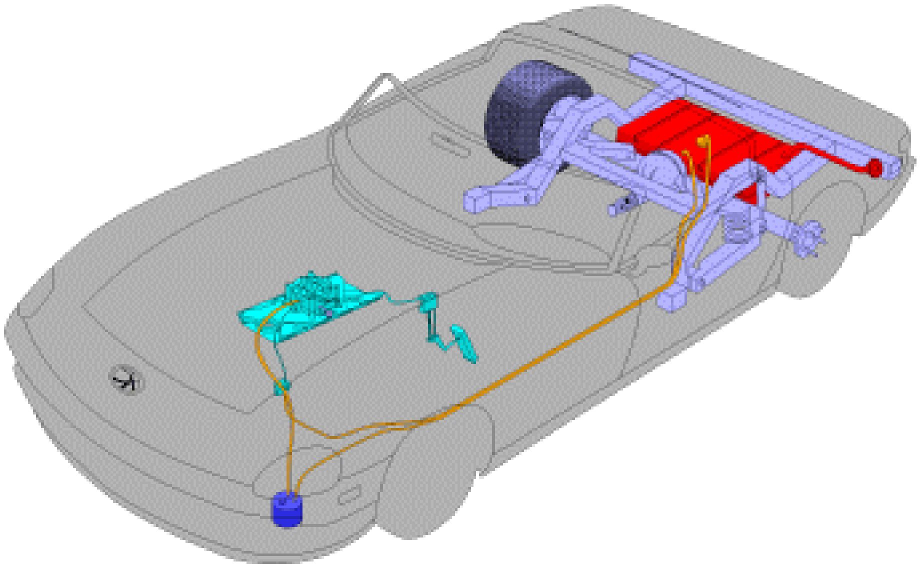
Fuel System Overview



Below is an overview of fuel system operation

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The Fuel System (Overview)

The purpose of the fuel system is to provide a mixture of fuel and air to the engine of the car. The air-fuel mixture must be in proportion to the speed and load placed on the engine. Major parts of the system include: fuel tank and cap, emission controls, fuel line, fuel pump, fuel filter, carburetor, and intake manifold as well as the fuel gauge, which indicates the amount of fuel in the tank.

Engine Fuel

Engine fuel is mainly made up of hydrogen and carbon, mixed so that it will burn with oxygen present, and will free its heat energy into mechanical energy. Liquid fuels are ideal for internal combustion engines, because they can be economically produced, have a high heat value per pound, an ideal rate of burning, and can be easily handled and stored. The most common engine fuels are gasoline, kerosene and Diesel fuel oil.

Gasoline has many advantages and is used to a greater extent than any other fuel in internal combustion engines having spark ignition. It has a better burning rate than other fuels, and, because it vaporizes easily, it gives quick starting in cold weather, smooth acceleration and maximum power.

Diesel fuel oil ranks next to gasoline in quantity used. It can be produced as cheaply as gasoline, but its use is limited to Diesel type engines. The use of kerosene as a fuel is usually limited to farm tractors, marine and stationary engines, all which operate at a fairly constant speed. Its traits are such that it cannot be properly mixed with air and controlled in variable speed engines.

Octane Rating

A gasoline's ability to resist detonation is called its "octane" or anti-knock rating. Gasoline from asphaltic base crude oil produces less knock than one from paraffinic base crude. Cracked gas has less tendency to knock than straight run gas. All marketed gasolines are a blend of straight run and cracked gasolines, so unless their blending is controlled, the anti-knock qualities will vary.

A mixture of iso-octane, which has a very high anti-knock rating, and heptane, which makes a pronounced knock, is used as a reference fuel to establish an anti-knock standard. The anti-knock value or octane number is represented by the percentage of volume of iso-octane that must be mixed with normal heptane in order to duplicate the knocking of the gasoline which is being tested. These ratings range from 50 in third grade gasolines to 110 in aviational fuels. The rating of 100 means a fuel having an anti-knock value equal to that of iso-octane. If the octane rating of a gasoline is naturally low, the fuel will detonate as it burns and power will be applied to the pistons in hammer-like blows. The ideal power is that which pushes steadily on the pistons, rather than hammer against them. The octane rating of a gasoline can be raised by treating it with a chemical which is not a fuel. The best chemical known is tetra-ethyl lead compound, which is added to the gasoline.

Tetra-ethyl lead is a liquid which mixes thoroughly with gasoline and vaporizes completely. Ethylene dibromide prevents the tetra-ethyl lead from forming lead oxide deposits on spark plugs and on valve seats and stems. Red dye is added to identify an ethyl treated gasoline and to warn against its being used as anything but an engine fuel. In 1975, it became illegal to use a leaded gasoline except in cars built prior to this time. With the addition of the catalytic converter, it is undesirable to burn leaded fuel, because leaded fuel will clog the converter and increase the back-pressure of the exhaust.

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 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.

Fuel Pump

The fuel pump has three functions: to deliver enough fuel to supply the requirements of an engine under all operating conditions, to maintain enough pressure in the line between the carburetor and the pump to keep the fuel from boiling, and to prevent vapor lock. Excessive pressure can hold the carburetor float needle off its seat, causing high gasoline level in the float chamber. This will result in high gasoline consumption. The pump generally delivers a minimum of ten gallons of gasoline per hour at top engine speeds, under an operating pressure of from about 2 1/2 to 7 pounds. Highest pressure occurs at idling speed and the lowest at top speed. Although fuel pumps all work to produce the same effect, there are various types that may operate somewhat differently.

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.

Electric Fuel Pump

Electric fuel pumps have been used for many years on trucks, buses and heavy equipment, and they have also been used as replacements for mechanically operated fuel pumps on automobiles, but only recently have they become part of a car's original equipment. The replacement types usually use a diaphragm arrangement like the mechanical pumps, except that it is actuated by an electrical solenoid.

The electrically driven turbine type of pump, first used on the Buick Riviera, was a great departure from the usual fuel pump design. It uses a small turbine wheel driven by a constant speed electric motor. The entire unit is located in the fuel tank and submerged in the fuel itself. This pump operates continuously when the engine is running. It keeps up a constant pressure which is capable of supplying the maximum fuel demands of the engine. When less fuel is required, the pump does not deliver at full potential, because the turbine is not a positive displacement type like the mechanical pump. Consequently, the turbine will run without pumping fuel and so, needs no means of varying fuel delivery rate like its mechanical counterpart. Since the fuel can flow past the spinning turbine blades, there is no need for pump inlet and outlet valves nor is there any need to vary its speed.

A relay for the electric fuel pump is used to complete the circuit to the fuel pump. This cuts off current to the fuel pump in the event of an accident.

Vacuum Pump

Several fuel pumps have a vacuum booster section that operates the windshield wipers at an almost constant speed. The fuel section then functions in the same way as ordinary fuel pumps. One difference is that the rotation of the camshaft eccentric in the vacuum pump also operates the vacuum booster section by actuating the pump arm, which pushes a link and the bellows diaphragm assembly upward, expelling air in the upper chamber through its exhaust valve out into the intake manifold. On the return stroke of the pump arm, the diaphragm spring moves the bellows diaphragm down, producing a suction in the vacuum chamber. The suction opens the intake valve of the vacuum section and draws air through the inlet pipe from the windshield wipers.

When the wipers are not operating, the intake manifold suction (vacuum) holds the diaphragm up against the diaphragm spring pressure so that the diaphragm does not function with every stroke of the pump arm. When the vacuum is greater than the suction produced by the pump, the air flows from the windshield wiper through the inlet valve and vacuum chamber of the pump and out the exhaust valve outlet to the manifold, leaving the vacuum section inoperative. With high suction in the intake manifold, the operation of the wiper will be the same as if the pump were not installed. When the suction is low, as when the engine is accelerated or operating at high speed, the suction of the pump is greater than that in the manifold and the vacuum section operates the wipers at a constant speed. Some pumps have the vacuum section located in the bottom of the pump instead of in the top, but the operation is basically the same.

Air Cleaners

Air cleaners are made to separate dust and other particles in the incoming air before it enters the carburetor. Thousands of cubic feet of air are drawn from within the car hood and passed through the engine cylinders, so it is important that the air is clean.

When driving on dirt or other dusty roads, dust particles are drawn through the radiator and find their way into the engine if it is not filtered and cleaned. Dust and other foreign materials in the engine will cause excessive wear and operating problems.

Fuel Gauges

Cars are equipped with fuel gauges which are operated along with the vehicle's electrical system. There are two types: the thermostatic type and the balancing coil type. The thermostatic type is made of a standing unit, located in the fuel tank, and the gauge itself (registering unit), which is located on the instrument panel. The fuel gauge used in some cars and trucks is of the electrically operated balanced coil type. These have a dash unit and a tank unit. The dash unit has two coils, spaced about 90 degrees apart, with an armature and integral pointer at the intersections of the coil axis. The dial has a scale in fractions between "Empty" and "Full". The tank unit has a housing, which encloses a rheostat, and a sliding brush which contacts the rheostat. The brush is actuated by the float arm. The movement of the float arm is controlled by the height of the fuel in the supply tank. The height of the fuel (called variations in resistance) changes the value of the dash unit coil so that the pointer indicates the amount of fuel available. A calibrated friction brake is included in the tank unit to prevent the wave motions of the fuel from fluctuating the pointer on the dash unit. Current from the battery passes through the limiting coil to the common connection between the two coils, which is the lower terminal on the dash unit. The current is then offered two paths, one through the operating coil of the dash unit and the other over the wire to the tank unit. When the tank is low or empty, the sliding brush cuts out all resistance in the tank unit. Most of the current will pass through the tank unit circuit because of the low resistance and only a small portion through the operating coil to the dash unit. As a result, this coil is not magnetized enough to move the dash unit pointer, which is then held at the "Empty" position by the limiting coil.

If the tank is partly full or full, the float rises on the surface of the fuel and moves the sliding brush over the rheostat, putting resistance in the tank unit circuit. More current will then pass through the operating coil to give a magnetic pull on the pointer, which overcomes some of the pull of the limiting coil. When the tank is full, the tank unit circuit contains the maximum resistance to the flow of the current. The operating coil will then receive its maximum current and exert pull of the pointer to give a "Full" reading. As the tank empties, the operating coil loses some of its magnetic pull and the limiting coil will still have about the same pull so that the pointer is pulled toward the lower reading. Variations in battery voltage will not cause an error in the gauge reading because its operation only depends on the difference in magnetic effect between the two coils.

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.

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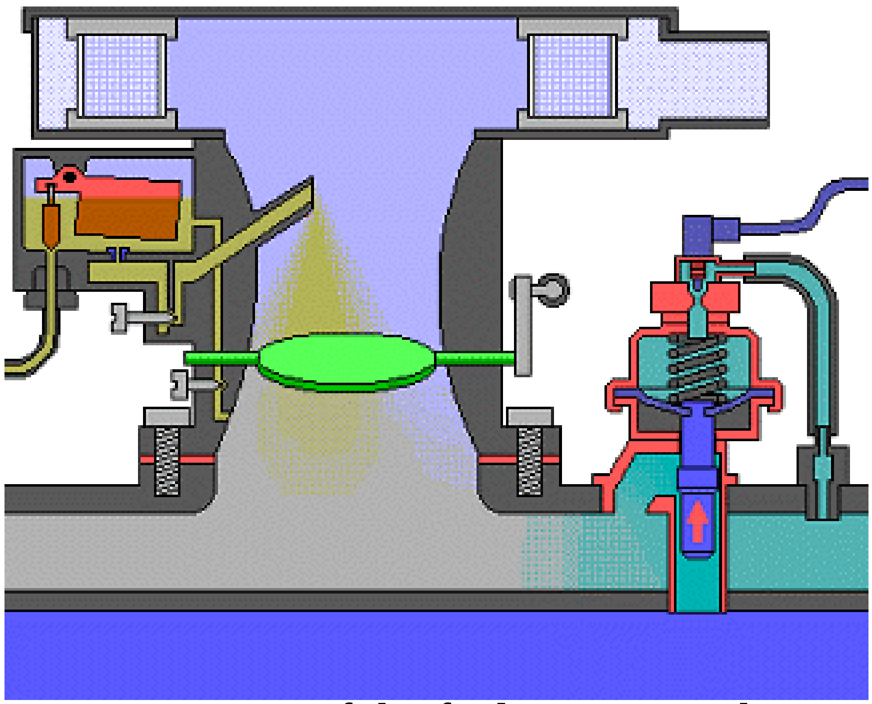
Fuel Intake System



Below is an overview of the fuel system intake operation

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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.

Ram Induction Manifolds

The ram induction manifold system consists of twin air cleaners, twin four-barrel carburetors and two manifolds containing eight long tubes of equal length (four for each manifold).

This system was designed by the Chrysler Company to increase power output by in the middle speed range (1800-3600 rpm). Each manifold supplies one bank of cylinders and is carefully calculated to harness the natural supercharging effect of a ram induction system. By taking advantage of the pulsations in the air intake column caused by the valves opening and closing, sonic impulses help pack more mixture into the combustion chambers.

In the Chrysler system, the air-fuel mixture from each carburetor flows into a chamber directly below the carburetor, then passes through the long individual intake branches to the opposite cylinder bank. The right-hand carburetor supplies the air-fuel mixtures for the left-hand cylinder bank, and the left-hand carburetor supplies the right cylinder bank. The passages between the manifolds are interconnected with a pressure equalizer tube to maintain balance of the engine pulsations.

Manifold Heat Control

Most engines have automatically operated heat controls which use the exhaust gases of the engine to heat the incoming fuel-air charge during starting and warm-up. This improves vaporization and mixture distribution. When the engine is cold, all of the exhaust gas is deflected to and around the intake manifold "hot spot". As the engine warms up, the thermostatic spring is heated and loses tension. This allows the counterweight to change the position of the heat control valve gradually so that, at higher driving speeds with a thoroughly warmed engine, the exhaust gases are passed directly to the exhaust pipe and muffler.

In the ram induction system, there is a heat control chamber in each manifold to operate the automatic choke and to heat the fuel mixture after warm-up. A heat control valve in each exhaust manifold will by-pass the exhaust gas through an elbow to the intake manifold heat control chamber. Heat outlet pipes then carry the gas down to the "Y" connector under the heat control valve.

Heat control is regulated by a coiled thermostatic spring mounted on the exhaust manifold. A counterweight is mounted on the other end of the heat control valve shaft and this counterweight, in conjunction with the thermostatic spring, operates to close and open the heat control valve.

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.

Supercharger

A supercharger is a compressor. Hence, a supercharged engine has a higher overall compression than a nonsupercharrged engine having the same combustion chamber volume and piston displacement and will burn more fuel. Unfortunately, the increase in power is not proportional to the increase in fuel consumption. There are two general models of superchargers, the Rootes type and the centrifugal type. The Rootes "blower" has two rotors, while the centrifugal uses an impeller rotating at high speed inside a housing.

Superchargers can be placed between the throttle body of the carburetor or fuel injection system and the manifold; or at the air inlet before the throttle body. Racing cars usually have it located between the throttle body and the manifold. This design has the advantage that the fuel can be supplied through the throttle body without modification to any part of the system. If the supercharger is placed in front of the throttle body, fuel must be supplied under sufficient pressure to overcome the added air pressure created by the supercharger. The advantage of a supercharger over a turbocharger is that there is no lag time of boost; the moment the accelerator pedal is depressed, the boost is increased.

Turbocharger

A turbocharger, or supercharger, can boost engine power up to 40%%. The idea is to force the delivery of more air-fuel mixture to the cylinders and get more power from the engine. A turbocharger is a supercharger that operates on exhaust gas from the engine.

Although turbochargers and superchargers perform the same function, the turbocharger is driven by exhaust gases, while the supercharger is driven by belts and gears. The turbocharger has a turbine and a compressor, and requires less power to be driven than a supercharger. The pressure of the hot exhaust gases cause the turbine to spin. Since the turbine is mounted on the same shaft as the compressor, the compressor is forced to spin at the same time, drawing 50%% more air into the cylinders than is drawn in without the turbocharger. This creates more power when the air-fuel mixture explodes.

A turbocharged engine's compression ratio must be lowered by using a lower compression piston, since an excessive amount of pressure will wear on the piston, connecting rods, and crankshaft, and destroy the engine. All of these parts then, as well as the transmission, must be strengthened on a turbocharged engine or it will be torn apart by the increased horsepower.

Breathers

The breather is the positive crankcase ventilation system directing atmospheric pressure to the crankcase. The atmospheric pressure then pushes the blowby gases to a low pressure area. The air that is directed into the crankcase must first be filtered; if it is not, the dust and sand particles will destroy the engine parts. When there is too much blowby, it is routed back through the crankcase breather element. It then enters the carburetor or throttle body with the incoming fresh air to be burned in the cylinders. In addition, the breather helps to keep the regular air filter cleaner for a longer period of time, since blowby contains oil vapor from the crankcase.

Float Circuit

Fuel in the carburetor must be maintained at a certain level under all operating conditions; this is the function of the float circuit. The needed fuel level is maintained by the float. When its attached lever forces the needle valve closed, the flow of fuel from the pump is stopped. As soon as fuel is discharged from the float bowl, the float drops. The needle valve opens and fuel flows into the bowl again. In this way, the fuel is level to the opening of the main discharge nozzle. The float level must be set with a high degree of accuracy. If the level is too low, not enough fuel will be supplied to the system and the engine will stall on turns; if the level is too high, too much fuel will flow from the nozzle.

Metering Rod

A metering rod varies the size of the carburetor jet opening. Fuel from the float bowl is metered through the jet and the metering rod within it. The fuel is forced from the jet to the nozzle extending into the venturi. As the throttle valve is opened, its linkage raises the metering rod from the jet. The rod has several steps, or tapers, on the lower end. As it is raised in the jet, it makes the opening of the jet greater in size. This allows more fuel to flow through the jet to the discharge nozzle. The metering must keep pace with the slightest change in the throttle valve position so that the correct air-fuel mixture is obtained in spite of engine speed.

Choke Valve

Chokes perform the fuel mixture adjustments necessary to start a cold engine. When the fuel-air mixture is too cold, the engine won't start properly, or will stall out periodically. The choke when engaged (closed) the choke causes the fuel air mixture to be increased, or "enriched". The choke is a special valve placed at the mouth of the carburetor so that it partially blocks off the entering air. When the choke plate closes, the vacuum below it increases, drawing more fuel from the fuel bowl. The rich fuel mixture burns even at lower temperatures, allowing the engine to warm up.

The manual choke is a knob on the dash, usually the push-pull type, which extends from the choke on the carburetor to the instrument panel. The driver closes the choke when starting the engine. The main thing to know about a manual choke is to push it back in when the engine has reached normal operating temperature. The trouble with the manual choke is that the driver often forgets to open it fully. This results in a rich fuel mixture which causes carbon to form in the combustion chambers and on the spark plugs. To correct this problem, the automatic choke was developed.

The automatic choke relies on engine heat. The choke valve is run by a thermostat which is controlled by exhaust heat. When the engine is cold, the valve will be closed for starting. As the engine warms, the exhaust heat will gradually open the choke valve. An automatic choke depends on a thermostatic coil spring unwinding as heat is supplied. As the engine warms up, manifold heat is transmitted to the choke housing. The heat causes the bimetal spring to relax, opening the valve.

An electric heating coil in the automatic choke shortens the length of time that the choke valve is closed. As the spring unwinds, it causes the choke valve in the carburetor air horn to open. This lets more air pass into the carburetor. The coil is mounted in a well in the exhaust crossover passage of the intake manifold. Movement of the bimetal spring is relayed to the choke valve shaft by means of linkage and levers.

Fuel Injection

The carburetor, despite all it advances: air bleeds, correction jets, acceleration pumps, emulsion tubes, choke mechanisms, etc., is still a compromise. The limitations of carburetor design is helping to push the industry toward fuel injection.

Direct fuel injection means that the fuel is sprayed directly into the combustion chamber. The fuel injected nozzle is located in the combustion chamber.

Throttle Body injection systems locate the injector(s) within the air intake cavity, or "throttle body". Multi-point systems use one injector per cylinder, and usually locate the injectors at the mouth of the intake port.

The fuel injector is an electromechanical device that sprays and atomizes the fuel. The fuel injector is nothing more than a solenoid through which gasoline is metered. When electric current is applied to the injector coil, a magnetic field is created, which causes the armature to move upward. This action pulls a spring-loaded ball or "pintle valve" off its seat. Then, fuel under pressure can flow out of the injector nozzle. The shape of the pintle valve causes the fuel to be sprayed in a cone-shaped pattern. When the injector is de-energized, the spring pushes the ball onto its seat, stopping the flow of fuel.

Mechanical Fuel Injection

Mechanical fuel injection is the oldest of the fuel injection systems. It uses a throttle linkage and a governor. It is now used mainly on diesel engines. Hydraulic fuel injection is used by some of the imports. Hydraulic pressure is applied to a fuel distributor as a switching device to route fuel to a specific injector. The fuel from the tank is carried under pressure to the fuel injector(s) by an electric fuel pump, which is located in or near the fuel tank. All excess is returned to the fuel tank.

Electronic Fuel Injection

The principle of electronic fuel injection is very simple. Injectors are opened not by the pressure of the fuel in the delivery lines, but by solenoids operated by an electronic control unit. Since the fuel has no resistance to overcome, other than insignificant friction losses, the pump pressure can be set at very low values, consistent with the limits of obtaining full atomization with the type of injectors used. The amount of fuel to be injected is determined by the control unit on the basis of information fed into it about the engine's operating conditions. This information will include manifold pressure, accelerator enrichment, cold-start requirements, idling conditions, outside temperature and barometric pressure. The systems work with constant pressure and with "variable timed" or "continuous flow" injection. Compared with mechanical injection systems, the electronic fuel injection has an impressive set of advantages. It has fewer moving parts, no need for ultra-precise machining standards, quieter operation, less power loss, a low electrical requirement, no need for special pump drives, no critical fuel filtration requirements, no surges or pulsations in the fuel line and finally, the clincher for many car makers, lower cost.

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.

Idle Circuit

The fuel delivery in a carburetor tends to lag behind the motion of the throttle. The basic carburetor operates when the throttle valve is fully open or partially open, but not when it's closed. No driver wants the engine to stop every time the foot leaves the accelerator; such a car would be tiring and stressful to drive, even in the best of road conditions, let alone in a traffic situation. To keep the engine running smoothly and evenly when no power is needed, the idle circuit was added inside the carburetor. The idle jet admits fuel on the engine side of the throttle valve. Additional air is mixed with this fuel through an air bleed. The result is an entirely separate carburetor circuit which operates only when the throttle valve is closed.

