C

CA (Cranking Amps)
Same as cold cranking amperes (CCA), except temperature at which the amperes are measured is 32°F and not 0°F. Cranking amperes is an indication of the ability of a battery to crank an engine for 30 s at a temperature of 32°F without battery voltage dropping below 7.2 V.

CAC (Charge Air Cooler)
A heat-exchanging device like an ICE cooling system radiator engine used to cool the air from the turbocharger, making it denser before entering the intake system. This action will increase horsepower. Air passes through the core of the cooler and, through convection, removes the heat from the air and makes the charge dense. It may be in the form of an intercooler, aftercooler, or charge air cooler.

CAFE (Corporate Average Fuel Economy)
Corporate Average Fuel Economy. A system of fuel economy standards developed in the United States (USA) by the Environmental Protection Agency (EPA) under the Clean Air Act.

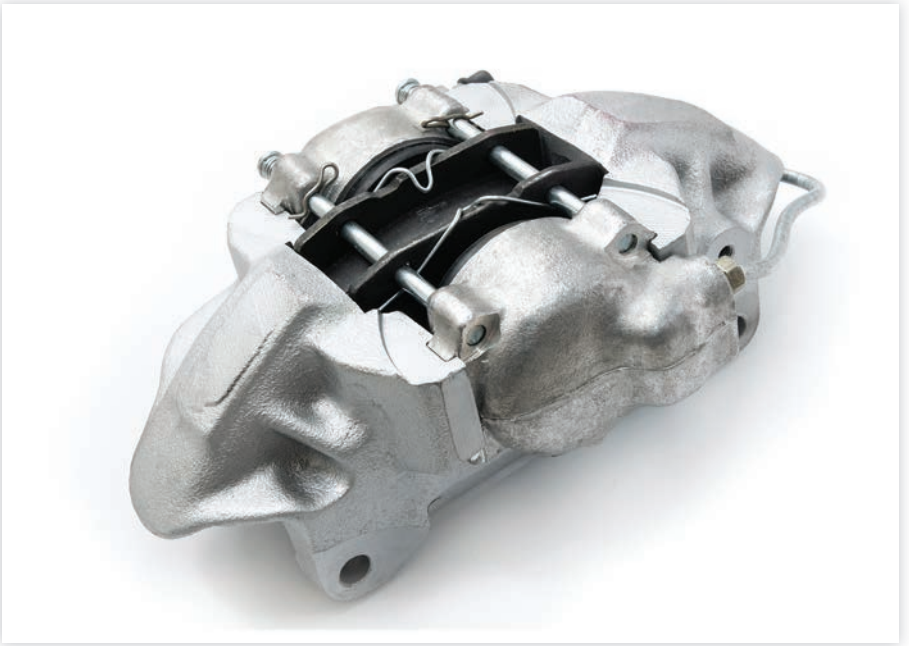
Cage
Bearing rollers are held in place by a cage between the inner race or cone and the outer race or cup.

Calibration Gas
A mixture of several gases used to calibrate an exhaust emission gas analyzer.

Caliper
A disc brake system brake application device. The hydraulic brake operation begins when fluid pressure from the piston chamber forces the caliper pistons to maneuver in, applying pressure to the pads and forcing them tightly against

the rotor to slow or stop the vehicle. The action of a hydraulic brake caliper is compared to the operation of a C-clamp. When applying a C-clamp, the action of turning the handle clockwise moves the inner clamping surface toward the item and the clamp body moves in the other way. This forces the outer clamping surface against the alternative side of the item. A C-clamp may be accustomed easily and uniformly apply high clamping force.

FIGURE C.1 Brake caliper.



BACHTUB DMITRII/Shutterstock.com.

Calories

A metric unit that expresses the amount of heat needed to raise the temperature of one gram of water by one degree Celsius.

Calorific Value (Fuel)

The heat energy potential of a hydrocarbon fuel measured in BTUs (British thermal units), joules or calories.

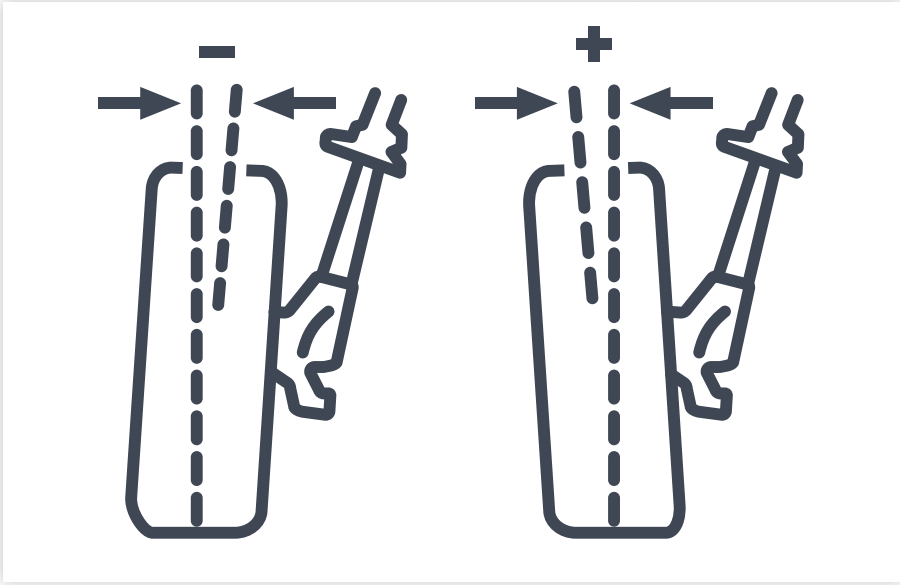
Cam Follower

See **Lifter** and **Valve Lifter**.

Camber

Side-to-side vertical tilt of the wheel as viewed from the front of the vehicle and measured in degrees. A positive camber wheel that leans away from the center of the vehicle at the top as viewed from the front of the vehicle. A negative camber wheel leans toward the center of the vehicle. A vehicle with camber pull will pull in the direction of the greatest positive camber. For more information on this, see **J670_200801** [4].

FIGURE C.2 Automotive steering geometry angle called camber, which is the vertical tilt of the wheel as viewed from the front.



vvushakovv/Shutterstock.com.

Camshaft

Part of an internal combustion engine (ICE) valve train that is driven by the crankshaft, which has lobes or hills and ramps that open the intake and exhaust valves to open through cam followers or hydraulic valve lifters, which are then closed by the valve springs.

Camshaft Gear Backlash

Set the dial indicator up again with the plunger tip resting on the edge of a camshaft gear tooth, in line with (tangential to) the edge of the gear.

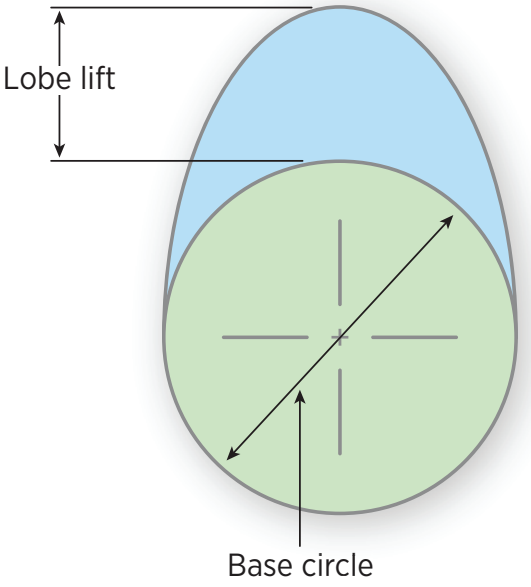
Camshaft Gear Runout

To measure the camshaft gear runout, you set up a dial indicator on the engine block with the plunger resting on the face of the camshaft gear just inside the gear teeth and rock it back and forth to measure the clearance between the gears or backlash.

Camshaft Lobe

Peak or high point on the camshaft that will push the cam follower to open the ICE poppet valve. It is opposite the base circle.

FIGURE C.3 Camshaft lobe.



Courtesy of John F. Kershaw Ed.D.

Camshaft Position (CMP) Sensor

A sensor that is mounted in the front cover or block to monitor the rotation position of the engine camshaft. The camshaft turns at one-half crank speed, so the signal generated by this sensor can be used to determine when the number one piston is at top dead center (TDC) on its compression stroke. The computer also uses this signal to determine when a spark should occur at each spark plug. For more information on this, see **J3063_202103** [8].

CAN (Controller Area Network)

"The SAE J1939 documents are intended for light, medium, and heavy-duty vehicles used on or off road, as well as appropriate stationary applications which use vehicle derived components (e.g., generator sets). Vehicles of interest include, but are not limited to, on- and off-highway trucks and their trailers, construction equipment, and agricultural equipment and implements. The purpose of these documents is to provide an open interconnect system for electronic systems. It is the intention of these documents to allow Electronic Control Units to communicate with each other by providing a standard architecture.

This particular document, SAE J1939-21, describes the data link layer using the Classical Extended Frame Format (CEFF) with 29-bit IDs, as defined in ISO 11898-1, December 2015. "For SAE J1939, no alternative data link layers are permitted." The J1939 fault code error message consists of a Source Address (SA) identifying the Electronic Control Module (ECM) sending the DTC (SA0 = Engine Controller #1), a Suspect Parameter Number (SPN) which identifies the parameter sending the fault code error message, and a Failure Mode Identifier (FMI) which identifies the type of fault detected. The SA or Source Address field is the control module sending the message (see Table C.1 in SAE J1939 below) [1].

TABLE C.1 Source address.

SA	Description
1	Engine
3	Transmission
11	ABS

On-Board Diagnostic (OBD) regulations require passenger cars, and light and medium duty trucks, to support communication of a minimum set of diagnostic information to off-board "generic" test equipment. This document supersedes SAE J1979 May 2007, and is technically equivalent to ISO 15031-5 2010, with the addition of new capabilities required by revised regulations from the California Air Resources Board and revised regulations from the European Commission. This document is intended to satisfy the data reporting requirements of On-Board Diagnostic (OBD) regulations in the United States and Europe, and any other region that may adopt similar requirements in the future. This document specifies:

- Message formats for request and response messages,
- Timing requirements between request messages from external test equipment and response messages from vehicles, and between those messages and subsequent request messages,

- Behavior of both the vehicle and external test equipment if data is not available,
- A set of diagnostic services, with corresponding content of request and response messages, to satisfy OBD regulations.