Venturi

"Barrel" is a popular term for the carburetor throat. There is one venturi in each throat. A two-barrel carburetor has a primary venturi for part-load running and a secondary venturi for full-throttle; a four-barrel carburetor has two primary and two secondary venturis. The venturi tube is important in carburetion. A "venturi" is a tube with a restricted section. When liquid or air passes through the venturi tube, the speed of flow is increased at the restriction, and air pressure is decreased, creating an "increase in vacuum" (a reduction in ambient pressure). This causes fuel to be drawn into the barrel. The venturi action is used to keep the correct air-fuel ratio throughout the range of speeds and loads of the engine.

Cetane Rating (Ether)

The delay between the time the fuel is injected into the cylinder and ignition is expressed as a cetane number. Usually, this is between 30 and 60. Fuels that ignite rapidly have high cetane ratings, while slow-to-ignite fuels have lower cetane ratings. A fuel with a better ignition quality would help combustion more than a lower cetane fuel during starting and idling conditions when compression temperatures are cooler. Ether, with a very high cetane rating of 85-96, is often used for starting diesel engines in cold weather. The lower the temperature of the surrounding air, the greater the need for fuel that will ignite rapidly. When the cetane number is too low, it may cause difficult starting, engine knock, and puffs of white exhaust smoke, especially during engine warm-up and light load operation. If these conditions continue, harmful engine deposits will accumulate in the combustion chamber.

Pressurized cans of starter fluid are available in emergencies, but are not desirable, because they tend to dry out the cylinders, and are dangerous if used improperly. There are also liquid forms of starter fluid available which can be added to the gasoline.

Fuel Additives

Tetraethyl lead was used in some gasolines to reduce or prevent knocking. However, in 1975, it became illegal to use leaded gasoline except in cars built prior to this time. Methyl Tertiary Butyl Ether (MTBE) is used in unleaded fuel to increase the octane. Gasoline exposed to heat and air oxidizes and leaves a gummy film. Detergents are now added to gasoline to prevent this. The detergents keep the carburetor passages and fuel injectors free from deposits, which could cause hard starting and problems in driving. Deposits also restrict the flow of fuel and cause a rough idle, hesitation of acceleration, surging, stalling, and lack of power.

Alcohol is frequently used as an additive to commercial gasoline, because it will absorb any condensed moisture which may collect in the fuel system. Water will not pass through the filters in the fuel line, so, when any water collects, it will prevent the free passage of fuel. It also tends to attack and corrode the zinc die castings of which many carburetors and fuel pumps are made. This corrosion will not only destroy parts, but also clog the system and prevent the flow of fuel. By using alcohol in gasoline, any water present will be absorbed and pass through the fuel filter and carburetor jets into the combustion chamber. Alcohol additives are often purchased and added separately into the gas tank to prevent gas-line freeze and vapor lock.

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.

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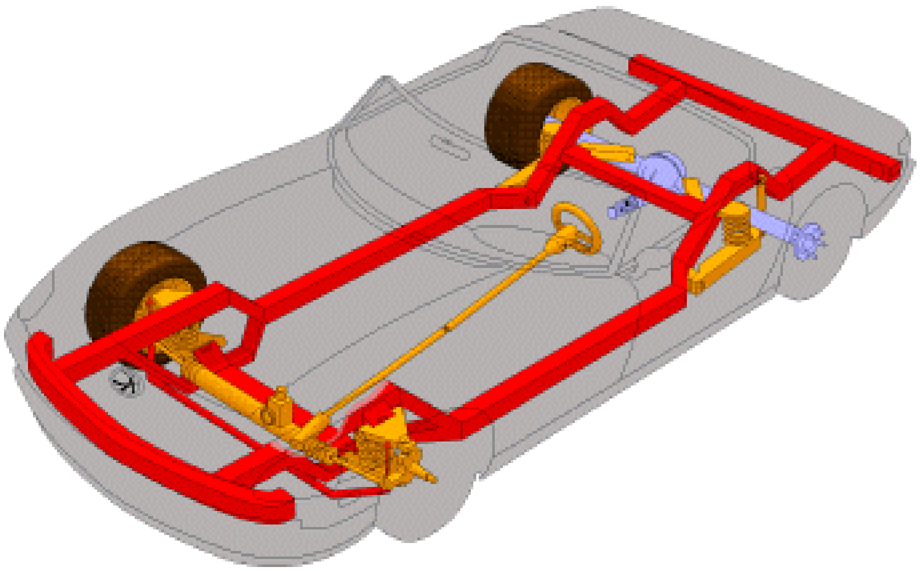
Suspension And Steering Systems Operation



Below is an overview of the suspension and steering systems

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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 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.

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.

Steering Linkage

The steering linkage is made of interconnected parts which move every time the steering wheel is turned. The rotating movement of the steering column activates mechanisms inside the steering box. Tie rod ends, which join the key parts, pass on the steering wheel's motion no matter what the angle of the linkage or the vibration from the road. In a pitman arm steering setup, 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. The steering arms pick up the motion from the tie rods and cause the steering knuckles to turn the wheels. The steering linkages need regular maintenance for safe operation, such as lubrication and inspection. Faulty steering links can cause tire wear at the least, and complete loss of control of the vehicle at worst. "Popping" noises (when turning the wheels) usually indicate worn out steering linkages.

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.

Manual Recirculating Ball Steering

With the manual recirculating ball steering gear, turning forces are transmitted through ball bearings from a "worm gear" on the steering shaft to a sector gear on the pitman arm shaft. A ball nut assembly is filled with ball bearings, which "roll" along grooves between the worm teeth and grooves inside the ball nut. When the steering wheel is turned, the worm gear on the end of the steering shaft rotates, and movement of the recirculating balls causes the ball nut to move up and down along the worm. Movement of the ball nut is carried to the sector gear by teeth on the side of the ball nut. The sector gear then moves with the ball nut to rotate the pitman arm shaft and activate the steering linkage. The balls recirculate from one end of the ball nut to the other through ball return guides.

Manual Worm and Sector Steering

The manual worm and sector steering gear assembly uses a steering shaft with a three-turn worm gear supported and straddled by ball bearing assemblies. The worm meshes with a 14-tooth sector attached to the top end of the pitman arm shaft. In operation, a turn of the steering wheel causes the worm gear to rotate the sector and the pitman arm shaft. This movement is transmitted to the pitman arm and throughout the steering train to the wheel spindles.

Worm and Tapered Peg Steering

The manual worm and tapered peg steering gear has a three-turn worm gear at the lower end of the steering shaft supported by ball bearing assemblies. The pitman shaft has a lever end with a tapered peg that rides in the worm grooves. When the movement of the steering wheel revolves the worm gear, it causes the tapered peg to follow the worm gear grooves. Movement of the peg moves the lever on the pitman shaft which in turn moves the pitman arm and the steering linkage.

Manual Worm and Roller Steering

The manual worm and roller steering gear is used by various manufacturers. This steering gear has a three-turn worm gear at the lower end of the steering shaft. Instead of a sector or tapered peg on the pitman arm shaft, the gearbox has a roller assembly (usually with two roller teeth) that engages the worm gear. The assembly is mounted on anti-frictional bearings. When the roller teeth follow the worm, the rotary motion is transmitted to the pitman arm shaft, pitman arm and into the steering linkage.

Power Steering

Over the years, power steering has become a standard equipment item on many automobiles. The demand for this system has caused power steering to be installed on over 90%% of all domestic new car production. All systems require a power steering pump attached to the engine and driven by a belt, a pressure hose assembly, and a return line. Also, a control valve is incorporated somewhere in the hydraulic circuit. "Power steering" is really "power assisted steering." All systems are constructed so that the car can be steered manually when the engine is not running or if any failure occurs in the power source.

Most power steering pumps contain a flow control valve, which limits fluid flow to the power cylinder to about two gallons per minute, and a relief valve which limits pressure according to system demands.

Power Rack and Pinion

Power rack and pinion steering assemblies are hydraulic/ mechanical unit with an integral piston and rack assembly. An internal rotary valve directs power steering fluid flow and controls pressure to reduce steering effort. The rack and pinion is used to steer the car in the event of power steering failure, or if the engine (which drives the pump) stalls.

When the steering wheel is turned, resistance is created by the weight of the car and tire-to-road friction, causing a torsion bar in the rotary valve to deflect. This changes the position of the valve spool and sleeve, thereby directing fluid under pressure to the proper end of the power cylinder. The difference in pressure on either side of the piston (which is attached to the rack) helps move the rack to reduce turning effort. The fluid in the other end of the power cylinder is forced to the control valve and back to the pump reservoir. When the steering effort stops, the control valve is centered by the twisting force of the torsion bar, pressure is equalized on both sides of the piston, and the front wheels return to a straight ahead position.

Integral Power Steering Gears

A representative of an integral power steering gear is used on certain General Motors rear-wheel drive cars and on American Motors four-wheel drive. This power steering gear uses a recirculating ball system in which steel balls act as rolling threads between the steering worm shaft and the rack piston. The key to its operation is a rotary valve that directs power steering fluid under pressure to either side of the rack piston. The rack piston converts hydraulic power to mechanical force. The rack piston moves up inside the gear when the worm shaft turns right. It moves down when the worm shaft turns left. During these actions, the steel balls recirculate within the rack piston, which is power assisted in movement by hydraulic pressure. (See also Manual Recirculating Ball Steering)

Power Steering Hoses

The power steering hoses are used to transmit hydraulic fluid under pressure from the pump to the power cylinder and to return. Besides this, the hoses must provide the proper amount of expansion to absorb any shock surge and offer enough restriction to the fluid flow to keep the pump cavity full of fluid at all times.

Power steering hoses are specially designed rubber hoses with metal fittings at each end which screw together with your power steering system. They contain power steering fluid at high pressures, and allow the system to circulate the fluids between the pump and the power cylinders.

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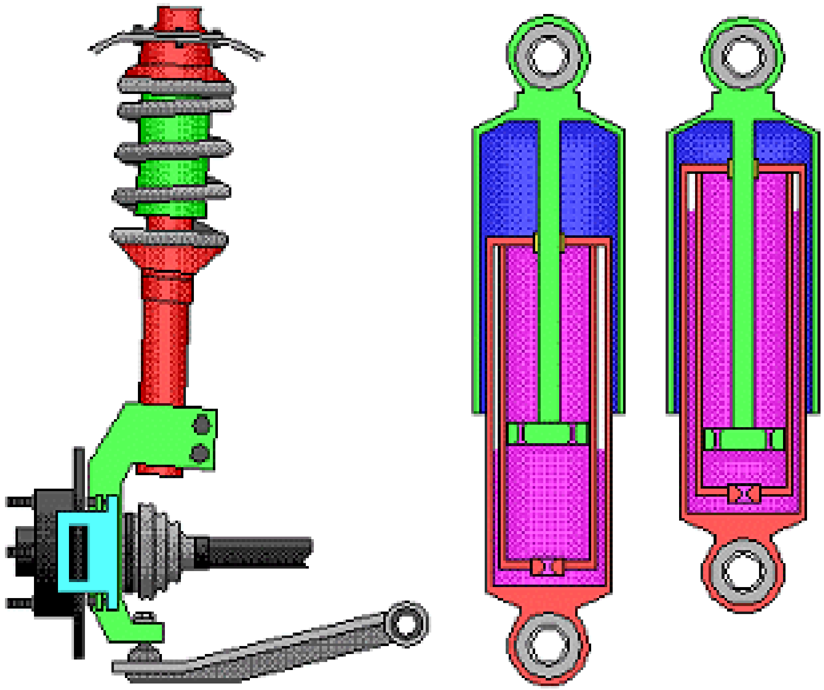
Suspension And Steering Systems Operation



Below is an overview of the suspension system operation

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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!

Coil Springs

Compression type coil springs may be mounted between the lower control arm and spring housing or seat in the frame. Other front suspension systems have the coil springs mounted above the upper control arms, compressed between a pivoting spring seat bolted to the control arm and a spring tower formed in the front end sheet metal. 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 in the frame members and sometimes support the rear coil springs to provide for up-and-down movement of the axle and wheel assembly.

Leaf Springs

Front leaf springs are used with solid axle beams in most truck applications. Corvettes use single-leaf, filament-wound, glass/epoxy front and rear springs mounted transversely; i.e., they are crosswise to the vehicle's centerline. Rear leaf springs are used on trucks and some passenger cars. Single leaf or multi-leaf springs are usually mounted longitudinally over the front axle beam or under the rear axle housing. The spring center bolt fastens the leaves together, and its head locates the spring in the front axle beam or saddle on the rear axle housing. U-bolts clamp the spring firmly in place and keep it from shifting. Eyebolts, brackets, and shackles attach it to the frame at each end. Leaf springs also serve as control arms, locating the rear end in position and transferring force to the chassis.

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 crossmember. The inner ends of the lower control arms are bolted to the crossmember and pivot through a bushing.

Shock Absorber Struts

A strut is a structural piece designed to resist pressure in the direction of its length. On typical "MacPherson Strut" use, the shock absorber is built into the strut. Most shock absorber struts are hydraulic units. Some MacPherson systems used on Ford vehicles are equipped with low-pressure, gas-filled shock struts. They are nonadjustable and nonrefillable. Like the hydraulic shock struts, faulty units must be replaced as an assembly. Another similar front suspension system is called the "hydraulic shock strut." This strut serves as a shock absorber and replaces the upper control arm. The coil spring, however, is located between the lower control arm and the body structure instead of being mounted directly on the strut.

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.

Tire Types and Markings

Size, shape, materials, and construction are all factors that will govern tires' longevity as well as the ride they furnish. The first and most important rule in choosing tires is to follow the directions and recommendations in the owner's manual. Check out the information embossed on the sidewall as well. This information can help the owner choose a set of tires that will suit both the car and the driver's personal needs. The markings on a tire will give the weight (load), size designation, serial number, tire type, carcass cords, DOT, and profile size. Other markings on the tire will probably be the brand name and the name of the tire.

The "size designation" is a combination of one letter and four numbers and is a three-part code.

The letter denotes the sidewall-to-sidewall width of the tire; the two numbers grouped with the letter refer to the height-to-width ratio; and the numbers following the dash indicate in inches the diameter of the wheel rim the tire will fit. To replace the tire, the own will find the sizes that will fit the car specified in the owner's manual.

As to "tire type," government regulations require that every passenger tire be stamped either "tubeless" or "tube-type," but more than 90%% of the passenger cars are tubeless. "Belted" would indicate that a tire has extra strength in its construction. In addition, if the tire were a radial, it would be designated as such - a necessary precaution because radials should not be mixed with other tire types except when the radials are used as the pair on the rear axle.

Bias Ply Tires

There are three general methods of arranging or laying down the tire plies. They may be laid down "on the bias," "on the bias and belted," or "radially."

The standard, and least expensive, tire is a bias ply. In this type of ply, the cord strips are arranged diagonally (i.e., at a bias) to the center line of the tread and alternate plies are reversed to cross at a 30 or 40 degree angle. The result is a uniformly firm body, which will wear satisfactorily at moderate speeds, with sidewalls that can stand curb bruises. In fast driving or hard turning, however, the tread elements squirm together and spring apart, producing heat that weakens the tires.

A veterinarian named John Dunlop in Belfast, Ireland gets credit for inventing the pneumatic tire. In 1888 he tried making better tires for his son's bicycle by using linen-covered sheet rubber. Although he was granted a patent for bicycle and tricycle tires, he sold his idea in 1889. The man he sold it to was named Harvey du Cros, Jr., who started the Dunlop Rubber Company. Dunlop himself was never part of the company.

Tire Rotation

The tire-rotation procedures charted below are not as difficult as they seem. At any given time, only one chart will pertain to any car. First find the number and type of tires you will be rotating. Then read down the column at the left. The top entry on the left is for regular rotation without snow tires. The second and third rows are for snow tire rotation. Remember, if radial tires are used in the front, then the snow tires should be radial also. When storing tires, it is a good idea to record its position on the inner face of each one, using chalk or tape. This will help when remounting the tire.

```
-------------------------------------------------------------------
                   4 TIRES (Non-radial) Rotation
-------------------------------------------------------------------
   From: R-front to: L-front to: R-rear to: L-rear to: Storage
-------------------------------------------------------------------
 Routine  L-rear      R-rear      R-front    L-front
 Fall     storage     storage     R-front    L-front    R-L:rear
 Spring   L-rear      R-rear      storage    storage    R-L:front
```

5 Tires (Non-radial) Rotation

From:	R-front	L-front	R-rear	L-rear	Rear Holding	Storage
Routine	L-rear	Rear/H	R-front	L-front	storage	L-R:rear
Fall	Rear/H	storage	R-front	L-front	storage	L-R:rear
Spring	L-front	Rear/H	storage	storage	R-rear	L-R:rear

4 Radial Tires

From:	R-front to:	L-front to:	R-rear to:	L-rear to:	Storage
Routine	R-rear	L-rear	R-front	L-front	
Fall	storage	storage	R-front	L-front	L-R: rear
Spring	R-rear	L-rear	storage	storage	L-R:front

5 Radial Tires

From:	R-front	L-front	R-rear	L-rear	Rear Holding	Storage
Routine	Rear/H	L-rear	R-front	L-front	R-rear	L-R:rear
Fall	Rear/H	storage	R-front	L-front	storage	L-R:rear
Spring	Rear/H	L-rear	storage	storage	R-rear	L-R:front

Tire Valves

The tire valve is really an air check that opens under air pressure and closes when pressure is removed. The inner valve or "valve core," acts as a check valve for the air. Positive sealing is provided by the "valve cap," which contains a soft rubber washer or gasket. It is this gasket, pressed against the end of the "valve stem," that seals the air in the tire. The careless practice of operating tires without the valve cap should not be followed, because, without the valve cap in place, there is usually a slow leak of air from the tire, causing the tire to run in an underinflated condition. If air should leak out around the base of the valve, it will be necessary to install a new tire valve assembly. This is easily accomplished with a special lever-type tool.

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.

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.

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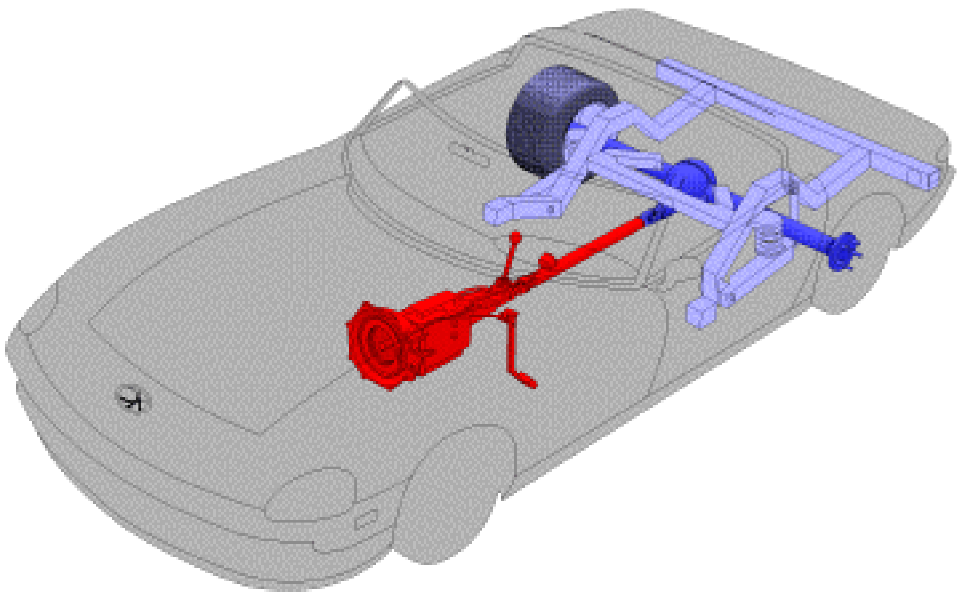
Automotive Driveline Overview



Below is an overview of auotmotive driveline operation

- Visit The Service Department To Submit Your Problem Or Question
- Click Here For A More Detailed Graphic And Operation Of Rear Axles

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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".

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.

Transmission Gears

Most cars have from three to five forward gears, and one reverse gear. The transmission changes the ratio of the engine speed and the wheels by connecting gears in various combinations. If a gear with 10 teeth is driving a gear with 20 teeth, the drive would be said to have a 2:1 ratio.

First gear connects the engine power to the drive wheels via a pair of reduction gear sets, which gives increased power and reduced wheelspeed when the car is beginning to move. This means the engine is turning much faster than the output shaft, typically around a 4:1 ratio. Intermediate speeds are delivered by changing the gear ratio closer to 1:1. Final drive is usually accomplished by directly linking the input and output shafts, giving a 1:1 gear ratio. Using a moveable set of different sized gears, it's possible to get several degrees of torque output. The differential pinion, driven by the drive shaft, turns the ring gear, which acts like a single speed transmission. This further reduces RPM's and increases torque by a set ratio.

Gears work exactly like levers. A small gear driving a larger one gives an increase in torque, and a decrease in speed, and vise-versa.

Transmission gears are heat-treated, high quality steel. They have smooth, hard teeth, cut on precision machinery while red hot. There are many types of gear teeth, but most transmissions use spur and helical gears. Most of the gears are the helical type, because they last longer and are more quiet than spur gears. There has to be enough room (a few thousandths of an inch) between the gear teeth for lubrication, expansion, and any irregularities in size.

Transmission Oil

The transmission needs lubrication to keep all of the gears and shafts running smoothly. This is accomplished by partially filling the transmission housing with thick transmission gear oil. When the gear gears spin, they fling the fluid around and lubricate all of the parts. Oil seals at the front and rear stop the fluid from leaking out of the housing.

Fluid levels should be checked when you change your oil, or if you notice difficulties or differences in shifting. This can indicate that the level of fluid might be low.

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

The clutch allows you to connect and disconnect the engine and the transmission, both starting up and during shifts. Friction plates route the rotation of the engine crankshaft to the gears, and then to the wheels. It takes the rotation up slowly, so that you aren't off to a screeching start. In a manual transmission, you disengage the clutch when you press the pedal down. The pedal works the thrust pad, and it presses levers in the middle of the clutch cover. Doing all this lifts the pressure plate away from the clutch plate. The flywheel (which is turned by the crankshaft from the transmission shaft) gets disconnected.

When you lift the clutch pedal, springs force the pressure plate and clutch plate against the flywheel. The clutch plate friction linings allow it to slide before becoming engaged. The sliding causes a smooth start instead of a jolt.

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.

The Flywheel

The flywheel is a fairly large wheel that is connected to the crankshaft. It provides the momentum to keep the crankshaft turning between piston firings.

The flywheel is the base for the entire clutch attachment. The side of the flywheel that the clutch is attached to is smooth, so that it provides a surface for friction. The clutch assembly is mounted to the flywheel, sandwiching the clutch plate in between. A bearing, called the "pilot bearing" is installed in a hole in the center of the flywheel. This lubricated bearing, either a ball bearing or a bronze bushing, is used to support one end of the clutch shaft, which is also the transmission input shaft. Around the flywheel is the ring gear, which the starter motor turns when the key is turned.

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.

Hydraulic Clutch

Another method used to activate the clutch throw-out fork is the hydraulic clutch. This method is often used when the mechanical design of the car makes it difficult to use levers and cables. It is also used to multiply force, reducing driver fatigue.

With a hydraulic clutch, when you press the clutch pedal, it moves a small cylinder called the "master" cylinder. Pressure is created in the master cylinder which is, in turn, transmitted to the "slave" cylinder. The slave cylinder is attached to the throw-out fork by a small adjustable rod, so when pressure is exerted on the slave cylinder, it operates the fork. Both master and slave cylinders are designed in such an uncomplicated way that they are easy to attach with hydraulic tubing.

Front Wheel Drive

Many cars use a front drive axle. Most front-wheel drive axles are constructed the same way as rear-wheel drive axles, with one exception. A front-wheel axle assembly must provide a way to turn the wheels as well as drive them.

The clutch or torque converter sends the power on to the transmission input shaft. Next, the power is sent on to the differential by gears or chains (belts). It goes through the differential gears through the axle and CV Joints and finally to the front wheels.

Front wheel drive was not new in the eighties when it became popular. Front wheel drive was introduced by the Pennington Car Company in 1900. Before that, steamers and electric cars had used it for years.

2WD, 4WD and AWD

2-Wheel Drive

The engine, clutch and gearbox are usually mounted on the frame at the front of the vehicle. The rotating motion produced by the crankshaft at the front of the vehicle is transmitted either to the two wheels at the rear (rear wheel drive), or the two wheels at the front (front wheel drive). Some cars are manufactured with rear mounted engines that drive the rear wheels, and front mounted engines that drive the front wheels.

4 Wheel Drive

4-wheel drive vehicles use live front and rear drive axles. When the front drive axle receives power from the transfer case, along with the rear drive axle, the vehicle can function well on off-road terrain (sand, rocks, mud, snow, etc.). A 4-wheel drive vehicle has one drive axle that is automatically in use. The operator of the vehicle has to activate and deactivate the second live drive axle.

All Wheel Drive (AWD)

All-wheel drive vehicles use live front and rear drive axles. When the front drive axle receives power from the transfer case, along with the rear drive axle, the vehicle can function well on off-road terrain (sand, rocks, mud, snow, etc.). A 4-wheel drive vehicle has one drive axle that is automatically in use. The operator of the vehicle has to activate and deactivate the second live drive axle. An all-wheel drive vehicle has both axles live at all times without manually activating or deactivating axles.

Automatic Transmissions

An automatic transmission is much easier to drive than a manual transmission, because you don't have to use a clutch pedal or gearshift lever. An automatic transmission does the work all by itself. The first automatic transmission appeared in 1939.

Automatic transmissions automatically change to higher and lower gears with changes in the car's speed and the load on the engine. These transmissions are also aware of how far down you have pushed the gas pedal, and shift accordingly.

The system is operated by transmission fluid pressure; shift valves control the gear changes. A "governor" controls the shifting of the gears. It's linked to the output shaft and throttle valve and controls the transmission fluid supply, at different pressures, to the shift valve. Here's how it works: the output shaft turns the governor. The faster the car goes, the faster the governor turns. Oil is sent from the pump to the shift valves by centrifugal force from the governor. The shift valves move out, and send the transmission fluid to the gear shifting mechanisms in the transmission. When you slow down, the valves move in, and send the transmission fluid in the opposite direction. This action changes the gears.

By routing the pressure to the clutches and brake bands, the different gears are selected.

Torque Converter

The torque converter is a type of fluid coupling between the engine and the gearbox to even out speed changes. The torque converter also multiplies engine torque.

The torque converter is used as a clutch to send the power (torque) from the engine to the transmission input shaft. It has three parts; an impeller connected to the engine's crankshaft, a turbine to turn the turbine shaft which is connected to the gears, and a stator between the two. The torque converter is filled with transmission fluid that is moved by the impeller blades. The stator's vanes catch the oil thrown off from the impeller, and use it to move the turbine's blades. When the impeller spins above a certain speed, the turbine spins, driven by the impeller.

In some designs, the torque converter locks the impeller and the turbine together when at highway speeds, which increases efficiency.

Brake Bands

A brake band is made of steel, and has a friction lining. One end of the band is attached a servo actuating rod.

A servo actuating rod is a hydraulic piston (a cylinder with a piston inside it) that is open at one end to allow oil to flow in. The piston is normally in the released position because it's kept that way by a spring. However, when pressurized oil is sent to the cylinder, the oil forces the piston forward. This causes the brake band to tighten, and this locks the brake.

Transmission Fluid

Transmission fluid is a special kind of oil used only for transmissions. It circulates through and lubricates the gears. Check your car's owner's manual for the type to use. No other type of oil should ever be used in your transmission.

Automatic Gear shifting

Almost all automatic transmissions use a pair of gear groups called epicyclic, or planetary gears. Each group consists of; an outside "ring" gear, a shared "sun" gear in the center, and a set of "planet gears", which mesh in between the sun and the ring gear. Planet gears are so named because each one turns on its own axis as they orbit the sun gear, like planets do. Each group of planet gears is held in a "planet gear carrier". By clamping the ring gears, the sun gear, and the carriers together in various combinations, and by locking some of them in stationary positions, it is possible to achieve three forward gear ratios, and reverse as well.

To increase torque: When the ring gear is stopped, and the power is applied to the sun gear, the planet gears are forced to go around the sun gear. This makes the pinion gears revolve more slowly around the inside gears, and drive from the carrier will have lower speed and increased torque.

To reverse the torque's direction: If the planet gear carrier is stopped, and torque is applied to the sun gear, the planet gears are forced to turn by the sun gear. This makes the ring gear revolve, but more slowly than the ring gear, which increases the torque, and in the opposite direction as the sun gear, giving reverse.

If two members of the gear set are locked together, planetary action is stopped and the gear set turns as one unit. When this happens, there are no increases or decreases in torque transmission.

In order to have more than 2 forward speeds, two sets of epicyclic gears are needed. By changing the number of teeth (size) of one set of planetary gears, 4 forward speeds can be produced.

The clutches within the transmission are used to connect the input torque, and the brake bands are used to lock the sun gear or the rear planet carrier. One way bearings serve to allow power flow in certain directions only, working as clutches. All of the clutches and brake bands are powered by hydraulic pressure, and regulated by the logic circuit which is connected to the governor and/or directly to a computer-controlled valve assembly. The transmission senses gas pedal position and drive selector position, and engages the proper clutches and bands for you to "Get out of Dodge".

The details of automatic transmission functions are vast, and different designs are introduced by the many automakers with great regularity. Some common principles shared by virtually all automatics are: fluid clutches, brake bands, one way bearings (one way clutches), and epicyclic gears. This crazy diagram is a simplified version of but one design among many, and if you think it's hard to understand, don't feel bad. It is!

In this type of transmission, to give first gear, the forward drive clutch (C) locks the turbine shaft to the front ring gear. At the same time, the second planet carrier brake band (D) locks the rear planet carrier in place. The power from the turbine shaft flows through the front ring gear, which turns the front carrier, which turns the sun gear. This reduces the RPM's and increases torque one time. The second reduction/multiplication happens when the sun gear turns the rear planet gears, each of which rotate within their stationary carrier. This causes the second ring gear to turn. The second ring gear transfers its torque to the output shaft through the second one-way clutch. (Does your brain hurt yet?)

Second gear is accomplished by engaging the sun gear brake band (B) and the forward-drive clutch (C). This gives one reduction in RPM.

Third gear (Drive) is engaged by locking the reverse-high clutch (A) and the forward-drive clutch (C). This gives a 1:1 (direct) ratio between the input and output shafts.

When reverse is selected, the reverse-high clutch (A) and the second carrier brake band (D) are locked. This reverses the torque direction, and reduces the ratio (twice) for use in backing up the car.

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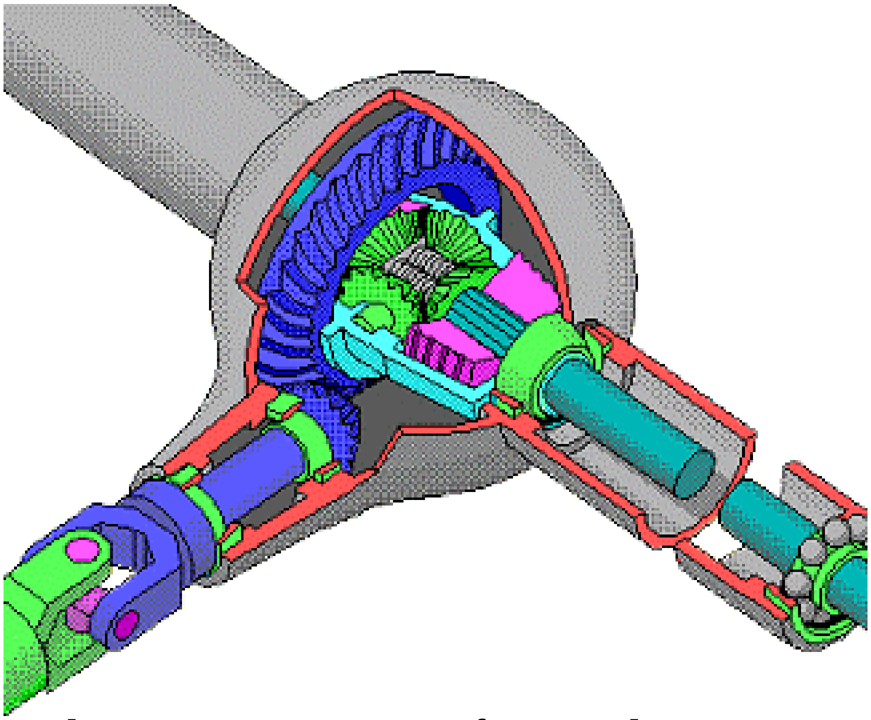
Rear Axle Operation



Below ia an overview of rear axle operation

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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.

Differential Fluids

For lubrication fluid, a very heavy oil, must be used in rear axle housings. Special hypoid oils are used in the differential case. Even another type of fluid, or oil must be used in a positraction type differential.

The oil is circulated by the ring gear, and flung all over all the parts. Special troughs, or gullies are used to bring the oil back to certain spots, like the ring and pinion area and the piston bearings. The fluid is kept in with gaskets and oil seals. The bottom of the housing has a drain plug, and another filler plug is located part way up the housing. The housing must never be filled above this plug.

The housing fluid lubricates some of the outer bearings, but others have lubrication fittings for the injection of wheel bearing grease. A hand gun, not a pressure grease gun must be used to grease these bearings (sparingly). A pressure grease gun could inject grease into the brakes-- greasy brakes are inefficient at best!

Finally, some bearings are filled with grease at the factory and are sealed. These never require attention unless they are defective.

Positraction Differentials

A positraction differential is a special traction differential. Its purpose is to improve the way your differential performs under adverse conditions. When one wheel starts to slip, these differentials transfer the torque to the wheel that is not slipping. The car can then continue to go forward. There are several different kinds of positraction differentials, but all of them are based on a friction device to provide resistance to normal differential operation.

A positraction differential provides better traction, which is handy when roads are slippery. It also lends itself to fast acceleration.

One type uses four differential pinions instead of two, with two pinion shafts. It also uses a series of four clutch discs. The differential pinions run into resistance when they try to turn the axle side gears. The resistance gets transferred to the pinion shafts driving the pinions. The shafts are forced to slide up little ramps. This action moves both shafts outward. The pinions cause the clutches to lock.

Other types use cone clutches, or disc clutches under pressure from coil springs. By restricting the differential action, torque is delivered to the slipping wheel.

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 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.

Constant Velocity Joints (CV Joints)

Front wheel drive cars need u-joints which not only allow up and down motion, but steering motion as well. the angle at which they turn requires a different design than the standard U-joint.

Constant velocity, or CV joints are universal joints that are able to transfer torque at large angles efficiently. These joints transfer power very smoothly. They are comprised of four basic parts: 1. The outer section, which has grooves machined on its inner surface, 2. the bearings, which are usually in a "cage", 3. the inner ball, which has grooves on its outer surface for the bearings to ride in, and 4. a rubber boot to protect the unit from dirt and moisture.

A common cause of CV joint failure is cracks in the CV boot. As dirt enters the CV joint, its parts grind themselves until a clicking noise is heard when turning, or until they fail completely. The boots should be replaced as soon as cracking is visible in their rubber folds.

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SAMPLE QUESTIONS

Here are summaries of some Sample Questions, and the responses provided by AUTOSHOP Online.

Question 1

> My 1994 Chrysler Concorde makes a ticking noise when the engine is running. It goes away when I accelerate. Should I be concerned about this?
> Click HERE to see a Sample Response

Question 2

> I've had my 1989 Honda Accord in for repairs to fix a severe vibration problem, but it still isn't fixed. It begins to shake when I approach freeway speeds, but the vibration goes away when I decelerate. What's wrong?
> Click HERE to see a Sample Response

Question 3

> Which car should we keep? We'll be getting a new car soon and getting rid of one of our current cars--a 1986 Mustang LX with 83,000 miles, or a 1989 Ford Escort GT with 106,000 miles. We mostly drive on expressways around Miami. The Mustang has been a good car, except for a small transmission leak that was fixed with sealant. The Escort has an electrical problem: the headlights flicker when the fog lights are on, and the radio display doesn't work periodically.
> Click HERE to see a Sample Response

Question 4

I have a 1991 Chevy 4x4. Every time I turn on the air conditioning, it does not work, and the word "AC" flashes on the heater panel. What causes this, and is it anything I can fix myself?
Click HERE to see a Sample Response

Response 1

The ticking noise on this Chrysler Concorde is commonly caused by the fuel injector rail. While a noise caused by a fuel injector rail may be a nuisance, this fuel injector rail problem will not do damage to your car, or interfere with your ability to continue to drive the vehicle. It may be repaired at your next appointment for scheduled maintenance.

Other causes of this type of noise would be symptomatic of low fluid levels such as engine oil, engine coolant or transmission fluid. Be sure to check these fluid levels, or have them checked. If all the fluid levels are OK, it's likely that your noise problem is the fuel injector rail. The parts associated with the fuel injector rail repair include:

- 4663929 Fuel rail assembly
- 4765016 Bracket
- 4473619 Intake plenum gasket
- 5277723 EGR tube gasket
- 4418903 Pressure regulator gasket

If this is not the source of your problem, there are a number of other possible causes. Check all the fluid levels, or have them checked. If all the fluid levels are OK, listen carefully to narrow down the possible sources of the noise.
Next sample question

Response 2

For a severe vibration approaching freeway speeds that becomes worse as you step on the gas, the most likely cause is a small worn area in a roller groove of one of the inner CV joints on a drive axle. Imagine a device that transmits straightline torque from the transmission through a coupling that sends the power to the wheels and allows for the up-and-down motion of the suspension. This joint at the transmission end has a cross that couples to the axle and a roller for each of the crosses. The inboard CV joint has three roller grooves, which allow for the in-and-out motion of the shaft. When one of these roller grooves gets a small dimple in it, the dimple catches the roller as it passes back and forth and momentarily tries to hold the axle straight. The more gas you give, the more this dimple tries to hold the axle, causing the outer end of the axle to shake violently and send the vibration through the suspension and the entire car.
The solution is to check the CV joints for wear, and to replace one or both if they are worn.
Next sample question

Response 3

(First, AUTOSHOP Online asked which engine was in the Mustang; the customer responded: 5.0 liter.)

Keep the Mustang. The transmission may need work in the future, but a Mustang with a 5.0 liter, 302 engine and lower mileage will last longer and have a better resale value when or if you decide to sell it. The Escort with the 1.9 liter engine has had more problems with the Electronic Engine Control and many more drivability problems than the 302 Mustang. Repairs will also be less with the Mustang for things like the transmission and the electronics. Yes, miles per gallon are lower with the Mustang, but overall it is a longer-lasting and more reliable car.
Next sample question

Response 4

The problem with your truck is a fairly common one, occurring most often in the spring, when the AC system is on with the heater in the "Defrost" position. This happens when the outside temperature is between 50 and 70 degrees F.

The blinking "AC" light is governed by the climate control head, which monitors how often the compressor clutch operates. When it turns on and off in less than 1.5 seconds ten times in a row, the climate control head disables the compressor, to keep it from being damaged, and activates the blinking "AC" light on the dashboard. It may be that the compressor was once low on Freon; sometimes, even after Freon has been added, the climate control head will continue to register a problem.

There are some things you can do to fix the problem. First, disconnect the battery for about a minute. Then reconnect the battery and start the truck. Select the AC function on the climate control panel and see if the compressor starts to operate. If the compressor cycles on and off very quickly and the "AC" light comes on again, you'll need to have the system serviced by a qualified AC technician. But if the AC starts to work properly, it should run fine.

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SERVICE DEPARTMENT

CUSTOMER FEEDBACK

Thanks again for using AUTOSHOP Online. In Customer Feedback, we strive to make sure you are satisfied with your experience. We hope we were able to help solve your repair problem quickly--if not, we're here to help, so let us know by filling out the Customer Satisfaction Form.

If you're still having a problem with your car, use the Further Assistance Form. Be sure to include your case number. This validates your request, and helps us review your diagnostic history.

Note: AUTOSHOP Online offers one free follow-up inquiry related to the original problem within one week from receipt of your original Inquiry. We're sorry, but we cannot offer free follow-up beyond this period. For later diagnosis, please submit a new inquiry.

If you would like to see how AUTOSHOP Online has helped others, visit the collection of Success Stories. And if you'd like to add your experience to this collection of automotive trouble and triumph, please complete the Your Success Story form and submit it for review.

AUTOSHOP ONLINE

SERVICE DEPARTMENT

CUSTOMER SATISFACTION

We are sorry but Autoshop-Online is currently closed for service questions.

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AUTOSHOP ON LINE

SUCCESS STORIES

We've gathered in this section some "Success Stories" from AUTOSHOP Online customers. If you would like to share your experience with others, be sure to let us know by submitting your success story.

Case Number: 952081

Date: 7/14/95

Name: (withheld)

City: Atlanta

State/Country: GA

Vehicle: 1992 Dodge Caravan

After having my van at several different places and not getting it fixed, I finally got the information I needed from the AUTOSHOP team. Next time I will start there.

My van had an intermittent problem with the lights on the dash coming and going. They would all come on or go all out. Once in awhile they would work correctly. I sent the inquiry to the AUTOSHOP team, and I heard right back.

The answer was that a wire under the dash that provided the ground connection for a bunch of stuff on the dash was loose. They also provided the exact location of the connection. I took the answer and my van to my neighborhood shop and they were able to repair the problem in no time.

Case Number: 953290

Date: 8/23/95

Name: (withheld)

City: Minneapolis

State/Country: MN

Vehicle: 1989 Dodge Caravan

Problem Starting and Stalling

The initial diagnosis at a repair shop was that the vehicle needed a new engine control computer at a cost of $400.

The AUTOSHOP team told me that the stalling problem was really caused by the injector circuit. Each time the injector fired it sent a faulty signal to the car's computer and the computer's response was to stop firing that injector. Replacing the injector solved the problem and the cost was less than half that of a computer.

Getting a second opinion saved me time and money.

AUTOSHOP ON LINE

YOUR SUCCESS STORY

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Here's your chance to record the saga of your car and how your problem was fixed or your question answered. Please include your case number for your story to be considered.

NOTE:
We reserve the right to edit these success stories for length and suitability.

Case Number:

Your FIRST name only:

City, and State or Country:

Car make, model and year:

Briefly describe the original problem or question:

What information helped you resolve this issue?

How did AUTOSHOP Online make your auto repair experience better?

Submit Form Clear Form

SERVICE DEPARTMENT

ABOUT SECURITY

You can choose from a number of payment methods. First, if you use the Fax Inquiry Form, you simply supply your credit card information on the form you fax to us. You can also use the electronic sumbission to send us your credit card information along with your Inquiry Form.

But there are also more secure ways to do this kind of business over the Internet. If you are using the Netscape Navigator as your Web browser, you can use the built-in encryption system called Secure Sockets Layer (SSL). When an SSL-equipped browser communicates with a Netscape server (like the one at AUTOSHOP Online), that communication is secure and cannot be intercepted.

For more information on the Netscape browser, Click HERE.

Alternatively, you can sign up for an account with First Virtual Corporation. All you need is a Web browser capable of filling out forms. First, you fill out a registration form transmitted by the First Virtual server. The form asks you to make up your own account identifier--a sequence of numbers and letters up to 24 characters long. You will use this identifier in all credit card transactions. You give First Virtual your credit card number offline, using your telephone's keypad. Then all transactions are processed by First Virtual, and you need not use your credit card number online. Go to information on becoming a First Virtual customer.

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AUTOSHOP ONLINE

MAINTENANCE TIPS

FROM THE CAR CARE COUNCIL

If you live in an area that has had some type of emission testing for the last several years, you are in a part of the country the EPA calls a non-attainment area. A non-attainment area is simply a metropolitan area that has levels of carbon monoxide and/or ozone that is greater than EPA standards.

The EPA has five levels of non-attainment: Moderate, Marginal, Serious, Severe, and Extreme. The level of non-attainment will determine the type of emission testing required. The two lower areas will require a basic emission inspection and the three worst areas will require an enhanced emission inspection, or as the EPA refers to it, High-Tech IM240.

If you take your car in for an emission inspection now it is most likely a basic inspection, and there is a very good likelihood that in about a year you will be required to start going through the High-Tech IM240 inspection.

Should you be concerned about this enhanced test? Not if you have followed the carmaker's maintenance recommendations and kept all of the emissions control devices in proper working order, changed the oil regularly and used the correct type of gasoline. However, if vehicle maintenance is not very high on your list of priorities or any of the emission control devices on your car have been removed or rendered inoperative, or you have been using leaded gasoline, your car will fail the High-Tech IM240 test.

This emissions test is very sophisticated. Cars are driven through a 4 minute driving cycle on a chassis dynamometer. During which time all of the exhaust that comes out of the tailpipe is run through a special analyzer and the amount of air that flows through the vapor storage system is measured. After the driving test is done the vapor storage system is pressurized and checked for leaks.

When the enhanced test is in full swing about 100 million cars will be tested. I have seen projections that anywhere from 30 to 70 million cars will fail the new test. Many cars that are barely squeaking by the basic test now will fail the enhanced test. And many cars that appear to breeze through the basic test will fail because the enhanced test checks the vehicle under driving loads, measures for pollution never before tested and thoroughly tests the vapor storage system. The vapor storage system has never been tested to this level before and it is the most neglected emission system on your car. If you go through the High-Tech IM240 test with the gas cap loose it will fail. Of course tightening a loose gas cap would be a cheap repair. The enhanced test will also find EGR valves and catalytic converters that aren't working and now you are talking several hundred dollars.