This document includes capabilities required to satisfy OBD requirements for multiple regions, model years, engine types, and vehicle types. Those regulations are not yet final for some regions, and are expected to change in the future. This document makes no attempt to interpret the regulations and does not include applicability of the included diagnostic services and data parameters for various vehicle applications. The user of this document is responsible to verify the applicability of each section of this document for a specific vehicle, engine, model year and region. SAE J1979/ISO 15031-5 specifies diagnostic services and functionally addressed request/response messages required to be supported by motor vehicles and external test equipment for diagnostic purposes which pertain to motor vehicle emission-related data. Any external test equipment meeting the requirements of SAE J1978 is intended to be able to use these messages to retrieve emissions-related information from the vehicle. Each section of this part of SAE J1979/ISO 15031-5 which specifies additional detail to existing sections of ISO 9141-2, ISO 14230-4, SAE J1850, and ISO 15765-4 supersede those specifications. This part of SAE J1979/ISO 15031-5 references the SAE J1979-DA (Digital Annex), which includes all definitions of PIDs, OBDMIDs, TIDs and INFOTYPES. NOTE: SAE J1979/ISO 15031-5 provides the mechanism to satisfy the requirements included in the country-specific regulations and not all capabilities included in this document are required by the country-specific regulations. SAE J1979 is not considered a final authority for interpretation of the regulations, so readers should determine the applicability of capabilities defined in this document for their specific needs. U.S. OBD requirements for 1996 and later model year vehicles. ISO 15031 5 was based on SAE J1979 and was intended to combine the U.S. requirements with European OBD requirements for 2000 and later model year vehicles. Updates for new regulatory requirements from US, China, Europe, and Brazil. This version also has support for the J1979-2 OBDonUDS updates." The SA, or Source Address, field is the control module sending the message (see Table C.1):

- SPN, or suspect parameter number (Table C.2)
- The SPN combines the elements of the J1857 PIDS and SIDS. It is used for multiple diagnosis uses as follows:
  - Identifying the least repairable subsystem that has failed.
  - Identifying subsystems or units that may not have completely failed but may be showing incorrect operation.
  - Identifying a specific event or condition that requires reporting.

- FMI, or failure mode identifier
- The FMI shows the type of failure in the subsystem as identified by the. Conditions can include system events or Status.

TABLE C.2 FMI descriptions.

J1939 Failure Mode Identifiers (FMI)	Description
0	Data valid but above normal operating range
1	Data valid but below normal operating range
2	Data erratic, intermittent or incorrect
3	Voltage above normal or shorted high
4	Voltage below normal or shorted low
5	Current below normal or open circuit
6	Current above normal or grounded circuit
7	Mechanical system not responding properly
8	Abnormal frequency, pulse width, or period
9	Abnormal update rate
10	Abnormal rate of change
11	Failure mode not identifiable
12	Bad intelligent device or component
13	Out of calibration
14	Special instructions
15	Reserved for future use

- PGN, or parameter group number
- The PGN contains both the FMI information, SA, and SPN, which is a larger J1939 message and thus called the PGN. The PGN contains commands, data, requests, acknowledgments, and DTCs. This serial data is sent over the CAN bus. Each PGN will contain a different set of SPNs.

TABLE C.3 SPN and PGN.

SPN	Description	PGN
102	Turbo boost	65270
247	Engine hours	65253
190	RPM	61444
110	Engine coolant temperature	53262
173	Exhaust gas temperature	65270
175	Oil temperature	65262
84	Vehicle speed	65265

- OC, or occurrence count
- The OC, or occurrence count, is the number of times an SPN/FMI has occurred.

For more information on this, see **J1939/21_2021** [1].

Cantilever Axle

A cantilever axle is a rigid unit that extends horizontally and is supported at only one end.

Capacitance

Term used to measure or describe how much charge can be stored in a capacitor (condenser) for a given voltage potential difference and measured in farads or microfarads.

Capacitor

A solid-state device that opposes a change in voltage. The property of opposing voltage change is termed "capacitance," which is additionally accustomed to describe the electron storage capability of a capacitor. A charged capacitor can deliver its stored energy similar to a battery. When capacitors provide electricity, we say they discharge. A capacitor can power a circuit for a brief period of time.

Capacitor Capsule MAP Sensor

MAP sensor that has one or two silicone chips mounted to form a sealed pressure chamber. The chips form diode-resonance circuits that change frequency and capacitance when deflected or moved by pressure changes. As engine intake manifold pressure in the capsule increases or decreases with load, it causes the diode resonance circuits in the sensor to change capacitance in picofarads.

Carbon

A chemical element using the symbol C and the atomic number 6. It contains four electrons available to form covalent chemical bonds and is part of all fossil fuels.

Carbon-Core Wire

Wire that has a constrained amount of resistance designed directly into the metal conductor to reduce radio interference or static from the high-voltage

pulses going to the spark plugs. Also called secondary resistance wire. For more information on this, see **J139_202002** [2].

Carbon Dioxide (CO_2)

A colorless gas with a density of approximately 60% higher than dry air. It consists of a carbon atom double bonded to two oxygen atoms. It occurs naturally in Earth's atmosphere as a trace gas. Natural sources include volcanoes, hot springs, and geysers, and it is freed from carbonate rocks by dissolution in water and acids. CO_2 is soluble in water and occurs naturally in groundwater, rivers and lakes, ice caps, glaciers, and seawater. It is present in deposits of petroleum and natural gas. CO_2 is odorless at normally encountered concentrations. CO_2 is produced by animal respiration, which includes humans and all mammals.

Carbon Monoxide (CO)

A colorless, odorless, and tasteless flammable gas that is slightly less dense than air and a by-product of the incomplete combustion of a hydrocarbon such as gasoline or diesel fuel. CO is partially burned diesel fuel that combines with O_2 (oxygen) to form CO_2. CO consists of one carbon atom and one oxygen atom.

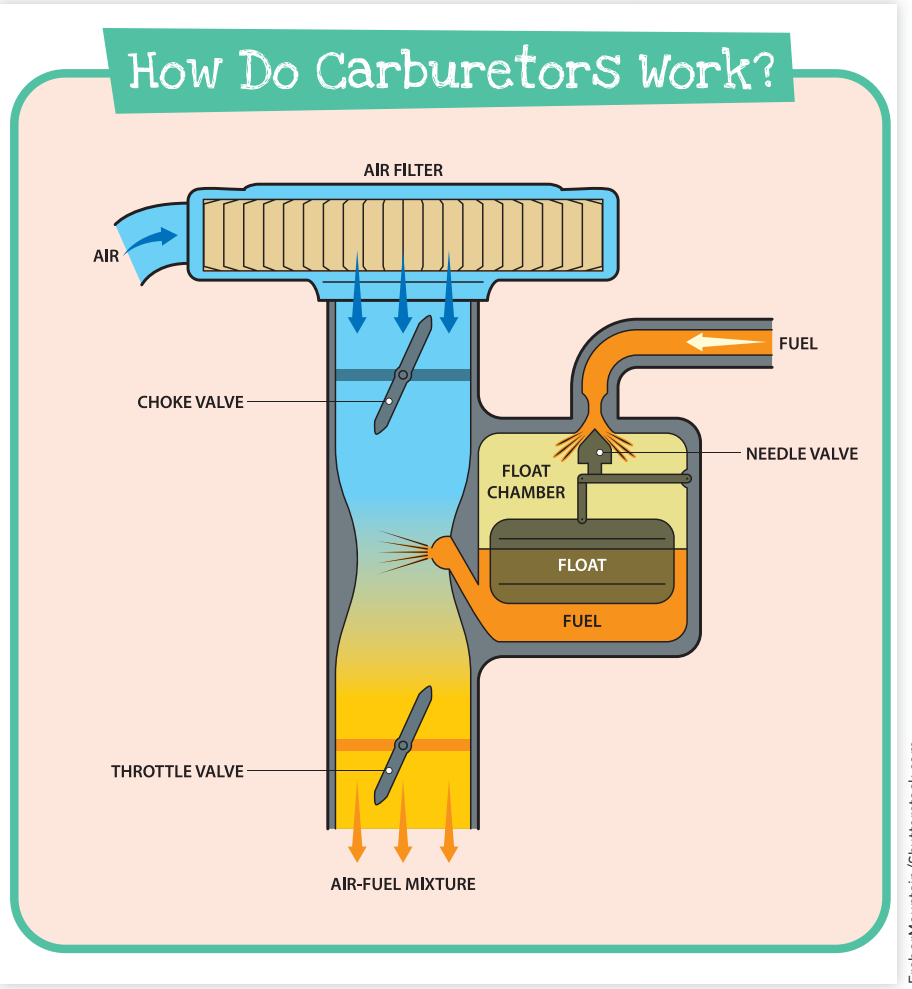
Carbon Residue

The amount of carbon residue left within the combustion chamber has a direct bearing on the engine deposits and cleanliness of combustion; therefore, the smaller the amount of carbon residue at the end of the combustion process the longer the engine life will be and the cleaner the exhaust smoke. The amount of carbon in a fuel is determined by burning a given quantity in a sealed container until all that remains is carbon residue. Carbon residue is expressed as a percentage by weight of the original sample of the fuel oil.

Carburetor

The carburetor mixes the right quantity of gasoline with air. If there is not enough fuel mixed with the air, the engine runs lean and hot and could damage the engine. If there is too much fuel mixed with the air, the engine runs rich and either will not run, or will flood in (producing black smoke), which is fuel burned without air. This causes stalling easily, fouled plugs, increased cylinder wall wear, and wasted fuel.

FIGURE C.4 Carburetor.



EreborMountain/Shutterstock.com.

Carburizing

A method of case-hardening low-carbon steel in which the metal component is heated above its ferrite-austenite transition in a suitable carbonaceous atmosphere.

Carcass

The main underbody of an automotive tire that the belts and tread are mounted and bonded to. For more information on this, see **J2047_201911** [3].

Carcass Plies

Main framework, or body of an automotive tire. For more information on this, see **J2047_201911** [3].

Case-Hardening

Case-hardening is the hardening of the surface of a metal component while allowing the metal to stay soft underneath, thus forming a skinny layer of harder metal at the surface. When hardening iron or steel with low-carbon content, this process involves infusing additional carbon or nitrogen into the surface layer. This process is completed after the component has been formed into its final shape, but can even be done to extend the hardening element content of bars to be utilized in a pattern welding or similar process.

Case-hardening is desirable for metal components that are subject to sliding contact with hard or abrasive materials because the hardened metal is more immune to surface wear. However, because hardened metal is sometimes more brittle than softer metal, through-hardening is not always the best choice. Case-hardening can produce a component that may not fracture because of the soft core and may absorb stresses without cracking but also provides adequate wear resistance on the hardened surface.

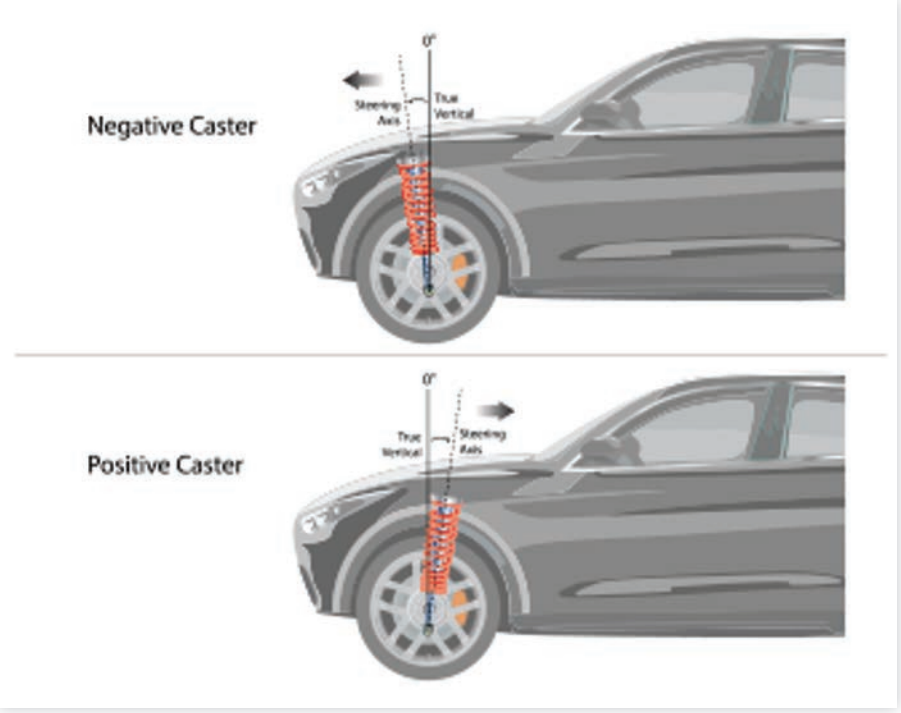
Case/Model-Based Diagnostic Reasoning

Compares system and component performance to expected performance. This is in addition to DTC (diagnostic trouble code) detection and isolation. This form of diagnosis analyzes and categorizes the problem using advanced algorithms. System problems are identified without meddling with system operation by substituting the suspect data from a sensor or component using a default data set.

Caster

The forward or backward tilt of an imaginary line drawn through the steering axis as viewed from the side of the vehicle when compared to the true vertical line. It is this imaginary line that the wheel turns around when the wheel is turned to the side. Caster is positive if the axis is leaning rearward and is negative if the axis is leaning forward. Caster is zero when the steering axis is straight up or down. Caster is measured in degrees. There is a small amount of positive caster designed into all vehicles. For more information on this, see **J670_200801** [4].

FIGURE C.5 Caster is an automotive steering geometry angle that is the forward or rear tilt of the front wheels through an imaginary line drawn through the center of the wheel viewed from the side.



Pankaj_Digari/Shutterstock.com.

Caster Sweep

A process used to measure caster during a four-wheel alignment adjustment and measuring process where the front wheels are rotated inward about 22° and then outward to make the measurement. For more information on this, see **J670_200801** [4].

Catalyst

A catalyst is a substance that increases the rate of a chemical reaction without itself undergoing a chemical change. Diesel exhaust catalysts speed up the chemical reactions that break down noxious exhaust emissions into harmless by-products and allow reactions to take place at lower temperatures. This is important because diesel engines have low exhaust temperatures and this additional burning helps the conversion of emissions into harmless gases. Diesel catalytic converters can temporarily store emission gases until correct conditions have been met to chemically break them down before going into the diesel particulate filter (DPF). The diesel oxidation catalyst (DOC) has to be near

500°F before it starts to work. Some systems use two DOCs, a close-coupled DOC that is in front of the SCR (selective catalytic reduction) unit and the other DOC is connected to the DPF.

Catalytic Converter

An emission control device located in the exhaust system that changes HC and CO into harmless H_2O and CO_2. In a three-way catalyst, NOx is also divided into harmless nitrogen (N_2) and oxygen (O_2). For more information on this, see **J1145_201109** [10].

Catalytic Substrate

Part of a ceramic converter consists of a ceramic base covered with a wash coat of material containing precious metal (e.g., platinum, palladium). Chemical reactions between the noxious emissions and the metals convert the emissions to nitrogen, water, and carbon dioxide. Metal foil catalysts alloyed with precious earth metals are also used. These catalysts have the capability to be electrically heated.

Cat-Back Exhaust System

A cat-back exhaust system includes a new Y-pipe, intermediate pipe, muffler, and tailpipe.

Catch Tank

An engine coolant tank that uses plumbing that goes into the top of the tank and does not have a hose that goes to the bottom. A catch tank collects or catches expelled coolant to be drained from that tank at a later point. While a recovery, reservoir, expansion, surge, or catch tank holds excess coolant, the recovery, reservoir, expansion, surge tanks will automatically put the coolant back in the system where the catch tank will hold the coolant until emptied.

Cathode

The negative electrode in a solid-state device like a diode.

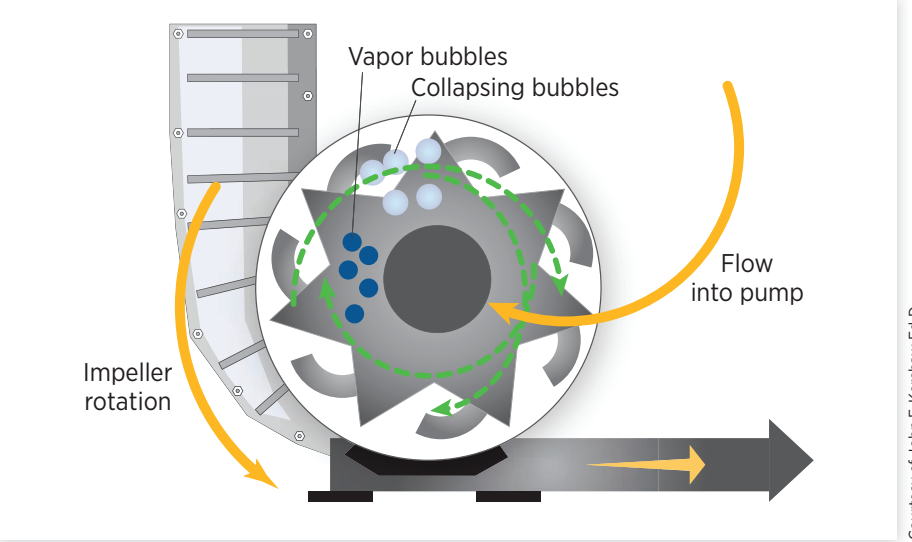
Cathode Ray Tube (CRT)

An electron beam tube with a cathode at one end and an anode at the screen end. A shot of electrons from the cathode to the anode creates a pattern on the screen.

Cavitation Erosion

Cavitation is the formation of vapor cavities in a liquid, which occurs when the pressure within the water pump drops causing vapor-filled cavities to form. These are bubbles or cavities that are the result of forces acting upon the coolant when it is subjected to rapid changes of pressure. When these vapor-filled bubbles get to areas of higher pressure on their way through the impeller, they collapse or implode with a shock on the impeller vanes. This is followed by a sudden rush of coolant into the voids created by the collapsing bubbles, resulting in mechanical damage. Low pressure can be due to various flow parameters, such as coolant viscosity, temperature, pressure, and flow nature.

FIGURE C.6 Cavitation.



Courtesy of John F. Kershaw Ed.D.

CCA (Cold Cranking Amps)

A rating that indicates how much current the battery can deliver for 30 sec at 0°F (–17.8°C) while maintaining a terminal voltage of 7.2 V (1.2 V per cell).

CCC (C3)

Computer command control (C3) is the name of the General Motors (GM) computer control system that uses an electronically controlled carburetor with a mixture control solenoid using 10% duty cycle.

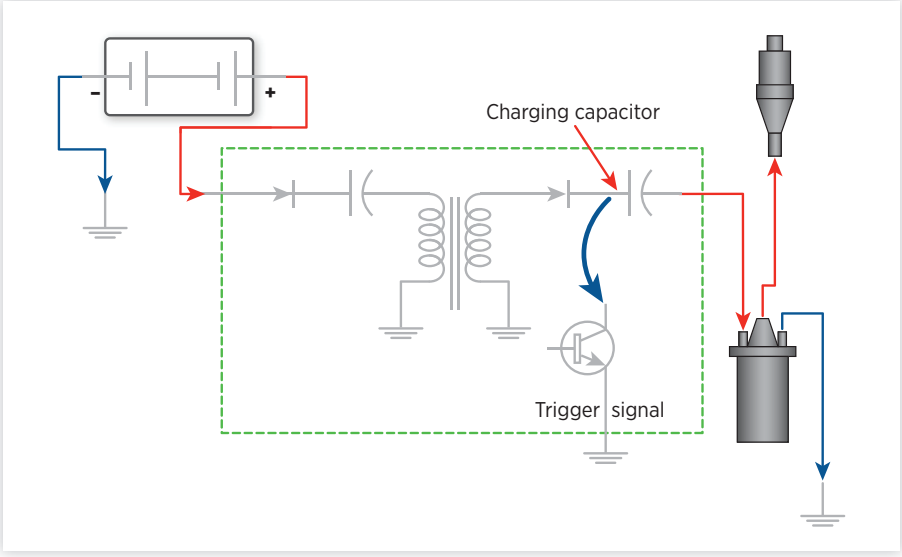
CCM (Comprehensive Component Monitor)

An internal program used on OBD II (On-Board Diagnostics Generation II) system in the engine management computer that is designed to monitor a failure in any electronic component or circuit (including emission-related and non-emission-related circuits) that provide input or output signals to the engine management computer. For more information on this, see **J1930DA_202105** [6].

CDI (Capacitor Discharge Ignition) System

A solid-state version of the magneto ignition with the breaker points being replaced by analog or solid-state transformer. It is found in some racing vehicles like NASCAR. The CDI system does not have the long charging times found in high-inductance automotive induction ignition coils. So it absolutely is more suitable for small engines and racing engines. Capacitor discharge ignition systems use the discharge current output from a high-voltage capacitor to leap the electrodes in spark plugs. For more information on this, see **J139_202002** [2].

FIGURE C.7 Capacitor DC type.