By now I hope it's clear why I said earlier that car owners who followed the carmakers maintenance recommendations will have an excellent chance of passing the enhanced test. Vehicle manufacturers must design and build a car that will meet emission standards set forth by the government. Manufacturers also must demonstrate that the cars can be operated for many thousands of miles and with proper maintenance, stay within mandated emission levels. All the knowledge that the manufacturers acquire regarding maintenance during emissions certification testing is in the owners manual buried under the maps in the glove box.

Why is the EPA pushing this enhanced test on us? The bottom line is simple. The current emissions testing is not doing the job. If the High-Tech IM240 test doesn't do the job the next step will be severe restrictions on stationary polluters (power plants), restricted use of our cars and/or an emissions tax on the gasoline we use. Any or all of these options will cost us alot of money. The least expensive way out of this problem is to maintain our vehicles properly.

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What is the IM240 and Why Should Car Owners Learn More About This Program?

If you are one of the millions of people who take their car in to be tested every year or two to see if its emissions controls are up to snuff, then you're already familiar with the main topic of this article--vehicle inspection and maintenance or I/M programs.
I/M programs are necessary because even cars with elaborate pollution control systems can have those systems go bad, either as a result of poor maintenance, simple aging, or active (and illegal) tampering. You might think that since I/M programs are already in place in many areas that the problem is solved. Not so. The trouble is that the idle emissions test that many states operated in the 1980's and which many still operate today, was designed to be just good enough for making pass/fail decisions on relatively low-tech cars. These tests are less effective when it comes to testing vehicles made and sold after 1981, which marks the introduction of stricter standards and more sophisticated pollution controls, including elaborate fuel metering systems, feedback controls, and onboard computers. Some of the shortcomings of the idle test include the fact that it test cars at only one or two speeds, and without any simulation of real world road conditions. For pre-1981 vehicles, this wasn't much of a problem because a pre-1981 car clean at idle was probably clean across the board; post-1981 cars, however, constantly readjust themselves based upon different driving modes, and so a post-1981 car that seems clean at idle can actually be a gross polluter whenever it accelerates or decelerates. As a result, the idle test sometimes passes cars that should be failed, and fails cars that should pass. Another problem is that the idle test cannot measure oxides of nitrogen (NOx) which along with hydrocarbon emissions contribute significantly to ozone (smog) production.

The IM240 was designed to correct all these problems. It has been introduced in several states and other states are considering its use. As a car owner, you should be asking how this new variety of I/M program may affect you and your family and how it can help you improve our nation's air quality. This article will give you the facts: Why the new program was introduced, how cost-effective it is, and the experience in two states, Colorado and Arizona, where the new program has been in effect since January, 1995.

BACKGROUND

The IM240 was developed by the Environmental Protection Agency (EPA) to help reduce ozone and carbon monoxide (CO) pollution. Cars give off gasoline fumes, called hydrocarbons (HC), which mix with NOx in sunlight to form ozone. Ozone damages lung tissues, aggravates respiratory disease, and makes people more susceptible to respiratory infections. It is also very damaging to building materials. CO, which also comes from cars, affect individuals with respiratory problems and impairs visual perception, manual dexterity and learning functions. While both the idle test and the IM240 were designed to detect high emitters of these pollutants they measure these pollutants differently. Unlike the idle test, the IM240 measures emissions while the vehicle is driven on a treadmill-like device called a dynamometer, which serves to simulate real world driving conditions. The test measures all important pollutants including HC, CO, and NOx. It also measures fuel economy and generates diagnostic information that helps in the repair process for vehicles that fail the test. Using the diagnostic output of the IM240, repair technicians can more accurately determine what is wrong with your car leading to less pollution from your vehicle and reducing the time and money you spend on repairs.

THE IM240 TEST

The actual IM240 test is fully automated and begins with a trained inspector driving your vehicle onto the dynamometer. The vehicle is restrained, an exhaust collection device is fitted onto the exhaust, and a cooling fan placed in front of the engine. The inspector "drives" the vehicle, rather like "driving" a car on a video racing game, and consists of applying the accelerator and brakes according to a prescribed cycle displayed on a computerized video screen. The cleaner the car, the shorter the test. The maximum test-time is four minutes (which is where the 240 in IM240 comes from), but the average test time is about two minutes. Car owners may worry that there could be some damage to their car, but this rarely occurs. A thorough safety inspection is made on cars prior to the test and the driving operation of the vehicle during the test is probably no more severe than what the vehicle experiences on its drive to the test location.

IM240-THE COLORADO EXPERIENCE

Colorado has been a leader in inspection/maintenance since the early 1980's. The development of the IM240 was inspired by this state's development of a transient loaded test similar to the IM240. Colorado designed its own I/M program to combat the high CO pollution in the Denver-metro area and reduce emissions in areas around the state. In January, 1995, Colorado began the high-tech IM240 program to test car models 1982 and older in Boulder and the Denver-metro area while operating idle tests in the less polluted areas of Colorado Springs, Fort Collins and Greeley.

Colorado has reported that its IM240 program is working smoothly. For the past fifteen years, Colorado has been in violation of the health-based air quality standards for carbon monoxide (CO). The graph below shows that the IM240 test is expected to reduce CO emissions from motor vehicles by 31% well as hydrocarbons by 28% and oxides of nitrogen by 9%. Data from 53,700 IM240 tests indicate that this is a realistic estimate.The data also indicates that IM240 is doing a much better job than the idle test. The average failed vehicle emitted 81 grams of CO per mile (the typical new car standard is about 3.5 grams/mile). After test and repair, the average vehicle emitted less than 33 grams of CO per mile, representing a reduction in CO emissions by 59%. By contrast, data on the idle test showed that on average, CO was reduced by only 13% (see graph above).

MOTORISTS REACTION IN COLORADO

A survey of 200 motorists in Colorado showed that most motorists were very aware of the air pollution problems. Most supported the program because it could effectively reduce pollution. A high percentage also supported the program because the repair shop and test facility are under separate ownership thereby limiting the potential of selling unnecessary repairs. Those who objected to the program, however, felt that it was too expensive. In fact, the IM240 typically costs motorists less than the idle test program. In Colorado, the price of the new IM240 test is $25 for a test every two years compared with $20 for the idle test which was needed every year.

THE IM240 PROGRAM IN ARIZONA

Arizona has been cited as having one of the better inspection/maintenance programs in the country. A facility that had separate test sites and repair shops was chosen as a way to limit the potential for fraudulent repairs. Their IM240 was implemented in January, 1995 for car models 1981 and older in the Phoenix-metro area. A combination of loaded and idle tests were chosen for the less polluted Tucson area.

Results in Arizona confirm that the IM240 is doing a great job in identifying the high emitting vehicles and helping determine what is wrong with the vehicle. 88% of cars passed and 13% failed the IM240 in the first four months of testing 232,823 vehicles. Of the vehicles that failed, 59% passed the test the first time after repairs were made.

REPAIR COSTS

Most car owners will be concerned about the cost of repairs if their vehicle is identified as high emitting. The average repair cost for a car in Arizona ranged from $15 for 1994 cars to $193 for 1989 cars. Cars that are pre-1981 cost less, on average, to fix than cars post-1981.

A few tips may help car owners reduce repair costs: it is better to fix the car as soon as possible because high emissions are usually a sign of some other problem with the car which, if left, may become worse and eventually cost more to repair. Also, at many test centers, a booklet is available which lists registered repair shops where program staff have worked with repair technicians to identify cost-effective ways to identify and repair the failures.

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MAINTENANCE TIPS

FROM THE CAR CARE COUNCIL

What's New In Alternative Fuel Vehicles

The environment is a hot topic now and probably will be for years to come. Automobiles have typically received the brunt of the criticism aimed at heavy polluters. But automobile manufacturers have made enormous strides in the past few years in the design and development of more "environmentally friendly" vehicles, commonly called alternative fuel vehicles or AFVs.

Flexible-fuel vehicles, or FFVs, which use a combination of gasoline and methanol, are in use now and provide a fairly convenient, low-cost alternative. FFVs are powered by a conventional engine with minor modifications.

Natural gas vehicles, or NGVs, also use a conventional engine and can burn cleaner than a flexible-fuel vehicle but require more substantial changes to the engine and vehicle fuel system for optimal performance.

Electric vehicles, or EVs, run on batteries and produce zero vehicle emissions but require the greatest degree of vehicle modification.

So if they're so much better for the environment, why isn't everybody driving an alternative fuel vehicle? Well, it's not that easy.

So far, none of the AFVs match the performance, cost and convenience of gasoline-powered vehicles.

FFVs use methanol, a fuel commonly used in high-powered race cars, which give them even more horsepower than conventional gasoline engines. However, except for parts of California, methanol pumps are few and far between, which poses problems for commuters. FFV's cost more than conventional vehicles. . . but less than the other alternatives.

NGV's require special equipment for refueling and about 5-8 minutes to refill. There exists the possibility to refuel at home, using a compressor on the household natural gas outlet.

Electric vehicles also pose the biggest problems in terms of cost and convenience. Acceleration puts the biggest power drain on an EV and fast, repeated, standing starts can shorten the vehicle's range. Recharging an EV's battery can take up to 8 hours for maximum range and may have to be done at night to avoid building more power plants. EV's are also the most expensive of the AFV's because they must have their high-cost batteries replaced after a fixed number of charges.

Despite the obstacles, most automobile manufacturers have an alternative fuel vehicle program in place. General Motors plans to introduce its electric car, the Impact, in 1995. Ford Motor Company plans to sell Flexible Fuel Tauruses in California and has plans for several fleets of electric vehicles for operation at utility companies around the country later this year and early next year. Nissan is currently at work on an electric vehicle that can recharge 100 percent in 15 minutes.

Even though gasoline is not problem free, it provides efficient transportation for millions. The engines that use it are light, powerful and dependable and over the years have reduced their emissions to very low levels. It will be a significant achievement for any alternative fuel to improve on their performance and affordability. Reformulated gasoline is an alternative you can be using today. It has considerable potential for reducing smog-producing emissions.

The transition from today's gasoline and diesel-powered vehicles to tomorrow's alternative fuel vehicles has potential to reduce our country's dependence on foreign oil, contribute to ongoing clean air efforts and reduce the level of harmful ozone formed in the atmosphere by the burning of fossil fuels.

In the near future, you may be faced with the decision to purchase an alternative fuel vehicle (AFV). I urge you to become familiar with the future choices for alternative fuels and vehicles. It may mean a better, cleaner world for us and future generations.

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MAINTENANCE TIPS
FROM THE CAR CARE COUNCIL

Proper Vehicle Maintenance

Efforts by government and industry since 1970, when the Clean Air Act was first enacted, have greatly reduced typical vehicle emissions. However, despite the increased technology of emission control devices used on modern vehicles, and the ever-more-stringent emission standards established by the U.S. Environmental Protection Agency (EPA), motor vehicles still account for the majority of air pollution in the nation.

Unfortunately, since 1970 the number of cars on the road and miles driven have nearly doubled. As a result, much of the progress we have made in decreasing emissions output and improving air quality has been offset by this increase in vehicles and vehicle miles traveled (VMT). Although emission control technology continues to improve, that alone will not solve our air quality problems. It is time that all citizens evaluate their contributions to air pollution and take the necessary steps for reducing their contribution. Besides driving less, proper vehicle maintenance is one of the most important steps you can take in reducing harmful emissions from your vehicle and cleaning up our air.

Although vehicle manufacturers are required by law to certify that a vehicle will meet emissions standards for its useful life, the ability of a vehicle to do so depends largely on proper maintenance of the vehicle by the vehicle owner; that is, having scheduled maintenance performed as recommended by the manufacturer. Proper maintenance will not only keep your car from being an excessive polluter, it will increase the running life of your car and may eliminate the need for costly repairs down the road. In addition, failure to properly perform scheduled maintenance may void your vehicle's emissions warranty, decrease gas mileage and detract from its resale value. To prevent this from happening, when you take your vehicle in for scheduled maintenance, or if you do it yourself, be sure that you or the mechanic follow the manufacturer's recommendations for service as found in your owner's manual or warranty booklet.

Along with proper vehicle maintenance, another method for reducing motor vehicle pollution is reducing the amount of time you drive your vehicle. This can be accomplished by consolidating trips, carpooling, and using mass transit or alternative forms of transportation such as biking or walking. Any method of transportation that reduces the amount of time you spend behind the wheel will also reduce air pollution and improve the quality of the air you breathe. In addition, leaving your car idling for a long period of time releases unnecessary pollutants into the atmosphere and is illegal in some cities. Turning the car off and restarting it uses less gas than idling does, and you are also polluting less.

The sources of air pollution are not limited to highway vehicles and factories. The EPA has determined that emissions from off-road vehicles and engines such as lawnmowers, chainsaws, generators, construction and farm equipment, marine vehicles and aircraft are also significant contributors to the nation's air quality problem. Therefore, performing regular maintenance on your lawn and garden equipment is another effective step you can take in reducing your contribution to air pollution. EPA is currently drafting regulations to control air pollution from these sources. Depending on the technology developed for controlling emissions from these sources, it may not be long until you have a catalytic converter on your lawnmower.

Remember you are the key to reducing motor vehicle air pollution. Proper vehicle and equipment maintenance will not only extend the running life of your car or equipment, but also improve air quality, which is critical for life to exist on Earth.

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MAINTENANCE TIPS

FROM THE CAR CARE COUNCIL

Do You Really Want Clean Air?

By Larry W. Yeager, Director, Technical Services BWD Automotive Corporation

Does it concern you that according to the Center for Disease Control there has been a 40 percent increase in asthma-related illnesses in the last decade?

Does it concern you that the American Lung Association says that about 23.8 million children and more than 14 million elderly are at risk from airborne pollutants because they live in areas with unhealthy levels of air pollution?

Do you know that vehicles account for about 50% of the air pollution problem?

Do you know that the vehicle population increases by 4 million cars per year?

Do you know that the number of miles that we drive per year doubled in the last ten years?

Why have I asked these questions? It is to make you aware of the fact that if you drive a car you are contributing to the air pollution problem we face. If you are part of the problem, shouldn't you be part of the solution?

What is the solution? The answer is simple.

1. Proper vehicle maintenance. Keeping your vehicle in proper running condition based on the recommendations found in your owners manual.
2. Be willing to accept an enhanced emissions test once every two years to confirm that your car is in compliance with federal emission standards.

Current language in the Clean Air Act Amendment of 1990 requires a 28% reduction in airborne pollutants by the year 2000. The EPA designed a test called IM240 that if implemented in the areas with the worst air quality the reduction requirements could be met at the lowest cost per ton of pollution removed.

IM240 is an enhanced emissions test where the vehicle is driven on a chassis dynamometer following a drive cycle that includes various acceleration rates, cruise speeds and deceleration rates. During the 240 second drive cycle the tailpipe emissions are measured in grams per mile.

Acceleration Simulation Mode (ASM) testing is another type of enhanced emissions test. This test run on a chassis dynamometer at fixed speed and load for a minimum of 30 seconds and tailpipe emissions are measured in percent.

Both IM240 and ASM testing have been proven to be much more effective in identifying vehicles with excessive emissions. IM240 and ASM testing can identify 40% more excess emissions than a combination of idle and 2500 RPM tests currently used by many states today.

Maine was the first state to implement IM240 in July of 1994. Keep in mind that Maine had no emission testing at all prior to July of 1994. Complaints about long lines, damage to vehicles and high cost to repair surfaced rapidly. The press, of course, concentrated on only one negative issue and many people who had never been to the test signed a petition to stop the testing. The EPA came in, audited the inspection process and other than a few new system start up glitches gave the Maine inspection program a clean bill of health. Some experts say that Maine did a poor job of educating the public about benefits of the emissions testing.

The fallout from Maine spread like wildfire. Other states considering IM240 began to reconsider. The EPA tried to enforce the implementation of IM240 by threatening to withhold road repair funds from the states who did not comply. A group of governors complained to Washington. This prompted a letter from President Clinton to Carol Browner, head of the EPA. The President asked the EPA to backoff and reconsider what the states were proposing in lieu of IM240. Of course, the EPA announced a program that would be much more flexible.

In spite of the fact that IM240 is working very well in Colorado and Arizona the new Republican controlled Congress has bills before it that could completely gut the Clean Air Act Amendment of 1990 and leave the EPA virtually powerless. Because of the complaints of a few and the desire of the Republicans to reduce the size of government. But remember this, air pollution does not recognize state boundaries. Air pollution from one state can be carried by prevailing winds to another state. So it seems that one standard for all will insure clean air for everybody. When the health of generations to come is at stake the idea of a federal agency (EPA) charged with the responsibility of maintaining the quality of our environment is an absolute must.

If you care about your health and the health of your children and your children's children, I suggest that you contact your Senator and Congressman and let them know that you want clean air. Tell them we need to keep the current language in the Clean Air Act Amendment of 1990 and all states that don't meet the national ambient air quality standard must comply with stricter emissions testing proven to reduce pollution levels. If you are part of the problem you should be part of the solution.

MAINTENANCE TIPS

FROM THE CAR CARE COUNCIL

CCAR: An Industry Program That Benefits the Motorist

Mr. Sherman Titens, President

Coordinating Committee for Automotive Repair (CCAR)

Have you had to make an appointment for auto service lately? You may have waited several days or longer, largely because of a shortage of technicians. Many maintenance services are assigned to those technicians who have been trained in the complexities of newer cars.

The shortage of people qualified to do this kind of work has become a serious problem for the automotive service and repair industry, according to Sherman Titens, President of the Coordinating Committee for Automotive Repair (CCAR), Kansas City, MO. `There are as many as 60,000 unfilled jobs in our industry," he says, "and this condition is likely to continue at least until the turn of the century."

Filling the Need

The urgent need for education and training, dissemination of information, were the basis for creating CCAR, Titens explains. Starting just two years ago as a partnership of industry-education-government, we're now affiliated with 34 national trade associations and professional societies. Our premise: "How do we provide for diagnosis and efficient repair of our vehicles in light of future technological changes?"

Beginning this year, millions of vehicles will be subject to the new EPA program and its emissions inspection and repair requirements. It is estimated that as many as twenty five percent of the vehicles tested will fail the inspection. Required repairs will involve new knowledge and technology on the part of the automotive technician. CCAR aims to help meet this challenge and to help technicians deal with the new On Board Diagnostics (OBDII) on future vehicles.

"CCAR exists because of the need for more coordinated and united activities to enhance the proficiency and image of automotive technicians," says Titens. "Achieving this objective is believed to be the most cost-effective way to improve vehicle maintenance. This will benefit the public in terms of improved air quality, safety, fuel economy and satisfaction with repairs."

In addition to being able to diagnose and utilize the data generated from the OBDII system, the technician will need to acquire greater knowledge of computers and electronics in order to make full use of the information provided by the OBDII system.

A Wide Range of Activities

To better coordinate and cross-pollinate the ideas and energies of government, industry and training/educational organizations, CCAR has formed an Inter-Agency Council which brings together government agencies and industry representatives to share and exchange information. Beyond this, a State IM Coordinators Network has been formed to keep states current on inspection and maintenance issues and technical training.

Two satellite video programs, focusing on career opportunities and professional development of automotive education instructors, will be broadcast to hundreds this fall.

Further, the CCAR program will offer an electronic education bulletin board for instructors' information exchange.

Another aspect of the organization's programs is an industry campaign to solicit and direct donated tools, equipment, educational materials and vehicles for technical school programs. Over two million dollars worth of items have been distributed to date.

Finally, CCAR is exploring the establishment of a national clearinghouse for regulatory information which affects employees of the five hundred thousand small businesses which operate in the automotive industry.

"Although it is young," says Titens, CCAR has demonstrated that the automotive industry can come together and work to improve the professionalism of the automotive technician.

For more information, write CCAR, at 4717 Central, Kansas City, MO, 64112.

MAINTENANCE TIPS

FROM THE CAR CARE COUNCIL

A Future For Women As Automotive Professionals

The demand for qualified automotive technicians to service more sophisticated vehicle technologies is increasing. Estimates suggest a current shortage of roughly 60,000 technicians nationwide, growing by 20,000 each year. If these estimates hold true, the industry could face a serious shortage of qualified technicians. One effort underway to combat this potential gap is the formation of an industry association that would organize around attracting and retaining women in the auto service profession. Women currently working in the industry are identifying other women throughout the nation to explore the possibilities of forming such an association. Anyone interested in this issue should contact Jessica Levy of Monroe Community College in Rochester, NY at 716-325-1242.

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MAINTENANCE TIPS

FROM THE CAR CARE COUNCIL

Community Campaign Improves Car Care Awareness

Most drivers are aware that a neglected vehicle pollutes our environment, wastes fuel and is a safety hazard. Unfortunately, many owners delay or ignore the repairs necessary to keep their cars in satisfactory condition.

One means of improving motorists' maintenance habits is through an annual campaign known as National Car Care Month.

Every October for the past 15 years, this project, coordinated by the Car Care Council, involves widespread support from government, consumer groups, and automotive industry associations and businesses.

Local groups join forces to plan and publicize National Car Care Month, announcing the times and places of free vehicle inspection lanes. Auto clubs, technical and automotive service establishments conduct the testing with the cooperation of trained technicians.

Results of these checks, tabulated by the Automotive Market Research Council, provide "grass roots" insight into the condition of a cross section of our car population.

In October of 1994, 6,569 confirmed inspections took place in 31 cities, with more than 8 out of 10 vehicles found to have some unsatisfactory part, fluid condition or emissions level.

A closer look at the results reveals:

Emissions - Among all vehicles inspected, nearly 20% failed,on average, with one site reporting as many as 48% failed.

Tires - 31% of vehicles failed due to incorrect tire pressure or worn tread.

Windshield Wipers - 14% of vehicles failed due to windshield wiper condition and/or malfunction. 18% had insufficient windshield washer solvent.

Fluids - 16% of vehicles failed due to low or dirty fluids (motor oil, transmission, power steering or brake fluid), an increase of about 20% over the previous 5 year average.

A third of cars 10 years old or older were low on motor oil.

NOTE: ***94% of vehicles 10 years old or older needed maintenance, the highest percentage in the***

history of this program.

Watch for National Car Care Month events in your community.

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MAINTENANCE TIPS

FROM THE CAR CARE COUNCIL

Students/Teachers Collaborate in Car Care Event

High school students, accustomed to being taught, now have the opportunity to teach while learning. It's part of a school oriented Car Care Event that involves vehicle check lanes, informative exhibits, car rallies and other activities to teach their communities about good car maintenance.

Armed with a step-by-step teacher's guide and other materials provided by the Car Care Council. Educators and students from various disciplines pool their resources to carry out this event. The result is a collaborative teaching project that educates students in life skills while motivating motorists to take care of their cars.