Courtesy of John F. Kershaw Ed.D.

CDR (Crankcase Depression Regulator)

The CDR valve operates by engine vacuum or pressure differential. Inside the CDR valve a spring holds open a valve plate that connects the body with a

flexible diaphragm. The valve plate can restrict the outlet passage to the air inlet duct when pressure differential pulls it closed against the spring force. At idle, diesels do not produce significant vacuum (pressure differential) so the airflow past the CDR outlet passage will not be great enough to close the CDR valve, so it is fully open. The CDR valve should be fully open because the crankcase pressure potential at idle is approximately one inch of water and because, at slow speeds there is more time for the air to leak past the rings. At higher engine speeds, the valve closes to provide more restriction. This action prevents the movement of oil vapors into the intake manifold by limiting the crankcase vacuum (measured at 2,000 RPM to be from 2 to 5 in. of water). If you did not restrict the CDR valve, it would attempt to depressurize the crankcase and suck all of the oil out of it.

CEEMAT (Converter Enhanced Electronically Managed Automated Transmission)

Designed originally for the military by Eaton. An electronically controlled manual twin shaft transmission that connect to the ICE with a torque converter and lock up clutch. It is no longer in production.

Cell

A lead-acid battery contains a number of individual cells. These cells are made up of alternating positive and negative plates. Between each plate is a separator that keeps the plates from touching but will let electrolyte (water and sulfuric acid) pass back and forth between them.

CEMF (Counterelectromotive Force)

An induced voltage that opposes the source voltage and any change (increase or decrease). The CEMF is additionally called a back EMF. It is a voltage that opposes the change in current which induced it. It is caused by magnetic induction (see Faraday's law of induction, electromagnetic induction, Lenz's Law).

Center Bearing

Center bearings are used on truck drivelines to support the center portion of the driveline when two or more propeller shafts are used. Driveshafts longer than 65 in. (165 cm) require a center support bearing, or carrier bearing for additional support. The center support bearing is a ball type. The bearing is mounted in a rubber cushion that is attached to a frame crossmember.

FIGURE C.8 Truck driveline center support bearing.

Toa55/Shutterstock.com.

Center Bolt

A bolt used to hold the leaves of a leaf spring together in the center. Also called a centering pin.

Center of Gravity

Single point where all of the vehicle weight is centered. If the vehicle could be balanced from its center of gravity, it would hang from that point in perfect equilibrium. The center of gravity is always above the ground and between the tires. Center of gravity location can be measured in three planes. It can be measured along the lateral axis (the track width), longitudinal axis (wheelbase), and the vertical axis (height above the ground). The center of gravity is always located above the road surface and between the tires. When a vehicle is cornering, this is the point through which all centrifugal force is assumed to act. Its position is determined by the load carried by the front and rear wheels—that is, by how weight is distributed. In a typical rear-wheel-drive vehicle, the weight distribution is approximately 60% fore and 40% aft; 60% of the weight is carried on the front wheels, 40% on the rear, and the center of gravity is closer to the rear than the front. On a typical front-wheel-drive vehicle, the weight distribution is approximately 75% fore and 25% aft. If the lateral weight distribution is unequal, the vehicle can experience unequal handling characteristics

when turning in one direction compared to the other direction. For more information on this, see **SAE J1594_201007** [5].

Centerline Steering

A term that describes the position of the steering wheel while driving on a straight, level road. The wheel should be centered or within ±3° as specified by many OEMs.

Centerlink (Relay Rod or Draglink)

The centerlink (relay rod/drag link) moves to the left and right under the vehicle because the steering wheel turns. The centerlink is connected between the pitman arm and also the idler arm. The connections between the pitman arm and idler arm are usually ball-and-socket type; therefore, the centerlink can swivel and move through various angles. Tie rods are attached to the centerlink with similar ball-and-socket-type joints. When the centerlink moves, it causes the tie rods to maneuver the wheel assembly.

Central Processing Unit (CPU)

Microprocessor inside the engine management computer that receives input sensor information, compares the input with information stored in memory, performs calculations, and makes output decisions to the output actuators.

Centrifugal Force

Centrifugal force is the natural tendency of objects, when forced to move in a curved path, to move away from the center of rotation as a result of centripetal force, which is the force directed toward the center. See **Centripetal Force** for formula.

Centrifugal (Mechanical) Advance

Spinning weights that move the distributor cam ahead, advancing the ignition timing in proportion to the engine speed. They react to centrifugal/centripetal force, moving the distributor cam or pole piece.

Centrifugal Oil Filter

An oil-driven rotor inside the oil filter metal housing. The oil flows into the housing, and the oil flow spins both the rotor and the oil. Centrifugal force pushes the heavy contaminants onto the sides of the housing, and the clean oil flows out.

Centrifugal Supercharger

A centrifugal supercharger is similar to a turbocharger but is mechanically driven by the engine instead of being powered by the hot exhaust gases. Centrifugal or spiral-type supercharger has internal compression like a water pump.

Centripetal Force

A force making a body follow a curved path with a direction at a right angle or orthogonal to the body motion and toward the fixed point of the middle of path curvature. This force results in the reactive centrifugal force. Centripetal force is determined by the following formula:

$$F = m\frac{v^2}{r} \quad \textbf{(C.1)}$$

where

m is the mass
v is velocity
r is radius
F is centripetal force

Cetane

Property of diesel fuel that is a measure of the ignition quality of the fuel relative to a reference fuel mixture composed of cetane and alpha-methyl-naphthalene, the percentage, by volume, of cetane in the mixture being the cetane number (CN). CCI stands for calculated cetane index. High CNs specify good ignition quality with a short delay period, and low CNs specify poor ignition quality with a long delay period, white smoke, and misfires. CNs are obtained using a single-cylinder variable-compression-ratio engine similar to determining the octane number of gasoline. The ignition quality of an unknown fuel is matched to a reference fuel. Cetane is a colorless liquid with excellent ignition qualities and is rated at 100. ASTM defines the CN as a percentage by volume of a test fuel containing cetane at a CN of 100 mixed with alpha-methylnaphthalene or heptamethylnonane that has a poor ignition quality CN of 0. The CN is the percentage of cetane and the zero ignition chemical to produce a similar ignition quality measured against the fuel being tested. In other words, a mixture consisting of 45% cetane and 55% alpha-methylnaphthalene has a CN of 45. Numbers 1 and 2 diesel fuel that are used on the highway have a minimum CN of 40.

Cetane Improvers

Fuel additives that will increase the CN value of a fuel. These chemicals should only be used when the OEM (original equipment manufacturer) recommends their use.

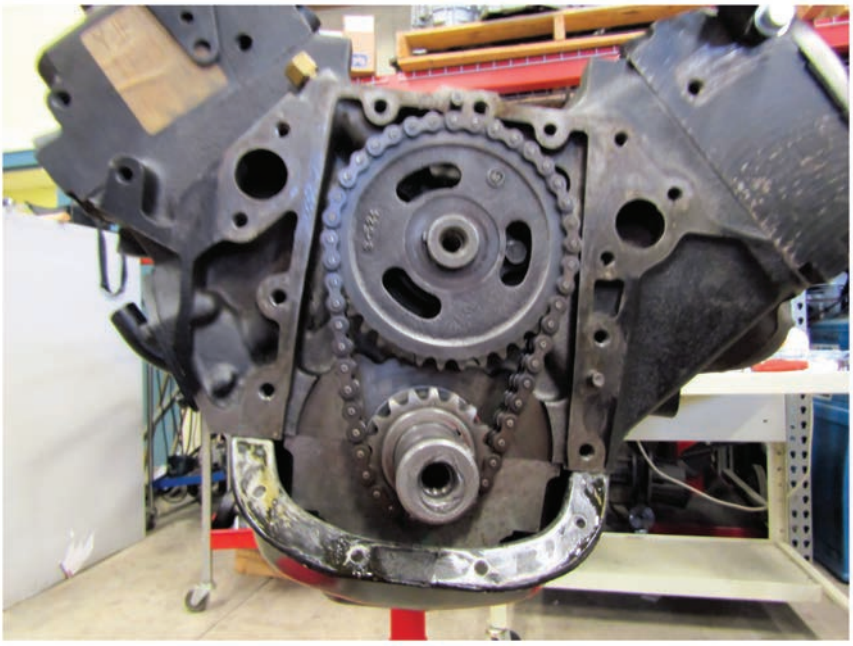
CFR (Cooperative Fuel Research) Engine

This is a research ICE with a variable compression ratio that can be adjusted to cause any fuel being tested to detonate, or explode, rather than burn evenly. The fuel tested is run in a CFR engine and the compression ratio is adjusted until the fuel detonates. This engine is used for testing, research, and instruction in the performance of fuels and lubricants for the ICE.

Chain and Sprocket Drive

This type of engine drive mechanism consists of a chain and two sprockets. The sprockets are toothed wheels, over which a single or double roller Morse chain is assembled, that allows the crankshaft of an ICE to turn the camshaft.

FIGURE C.9 ICE chain and sprocket drive.



Courtesy of John F. Kershaw Ed.D.

Chain Tensioner

A spring loaded or hydraulic device that applies a force to create or maintain tension on the camshaft drive chains.

Chamfered Edge

A chamfered edge is another name for beveled edge that allows the easy entry of a shaft into a bore.

Chapman Strut

A type of MacPherson strut independent rear suspension used for sports and racing cars. The name comes from Colin Chapman of Lotus.

Charles's Law

Charles's Law states that a volume of an ideal gas is directly proportional to the absolute temperature at constant pressure. Kelvin temperature and the volume will be in direct proportion when the pressure exerted on a sample of a dry gas is held constant. Charles's Law formula is determined as follows:

$$V \propto T \ \frac{V}{T} = k \qquad \textbf{(C.2)}$$

Chassis

Chassis is the frame, suspension, steering, and machinery of a motor vehicle.

Chassis Ground

A method of grounding a circuit that uses the metal part of a component to attach to ground.

Check Engine Light

A dashboard warning light that is controlled by the vehicle engine or body management computer; since the adaption of SAE standard J-1930, it has been referred to as MIL, or malfunction indicator light. Some vehicle manufacturers refer to this light as the service engine soon (SES) light.

Check Valve

A valve that permits flow in only one direction.

Chlorofluorocarbon (Freon Refrigerant)

Chlorofluorocarbons are fully or partly halogenated paraffin hydrocarbons that contain only carbon, hydrogen, chlorine, and fluorine and commonly known as the DuPont brand name Freon. Freon was formerly used as a refrigerant in air conditioning and invented by Charles Kettering of GM.

Choke

A butterfly valve located in the top of the air horn of a carburetor that when partially closed creates a low-pressure area causing additional fuel to flow out of the main jet to enrichen the fuel mixture for cold starting. This is because cold air does not absorb the moisture in cold air so the additional gasoline will absorb this moisture.

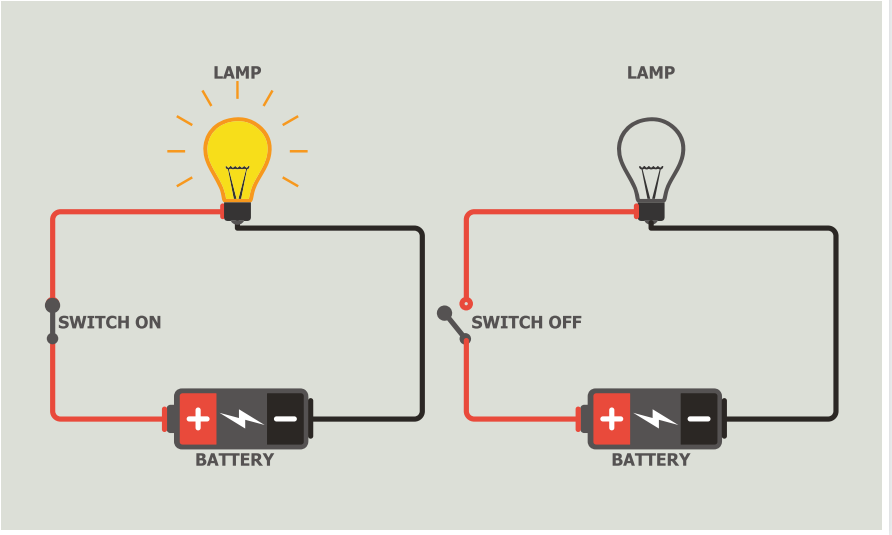
CHT (Cylinder Head Temperature) Sensor

A sensor that measures cylinder head temperature.

Circuit

A circuit is a closed electrical path for a current. For current to flow continuously from a voltage supply, like a battery, there must be a whole circuit or path. Current flows from one end of a circuit to the opposite when the ends are connected to opposite charges (positive and negative). We usually call these ends "power" and "ground." Current flows only in an exceedingly closed or completed circuit. If there is an opportunity somewhere within the circuit, current cannot flow. We usually call a prospect in each circuit as open. Every automotive circuit contains a source of power, conductive material (wires) load, controls, and a ground. These elements are connected to each other with conductors, like a copper wire. The first power source in a car or truck is the battery. As long as there is no external connection between the positive and negative sides, there is no flow of electricity. Once an external connection is connected between them, the free electrons have a path to flow on. The electrical circuit is connected between the positive and negative sides.

FIGURE C.10 Circuits contain a power source, path, control switch, and load.



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Circuit Breaker
Circuit protection device consisting of a contact point set attached to a bimetallic strip. The bimetallic strip will heat and bend as current flows. Unlike a fuse, it does not blow out.

Circuit Number
The number, or number and letter, that manufacturers use to identify a specific electrical circuit in a diagram.

Circuit Resistance Tests
Tests used to locate wiring problems in a charging system such as a loose connection, corroded terminal, partially burned wire, or other similar types of troubles.

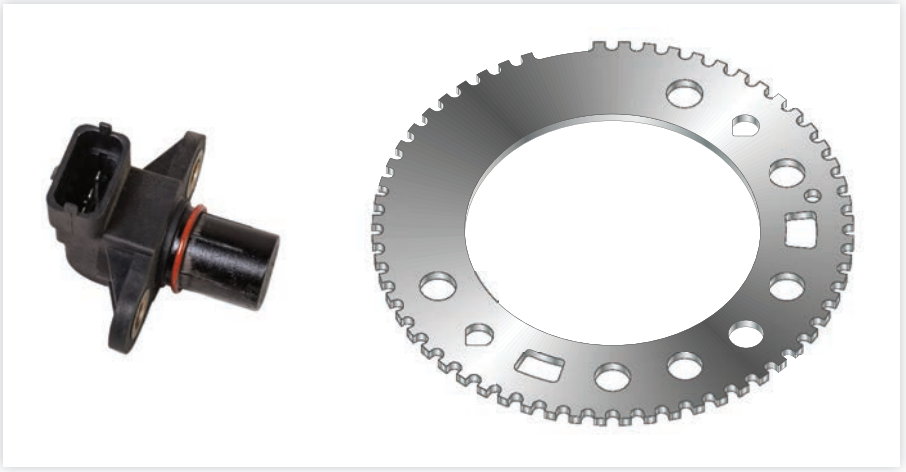
Circuit Sensing
A system that uses a computer instead of dedicated sensors to monitor components and circuit operation.

Circular Mil
Circular mil equals the area of a circle that has a 0.001-in. diameter.

Circumference
The distance around a closed curved.

CKP (Crankshaft Position) Sensor
Provides a signal to the engine management computer that can be used as a reference to calculate RPM, which tells the computer that the engine is cranking and/or running. It also identifies the cylinder position for sequential fuel injection and ignition and on systems using the sequential COP (coil-on-plug) ignition. It is used in conjunction with a reluctor wheel with a number of teeth with one missing tooth. It has a tooth a specific number of crank degrees. This crank trigger is needed for ignition systems. For more information on this, see **J1930DA_202105** and **J1145_201109** [6, 10].

FIGURE C.11 CKP sensor.



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Fouad A. Saad/Shutterstock.com.

Class 2 Serial Communications

An electronic data transfer medium that toggles the line voltage from 0 to 7 V, with 0 being the rest voltage, and by varying the pulse width.

Class B Data Communications Network Interface

Class B Data Communications Network Interface is used for OBD II communications. "The term 'test tool' is synonymous with OBD II Scan tool. This technical report is being stabilized because it covers technology, products, or processes which are mature and not likely to change in the foreseeable future. This SAE Standard establishes the requirements for a Class B Data Communication Network Interface applicable to all ON/OFF Road Vehicles. It defines a minimum set of data communication requirements such that the resulting network is cost effective for simple applications and flexible enough to use in complex applications. Taken in total, the requirements contained in this document specify a data communications network that satisfies the needs of automotive manufacturers. This specification describes two specific implementations of the network, based on media/Physical Layer differences. One Physical Layer is optimized for a data rate of 10.4 Kbps while the other Physical Layer is optimized for a data rate of 41.6 Kbps.

The Physical Layer parameters are specified as they would be detected on the network media, not within any particular module or integrated circuit implementation. Although devices may be constructed that can be configured to operate in either of the two primary implementations defined herein, it is expected that most manufacturers will focus specifically on either the 10.4 Kbps implementation or the 41.6 Kbps implementation depending on their specific application and corporate philosophy toward network usage. However, low-volume users of network-interface devices are expected to find it more effective to use a generic interface capable of handling either of the primary implementations specified in this document. This SAE document is under the control and maintenance of the Vehicle Networks for Multiplexing and Data Communications (Multiplex) Committee. This committee will periodically review and update this document as needs dictate." For more information on this, see **J1850_201510** [16].

Clearance Volume

Cylinder volume not swept by the piston and enclosed in the copper head gasket. It equals 0.785 times bore diameter squared times the deck clearance. The combustion chamber volume is measured using two different processes to measure the combustion chamber size.

C-Lock Axle

An automotive rear axle that is secured in the differential housing with a C-lock installed at the differential end of the axle shaft. The C-lock is named because it is shaped like the letter "C."

Clock Generator

A quartz oscillator of a computer that generates a gentle stream of one-bit-long voltage pulses. Both the microprocessor and, therefore, the memories monitor the clock pulses while they are communicating. Because they understand how long each voltage pulse should be, they are between a 01 and a 0011. To finish the method, the input and output circuits also watch the clock pulses.

Clock Spring

Electrical current is provided to the supplemental restraint system (SRS), also called an air bag, through the spiral cable, which is also known as a coil or clock spring. This is a contact strip that maintains electrical contact when the steering wheel is turned though it path. For more information on this, see **J1538_201504** [11].

Closed Loop

The OBD fuel system mode in which the engine management computer reads and responds to feedback signals from an exhaust gas oxygen sensor, changing the pulse width or the time of the fuel injectors or mixture control solenoid to keep the fuel ratio stoichiometric. For more information on this, see **J1930DA_202105** [6].

Closing Ramp

The ICE camshaft lobe that opens the intake and exhaust valves has two sides or ramps, a closing and an opening ramp or side. The closing ramp is where the cam follower or lifter rides on to close the intake or exhaust valve.

Cloud Point

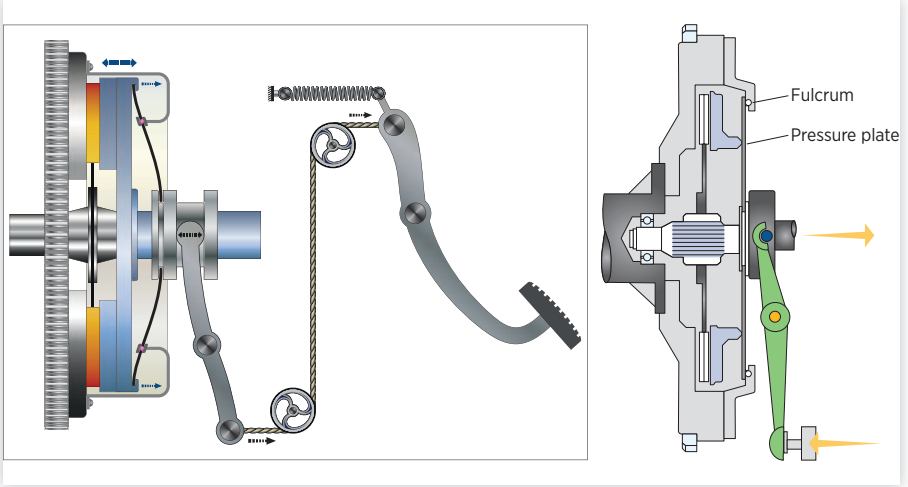
A diesel fuel property, that is, the temperature at which the wax crystals in the paraffin base diesel fuel begins to settle out with the result that fuel filter plugging can take place. It is called cloud point because when these wax crystals become big enough, they will cause the fuel to appear cloudy. Cloud point generally occurs 5 to 8°C (9–14°F) above the pour point.