In a recent pilot program, journalism students worked on editorial and advertising while distributive education students gathered support from local businesses. Many of these students created and manned the consumer education booths on Car Care Day. Meanwhile, the auto mechanics department assembled the work teams that operated check lanes. Finally, the English Department's applied communications class compiled the data and wrote articles comparing their county to other check sites in the nation.

Marketing instructor Billy Ross said that, ". . . as long as the project remains student-focused and students are allowed to do most of the work, an amazing amount of learning will take place."

Barbara Garnett, applied communications instructor was impressed by the effectiveness of on-the-job-training. She said her students "learned so much about their computers while preparing for Car Care Day. It's almost impossible to teach that fast and that thoroughly using traditional teaching methods."

For more information on how your school can participate, write Car Care Council, One Grande Lake Drive, Port Clinton, OH 43452.

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FROM THE CAR CARE COUNCIL

Teen Driving

By Bob Bondurant, former professional race car driver, now president of the Bondurant School of High Performance Driving in Phoenix, Arizona and consumer advisor for Ford Motor Company.

Today's teenage drivers are responsible for about five times as many fatal crashes per license holder as are drivers between the ages to 35-64. We often assume these fatal teenage accidents involve alcohol. In fact, carelessness and poor decision-making are most likely the cause in the majority of these incidents.

Driving an automobile requires making skilled and well-timed decisions several times a second. Such decisions are based on prior knowledge and driving experience.

However, public education faces more and more funding cuts, and driver's education programs are usually one of the first to face the guillotine. Many state programs previously established time requirements for in-class and on-road training. For example, a student in Michigan had to spend 30 hours in classroom instruction and 6 hours behind the wheel with a driving instructor. The new trend steers toward knowledge and competency-based programs. Most often, as long as students show up to class, pass a written test, and demonstrate basic driving skills behind the wheel, they can receive their license.

Students must demonstrate objectives at a level specified by each state's department of education to earn their driver's certificate. The purpose of most driver's education programs is to expose students to the basic skills they need to maneuver a vehicle. Students are orientated to residential, country, light and heavy city traffic, and expressway driving. They learn basic driving maneuvers such as starting, stopping, and backing the vehicle. Before passing a course, students must demonstrate turning, turn-arounds, and lane changing as well as parallel and perpendicular parking. Lastly, students must show an understanding of traffic laws.

But safe driving requires more than just basic skills. Safe driving requires experience.

It is the belief of Ford Motor Company and the Bob Bondurant School of High Performance Driving that experience should be acquired through on-road and simulation training before a teen is licensed. A teen should not have to learn the hard way by rear ending a vehicle during rush hour, or by spinning into a ditch on a snowy night.

Students need to spend less time in the classroom and more time behind the wheel - - not necessarily on the road, but in a parking lot or a test track in accident simulation. Practicing how to avoid a collision benefits a student in ways text-book training cannot.

Parents can play a significant role in their teenager's development into a skilled and responsible driver by allowing them to gain experience behind the wheel. Many states require fresh graduates of driver's education to drive with a permit, with a parent, for thirty days before receiving their license. This is the opportunity for teens to gain their most critical driving experience. The Automotive Club of America provides parents with a checklist they can use to monitor their teen's driving maneuvers.

However, completing a driver's education course does not mean a teen is ready to receive his/her license. A driver's license can be obtained as early as the age of 16 in the United States, but in many countries the legal driving age is eighteen. My point is, that if a parent feels their teen is not ready on his/her sixteenth birthday to handle the responsibility of driving a vehicle, a safer option might be to wait a month or two, or maybe even a year.

Motor vehicle incidents are the number-one killer of young Americans aged 15 to 24, and Ford Motor Company is committed to changing that statistic. With this in mind, Ford Motor Company recently offered the Ford Motor Company Teenage Driving School with Bob Bondurant to select high school students in Dallas. The program was designed to help reduce fatalities by teaching teens improved driving skills.

The program consisted of two half-day sessions and engaged students in demonstrations and activities to illustrate skid control, including front- and rear-wheel slides. They participated in a crash simulator to sharpen reflexes, learned maneuvering and braking techniques and heel-and-toe downshifting.

Teenage drivers need to be equipped with sight and thought processes which allow them to make correct decisions in the ever-changing traffic environment. Proper on-road instruction and experience can help a young driver meet the many challenges of vehicle operation.

The Ford Motor Company Teenage Driving Program provides teens the "hands-on" experience that cannot be learned or appreciated through traditional training.

Driving is not just a physical task. Students can demonstrate basic skills, but still may not have proper mental attitudes and responses to driving situations. They must be taught respect for the vehicle they drive, as well as the other drivers on the road. For teens, a more thorough understanding of how a car operates is essential in achieving optimum performance and response, under all "types" of conditions.

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FROM THE CAR CARE COUNCIL

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A typical inspection lane includes checks of lights, windshield wipers, tires, exhaust emissions and other functions affecting the vehicle's safety and performance. It's a volunteer project with no charge for the service.

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MAINTENANCE TIPS

FROM THE CAR CARE COUNCIL

Is Your Car...

Does your car squeal with pain when you apply the brakes? This could be the sound of your "chirper", a signaling device built into the system to warn you of worn brake pads. A squealing or grinding noise also is characteristic of the new, semi-metallic friction material used on brake pads and linings. This material replaces the hazardous asbestos previously used.

Brake performance on vehicles of recent years is significantly improved, as is the service life of braking system parts. Unfortunately consumer attitude toward preventive maintenance has not kept pace with technology. A national consumer survey showed vehicle neglect is on the rise even though nearly half of motorists ranked brake failure as their number one fear among driving emergencies.

Surprisingly, notes the Car Care Council, less than 20% identified brakes as a system to be checked regularly.

The U. S. Government Accounting Office reports that states without vehicle safety inspection programs had accident rates 17% higher than those with inspection programs.

Whether or not your vehicle's brakes are inspected periodically, as they should be, be aware of the signs of brake trouble and take corrective measures at once.

Listen for unusual noises when brakes are applied. To improve hearing, try applying brakes at slow speeds with windows down.

Note: Brake work performed in time saves money as well as lives. Some owners, to squeeze extra miles out of their worn brake pads, have been known to disable the "chirper" (mentioned earlier.) This is a classic case of false economy, warns the Council. In addition to affecting driving safety, metal-to-metal wear of rotors or drums adds hundreds of dollars to a brake system overhaul.

If brake fluid needs topping off frequently, find and correct the leak.

If brakes pull to one side, if they shudder or if the pedal pulsates, have a qualified technician check out the trouble.

If the pedal "fades", feels spongy or falls to the floor under steady foot pressure, take the vehicle in for service.

Invest in the best quality brake work you can obtain. It's an excellent form of insurance.

For more information on this subject send a stamped, self addressed envelope for the Council's free pamphlet, "HOW TO KEEP YOUR BRAKES FROM LETTING YOU DOWN." Their address is Car Care Council, Department B, One Grande Lake Drive, Port Clinton, OH 43452.

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MAINTENANCE TIPS

FROM THE CAR CARE COUNCIL

How to Keep Your Brakes from Letting You Down

Think of your car's brake system as an extension of your body. If you push on the pedal and the car doesn't respond as you expect it to, you may be in trouble. When your brakes feel good you'll feel better about driving. There are no short cuts on brake work. Invest in the best service you can get.

Brake Failure Symptoms

Noises

Your brake system may be crying for help if you're hearing strange noises when you depress the brake. Two of the most common are squeaks are grinding.

Squeaks

Friction from the brake lining causes heat. Under extreme conditions this can damage the pads and/or lining, brake drums and rotors.

Grinding

A metallic grinding sound indicates your brake pads are worn through. Metal-to-metal contact will damage drums or rotors.

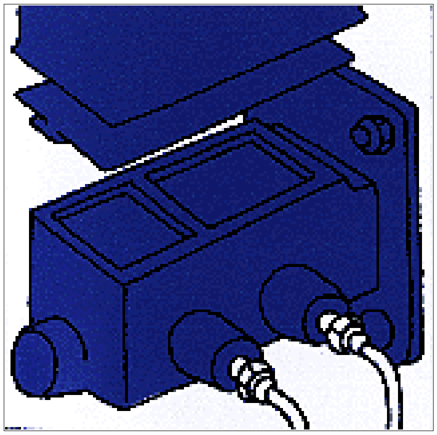
Low or Fading Brake Pedal

Do your brakes require pumping to stop the car? Does the pedal sink to the floor board when you're stopped at a light? There may be a leak in the brake system, air in the brake lines, or the need for a brake adjustment.

Pulling to one side or brake drag

Worn or uneven brake linings or a damaged brake line can cause your vehicle to pull to one side. Brakes that are out of adjustment or have contaminated fluid can cause brakes to drag.

Inspecting Your Brakes



1 Master Cylinder

The master cylinder, heart of the brake system, contains a reservoir for brake fluid. It is located on the firewall and should be checked periodically to ensure the proper fluid level.

2 Brake Lines

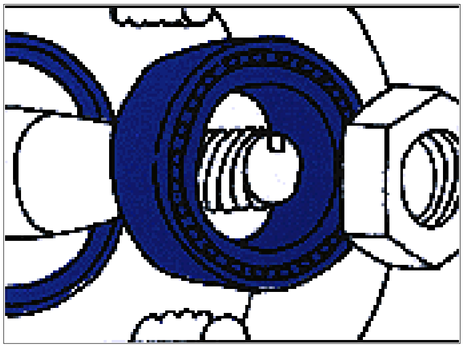
Attached to the master cylinder, steel brake tubing runs to all four wheels. Brake lines should be inspected for rust, which can lead to leaks. If the lines are damaged they should be replaced.

3 Brake Hoses

Rubber brake hoses run from the brake lines to the brake calipers and wheel cylinders. Constant exposure to road grime, dirt, salt and other elements can cause the rubber to become brittle and crack, leading to brake failure.

4 Linings and Pads

The pads and brake shoe linings should be checked periodically for uneven or excess wear, glazing, or saturation from brake fluid or grease.



5 Calipers and Wheel Cylinders

Brakes are activated by brake fluid pressure from the master cylinder pushing a piston located in the caliper or wheel cylinder against the pad or shoe. A leak can cause erratic braking or brake failure.

6 Bearings and Seals

Wheel bearings should be inspected and lubricated periodically. Worn wheel bearings, which can cause faulty steering as well as erratic braking, should be replaced.

7 Parking Brake

The parking brake should be adjusted periodically.

MAINTENANCE TIPS
FROM THE CAR CARE COUNCIL

Expert Advice On Finding A Good Mechanic

Truck or van is the second costliest purchase you will ever make -- out ranked only by your home. And it's also likely that you're discouraged by the thought of maintaining your vehicle. Today's vehicles seem too complex for your own backyard tinkering, and finding a good repair facility with competent mechanics seems more difficult than it should be.

Fortunately there's a group that can help take much of the guesswork out of finding a competent mechanic. The independent, nonprofit National Institute for Automotive Service Excellence, better known as ASE, is dedicated to improving automotive service and repair by testing and certifying the competence of individual mechanics, or "technicians," to use today's terminology.

ASE is the only automotive certification group that is both national in scope and industry-wide. It is self-supporting, with a forty-member, volunteer board of directors drawn from all segments of the automotive service industry, as well as representatives from education, government and consumer groups.

ASE means Good News for Consumers

ASE-certified technicians have <i>*proven* </i>their competency to you, to their employers, and to themselves by passing national, standardized exams.

Because ASE's program is voluntary, technicians who have paid in time and money to earn ASE certification can be counted on to have a strong sense of pride in their profession. Moreover, prior to taking ASE exams, many mechanics attend training classes or study after work to increase their knowledge, another plus for consumers.

ASE certifies only the individual technician, not the repair shop itself, but it stands to reason that employers and managers who encourage their technicians to earn ASE's national credentials will be concerned about all aspects of their business.

The Nuts and Bolts of ASE Certification

Twice a year some 100,000 technicians sit for ASE certification exams at over 600 locations. The exams are administered in the field by ACT, the same organization that offers college entrance and other professional exams.

The exams, which stress real-world diagnostic and repair problems, are designed by representatives from the automotive service and repair industry, vocational educators, and ASE's own in-house technical specialists.

There are eight automobile exams: Engine Repair, Engine Performance, Electrical/Electronic Systems, Brakes, Heating and Air Conditioning, Suspension and Steering, Manual Drive Train and Axles, and Automatic Transmissions. There are also tests for collision repair/refinish technicians, engine machinists, parts specialists, and medium/heavy truck technicians.

The exams are no cinch to pass; on average, one out of three test takers fail any given exam. But those who pass and fulfill the work experience requirement earn the title of ASE-certified Automobile Technician, while those who pass all eight auto exams earn Master Auto Technician status.

Every ASE technician is issued credentials listing his (or her) exact areas of certification and an appropriate shoulder insignia.

Nor does it end there: certification is not for life; ASE requires its technicians to recertify every five years to keep up with technology and to stay certified.

How to Find an ASE Certified Technician

ASE-certified technicians can be found at every type of repair facility: new car dealerships, independent garages, service stations, tire dealers, special shops, and major franchises. There are about 375,000 ASE technicians at work across the nation.

Repair facilities with one or more ASE-certified technicians are entitled to display the blue and white ASE sign and post their certified technicians' credentials in the customer service area.

Choosing the Right Technician

As with physicians, auto technicians specialize. Because ASE offers certification in all major technical areas of auto repair and service, it's wise to ask the shop owner or service manager specifically for a technician who is certified in the appropriate area, say, brakes, engine repair, or air conditioning. The technicians are issued pocket-sized credential cards listing their exact areas of certification.

For free information about ASE technician certification, send a business-sized, self-addressed, stamped envelope to: ASE Consumer Brochure, Dept. CCC-F95, P.O. Box 347, Herndon, VA 22070.

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MAINTENANCE TIPS

FROM THE CAR CARE COUNCIL

Choosing a Repair Shop

A Checklist

Here are some tips from the non-profit National Institute for Automotive Service Excellence (ASE) on finding a good repair establishment:

- Start shopping for a repair facility *before* you need one.
- Ask friends and associates for recommendations; consult local consumer organizations.
- Arrange for alternate transportation in advance so you will not feel forced to choose a shop based solely on location.
- Look for a neat, well organized facility, with some vehicles in the parking lot equal in value to your own and modern equipment in the service bays.
- Look for a courteous staff, with a service writer willing to answer all of your questions.
- Look for policies regarding labor rates, diagnostic fees, guarantees, acceptable methods of payment, etc.
- Ask if the repair facility specializes or if it usually handles your type of repair work.
- Look for signs of professionalism in the customer service area such as civic, community, or customer service awards.
- Look for evidence of qualified technicians: trade school diplomas, certificates of advanced course work, and certification by ASE.

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MAINTENANCE TIPS FROM THE CAR CARE COUNCIL

Auto Repair Improves With Good Communication

Ask a car owner why that grinding noise in her brakes has gone unchecked and she'll probably say it's too big of a hassle or she's short on cash. However, the real reason may be a problem that's capturing the attention of the media, the public, and even law enforcement officials nationwide: SHE'S AFRAID SHE'S GOING TO GET RIPPED OFF.

If repair fraud is one of your fears, you're not alone. The National Better Business Bureau reports that auto repair and service is a leading consumer complaint. But this industry is not burying its head in the sand. Instead, it's turning the fraud fiasco into an opportunity, and motorists are the beneficiaries.

"Professional shop owners are going the extra mile to build this trust, especially when communicating with customers."

The key words are trust and communication. Because it takes communication to build trust, car owners and their technicians must not only communicate, but communicate effectively. How is that done? Here are some suggestions.

First, inquire about your technician's ASE (Automotive Service Excellence) credentials. This "communicates" that you expect the person who repairs your car to be judged competent by the standards of a national organization.

Second, take a list with you that "communicates" every aspect of your car's problem. It's not enough to say you're having brake trouble. Does the car shimmy when it comes to a stop? What about when you're slowing down but don't come to a full stop: What does the noise sound like? These are the things customers often forget to mention, yet they are priceless tools for the technician, saving him valuable diagnostic time.

The third "communication" suggestion is the most important. Get a written estimate that includes a statement saying no additional work will be done without your authorization. This is also the time to inquire about the warranty offered on the work and parts. If you're new to this facility, and want to double-check their diagnosis, get a second opinion. If the estimate sounds too pricey, call other shops and see what they'd charge for that job.

Fourth, read your bill. If you have any questions, ASK. Make sure the repair warranty you discussed earlier is included.

Fifth, when you pick up your car, drive it around the block BEFORE you pay the bill. If the problem still persists, it's easier to "communicate" your concern at this point.

Finally, there is the advantage that plastic has over real, live, paper money, and that is recourse. If you have a problem with a service facility, simply notify your credit card company that you are dissatisfied. Until the dispute is settled, you won't owe the repair shop a dime.

The extent to which your service center can satisfy you is somewhat dependent upon the information you provide. Communicating what you expect of them is the best way to enjoy a long and happy relationship with your automotive technician.

The Car Care Council offers a free pamphlet called, "HOW TO FIND YOUR WAY UNDER THE HOOD AND AROUND THE CAR." To receive a copy, send a self-addressed, stamped envelope to Car Care Council, Department UH, One Grande Lake Drive, Port Clinton, Ohio 43452.

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MAINTENANCE TIPS

FROM THE CAR CARE COUNCIL

Cool Runnin'

Whether your vehicle has manual air conditioner (A/C) or an automatic temperature control system, it is generations ahead of the A/C systems found in vehicles a decade ago. Both automatic and manual A/C systems use electronic controls and interact extensively with other vehicle systems. As a result, specific equipment is required to ensure proper diagnosis and service.

In addition, responding to environmental and legislative pressures, leading automakers have redesigned car, van and truck A/C systems to eliminate the use of R-12 (freon), which has been shown to cause damage to the earth's ozone layer.

Most '94 (and some '93) vehicle A/C systems operate using an "ozone friendly" new refrigerant called R-134a. Ask your local auto service professional which type of refrigerant is used in the vehicle you own or are considering buying.

Don't worry, whether your car's A/C uses R-12 or R-134a, you'll still be able to stay cool on those hot summer days. That is, of course, as long as you keep it properly maintained. Since the EPA (Environmental Protection Agency) outlawed the sale of R-12 in small containers, the days of topping off a car's A/C with a quick shot of freon are over.

Caution: Don't be fooled by so-called "drop in" replacements. The EPA has not approved anything other than original-type refrigerants for use in vehicle A/C systems. Furthermore, service industry experts warn that unapproved refrigerant blends can cause significant and costly damage to A/C and other system components.

"Oh great," you say. "What am I going to do now that I can't simply replace the R-12 that leaks out?" According to Bob Lanzendorf, Product Manager for Everco Industries, a leading supplier of A/C replacement products, the answer is simple. "Treat it like any other part of today's high-tech vehicle and have it serviced by a professional," he said. "Having your car's A/C maintained by experts lets you stay cool on the hottest summer days, while helping to safeguard our earth's fragile environment for future generations."

"So," you say, "how do I find out if an auto service facility can do the job right?" Just ask. Most service shops have invested in equipment and training to prepare their technicians to work on both R-12 and newer R-134a A/C systems. They will be glad to show you their credentials and explain system changes. You may even notice signs at local repair shops announcing "ozone friendly" A/C service and repairs.

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FROM THE CAR CARE COUNCIL

Cars Cooling System Service

Since the colder months will soon be upon us, there are several things considered critical in your vehicle's maintenance. And since the engine is the heart of your vehicle and directly affects its operation, here is what you can do to ensure proper engine life and performance. A vehicle's cooling system should be serviced seasonally to prevent premature engine wear due to extreme climate or engine temperature.

According to Everco Industries, a leading manufacturer of automotive cooling system parts, one sure way to prepare the engine's cooling system for these extreme climate conditions is to have your local service dealer perform a few basic preventive maintenance checks during your next routine servicing:

1. **Check for external leaks.** Usual areas of leakage are water manifolds, radiator seams, water pumps, freeze plugs and all hose connections. The condition of radiator hoses should be carefully scrutinized for possible deterioration from age and/or wear from rubbing against accessory brackets, etc. Be aware that in many cases radiator hoses wear from the inside out, so outside appearance can be deceiving.
2. **Check for internal leaks.** Pull the oil dipstick and check for evidence of coolant. It will show up as minute droplets or sludge and should be easy to spot. This could indicate a cracked head, block or blown head gasket.
3. **Check the radiator.** This is the one component in your vehicle's cooling system which can quickly diminish the efficiency and durability of the engine. Check for obstructed air flow and clean any debris from the fins. Also check the radiator mounting for loose bolts or cracked brackets from vibration and stress.
4. **Check the cooling fan.** If the vehicle is equipped with a centrifugal thermo-static type fan clutch, it is important to spot problems before they occur. Check for wear by moving the fan blade back and forth. Over 1/4" of play in either direction could point towards excessive bearing wear. You should also turn the fan by hand. If it free-wheels or there is a rough grating feel as the fan turns, this could mean excessive fluid loss or bearing wear respectively. If any of these conditions exist or there is evidence of fluid leakage, the fan clutch should be replaced. If the vehicle is equipped with an electric cooling fan, a quick performance check can be made by turningon the A/C and checking to make sure it operates without excess vibration or noise. Also check all electrical connections for signs of corrosion, or physical damage. With the engine hot, check to see if the fan is coming on at the correct temperature and operating properly.
5. **Check the coolant level and conditions.** As a general rule the coolant level should be 1" to 2" below the radiator filler neck when cool. Use an antifreeze tester to determine the protection range of the coolant. It should be at least adequate for the geographic area where you live. If the coolant

is over two years old or has rust in it, system flushing and refilling with new antifreeze solution is recommended and will be sufficient for most climates. The two year replacement interval is necessary to maintain proper rust inhibitor and other additive protection in the cooling system.

6. **Check the radiator cap.** If your cap is rusted or the rubber seal is dried out, it should be replaced. A pressure tester should be used to be sure the cap is operating at the recommended pressure level.
7. **Check the thermostat.** Remove the radiator cap and start the engine. Insert a suitable thermometer into the radiator neck. When the coolant level drops in the radiator, the thermostat has opened and is allowing circulation. Record the temperature on the thermometer and compare to the thermostat specifications. It should be no more than a few degrees either way of the actual thermostat setting. If you are not in the correct range, the thermostat will have to be replaced. Be sure to install a new gasket and inspect the thermostat seating area for corrosion and pitting.
8. **Check drive belts.** Visually inspect all belts for glazing or deterioration. These conditions usually are caused by wear but can be accelerated by improper adjustment, engine fluid spillage, lubricant leakage or improper belt sizing. Check the vehicle manufacturer's specification listing for proper belt size, tension and/or deflection specifications.
9. **Check heater operation.** A quick functional testing of the heater unit can save a lot of mid-season grief. Visually inspect all hoses for deterioration from age and wear. Also make sure hoses are not taut. This situation can cause leaks at the heater core. Check the floor under the heater assembly for signs of coolant loss. This could point towards a leaking heater core. Also make sure to check the heater valve. Check vacuum lines for leakage or deterioration. Lubricate all control cables, such as the heater valve control cable, etc. Last but not least, check all function switches and blower motor switches for proper operation. Having basic cooling system checks made during routine servicing can prevent costly breakdowns and inefficient operation of equipment during extreme climate conditions. Preventive maintenance is the key to being able to drive your car longer while reducing long term expenses.