Clutch

A powertrain device used to connect two rotating components. You need a clutch because the engine spins all the time, and the car wheels do not. You need to disengage the transmission from the engine when you stop the vehicle without stopping the engine. A clutch allows you to smoothly engage a running engine to a non-spinning transmission by controlling the slip between the engine and transmission.

The flywheel is connected to the engine, and the clutch plate is connected to the transmission. When your foot is off the pedal, the springs push the pressure plate or clutch cover assembly against the clutch disc, which in turn presses against the flywheel. This locks the engine to the transmission input shaft, causing them to rotate at the same speed. The amount of force the clutch can hold depends on the friction between the clutch plate and flywheel and how much force the spring puts on the pressure plate or clutch cover. There are push-type clutches as shown in C12 and a pull-type, where the release bearing is pulled rather than pushed in C12A. For more information on this, see **J1479_201211** [7].

FIGURE C.12 Push-type clutch (left) and clutch brake (right).



Fouad A. Saad/Shutterstock.com.

Courtesy of John F. Kershaw Ed.D.

Clutch Brake

Most heavy-duty non-synchronized manual transmissions use a clutch brake that is splined to the transmission input shaft. The clutch brake is a disc, with friction material, that slides on the input shaft. It is squeezed between the release bearing and the transmission front cover during clutch release to stop the rotation of the input shaft. It is used with non-synchronized transmissions to allow shifting into a gear while the vehicle is not moving. It can stop the rotation of the input shaft so that a clash-free shift can be made when the vehicle is at a stop and the engine running. The clutch brake is designed to come into contact with the machined pad at the front of the transmission housing. For more information on this, see **J1479_201211** [7].

FIGURE C.13 Clutch brake.

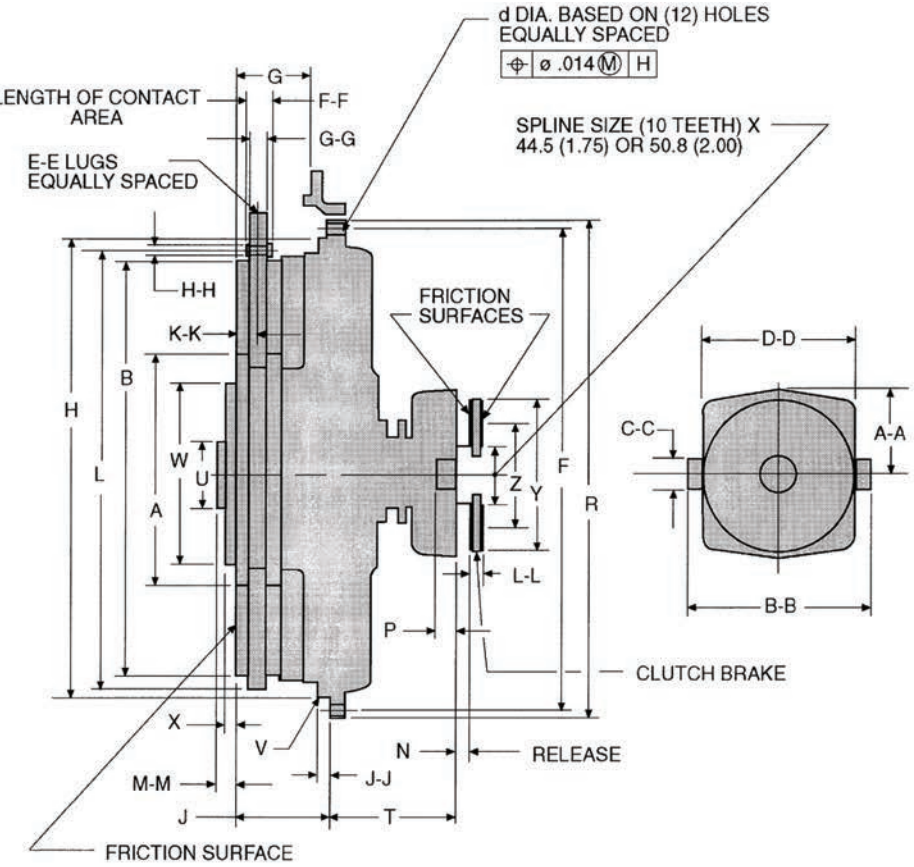
Dim	MM	IN	Dim.	MM	IN
A	187.5	7.38	X**	5.1	.20
B	349.3	13.75	Y	120.7	4.75
d*	10.3	.406	Z	73	2.90
F	393.7	15.50	A-A	65	2.56
G	63.5	2.50	B-B	147.4	5.81
H	374.7	14.75	C-C**	31.8	1.25
J	74.7	2.94	D-D	124	4.88
L	368.3	14.5	E-E		6
N	12.7	.50	F-F	14.5	.57
P	26.9	1.06	G-G	12.7	.50
R	412.8	16.25	H-H	10.4	.41
T	106.7	4.28	J-J**	4.1	.16
U	58.7	2.31	K-K	19.1	.75
V	.8X45°	.03X45°	L-L	10.03	.395
W	177.8	7.0	M-M**	13.2	.52

Applicable with most
SAE housing size #1 and 2

Housing variations may affect fit.

* For reference only. For exact dimensions consult SAE J1857 flywheel recommended practice. Clutch dimensions should allow for proper allowance.

** Maximum



Clutch Disc

The friction disc is a thin piece of steel sandwiched between two layers of friction material. The friction material is the wearable portion of the disc that has a high coefficient of friction and holds onto the flywheel or intermediate plate when clamping force is applied to resist slipping and loss of power. The friction material, either organic or ceramic, is bonded by glue or riveted to the steel. On a riveted disc, the rivet heads must be below the surface of the friction material so that they do not rub on the flywheel or pressure plate. Brass rivets are used because brass is softer than the cast iron flywheel and pressure plate. Even if the friction material wears down far enough to let the rivets touch the flywheel or pressure plate, the rivets wear away instead of damaging the flywheel or intermediate plates. Grooves cut into the surface move dust from worn friction material away from the clutch operating surface. Another design has small pieces of friction material riveted or bonded to cushion springs, also called Marcel springs. Rivets hold the cushion springs to the steel disc. The cushion springs can flex slightly as the clutch engages and disengages.

Breaking the friction material into segments has several advantages. The cushion springs smooth out clutch engagement while the flexing motion helps break any vacuum between disc and flywheel or pressure plate. Small gaps between segments provide better cooling. Clutch friction material can be organic or ceramic facings. Ceramic facings have an increased tolerance to heat and are therefore more commonly found on heavy-duty truck applications. ICE input torque >500 lb/ft (670 Nm) requires the use of a multiple-disc clutch. Multiple-disc clutch systems have two or more driven friction discs that are separated by intermediate driving plates between the pressure plate and flywheel. While single-disc systems work well on cars and light trucks and some medium duty trucks, a single-disc system would fail quickly under the increased load of high-torque diesel engines.

FIGURE C.14 Single clutch (left) and dual disc truck clutch (right).

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Sergey Ryzhov/Shutterstock.com.

CNG (Compressed Natural Gas)

CNG, or compressed natural gas, is a combustible fuel in a gaseous from made of gasoline which is mainly composed of methane (CH_4), compressed to less than 1% of the volume at standard atmospheric pressure of 14.7 psi. It is stored at a pressure of 20–25 MPa (2,900–3,600 psi).

CO (Carbon Monoxide)

Carbon monoxide, which carries the chemical formula CO, is a colorless, odorless, and tasteless flammable gas that is slightly less dense than air and a by-product of the incomplete combustion of hydrocarbon such as gasoline or diesel fuel. CO is partially burned diesel fuel that combines with O_2 (oxygen) to form CO_2 (carbon dioxide). CO is composed of one carbon atom and one oxygen atom. It is not a major concern in diesel engine emissions.

Cocktail Shaker Piston

Combustion heat transfer that takes place in a reciprocating hollow piston partially filled with engine oil.

COE (Cab-Over-Engine)

Cab-over, or cab-over-engine (COE), cab forward, or forward control (UK), is a truck style with a vertical front or flat face with the cab of the truck sitting above or forward of the engine and front axle.

Coefficient of Friction

The amount of resistance that exists between two surfaces. The formula of friction: F = N (normal force) × μ (coefficient of friction constant). Using the symbol μ, it is a measure of how effortlessly one object moves in relation to another object and the ratio of the force of friction to the normal force found using the formula:

$$\mu = \frac{f}{N} \tag{C.3}$$

where

f is the force of friction
N is normal force

Tire quality has more of an effect on braking. A higher coefficient of friction exists between a given road surface and a tire that has an acceptable amount of tread on it. A lower coefficient exists when a tire with little or no tread.

TABLE C.4 Tire and road conditions.

Road condition	Tire condition	Resultant coefficient of friction
Dry pavement	New tire	1.0 (highest)
Dirt road	New tire	0.9
Dry pavement	Old, worn tire	0.8
Dirt road	Old, worn tire	0.7
Gravel	New tire	0.6
Gravel	Old, worn tire	0.5
Wet road	New tire	0.4
Wet road	Old, worn tire	0.3
Ice	New tire	0.2
Ice	Old, worn tire	0.1 (lowest)

Cogged Belt
A drive belt with cogs or slots that run perpendicular to the belt length. These slots reduce the belt bending resistance.

Coil Spring
A spring steel rod wound in a spiral shape.

Coke
The carbon residue left after ICE combustion.

Collector
The conductive outside layer of semiconductor material in a transistor.

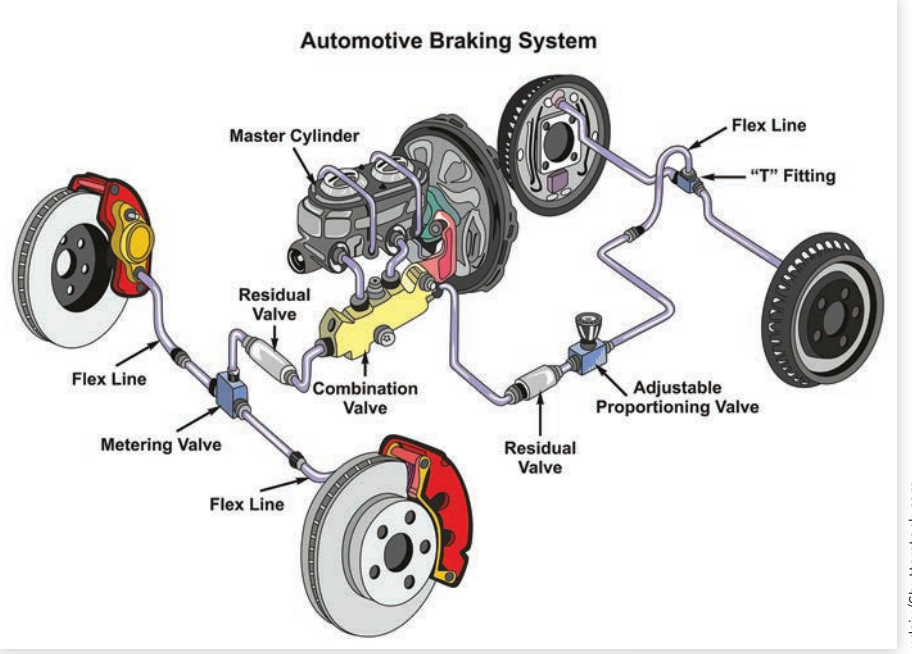
Collision Alert Indicators
A series of red LEDs which will flash when approaching another vehicle too rapidly. The collision alert indicators are located within the electrical device area. The collision alert indicators receive power and ground and are discretely controlled by the instrument cluster through a pair of low control circuits. When requested by the frontview camera controller, the board will pulse the low control circuits, flashing the LEDs as a visible alert that another vehicle is being approached too rapidly. The instrument cluster controls the head-up display via a CAN (controller area network) system. The instrument cluster will command the head-up display to flash the collision alert indicator as a visible alert when approaching another vehicle too rapidly, as requested by the frontview camera module. The EBCM (electronic brake control module) starts

out the braking functions of intelligent brake assist and automatic collision preparation. For more information on this, see **J3063_202103** [8].

Combination Valve

Some vehicles combine the pressure differential valve, metering valve, and proportioning valve into a single valve body.

FIGURE C.15 Automotive brake system.



udaix/Shutterstock.com.

Combustion

The high-temperature burning of the fuel and air mix in the combustion chamber of an ICE.

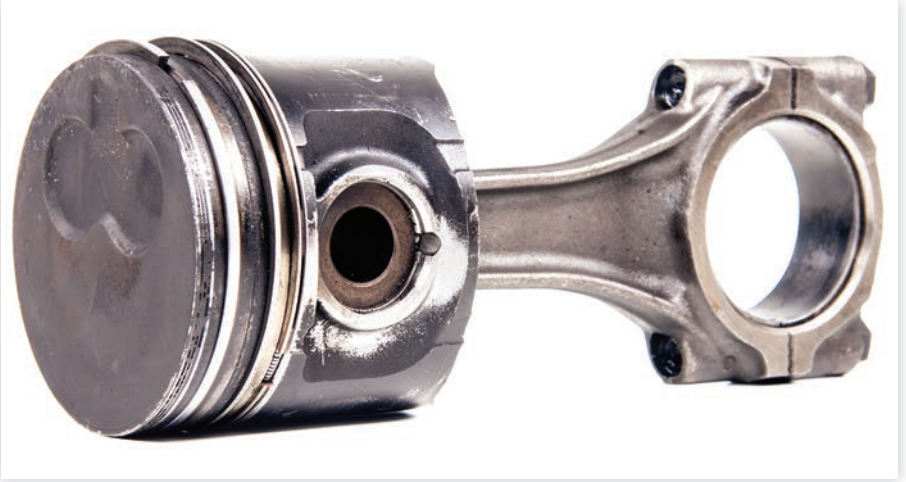
Combustion Chamber

The volume of the space in the cylinder above the piston with the piston at top dead center (TDC) during the compression stroke where the cylinder head and piston crown form the combustion chamber. For more information on this, see **J604_201108** [9].

Comet 5 Piston and Prechamber

The Ricardo Comet 5, or toroidal piston, has a combustion chamber area that is shaped like one-half of a four-leaf clover and designed to overlay a piston displacement (squish) rotary swirl at right angles to the induction-produced swirl around the piston axis. The resulting dual turbulence spirals around the piston axis and resembles a tornado, hence the term toroidal.

FIGURE C.16 Ricardo Comet 5 piston.

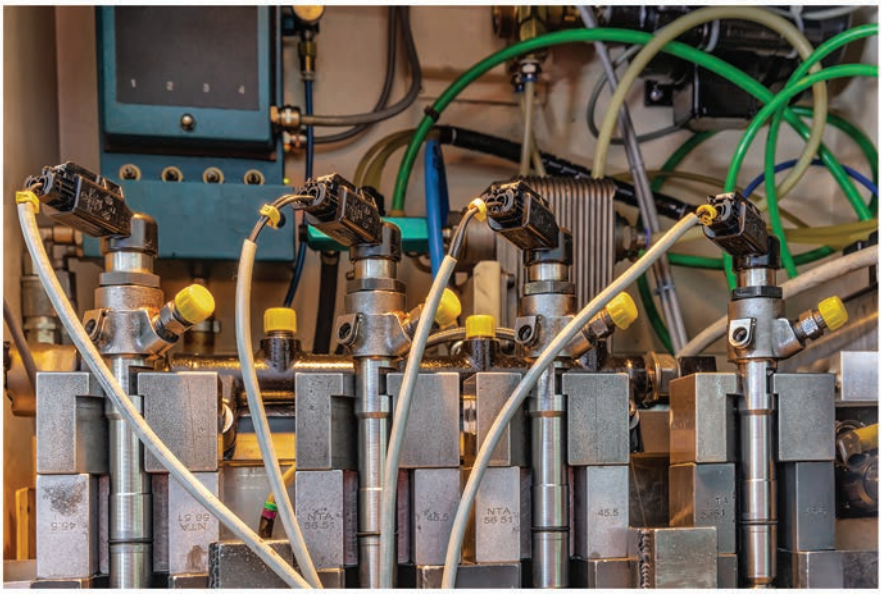


adziohiciek/Shutterstock.com.

Common Rail Fuel Injection

Diesel high-pressure fuel injection systems where fuel pressurization is done independently of engine speed. So no matter what the engine rpm or load is, the fuel is pressurized for injection to the optimal values required. A high-pressure pump driven by the engine pressurizes fuel to the level required for injection for any given engine load and speed condition. Since the quantity of fuel the high-pressure pump can deliver is more than the engine requirements, pressure and volume output of the pump is electronically controlled. The pump supplies fuel at injection pressure to a common fuel rail, which is connected to the electronically operated fuel injectors located in each cylinder. Since all the injectors are connected to the same fuel rail and supplied the same fuel pressure, the system is termed common rail. Injection timing is controlled by an electrical actuator (solenoid) on each injector while the fuel rate is controlled by the on/off times of the actuator and the fuel pressure in the fuel rail.

FIGURE C.17 High-pressure common rail diesel fuel injection.



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Companion Cylinder (Paired Cylinders)

Used in a waste-spark or distributorless ignition system each end of the secondary winding is connected to a cylinder exactly opposite the other in the firing order.

Companion Flange

Mounted on the differential pinion shaft. The companion flange is a splined flange that transmits power to the pinion gear as discussed in the differential section.

FIGURE C.18 Companion flange being measured for trueness.

Courtesy of John F. Kershaw Ed.D.

Compensating Port (Master Cylinder)

The compensating (vent, fill, inlet) port in front of each piston primary seal is open when the brakes are not applied. The compensating port provides a very small passage between the brake fluid reservoir and the high-pressure chamber of the master cylinder. The compensating port serves two important functions. First, it allows fluid to flow into the master cylinder when the hydraulic system is initially filled, and when closed off, pressure builds. Second, once the system is in service, it allows fluid to flow between the reservoirs and high-pressure chambers to compensate for changes in hydraulic system fluid volume. These changes are caused by variations in fluid temperature or wear of the brake linings.

Compound-Wound Motor
A motor that has both a series and shunt windings.

Comprehensive Component Monitor
See **CCM**.

Compressibility
The ability of a gasket to conform to the surface irregularities.

Compression Brake
A diesel engine does not use a throttle valve except for the regeneration process in a diesel particulate filter, so it cannot use engine compression to slow the vehicle unless the exhaust valves are held open. The high compression ratio of diesel engines results in very high cylinder compressed air pressures to produce the high power and torque at the engine flywheel. This high pressure is used to convert the power-producing engine into a high-pressure air compressor. When activated, the engine compression brake, commonly called a Jake Brake (Jacobs Company), changes the engine exhaust valve opening while consecutively turning off fuel injection into the cylinder to provide a retarding force at the drive wheels. At lower engine speeds, the braking performance is lower. At rated engine speed, the compression braking horsepower will be higher.

Compression Ignition Engine
See **Diesel Engine**.

Compression Ratio
Compression ratio is the ratio of the volume at BDC to the volume at TDC (clearance volume). A higher compression ratio means higher thermal efficiency or that portion of the heat supplied to the engine that is turned into work. As the compression ratio increases, the expansion ratio also increases; thus, thermal efficiency increases. The internal energy of the combustion gas is increased as heat is added to the gas. High heat generated by this greater compression will cause the fuel, upon injection, to atomize or break up into finely divided particles, allowing it to mix easily with the air.

In an ICE, compression ratio is the ratio of the total cylinder volume to the combustion chamber clearance volume. It is the volume at BDC divided by the volume at TDC and calculated in this formula:

$$r = \frac{V_d + V_c}{V_c} \qquad \textbf{(C.4)}$$

where

r is the final compression ratio
V_c is volume at TDC
V_d is volume at BDC

For more information on this, see **J604_201108** [9].

Compression Sensing Ignition

Waste-spark ignition systems that use the voltage required to fire the cylinders to see the cylinder position. It requires the next voltage to fire an electrical device under compression than it does when the spark plug is being fired on the exhaust stroke. The electronics within the coil and also the PCM can detect which of the two cylinders that are fired at the same time requires the upper voltage, which indicates the cylinder on the compression stroke. Engines equipped with compression sensing ignition systems, do not require the utilization of a camshaft position sensor to work out the cylinder number.

Condensation Point

Point at which a gas changes into a liquid.

Condenses

The action of making a substance more dense or compact by reducing the volume or extent of the concentrate. The process of applying pressure to a gas, which compresses the expanded gas molecules back into liquid form or cooling the gas so the molecule contracts back into a liquid.