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MAINTENANCE TIPS

FROM THE CAR CARE COUNCIL

Cooling System

"Tune-up" Checklist

- Flush dirt, bugs and leaves from front of radiator with a brush and garden hose.
- Inspect the radiator cap. Replace it if the rubber gasket is broken, dried out or missing.
- Check the condition and level of coolant. If it is rusty, clean the system and replace with a 50/50 mixture of water and ethylene glycol anti-freeze.
- Inspect radiator and radiator hoses for leaks, cracks or soft, mushy condition. Tighten all clamps. Replace hoses as needed.
- Look for the heater hose running from the engine, through the firewall, to the heater core under the dash. Replace swollen or cracked hoses. To check the hoses, start the engine and turn on the heater. If after ten minutes the hoses are cool, they could be clogged.
- Inspect all engine belts for wear and cracks. Replace if worn, cracked or glazed. Adjust loose belts. Note: Some engines have a V-ribbed belt that drives some or all of the accessories. If the belt grooves show excessive cracks or "chunking", replace the belt.
- Check the thermostat operation by running the engine for 10-15 minutes. Generally, it's OK if you can feel warm coolant surging through the upper hose. Beware of an engine that runs too hot or too cool. Tighten loose bolts on the thermostat housing at the engine.
- Clean the engine exterior. Excessive oil and dirt will hide leaks, or insulate the engine, causing it to run hot.

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Engine Light

Does your car have aluminum cylinder heads? If you don't know it would be wise to find out, says the Car Care Council. Aluminum heads are more vulnerable to damage from overheating than the traditional cast iron type. Excessive heat can warp the temperature-sensitive heads, resulting in a major repair expense. And it can happen so fast you may not have been aware your car was in trouble.

The most common causes of overheating, according to the Council, is loss of coolant due to a leak. Another culprit is a sticking thermostat, which prevents coolant from circulating through the engine.

The Council recommends an annual inspection of cooling system components, including a pressure test to look for leaks.

Avoid the expense and inconvenience of a breakdown on the road, far from home. Overheating, a leading cause of mechanical breakdowns, is notorious for interrupting vacation travel.

For a free pamphlet on cooling system maintenance, send a stamped, self addressed envelope to Car Care Council, Dept. CS, One Grande Lake Drive, Port Clinton, OH 43452.

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Have You Flushed Your Cooling System?

Your car ran fine all summer with no sign of trouble, so why bother with it this fall?

Here's why. The cost of overhauling an engine can run into thousands of dollars; automatic transmission repairs also are expensive. And cooling system neglect could be responsible.

This system performs several functions: (1) it must keep the engine running within specified temperatures, not too hot and not too cold; (2) it cools the automatic transmission and, lest we forget, (3) it circulates hot water through the heater.

Temperatures inside an engine may soar to 4,500 - 5,000 degrees F., enough to melt an engine block in a matter of minutes if it were not for the cooling system.

Over the years there have been numerous developments that make it harder for the cooling system to perform these tasks. Today's engines run much hotter than in years gone by. Added emission control systems, smaller radiators and crowded engine compartments add to the challenge.

Use this check list to be sure your car will survive the cold months ahead.

To avoid problems resulting from rust, dirt and mineral deposits in the cooling system, it's best to give it an internal cleaning every year or two.

It's Easy! Here's How:

1. Begin with the engine cold and ignition off. Remove the radiator pressure cap.
2. Open the petcock at the bottom of the radiator and drain the coolant into a bucket.
3. Close the petcock and fill the radiator with water.
4. Start the engine and turn the heater control to hot. Add cooling system cleaner and idle the engine for 30 minutes (or as per the instructions on container).
5. Stop the engine and allow it to cool for five minutes. Drain the system.
6. Close the petcock, fill the radiator with water and let the engine idle for five minutes.
7. Repeat step No. 5. Close the petcock.
8. Install new 50/50 mixture of water and ethylene glycol antifreeze/coolant.

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MAINTENANCE TIPS
FROM THE CAR CARE COUNCIL

Buy Quality Booster Cables

A precautionary message in your car owner's manual or on top of your battery tells how to connect jumper cables safely to prevent sparks and a possible explosion. An additional statement might warn about the dangers of using substandard quality jumper cables. These can produce a situation similar to connecting a thin, poorly insulated extension cord to an electric heater. The wire could heat up, eventually melting the insulation and causing a short circuit. In household wiring a fuse or circuit breaker probably would prevent a fire. In the case of jumper cables, where there is no circuit breaker protection, inadequate strands of wiring, leading to melted insulation, could be a real hazard.

Among other shortcomings of inferior booster cables include:

- High resistance in inferior cables can damage the starter motor when subjected to long periods of cranking.
- Flimsy, poorly insulated clamps with weak springs can provide poor electrical connections.
- Poor quality cable jackets (insulation) become excessively stiff in freezing weather.

The engineers of Associated Equipment Corporation offer tips on features to look for:

- Built in warning lights to signal incorrect connection.
- Flexible cable guards at the clamp handle to prevent wear at stress points.
- Pure copper wire in the cables for best conductivity.
- Adequate length and gauge of cable (12 - 16 ft; 4 gauge).
- Tangle-free design with a heavy duty insulated jacket.
- Clamps covered with bonded vinyl insulation.
- Insulated clamp jaw with no exposed metal parts which could arc when contacting vehicle frame or other parts.
- Clamps should fit both top or side terminal batteries.

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MAINTENANCE TIPS FROM THE CAR CARE COUNCIL

Oh Say, Can You Be Seen?

How often have you had to brake suddenly with another driver right on your tail? Your eyes dart to the rearview mirror, hoping he'll see your brake lights in time.

But what if your brake lights aren't working properly? There's better than a 50/50 chance they're NOT, according to figures from a survey by American Automobile Club of Cleveland, OH. They found 55% of vehicles checked had brake lights that needed some kind of repairs. This was by far the most prevalent mechanical discrepancy found during a Car Care Clinic.

Bob Knop, manager of the Club's Approved Auto Repair Department, which conducts the clinics, says most problems were found with the brake light, generally because of a burned out bulb.

Our Subconscious Response to Lighting

"We've grown to depend on lighting to signal our intentions," says Janine Sine, Manager for the G.E. Automotive Lighting Division. "We respond almost subconsciously to fellow motorists' turn signals, brake lights or emergency flashers. It's a form of communication as vital to driving as road signs and center lane marking. When they're missing we're unaware of the danger ahead."

Another common lighting problem, according to Sine, is found on vehicles with four light systems with separate units for high and low beams. Because the high beam lamps are replaced less often the lens is subjected to years of abuse from pebbles and other road debris. Eventually hair-line cracks develop and moisture works its way inside, corroding the reflector. The unit may appear to be working OK but it is not putting out as much light as it should.

Lights on for Safety

"Some day it may be widespread practice in the U.S., as it is in Canada and Sweden, that headlights be turned on whenever the car is driven. It's a proven safety measure and already is the law in the U.S. on two wheeled vehicles where lights automatically turn on with the ignition switch. Obviously, they are more visible to other drivers," says Sine.

"An Avis traveler safety study showed vehicles with daytime running lights (DRL) had a better accident record than vehicles not so equipped."

But lights are worthless if they are not working, Sine emphasizes. All exterior lights should be checked periodically, not only for burned out bulbs and flashers but also for poor illumination of headlamps due to damaged reflectors.

The best way to check your system is to have one person turn on the lights, the emergency flashers and turn signals and apply the brakes while someone else walks around the vehicle to see that everything is working.

It's also a good habit during every gas fill-up to check for dirt (and ice) on all lenses, front and rear. To help maintain cleanliness you can apply a glass treatment such as RAIN X(TM) to help repel rain, sleet, and snow.

Proper Headlight Aim is Important

At one time or another most of us have been blinded by the glare of oncoming headlights. You flash your high beams to signal the oncoming driver to dim his lights. He responds by turning on his high beams, indicating it was his low beams that had been blinding you. They were aimed too high.

Are you sure your headlights are not blinding others? Here, from G.E., is the recommended way to check headlight aim.

1. Put your car on a 35-40 foot stretch of flat or evenly sloped pavement such as a driveway facing a wall or garage door.
2. Shine your low beams on the door from 2 to 3 feet away and outline the bright spots on the door with a pencil or tape.
3. Back the car to about 25 feet from the door. The top of the low beams should shine no higher than the top of the marks on the door or lower than the center of the marked circle. If your vehicle has four headlights the center of the high beam (the inner or lower two lights) should align with the top of the low beam marks. If you have only two headlights, the high beams are automatically aimed when you aim the low beams.

For most accurate aiming take your vehicle to a professional. If, on the other hand, you're a "do-it-yourselfer", follow these instructions from G.E.:

Remove the outer trim for access to the adjustment screws. To raise the beam turn the top adjustment screw clockwise; counter clockwise to lower the beam. Turn the side adjustment screw clockwise to move the beam to the right and counterclockwise to move it to the left.

Bring each beam into its final position by turning the adjusting screws clockwise so the headlamp will be held against its tension springs when the operation is completed.

If your lights continue to be out of adjustment, consult a service technician.

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MAINTENANCE TIPS
FROM THE CAR CARE COUNCIL

Oxygen Sensors

Modern, sophisticated cars don't require as much servicing as older models. Still, if your car was built since the mid-1980s, chances are it has an oxygen sensor in its exhaust system. You may never have encountered an oxygen sensor before, but according to car care experts at AlliedSignal it's a part which requires periodic replacement as part of your routine servicing. Otherwise, you could experience poor vehicle performance on the highway.

"An oxygen sensor is designed to measure the oxygen content of a car's exhaust gases," explains Paul Coccari, product manager of AlliedSignal's Autolite electronics. "This information helps the engine-control computer regulate the mixture of air and fuel burned in the engine to provide an optimal balance of power, economy and clean exhaust."

Coccari adds that oxygen sensors are relatively simple to replace with most models costing $50 to $100. Replacement intervals range from 30,000 to 50,000 miles, and are generally listed in the owner's manual.

While on-time oxygen sensor replacement is vital, many motorists don't have the job done when they should because there isn't a noticeable difference in the way a car drives when the sensor stops functioning normally. Some motorists may even skip oxygen sensor servicing on purpose, figuring there's no need to do anything until the car starts to "act up".

"Either way, they're making an expensive mistake," Coccari explains. "An engine may use too much fuel when the oxygen sensor isn't working. This doesn't just hurt economically, it also creates dirty exhaust, polluting the air."

An alert motorist may notice worsening fuel mileage or driveability problems and have the sensor changed, says Coccari. But he adds that since most drivers don't notice anything wrong until driveability suffers, dirty exhaust may already be coming from the vehicle creating an environmental problem.

Seeing The Light

Because oxygen sensor replacement is important, many car makers include hard-to-ignore reminders, like a glowing red light on the instrument panel as the sensor replacement interval approaches. Coccari says the light keeps glowing (while the ignition is on) until the car is serviced.

Another Indicator

Some cars' instrument panels include a different dash light meant to indicate problems with components of the engine control system, including the oxygen sensor and other items. Typically, these lights are labeled "service engine soon," "check engine," "power loss," or something similar. If your car uses this system (check your owner's manual), Coccari says you still must replace your oxygen sensor at the mileage interval specified by the car maker.

Coccari explains that the light won't come on simply to let you know it's time to replace your oxygen sensor, it's up to you to keep track of when the sensor needs servicing.

"Since its glowing may indicate one or more of a number of problems, a service technician will have to `interrogate' your car's computer to find out which system or systems aren't working correctly. Further tests may then be needed to find out what's wrong with the affected system or systems."

If you're a serious do-it-yourselfer (DIYer), Coccari says to consult the correct shop manual for your car if this light comes on. In many cases, the manual will explain step-by-step procedures to make the light signal (using semaphore-type flashing codes) where the problems lie.

Care About Your Car

Coccari says routine auto servicing is different than it was a few years ago. Though in most respects it's easier, it still comes down to paying a little now or a lot later.

"Today's high-tech cars don't need constant attention, but there hasn't been a car invented yet that can take care of itself. Make a point of learning your new car's service requirements. As with the oxygen sensor, something you've never heard of before may need occasional attention."

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MAINTENANCE TIPS
FROM THE CAR CARE COUNCIL

How To Offset Higher Gas

One way to deal with increased gas prices is to drive less. Another is to improve your driving habits; easy on the gas pedal. But old habits are hard to break.

Another conservation measure is to be sure your car is using no more fuel than it was designed to use by keeping track of your gas mileage.

You may not notice a drop in fuel economy month by month but it could add up to well over $150 a year. The Car Care Council bases this figure on the typical car using 500 gallons of gas a year at $1.10 per gallon, it works out like this:

1. If the engine needs a tune-up it could be wasting 15% (or more) of its fuel, due to misfiring spark plugs, inefficient fuel system and malfunctioning emission controls. The cost: about $5.00 per month.
2. If tires are 8 pounds underinflated, not an uncommon condition, rolling resistance of the tires increases by 5%. The monthly cost in wasted gas: $2.30.
3. If wheels are just 1/4" out of alignment, another factor that affects rolling resistance, chalk up another 2% or about $1.00 a month. Note: this condition, as well as underinflation, accelerates tire wear, thereby adding to the cost of neglect.
4. A cooling system thermostat stuck in the open position, causing the engine to run too cool, can reduce engine efficiency by another 7%. The monthly cost: $3.20.

That adds up to a monthly loss of $11.50, says the Council. They point out that, while this hypothesis is intended to emphasize preventive maintenance in terms of energy conservation, it also bears on safety and reduced exhaust emissions.

And, going back to hard-to-break habits, for every five miles per hour you press beyond 55 mph, you'll lose about one mile per gallon. A heavy foot when the light turns green also guzzles gas.

MAINTENANCE TIPS

FROM THE CAR CARE COUNCIL

Springtime Ritual

Springtime. Time to shake the winter doldrums. Whether you have traveled great distances over the winter or stayed home by the fire, it's important to make sure you perform a thorough inspection of your vehicle before heading out on a family vacation.

"Many times people neglect their vehicles over the winter due to the cold or the belief that the car is fine because they didn't use it that much," explains Gary Donahue, lead trainer for AlliedSignal Automotive Aftermarket. "However, sludge can build-up in the engine and cause expensive problems down the road. The quickest, and easiest, way to avoid this problem is installing fresh oil and a quality oil filter."

Easy To Do

Changing the oil and filter isn't very complicated. Donahue explains that on many cars, the oil drain plug is easily accessible and can be removed without having to raise the vehicle. Likewise, the oil filter is easily accessible and can be removed either by hand or with an oil filter wrench.

"Any pan or basin with a capacity of a couple of gallons will give you plenty of room to handle the four to six quarts of oil contained in most engines," Donahue explains. "You get it to come out by simply unscrewing the oil drain plug from the oil pan at the bottom of the engine counterclockwise. It's always best to take the car for a short ride to warm the oil before removing. This will make it flow easier."

Once you've changed the oil, be sure the drain plug is in place, and add fresh oil. Make sure you use a quality oil. A quick check of your owner's manual will give you the recommended weight and quantity for your driving conditions.

Most oil filters on cars today are a spin-on unit. They can easily be removed by hand or using a filter wrench according to Donahue. After removal, make sure the oil filter base of the engine where you'll be installing the new filter is wiped clean. Then, before you screw the filter into place, coat the gasket with clean oil. Once the gasket contacts the base, tighten it according to manufacturer's instructions.

With the new filter in place, check the dipstick to be sure there's enough oil, start the car and let it idle. Check for leaks while it's running, then check the dipstick again. You may need to add oil to make up for the amount that was pumped into the new filter.

You're almost done. With one major exception - what do you do with the old oil and oil filter.

Clean-up/Recycle

Properly disposing of the used oil and oil filter is not only critical to protecting the environment, it's being regulated in many states as landfills are becoming overcrowded. Recycling only 20% of all filters produced annually will:

- save nearly 400,000 cubic yards of landfill space;
- remove several million gallons of oil from landfills; and,
- recycle more than 34,000 tons of filter scrap which can be used to produce steel products.

Proper Steps

After you drain the oil, put it in a recyclable container that you can easily transport in your car to the recycling center. This can be a container made especially for oil changes, an old plastic liter soda bottle or other container that can be sealed to avoid spillage.

Once you've removed the old filter, and initially drained it of used oil into your collection pan:

- Drain the filter over an oil collection pan for approximately 12 hours to remove all free flowing oil;
- Put the oil from the filter into the plastic jug containing the oil from your car;
- Place the used oil filter in a leak proof bag or container and transfer it, along with the used oil, to the nearest designated recycling facility.

The used oil and filter should be taken to your nearest recycling center that accepts used motor oil. Designated locations for recycling may be a local municipal drop off recycling center, a municipal garage or a business providing oil change services. Some of these facilities may also accept your used filter.

For more information on recycling sites in your area, contact the recycling coordinator for your community or look under recycling in the Yellow Pages. For a brochure on the environmental benefits of recycling used oil filters write:

Environmental Manager-R, AlliedSignal Automotive Aftermarket, P.O. Box 6346, Providence, RI 02940-6346.

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MAINTENANCE TIPS
FROM THE CAR CARE COUNCIL

Vehicle Designers

Car care and health care: what's the connection? Ask anyone whose bald tires lead landed him in the emergency room. Ask an asthmatic who becomes ill from thick air pollution in rush hour traffic.

The latter is a serious issue with environmentalists as well as automotive designers. 1994 model cars produce a fraction of the harmful emissions that their 1984 predecessors did.

Still, nearly two thirds of the total carbon monoxide, more than a quarter of the hydrocarbons and a third of the nitrogen oxides which pollute our atmosphere come from motor vehicles. These percentages decrease dramatically as the vehicle population, with enhanced emission control systems, gets younger. And as we improve maintenance of existing vehicles we significantly reduce harmful exhaust.

Periodic engine checkups, along with necessary maintenance, can make a big difference in exhaust emissions. Even the simple replacement of a dirty air filter, one of the most common offenders, can reduce emissions and save gas.

Car Care Council offers a few more things motorists should know about vehicle condition:

If smoke is coming out of the exhaust, it may mean:

- The fuel system is malfunctioning;
- The engine control computer system is malfunctioning;
- The engine may need major work due to worn piston rings or valves.

If an exhaust analyzer shows high carbon monoxide content, it may mean:

- The air filter is dirty;
- The PCV (positive crankcase ventilation) system is clogged;
- The cold start system is malfunctioning;
- The fuel system is operating too rich;
- The ignition timing is incorrectly adjusted;
- The thermostatic air control is malfunctioning;
- The air injection system is malfunctioning.

If an exhaust analyzer show high hydrocarbon content it may mean:

- Fouled spark plugs;
- Faulty spark plug wires;

- Faulty ignition cap or rotor;
- Incorrect ignition timing;
- The fuel system is too rich;
- There's a vacuum leak.

For most cars, with their numerous sensors, computers and other electronic circuitry, accurate diagnosis is a "must". In the long run this procedure, along with needed service, can save time, fuel and, of course, our environment.

For more information on this subject send for the Council's free brochure, "THE EIGHT MOST COMMON SIGNS YOUR CAR NEEDS A TUNE-UP". Their address: Car Care Council, One Grande Lake Drive, Department T, Port Clinton, OH 43452.

MAINTENANCE TIPS FROM THE CAR CARE COUNCIL

A Reminder to Business Owners and Managers:

Is Your Delivery Vehicle Driving Business Away?

Mrs. Hayes was about to call M & K Carpet Service when one of their vans rumbled down her street. Because the muffler was gone, the noise was deafening; the sign on the side was scratched, the vehicle was filthy and, in general, it looked as if M & K didn't give a hoot.

Mrs. Hayes sat down to rethink her choice, and a potential customer quickly became a lost opportunity.

Whether a business uses a single delivery vehicle or an entire fleet, it's important for owners and managers to understand that those vehicles not only deliver products, they also deliver valuable impressions to the community. You can portray the right impression by maintaining the exterior of your vehicle and keeping a close watch under the hood.

Overall body appearance is of the utmost importance. Chipped paint, broken signal lights and/or damaged body parts affect your vehicle's looks as well as its value. Regular washing and waxing combined with seasonal cleaning helps not only add years to the life of a paint job, it says you care about your business.

Now examine the accessories that can affect the looks as well as the safety of your vehicle. Broken mirrors, missing or mismatched hubcaps or a bent antenna are just a few of the difficulties that can plague a delivery vehicle. The good news is that these items are generally simple and inexpensive to repair.

The last exterior detail is perhaps the most important: the sign painted on your vehicle. This "billboard on wheels" not only says what you do, but how you do it. Consider the negative impression of a dirty, faded, peeling or chipped sign.

The best looking vehicle in town is useless if it's not functional. Excessive downtime due to neglect can nibble at profits until there's nothing left.

A businessman should think of his delivery vehicle as an important business machine that cannot go unserviced. Someone should be put in charge of regular maintenance of that machine. Whether it's the owner, the delivery person or a third party, remember that a job assigned to no one is no one's job.

To assist the responsible party, the Council offers a free pamphlet listing the main areas to be checked regularly. Send a stamped, self-addressed envelope to Car Care Council, Dept. UH., One Grande Lake Drive, Port Clinton, OH 43452.

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Keep Car Cool

Summer heat is hard on a car's interior. It can cause the headliner (ceiling fabric) to droop, the padded dash to crack and upholstery to fade.

Many summer related problems can be addressed with a little common sense. Try to park in the shade. Avoid those wide open spaces that allow relentless full time exposure to the sun.

Try to park near a building to assure your car of some shade at least part of the time.

Finally, purchase a sun shade. These inexpensive cardboard blockers placed in the windshield and rear windows help lower the interior temperature.

More tips on protecting your car's interior are in a free pamphlet, `HOW TO KEEP YOUR CAR LOOKING YOUNG', published by the Car Care Council. Send a stamped, self addressed envelope to the Car Care Council, Dept. N, One Grande Lake Drive, Port Clinton, OH 43452.

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MAINTENANCE TIPS

FROM THE CAR CARE COUNCIL

Fixing Up That Ailing Car or Replace?

This May Help You Make A Decision

By Donna Wagner, Director of Operations, Car Care Council, Port Clinton, OH

The new models are out, and many of us look longingly at the variety of sleek, new vehicles in dealers' showrooms. Meanwhile, "Old Faithful" sits at home in the driveway. She's in need of new tires, a brake job and some fresh paint, but she's paid for. And so the dilemma begins.

When an aging car needs repairs, too often the solution lies in the quickest route to the car dealer. But what if the down payment (plus a little extra) were spent on your old car instead, making it serviceable for another year or two? Statistics show that more owners are fixing up and driving their old cars. In fact, the average car age (9 years) is the highest it's been since the early 1950's.

To renew or replace? It's a big decision with several pros and cons to consider. Here are some points in favor of renewing:

- No big car payments and, therefore, an opportunity to save for a future new car purchase;
- Less sales tax to pay;
- Savings on insurance premiums;
- A new car loses an average of 25% of its value when it leaves the lot; 40% of its value in four years;
- You know your old car's problems and quirks;
- Your old car will be in better shape for future trade.

Of course in every financial endeavor there is a point of diminishing return. Trading cars is no different. If the cost of the combined repairs far exceeds the value of your old car, chances are you should trade up. Consider the following points that favor replacing.

- Has your life-style (family size, business, recreational interests) changed so that "Old Faithful", even fully restored would no longer fit your needs?
- If you have neglected maintenance and repairs too long your car may need major mechanical work. For example, overhauling both the engine and transmission on a typical car may cost $2,000. If this price exceeds the value of your car, it's probably time for a new or newer vehicle.
- Even if the mechanical systems can be restored for a reasonable price, will body and/or interior fix-up work be costly?

- How important are state-of-the-art safety and fuel economy features of a newer vehicle? How vital is the "image" created by the vehicle parked in your driveway?

In the end, you are the only one who can put pencil to paper and make the decision. More information is available in the pamphlet, "Renew vs. Replace (Rx for Making a Decision)." Send a self-addressed, stamped envelope to Car Care Council, Dept. R, One Grande Lake Drive, Port Clinton, OH 43452.

MAINTENANCE TIPS

FROM THE CAR CARE COUNCIL

Auto Log Book Pays

Logging, defined as the act of entering information in a log book, is done by pilots, fleet operators, the military and virtually anyone to whom vehicle performance and dependability are essential.

Maintaining a log book is a good idea for private owners too, says Car Care Council, who suggest that setting up and maintaining an auto "diary" is a simple procedure. It's a matter of keeping a pencil and note pad handy to record anything of importance about the maintenance and operation of the car or truck.

Essentially there are six types of entries, according to the Council:

1. Gasoline fill-ups and mileage;
2. Addition of various fluids such as engine oil, coolant, power steering fluid and at what mileage;
3. Maintenance services performed: what, when, by whom and how much it cost;
4. Services performed other than routine maintenance, i.e. body repairs or paint, accessories installed, etc.;
5. Insurance and/or registration information;
6. Basic part numbers and/or specifications which may not be readily found in the owners manual (belts, hoses, headlamps, spark plugs, filters, etc.)

Most businessmen, whose vehicle expenses are tax deductible, know the importance of maintaining good records. For them and for others there are these additional considerations, say the Council:

Keeping a running record of gas purchases vs. distance driven will show a decrease in gas mileage, warning of a malfunction or need for tune-up.

A log book will make you aware of abnormal oil or fluid consumption, which could be the tip-off to a leak or other potential problem.

It also serves as a reminder that the vehicle is overdue for an oil and filter change, transmission service or other important maintenance.

When it's time to sell or trade, this kind of documentation can make a substantial difference in the vehicle's saleability. A used car buyer likes to know what maintenance has been done and when.

In case of mechanical trouble, especially with an older vehicle, it may be useful to report to a mechanic exactly what work has been done.

If yours is an import car, you may want to jot down not only the original numbers for basic parts but also the conversion numbers from among the readily available domestic brands. This can be a big time saver when a crisis occurs far from a major source of auto parts.

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AUTOSHOP ON LINE

MAINTENANCE TIPS

FROM THE CAR CARE COUNCIL

The Dozen Most Wanted

Remember how annoying that black mark was on the living room wall? Or the squealing door hinge? Eventually it goes unnoticed. Too often we adjust to car problems that need attention, too. According toVehicle Maintenance Council 4 out of 5 cars need maintenance, such as the items listed below. Is yours one of them?

1. WORN BRAKE PARTS. Postponing needed brake service, in addition to being a safety hazard, can escalate the cost of a braking system overhaul.
2. TIRED WINDSHIELD WIPER BLADES. Don't wait for a rainy day to replace worn blades.
3. BURNED OUT LIGHTS. Can you see and be seen? Check all your lights regularly to be sure.
4. CLOGGED FILTERS. Scheduled replacement of air, oil, gas, fuel, transmission and other filters extend car life and improve performance.
5. WORN SPARK PLUGS. Worn plugs waste gas and increase exhaust emissions. They also cause the engine to run poorly.
6. CORRODED BATTERY CABLES. Corroded cables and a weak battery cause starting trouble. Have battery and charging system checked if the engine turns over slowly.
7. GLAZED BELTS, ROTTEN HOSES. A slipping belt can affect engine cooling, alternator, power steering, and air conditioner. Replace worn belts before they let you down . . brittle or rotten cooling system hoses can lead to overheating. Others, such as vacuum and power steering hoses, hinder performance and safety.
8. NEGLECTED COOLING SYSTEM. Periodic servicing of the cooling system helps prevent deterioration of radiator or heater core.
9. LEAKING SHOCK ABSORBERS. Worn shocks or struts affect ride control and shorten tire life.
10. DAMAGED CV JOINT BOOTS. These rubber boots protect the critical CV joints that deliver power to your wheels. They should be inspected regularly and replaced as needed.
11. LEAKING MUFFLER. Have your car put on a lift occasionally to check the muffler and other parts of the exhaust system.
12. TIRED TIRES. Worn tires are dangerous. Proper inflation, alignment and balance will extend tire life.

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Face the Consequences

You have probably heard your dentist say, "If you ignore your teeth they will go away".

Without proper dental hygiene and regular visits to the dentist, it is very likely that someday you will be soaking your teeth instead of brushing them. The same thing can be said about your car. If you deny your car proper preventive maintenance and avoid regular car trips to a good technician, then, like your teeth, your car will go away.

Up until the mid 1970s, most car owners practiced preventive maintenance. This was largely due to the fact that as the ignition points wore out and lead in the fuel masked the spark plug, vehicle performance and economy began to deteriorate very noticeably. The car would then be brought in for the proverbial "tune-up". This tune-up usually took place about once a year or every 12,000 or 15,000 miles.

This was also a good opportunity for the technician to check for additional maintenance needs in areas such as the radiator and heater hoses, and coolant condition, the fan belts, the vacuum hoses, the fuel and air filters, the canister filter and the condition of the battery, the tires and the emission control and exhaust systems, just to name a few.

With the advent of electronic ignition and unleaded fuel in the mid 1970's, as well as the addition of computer controls in the early 1980's, the deterioration of the cars' performance and mileage is hardly noticeable. This, combined with the fact that there are very few full service gas stations left today (full service meaning that there is a knowledgeable person on hand to check under your hood as a form of preventive maintenance while filling the tank), causes most vehicle owners to practice what is called "reactionary maintenance".

Reactionary maintenance is when you continue to drive your car as long as it runs well, neglecting to raise the hood to check the oil or anything else. Then, the first time you notice a change in drive-ability, usually at 50,000 to 60,000 miles, you rush to a repair facility and want the problem fixed in a couple of hours.

And you often complain about the cost of repairs. It may sound a little harsh, but this scenario happens thousands of times each day across the country.

Today's cars need regular, preventive maintenance. Even though oil and gasoline have improved, and car manufacturers will try to persuade you that their product has improved, new cars still wear out. Actually, new cars are wearing out faster than old ones due to the lack of preventive maintenance.

If you want your car to last as long as the payments, dig the owner's manual out of the glove box. Turn to the "Maintenance Instructions" section and read it carefully. Pay particular attention to the page which discusses oil change intervals. You will note that the manufacturer differentiates between "normal driving conditions" and severe driving conditions".

Usually, severe driving conditions are defined as: driving through dusty areas, towing a trailer or boat, frequent idling or idling for long periods, and driving for 10 miles or less in freezing weather. Cars operated under these conditions should have an oil and filter change every 3,000 miles or three months, which ever occurs first.

Normal driving conditions occur if your driving does not fall in any one of the severe driving categories. However, less than 25 percent of the cars on the road actually qualify for the normal driving category. In addition, if your car is equipped with a turbo-charger, frequent oil changes are a must.

If the turbo becomes coked up, it could cost as much as $1,000 to replace it, and the factory warranty won't cover the bill if you can't show proof of oil changes at the factory-recommended intervals.

Engine coolant and transmission fluid are two more items that must be changed regularly to ensure a long life for your car. Engine coolant should be changed every two years and diluted with 50 percent water, as pure engine coolant will freeze at around 0 degrees Fahrenheit. This mix gives you the best cold weather protection and the best heat dissipation ability in hot weather.

The life of the automatic transmission fluid is basically determined by how hot the fluid has been during operation. (See the chart.) Since you have no way of really knowing how hot the fluid has been, an easy way to check is by pulling out the transmission dipstick and looking at the fluid. If the fluid is brown instead of red and smells like you just ran over a skunk, it needs to be changed ASAP! It is a good habit to have the transmission fluid changed every two years or 24,000 miles.

The high temperatures under the hood of today's cars take their toll on rubber and neoprene components such as radiator and heater hoses, fuel lines, and vacuum hoses. One of the main causes of breakdown is fan belt and/or radiator/heater hose failure. The best insurance against this catastrophe is to have the belts and hoses replaced every two years.

And while on the subject of rubber, I shouldn't forget to mention the tires. There is no reason why steel belted radial tires shouldn't last at least 70,000 miles or longer. It takes only three things to make this happen. 1) Have wheel alignment and tire balance checked once a year. 2) Keep tires properly inflated and check weekly. 3) Rotate tires every 6,000 miles.

Perhaps the key is to examine the tires once a week. If you notice any unusual tire wear patterns, have a good alignment shop check the alignment, the suspension components, and the tire balance. Tire wear problems do not fix themselves.

One final area which I would like to discuss is the battery. Most batteries are replaced on the first cold morning that the car won't start. The average life of a battery is three and one-half years. If you are driving around with a battery that is older than that, then you shouldn't be surprised if you are stranded at the train station parking lot or the shopping center when it is 10 degrees below zero and the wind is blowing at 20 m.p.h.

Why not just replace the battery before this happens? That is what preventive maintenance is all about; looking, checking, and replacing automotive components before they fail.

You are probably thinking to yourself that preventive maintenance is too expensive to follow. On the contrary, would it be more expensive to replace the battery in your car before it leaves you stranded, or pay a service call and a new battery plus the inconvenience of being stranded? The fact is, preventive maintenance is cheaper in the long run than reactionary maintenance. The question that often remains is: "Where do I get the money for preventive maintenance?" Most people budget only for car payments, insurance, and gas.

All that really needs to be done is to keep the close track of the miles you drive each week. Set aside ten cents for each mile that you drive and place this money in an interest bearing account.

At the end of one year, if you have driven 15,000 miles, you will have saved $1500 to spend on preventive maintenance. That will buy a lot of maintenance. Any money left over can either be left in the account to let your balance grow, or can be put towards the principal of your car loan. This will reduce both the interest you are paying as well as the number of payments.

Your car is a major investment, so why not take care of it? If you borrow $16,000 to purchase a car at 14 percent interest, and you pay this off over a period of four years, you will eventually pay almost $5,000 in interest. That's $21,000 that you pay out of your budget in a four year period.

If you practice preventive maintenance, your car will outlast your payment book. Then, if you keep your car for another four years and make those same car payments to yourself, you will have $21,000 to spend. I don't know about you, but I could think of all kinds of neat toys to buy.

Remember, it is cheaper to look at, check, and replace components before failure than it is to drive your car until it drops. If you are not fixing your own car, there are thousands of repair facilities across the country that are very capable of performing the preventive maintenance which I have discussed in this article. Give preventive maintenance a try, and you will find yourself with money in your pocket.

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Preventive Maintenance

Today's cars come equipped with high-tech computer-controlled systems that have vastly improved driving performance. But some vehicle owners are finding this state-of-the-art technology intimidating, and many drivers put off looking under the hood until something goes wrong.

Improvements in electronic ignition and fuel injection systems on newer cars have virtually eliminated the "traditional" tune-up practices of adjusting carburetors, installing points, and setting the timing. However, with regular preventive maintenance, vehicle owners can still improve the performance and fuel efficiency of today's cars.

"Once they've purchased a new car, some people are led to believe that all they have to do is drive it, fill it with gas, and change the oil-- and then they expect it to last five or 10 years until they trade it in," said Roger Kwapich, manager of technical services for Champion Spark Plug Co., a division of Cooper Automotive. Kwapich also hosts "Gasoline Alley," a radio talk show about car care and automobiles.

"Granted, the engines and transmissions being built for today's cars are far superior to those in older models, but only if you maintain them. And that's a big if," Kwapich said. "There's this perception that a car can be like a washing machine. That it will last for years without ever needing maintenance. But that's not how it works in the real world."

One constant in the realm of evolving engine technologies is the spark plug. A critical link in any engine's ignition system, misfiring or worn spark plugs can affect how efficiently a vehicle burns the fuel/air mixture, ultimately affecting engine performance.

Cars in need of new spark plugs and a tune-up could experience measurable fuel economy improvements, Kwapich said. Over the years, Champion estimates millions of motorists have been reducing the miles-per-gallon they are obtaining by neglecting proper care of their cars.

Although tune-up intervals vary from car to car, and some owner's manuals indicate newer models can go almost twice as long as older vehicles between tune-ups, preventive maintenance and checking the car periodically can help assure it continues to deliver peak performance.

"Preventive maintenance today will help your car last until tomorrow," Kwapich said. Since spark plugs are often victims of other problems in an engine, they can reveal valuable "clues" for evaluating engine performance. By examining the condition of the spark plugs, a professional mechanic can confirm a vehicle is running properly, or spot minor problems before they become major malfunctions.

Many other preventive, under- the- hood checks can be accomplished by the car owner at home without a mechanic. No matter how high-tech the engine, just a visual inspection of belts and hoses can reveal cracks, frays, leaks and bulges-- sure signs of impending part failure. And drivers can easily monitor engine fluid levels by periodically checking to be sure oil, radiator, battery, power steering, brake and automatic transmission fluids are filled to recommended levels.

Regularly rotating the tires can also pay off big, not just in better handling and energy efficiency, but in safety, too.

"Lots of people overlook the need for maintenance because they still perceive their car as brand new," Kwapich explained. "For instance, people often buy new cars right before they leave on vacation, then forget that those accumulated miles may warrant an oil change or tire rotation when their vehicle is only a couple of months old."

Today's high-tech automobiles can accumulate a lot of mileage with very little evidence of wear and tear, making it easy for motorists to avoid looking under the hood while their vehicle is running well. But preventive maintenance can be a valuable investment, increasing fuel efficiency and saving the expense of emergency repair service, towing charges and even the inconvenience of a breakdown.

"If car owners put a few dollars into maintenance, they are almost certain to get better overall performance and vehicle longevity," Kwapich said.

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MAINTENANCE TIPS FROM THE CAR CARE COUNCIL

You're Only As Safe As Your Car's Last Inspection

Your Car Is A Comfortable Place to Be... Until... A Breakdown Places You In A Precarious Situation

By Donna Wagner, Director of Operations, Car Care Council, Port Clinton, OH

n days of old the worst thing a stalled motorist had to fear was not being seen and getting hit. Occasionally, in severe weather the driver of a disabled car would become the victim of a fallen tree or overexposure. But in today's world, we're warned not to seek help on the road, nor are we to offer it. The smart thing to do is wait for the authorities. Following that advice still involves an often lengthy waiting period, leaving the stranded driver terribly vulnerable. Car Care Council's Donna Wagner says there's a better way, and it starts with maintenance.

"Most motorists break down due to one of five common causes," she says. "They are: out of gas; the engine has stalled and won't start; a dead battery; a flat tire or an overheating engine."

"The encouraging aspect is that all of these difficulties are avoidable with common sense and a little effort."

Wagner suggests these preventive measures:

1. Periodic mechanical checkups, especially when engine stalling, hard starting or other such symptoms are signaling trouble;
2. Regular tire inspection to spot damage, unusual wear or underinflation that can lead to tire failure;
3. Seasonal checks and preventive maintenance of the cooling system, a frequent factor in roadside breakdowns;
4. Pay close attention to the gas gauge. Make it a habit to keep the tank half full at all times. This also safeguards against condensation in the tank. If moisture in the gas line freezes, the engine can stall; and
5. Consider investing in a CB radio or a cellular phone.

If all else fails, and you find yourself on the roadside, follow these tips:

- Try to move the car out of traffic to a safe location.

- Turn on the emergency flashers.
- If at all possible, stay inside the car with the doors locked until help arrives.
- Ask anyone who stops to offer aid to call for roadside assistance.

To help you prepare for winter, Car Care Council offers an informative pamphlet entitled, ARE YOU SURE YOU AND YOUR CAR ARE READY FOR WINTER? Providing detailed preventive maintenance tips, the illustrated brochure includes a handy 36 point bumper-to-bumper check list plus suggestions for a blizzard emergency kit.

For your free copy, send a stamped, self-addressed envelope to Car Care Council, Department W, One Grande Lake Drive, Port Clinton, OH 43452.

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MAINTENANCE TIPS

FROM THE CAR CARE COUNCIL

Four Wheel Alignment

"Alignment" can be a scary word for motorists.

The term, especially "four wheel alignment" conjures up visions of inscrutable equipment and highly specialized automotive service. Even drivers who understand the term "tuneup" are often mystified by "alignment." And the new trend toward four wheel alignment can appear to be an expensive service for which the unwary motorist seems to be paying extra.

Don't reject out of hand the terms "alignment" or "four wheel alignment" the next time a service technician recommends it to you, advises Perfect Circle, a well-known supplier of aftermarket chassis, engine and sealing products. Alignment is an important service that your car really needs from time to time.

Mike Jones, Perfect Circle Chassis Marketing Specialist, advises that alignment is recommended for today's cars and light trucks in at least four situations:

1. When you buy new tires. "In fact," says Jones, "if your old tires wore unevenly, bad alignment could be the reason they had to be replaced, and the same thing could happen quickly to your brand-new tires!"

2. When you have a rack & pinion steering unit or certain other steering parts in your car replaced, alignment is necessary;

3. When certain warning signs appear on your car, indicating that alignment is needed;

4. Or about every 30,000 miles, whether warning signs appear or not.

Just What Is An Alignment

"Basically, alignment is mak- ing sure the wheels are operating parallel with one another, and that the tires meet the road at the correct angle. Wheel alignment is much simpler than most people think," explains Perfect Circle's Jones. "It is simply adjusting the relationship between the suspension and steering components, the wheels, and the frame of the vehicle."

"Carmakers recommend certain measurement specifications for each of these angles on every one of their vehicles. When the angles are all as specified, the car or truck is properly aligned, and the best possible compromise has been achieved among minimum rolling friction, maximum tire mileage, stability of the car on the road, and steering control for the driver."

"Everyday road shock and general wear and tear can knock some of these angles out of spec. When that happens, control of the vehicle may be threatened, and the tires may begin to wear unevenly and rapidly. The car needs to be `realigned,' to have all the proper angles restored," Jones concluded.

Warning Signs Are Easy To Spot

The warning signs suggesting the need for alignment are easy to spot, says Jones. They include:

- *Unusual tire wear*. Look closely at all four of your tires. If one or more of them demonstrate excessive wear on one side, or wear in a cupped, scalloped or diagonal stripe pattern at edges or across the tread, or uneven wear but with "feathered" edges on the treads, an alignment could be needed.
- *Unusual steering feel*. If the steering feels stiffer than it used to, or if the wheel does not return to the center position when released, or if the car feels skittish and like it is riding "on tip-toes", your wheels may be out of alignment.
- *If the steering wheel is cocked to one side* when the front wheels are pointing straight ahead, an alignment is almost certainly needed.
- While driving, if the car wants to *pull to one side, tends to wander or weave,* or is subject to *front end "shimmy"*, you should have the alignment checked immediately.
- Or if your car *wants to move "crab-like"* on the road, with the rear end cocked off to one side while moving straight ahead, you're a top candidate for *serious alignment.*
- There are three basic wheel angles which determine whether a vehicle is properly aligned and goes where it is pointed. Not every angle applies to every wheel, and not all angles are adjustable on all cars, but the three angles must be set properly for the alignment to be correct:
- *Camber* is simply the inward or outward tilt of a wheel compared to a vertical line.
- *Caster* is the degree that the car's steering axis is tilted forward or backward from the vertical as viewed from the side of the car.
- *Toe* refers to the directions in which two wheels point relative to each other. "Toe-in" means the wheels point toward each other in a "pigeon-toed" stance; toe-out means the wheels point away from each other.

Four-wheel alignment is the standard service today, and it is essential on vehicles with front wheel drive (FWD) and independent rear suspension. The rear wheels should follow the fronts in a parallel path. If the rear wheels are pointed in a slightly different direction, they cause a condition called "rear axle steer," which can affect tire wear and the vehicle's stability.

What Happens During An Alignment?

Before an alignment, the technician will begin with a thorough inspection of the entire undercar, including steering linkage, suspension parts, wheels and tires, and the vehicle's frame and ride height. He's looking for parts that are loose, bent or near failure.

Once this inspection is complete, your car will be driven onto the alignment machine. The technician will check and adjust, in order, camber, caster and finally toe, beginning with the rear wheels. (Remember, not all wheels are adjustable on all vehicles.) He may use regular wrenches and variety of specialized tools and devices, manufactured by automotive suppliers such as Perfect Circle, to make the necessary adjustments. The tools can include:

- Alignment shims, half-shims and wedges

- Eccentric bolts and cams
- Adjustable and non-adjustable bushings
- Offset control arm shafts.

Some Vehicles Have Special Problems

Perfect Circle's Jones pinpointed several vehicles whose designs require special alignment solutions. Perfect Circle has created replacement parts that address alignment challenges with these vehicles:

1. *Ford Tempo and Taurus, Mercury Topaz and Sable, Lincoln Continental.* These very popular FWD vehicles have a tendency late in life to develop rear wheel misalignment, resulting in tire wear and handling difficulties. Perfect Circle has developed a line of eccentric camber/toe bushings, which service dealers can insert in the suspension to adjust camber and toe and bring them back to factory specifications.

2. *GM "A" and "X" car, '88-89 GM 2WD and 4WD pickups, and early Chrysler "H" and "P" cars.* Again, replacement cam bolt kits allow alignment adjustments to bring worn steering back to factory specs.

Future Alignment?

"We are entering an age of rapid change in suspension/steering design, after many years without significant changes," observes Perfect Circle's Jones.

"The majority of cars sold in this country today are front wheel drive. Most of these cars are dependent on proper alignment at all four wheels to operate safely and achieve acceptable tire wear. Believe me, the cost of a four wheel alignment is well worth it in vehicle handling alone. And it could save you several times its cost in reduced tire wear," Jones concluded.

MAINTENANCE TIPS
FROM THE CAR CARE COUNCIL

Shocks & Struts

"If shock absorbers were like air filters or tires, you wouldn't hesitate to inspect them," say automotive engineers. But a worn shock or strut, unlike a clogged filter or a flat tire, won't disable the car. But it can do worse, warns the Car Care Council. Because of the loss of ride control, even one bad shock absorber can lead to an accident.

Shock absorbers and struts, part of the complex steering/suspension system, usually wear gradually. The vehicle owner may not realize how the ride or handling characteristics have deteriorated until an emergency arises.

Many owners, in fact, do not realize these components require periodic checking and replacement.

To increase car owner awareness, the Council answers five of the most commonly asked questions about shock absorbers and struts.

Q. Will new shocks cure the weak springs on my car?

A. No. Shock absorbers cannot replace springs. Special load carrying or booster shocks, however, can help support limited overload weight.

Q. Isn't the shock absorber's function to smooth out the ride?

A. That's only part of its job. Shock absorbers (and/or struts) do a lot more than that. They improve handling by reducing from end drive when braking. They also add to safety by controlling body sway and roll on turns even on smooth highways. Good shocks also prevent wheel hop, which can lead to loss of control.

Q. Don't the new gas-charged shocks and struts last longer because there is no fluid to leak out?

A. Gas-charged shocks and struts do last longer than their predecessors, but they still have fluid. One purpose of the gas, usually nitrogen, is to prevent aeration of the fluid which causes foaming. Foaming of the fluid hinders shock absorber performance.

The gas charge also improves internal valving of the shock, improving both stability and ride.

NOTE: When either shocks or struts are replaced, they should be replaced in pairs for proper handling characteristics.

Q. Do I need to have the wheels re-aligned after having new shock absorbers installed?

A. No. But you'll probably need wheel alignment service if you've had new struts installed. That's because struts are an integral part of the suspension system.

Q. Can I get my worn shocks repaired?

A. No. These are sealed units which must be replaced. Some struts, however, can be rebuilt with a replacement cartridges, (essentially the shock absorber component within the unit) which can be installed when the old on is worn out.

For an illustrated pamphlet on this subject send a stamped self addressed envelope to the Car Care Council, Department RC, One Grande Lake Drive, Port Clinton, OH 43452.

Undercar Inspection Is Part of Winter Preparation

Fall is the season to prepare for the wear and tear of Old Man Winter on your car. When preparing for a long season of driving on snow, water, ice and loose gravel, a lubrication and check of your car's steering and suspension is a good precaution.

Water can get inside many steering and suspension parts, says Art Frank, assistant director of training at the Moog Technical Training Center in St. Louis, MO. He explains, "That's the main reason for regular inspections and lubrication; once water gets into a part such as a tie rod, the contamination can create premature wear. Keeping the parts lubricated and full of grease reduces the possibility of contamination."

This is also a good time to check on irregularities in the way a vehicle handles, says Frank. He points out, "A vehicle's chassis problems don't happen overnight. They take time to develop and surface. Pay attention to how a vehicle handles. Does the steering feel loose? Does the vehicle pull to either side? Does it shimmy or vibrate at certain speeds? Does the ride seem harsh when you hit a bump?"

According to Frank, "When the vehicle is on the lubrication rack, a complete undercar check-up can pin-point problems such as premature tire wear, splits in the rubber bushings, or worn shocks and springs."

Based on industry research, four out of every seven vehicles need repairs; 57% of the vehicles in for a check-up need alignment. Also, 31% of vehicles in for repairs show ball joint wear and 20% of all vehicles brought in for alignment need idler arm replacement.

Looseness in the steering, coupled with excessive tire wear, may indicate the need for steering linkage replacement, says Frank. "Tight" steering, excessive movement in any direction, or a popping or rubbing noise can be a sign of worn upper strut mounts. Ball joints also should be checked for looseness and damage to their dust boots.

An undercar inspection should include a check for looseness, off center or worn bushings. The combination of age, oil and heat -- particularly after a long, hot summer -- can cause the rubber bushings to crack, distort and wear. Bushings in such condition should be replaced.

With cooler morning temperatures coming on, a vehicle may exhibit signs of `morning sickness' in the form of sluggish steering. "While this symptom usually disappears as the engine warms up, it's a good warning sign that your car's rack and pinion system could use a check up," explains Frank.

Within the rack and pinion system's control valve are Teflon ring seals which wear grooves in the aluminum housing over the course of driving. When the seal contracts in cold weather and pulls away from the grooved housing, a loss of assist in steering can result. The deeper the grooves, the longer the warm-up period. This problem is easier to detect in colder weather, but drivers should be aware it can happen in any climate.

Bellows boots used to keep contamination from rack and pinion systems, as well as CV (constant velocity) joints on front-wheel drive vehicles, need to be inspected for cracks, wear and deterioration before water, snow and ice become a factor on the road.

"The accumulation of snow and ice around a CV boot can easily lead to a tear and eventually damage the CV joint it should protect," says Frank. "Replacing the joint is expensive. Replacement of a boot is far less expensive."

A suspension inspection should include a check of springs, shock absorbers and struts. However, Frank emphasizes, "Contrary to the belief that shock absorbers carry most of the weight of the vehicle, the springs are the primary suspension parts that support the weight. New shocks or struts will not fix a weak spring problem."

If new springs are needed, you have options: install replacements similar to the originals, or install variable-rate springs. Frank explains, "Variable rate springs have an advantage in that they automatically increase their resistance as weight or pressure is increased. This results in a smooth, comfortable ride when loaded or empty, and improve handling."

Frank recommends inspecting and replacing springs at the same time shock absorbers or struts are installed, if the need is found.

Mileage, road conditions, weather and driving habits will all affect the service life of alignment, component parts and tires. A comprehensive inspection of your car's steering and suspension systems in the fall might make the difference in winter driving -- both in your pocketbook and in improve driveability under hazardous road conditions.

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Worn Shocks Can "Sneak Up" On You

Have you ever noticed how quickly you can become accustomed to an annoying shake or rattle? You may forget it's there until the condition becomes serious. Worn shock absorbers or struts are a classic example of the kind of deterioration that warrants early attention. The first indication of pending failure of these critical parts is when the vehicle dives when brakes are applied, sways on turns or "bottoms out" on a bumpy road.

A visual inspection under the car often discloses potential trouble, such as a leaking or damaged shock or worn parts such as rubber bushings.

The Car Care Council warns that weak shocks and/or struts lead to poor ride control which affects more than comfort: it's a safety factor as well.

For a free pamphlet on ride control components send a stamped, self addressed envelope to Car Care Council, Dept. RC, One Grande Lake Drive, Port Clinton, OH 43452.

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Investigate The Causes of Tire Wear Problems

Tire wear patterns, such as scuffing, cupping and outside shoulder wear, often are an indication of a larger problem with a vehicle's chassis components, reports Terry Hawkins, alignment specialist and senior instructor with Moog Automotive.

"The cause of uneven tire wear can be as simple as under inflation or over inflation," says Hawkins, "but it also can result from loose parts such as shocks, struts, ball joints, steering linkage or from weak springs." As a precaution against tire failure -- the No. 1 cause of highway breakdowns -- Hawkins recommends checking tires regularly for the following conditions:

Shoulder wear, which can be caused by under-inflation or hard cornering. Many shredded rubber tires seen along highways are the result of either under inflated tires, running too long and too hot, or from severe misalignment.

Center tread wear, which usually indicates over-inflation. Over inflation results when a vehicle owner tries to compensate for a slow leak by over inflating the tire to make it stay up longer.

Cupping can be caused by an unbalanced tire condition, faulty wheel bearings, loose parts, fatigued springs or weak shock absorbers. Check the condition of the shock by forcefully bouncing the front end of the car several times and releasing it on the down stroke. Failure of the vehicle to settle after two strokes suggests worn shocks or struts.

Camber or toe wear indicates misalignment due to loose, worn or bent steering linkage components. Many camber and toe wear problems can be traced to spring fatigue, which causes the vehicle's frame to ride closer to the road. Once the vehicle is below the manufacturer's height specifications, it is not possible to achieve the correct camber change designed into the suspension without replacing the springs. The vehicle also experiences excessive toe change as the suspension travels through jounce and rebound, again causing abnormal tire wear.

Diagonal scuffing and cupping across the face on rear tires signals problems with toe. Diagonal tread wear or cupping on rear tires is caused when the direction the vehicle's wheels are heading is not in line with the geometric center line of the vehicle. When this condition occurs, front-wheel steering can be affected and lead to tire slip or loss of traction or control. (Note: The wear pattern that develops on rear tires from improper toe will vary depending on tread design. Wear patterns from rear-wheel misalignment may resemble cupping on tires with highway tread design and diagonal scuffing on tires with an all season tread pattern.)

Early detection is key

"Once a particular wear pattern develops," says Hawkins, "it will continue for the life of the tire." New tires will not correct a wear pattern problem and will soon begin to wear unevenly or prematurely if the cause of the problem is not repaired.

"In the classroom, I ask my students, `When was the last time you replaced a set of tires that were worn evenly all the way down to the bottom of the tread?' You don't see that. Tires are commonly worn in patches or along their edges due to misalignment, or loose chassis parts."

In order to achieve optimum tire performance, vehicle owners should follow a preventive maintenance schedule that includes frequent checks of tire pressure and rotation of tires every 6,000 to 7,500 miles.

"Every car owner should have a tire gauge to monitor tire pressure once a month or whenever they check their oil," says Al Lynch, manager of technical services for Moog. "Tire pressure should conform with the manufacturer's recommendations, found inside the passenger door, door jamb, or glove box, to accommodate the rated vehicle load."

Tire wear patterns often are easier to feel than to see, adds Lynch. "Before feeling the tire," he cautions, "make sure there are no pieces of steel belting or metal embedded in the rubber which could result in a cut or splinter. Also make sure the vehicle is turned off and the parking brake is engaged.

"As you check each tire, be sure to feel both side to side and up and down the tread. If the tread pattern on the outside of the tires feels worn, either a camber or toe problem may exist which means it is time to have the wheel alignment checked by a qualified technician.

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MAINTENANCE TIPS

FROM THE CAR CARE COUNCIL

Scrap Tires

When you buy a tire or battery you're likely to pay a surcharge that goes to the Solid Waste Management Fund. It's part of the solution to the solid waste problems facing our nation, a condition to which millions of junk tires annually make their contribution.

The good news is that used tires are a valuable resource; they just need proper storage and handling. They can be used in asphalt paving, as a supplementary fuel in many industries and as a raw material in molded plastic and rubber products.

The bad news: tens of thousands of tires land in the junk pile before their normal life expectancy, says the Car Care Council. Due to motorists' poor maintenance habits, they're damaged and/or wear unevenly, requiring replacement before their normal "retirement" time.

Storage of waste tires is a challenge to tire recyclers. In addition to littering our landscapes they present a fire hazard and, because they provide a breeding place for insects and rodents, a health hazard as well.

With periodic wheel alignment and balancing, along with monthly checks of tire inflation, tires will last 10% - 20% longer, says the Car Care Council. That means fewer scrap tires to dispose of; real savings to vehicle owners.

AUTOSHOP ONLINE

Space Saving Spare Tire May Harbor Unpleasant Surprise

By Donna Wagner, Director of Operations, Car Care Council, Port Clinton, OH

KA-BOOM! THUMP, THUMP, THUMP. Your car has a flat tire but there's no need to worry. Those compact spares are much easier to maneuver than the old fashioned ones. In fifteen minutes you, or some good Samaritan, are finished and back on the highway. But before reaching the next exit, pieces of your spare tire are flying over the interstate.

A functional spare is a comforting accessory, but an underinflated or dry rotted one is worthless. One that is buried under tons of trunk trash is useless, too. By avoiding the following pitfalls, you can be assured that your baby tire is as capable as his big brothers.

UNDERINFLATION Underinflation is the culprit in most bad spare scenarios. If your spare is low, it may shred on the way home or to the service facility. The distance you can travel before this happens is directly related to the tire's inflation level. Check the pressure of the spare, as well as the other four tires every month or two.

DRY ROTTING Tires, like clothing, tend to deteriorate with age. Although this problem is not as common as underinflation, it bears consideration. Tires do have a shelf life. After a period of time, they may begin to develop small cracks in the sidewall, your first clue to this condition.

INACCESSIBILITY The leading reason spare tires fall victim to underinflation and dry rotting is inaccessibility. If you do your own vehicle maintenance, clear out the trunk and check that "Mickey Mouse" tire. If you take your car to a shop, most automotive technicians are happy to check your spare if they can get to it. However, few will move your cargo for the sake of your spare.

FINAL NOTES 1) Some space saving spares are made to travel up to 3,000 miles at highway speeds; most are limited to 50 m.p.h. It is, as car makers state, for temporary use. Replace it with a full-size tire as soon as possible. 2) Keep your compact spare and its wheel together and do not use them on another car. 3) Do not use tire chains on the space saving spare. They won't fit and will damage the car as well as the chains. 4) Don't even think about driving through a car wash that pulls the car along guide rails. The spare can get caught on the rail and damage the tire, wheel and possibly other parts of your car as well.

Remember: a flat tire in the trunk is about as useful as a flashlight without batteries.

TLC For Tires

Each year Americans spend millions of dollars on the purchase of tires. Unfortunately, they don't spend very much time taking care of them.

What most people don't realize is that tires add value to their cars when properly cared for. And proper tire maintenance involves very simple, routine tasks that can save consumers both money and headaches.

"Tires are some of the most important parts of a car, helping a car perform to its maximum capabilities," said Stan Cooper, Firestone's marketing manager for consumer products. "On the other hand, they're also some of the most overlooked components of a car. By giving them a little attention every month, consumers can enhance the performance of their cars and make their tires last a lot longer.

So what can you do to provide your tires a little TLC? The first step in caring for your tires is keeping them properly inflated. The single greatest cause of tire damage is improper inflation -- which results in early and irregular wear and also decreases your car's gas mileage.

Your car owner's manual will have the correct tire pressure for your tires. Investing in your own air pressure gauge is money well spent. Gauges are easy to use; your tire dealer can show you how. Firestone recommends that you check the air pressure in your tires at least once a month and perform visual checks regularly to detect possible leaks.

By having your car's alignment checked, you ensure that your wheels are moving in a straight line when you steer straight, therefore cutting down on irregular tread wear. Misalignment can result in tire damage as well as damage to our car's suspension system. And that can be costly.

Have your alignment checked about every 10,000 miles or at least once a year. You'll probably want to call ahead to make an appointment with your tire dealer for this job, which usually takes less than an hour.

Balancing your tires is also very important. When your tires aren't balanced correctly, your car will behave a lot like the way your washing machine does when the clothes clump in one spot during the spin cycle. The washer rocks wildly from the uneven weight distribution. When your tire and wheel assemblies aren't balanced, you'll get an uncomfortable ride, the steering wheel will vibrate, and you'll do damage to your tires and your suspension system as your tires bounce against the pavement.

Protect your investment in your tires by checking inflation and tread depth each month and by visiting your tire dealer for rotation, alignment and balancing when necessary. You'll extend the life of your tires, enhance your car's performance and improve your car's fuel efficiency.

Easy Does It With The Spin

Some drivers have the idea that if they can't get off ice or out of the rut by spinning their wheels at half speed, they just might be able to scare the car out by gunning the engine. Then it's "SCREECH" as the spinning tire digs and melts its way through to hard surface. Then it's "SNAP - CLUNK" as something breaks. With the torque of the engine suddenly applied against drive line components, something has to go.

That's more than the universal joints or CV joints, in a front wheel drive car, were designed to handle. These flexible joints that transmit power from the engine to the wheels twist as much as 29 million times in ten thousand miles. When they become worn a little, extra slack can be just enough to allow a sudden jerk to cause a break. And if you've been the heavy-footed "jerk" you may pay a hefty repair bill, warns the Car Care Council.

The spinning wheel, incidentally, turns at double the speed shown on your speedometer, enough to cause a tire to fly apart. To protect your tires, your driveline components and your automatic transmission, take it easy when you try to "rock" your car out of a snow bank.

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MAINTENANCE TIPS
FROM THE CAR CARE COUNCIL

How To Avoid Being Stuck In "Park"

Have you ever wondered why you had so much trouble shifting out of PARK on a steep grade? An automatic transmission, when in PARK position, locks the driving wheels. On a steep grade you'll need more than normal pressure to move the shift lever. This is because the transmission's parking pawl resists the vehicle's tendency to roll.

To help a stuck shift lever, on a very steep grade, the vehicle will need an uphill push or pull, thereby releasing pressure on the transmission.

The Car Care Council suggests a simple procedure to prevent being jammed in PARK on a grade:

1. Do not put it in PARK until, with foot brake applied, you've secured the parking (emergency) brake.
2. Before releasing the parking brake, apply the foot brake and move the shift lever to NEUTRAL or DRIVE.

Three Senses Help Spot Car Trouble

One of the most agonizing noises a car owner may ever hear is the scraping or grinding sound of an automatic transmission that's low on oil. Even in a well insulated car, the metal-to-metal sound is awesome.

According to the Car Care Council, at the first indication of such a noise, the transmission fluid should be checked. If the level is low, adding fluid may correct the trouble.

If the noise persists, the culprit could be a clogged transmission filter which is preventing fluid from reaching the pump. The result, the transmission is starved of fluid, with eventual destruction of the pump and other components. This can add up to a very large repair bill.

The above mentioned horror story should never happen, says Car Care Council, if automatic transmission fluid is checked regularly (at least as often as the oil is changed) and if fluid and filter are replaced periodically.

The Council recommends checking fluid only when the vehicle has been run for a few miles after the engine has reached normal operating temperature.

Check to see if it is discolored, rather than pink or red, which is normal. When fluid has turned brown, this is an indication that it has been burned. Note also if it smells burned. Burned fluid should be drained and replaced, along with the filter.

The Council also notes that the tip of the dip stick should be cool enough to touch; an automatic transmission should operate at 150-200deg.F. Severe service driving, which can overheat the transmission, may call for the addition of a transmission cooler. Fluid life is greatly extended when it is kept within normal operating temperature.

Most types of "severe" service driving require most frequent fluid and filter changes, as well as other periodic services.

This type of service is described as follows:

- Frequent idling for long periods of time, such as stop-and-go driving in heavy traffic.
- Sustained highway driving in hot weather.
- Towing a boat or trailer, or carrying heavy objects on a rooftop rack.
- Driving in dusty conditions.
- Prolonged operation at sub-zero temperatures.

- Driving on steep hills or mountains on a regular basis.

Preventive maintenance is critical to long, efficient car life, summarized Car Care Council. When it is neglected one's senses of sight, sound and smell may signal trouble.

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MAINTENANCE TIPS
FROM THE CAR CARE COUNCIL

"Mama Always Said: Life Is Like..."

...Buying a Used Car"

Forrest Gump's mama's line, "life is like a box of chocolates; you never know what you're going to get," could apply to used car shoppers. Unless you poke through the bottom of the candy, you may wind up with a yucky cream instead of a delicious caramel.

Most teenagers' dream of a used car that's not too pricey, runs well and looks sharp, with an emphasis on "sharp". Unfortunately, these three characteristics are not always found in the same vehicle. That means it's your job to "poke through the candy" and find out what's inside.

If your car knowledge is limited, find a mechanic or friend who is wise in the ways of vehicles. Ask or pay him/her to accompany you to the car lot. Have these key items checked before you plunk down your life savings.

FLUIDS - Most cars have over ten fluids. The important ones to check are the engine coolant, oil, transmission, power-steering, and brake fluids. Contaminants or low fluids can be your clue that the car has been poorly maintained.

ACCIDENT ALERT - Problems in the following areas may indicate a previous accident: bent or welded frame; doors, hood and trunk that have gaps or do not close properly; paint color is not uniform; ripples in the metal. You'll have to get it on a lift for a full inspection, but it's worth the trouble.

STEERING AND SUSPENSION - Too much play in the steering may mean worn parts; that's bad and usually expensive news. A car's suspension system refers to its shocks and/or struts. If this system (aptly named because it literally "suspends" your car over its four tires) is in bad shape, you could lose the ability to steer over rough terrain, making your ride dangerous and bumpy. Your car expert friend will use the "bounce test" to check it out.

EXHAUST - That hot-rod noise may sound cool, but it could mean a leak in one of several places. If this leak is in the catalytic converter, you could possibly fail a motor-vehicle inspection.

BELTS AND HOSES - Worn belts and hoses can be good indicators of how the previous owner(s) maintained the car. If these items are in bad shape, beware.

ENGINE AND TRANSMISSION - Because the engine powers the car and the transmission "transmits" this power to the wheels, these two systems are important players. Check them both visually and with a test drive. The car should run quietly and smoothly. If it is a manual, the gears should shift easily.

BRAKES - While your dream car is up on the lift, make sure the brake system is examined. This involves removing a couple of wheels. Look at the pads, shoes, rotors, drums and hydraulic parts.

TIRES - Check the tread on all five (the spare makes five) tires. Worn treads mean you'll soon be investing in new tires. Treads that have worn unevenly indicate poor alignment.

Resist the urge to follow your heart with your wallet until you know the car inside and out. As time goes by you'll be glad you "poked your finger through the chocolate" and found out what was in the center.

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AUTOSHOP ON LINE

MAINTENANCE TIPS

FROM THE CAR CARE COUNCIL

Three Tips For Buying A Better Used Car

The Car Care Council has three tips for newcomers to the world of used car buying.

First, do your homework. Read consumer magazines and price guides. This will help you decide what features you want, what specific cars fit your needs and what price range to expect.

Second, use an evaluation sheet to keep track of the cars you check out. Jot down what your inspection of each auto reveals. It will come in handy when comparing the pros and cons.

Finally, never, ever buy a used car (or a new one either) on impulse. There are many places to shop for a used car, don't just stop at the first one.

EVALUATION SHEET FOR USED CAR SHOPPERS

Seller

Wholesale Price (price guides available at bank)

Retail Price (price guides available at bank)

Negotiated Price

Warranty

Equipment:

Heating/Cooling

Audio

Transmission

Automatic

Manual

Drivetrain

4 Wheel Drive/Front WD/Rear WD

Air Bags

ABS Brakes

Other

Items to Check:

Exterior

Sits Level

Doors/Hood/Trunk

Bumpers/Fenders

Body

Paint

Glass

Tires

Suspension

Other

Interior

Window Operation

Fabrics

Switches/Handles

Pedals

Other

Under the Hood

Leaks

Belts/Hoses

Fluids

Other

Driving Test

Starting

Noises

Brakes

Shifting

Steering

Ride/Performance

Other

Mechanic's Check

Needed Repairs

Estimated Cost

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