Conditional Driving Automation

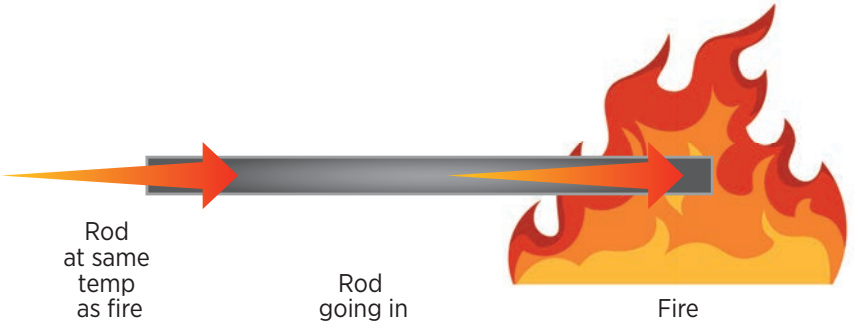
SAE Level 3 or Conditional Driving Automation uses various driver assistance systems to make decisions supported changing driving situations round the vehicle. People inside the vehicle donot necessarily supervise the technology, which implies they will engage in other activities. However, a professional driver must be present, alert, and ready to take hold of the vehicle at any time, especially within the case of an emergency because of system failure. You cannnot sleep while sitting in the driver's seat of a Level 3 conditional autonomous vehicle. Audi developed a Level 3 conditional assistance technology for its 2019 A8 sedan, but it never received regulatory approval for the system in Germany and has since been put on hold. Honda became the primary automaker to sell an approved Level 3 conditional assistance system to consumers. Other vehicles equipped with Level 3 driving automation but are looking ahead to regulatory approval include the redesigned 2021 Mercedes-Benz S-Class and therefore the

all-new 2022 Mercedes-Benz EQS electric vehicle. The Mercedes technology is termed Drive Pilot. For more information on this, see **J3016_201401** [12].

Conduction

Transfer of heat from molecule to molecule through solids and fluids in close contact at rest. It is heat transfer from one solid to another. No displacement of the heated body takes place during conduction. Heat travels through the rod via conduction from one molecule to another until the end you are holding approaches the temperature of the end in the fire. The action of a solid to conduct heat is called conductivity [13].

FIGURE C.19 Conduction.



Courtesy of John F. Kershaw Ed.D.

Conductive Material

Conductive materials like a copper wire with an insulator readily permit the flow of electrons and connect the elements of the circuit: power source, load, controls, and ground.

Conductor

A material that gives a path for electricity to flow. Conductors are materials with fewer than four electrons in the outer orbit of their atom. Copper is a wonderful conductor because there is just one electron in its outer orbit. This orbit is far enough from the nucleus of the copper atom that the pull or force holding the outermost electron in orbit is comparatively weak. Copper is the conductor most utilized in vehicles because the cost of copper is affordable compared to the relative cost of other conductors with similar properties.

Cone Clutch

A connection or clutch mechanism used in limited slip differentials that use the principle of a tapered fit to make a solid connection.

Connected Vehicle

A vehicle equipped with different types of telematics to incorporate Internet access, and Wi-Fi, which also stands for wireless local area network (WLAN), to connect the vehicle to the environment outside of the vehicle. Telematics is an interdisciplinary field that encompasses telecommunications, vehicular technologies, road transportation, road safety, engineering (sensors, instrumentation, wireless communications, etc.), and applied science (multimedia, Internet, etc.).

A connected vehicle can share Internet access with other devices both inside as well as outside the vehicle. These vehicles also are equipped with special technologies that tap into the net or WLAN and supply additional benefits to the driving force. For safety-critical applications, it is anticipated that at some point all vehicles are going to be connected using dedicated short-range communication (DSRC) radios, operating within the FCC-granted 5.9 GHz band.

Connecting Rod

Steel rod that connects the piston to the crankshaft and transmits piston up and down motion to rotary motion in the reciprocating piston engine.

Connector

Plastic or rubber device with metal terminals or connection points for two or more wires. Many connectors have locking clips that hold the connectors together, ensuring a good electrical connection.

Contamination

The presence of a minor and undesirable constituent during a material, physique, natural environment, workplace, etc.

Continuity Tester

A piece of equipment used to check a circuit for power or continuity. It uses a probe at one end for touching conductors and a clip for grounding or connecting to the other end of a wire segment. It can also be referred to as a test light.

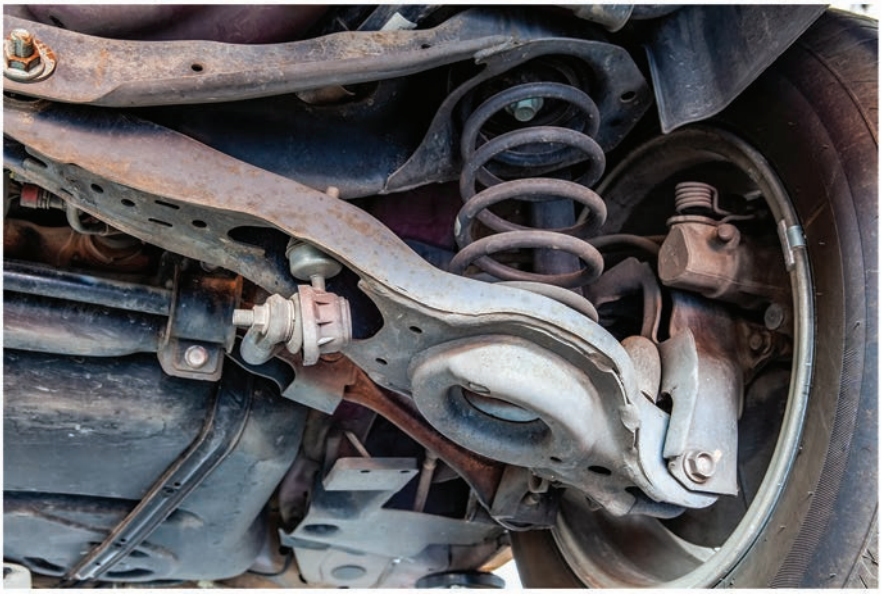
Continuous Monitor

An OBD II or HD-OBD software monitor that continuously monitors all emission-related controlled systems. There are two types: Misfire type A and Misfire group B, which exceeds EPA federal test procedure (FTP) or cause vehicle to fail inspection and maintenance tailpipe emissions test. The MIL will turn on and a DTC ID stored. For more information on this, see **J1930DA_202105** [6].

Control Arm

A metal strut on the suspension that is found at the highest and bottom of the wheel spindle. The upper and lower control arms allow the front wheels to change direction.

FIGURE C.20 Automotive front suspension control arm.



Greg Brave/Shutterstock.com.

Control Device

Perform many alternative jobs, like turning lights on and off, dimming lights, and controlling the speed of motors. Control devices work by completely stopping current flow or by varying the speed of flow. Controls accustomed stop current flow include switches, relays, and transistors. Controls are used to vary the speed include rheostats, transistors, and other solid-state devices. Control devices may be on the positive or negative side of the circuit.

Control Module

A computer that controls the operation of a system, supported sensor inputs. There are many types: ECM (engine control module), PCM (powertrain control module), BCM (bdy control module), EBCM (electronic bake control module), VCM (vehicle control module), etc.

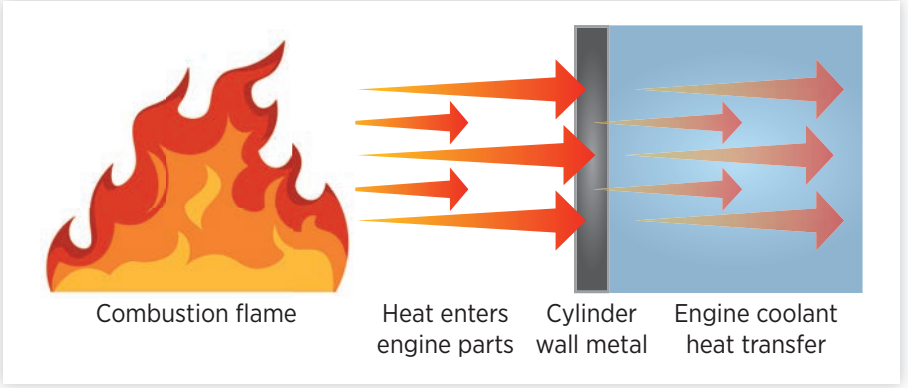
Controller Area Network (CAN)

See **CAN**.

Convection

Heat transfer by the molecular motion in the heated substance itself and only takes place in liquids and gases. It is heat transfer by circulation though fluids like coolant (or air in air-cooled ICEs) in motion between the fluid and a solid surface in motion like the piston. It is heat that is transferred to the cylinder wall from the heat of combustion where it goes into the coolant and is carried away at the radiator. This form of heat transfer also includes conduction as well as fluid motion. There are two forms of convection heat transfer: natural convection is when the fluid motion is caused by different densities in a gravitational field and forced convection is the method of heat transfer between a fluid and a solid surface in relative motion, when the motion is caused by forces other than gravity. Most of the heat in an ICE flows between the coolant (working fluid) and the engine parts that is transferred via forced convection [13].

FIGURE C.21 Convection.



Courtesy of John F. Kershaw Ed.D.

Conventional Current Theory

A theory that says that electrons flow through a circuit from positive (+) to negative (–). Electrons leaving the positive terminal of the battery flow through the circui, and then reenter the battery through the negative terminal.

Coolant

Liquid mixture of antifreeze and water or other chemicals that do not readily freeze in the engine cooling system. Coolant transfers heat from the engine to the radiator, protects the engine and the cooling system from rust and corrosion, and prevents freezing in cold climates. All coolants except the waterless racing type are a mixture of antifreeze and water. Water is best at absorbing more heat per gallon than any other liquid coolant, but it will cause corrosion of the metal in the engine.

Coolant Reservoir Tank

A coolant tank used on older vehicle in the fifties, sixties, and early seventies had a hose attached to the filler neck of the radiator, below the cap, and that hose was vented to the atmosphere by dripping on the ground just below the radiator. When coolant expands from engine temperatures rising, it typically creates steam, and the vented cap allows that steam to vent in order to protect your cooling system. However, as the steam expands, so does the pressure, and often times the vented cap also expels coolant through the hose to the ground. This system was good for engine cooling, but not good for the environment. In the late seventies, the addition of environmental control brought about adding a reservoir to that vent tube allowed the steam to be expelled, but also allowed for the coolant that came with it to be captured in the reservoir tank instead of going to the ground. Capturing that expelled coolant meant that it could then be recovered and reintroduced back into the radiator, hence the term recovery or reservoir tank. Returning coolant back to the radiator is possible because the combination of the reduced steam pressure allows the atmospheric pressure to push coolant from the tank back into the radiator through the vented radiator cap. This adds more coolant to your system and helps to keep the engine cooler. In contrast to the expansion tank, the overflow/recovery/reservoir tank featured a vented cap and was not required to be above the cylinder heads [13].

Cooling Fan

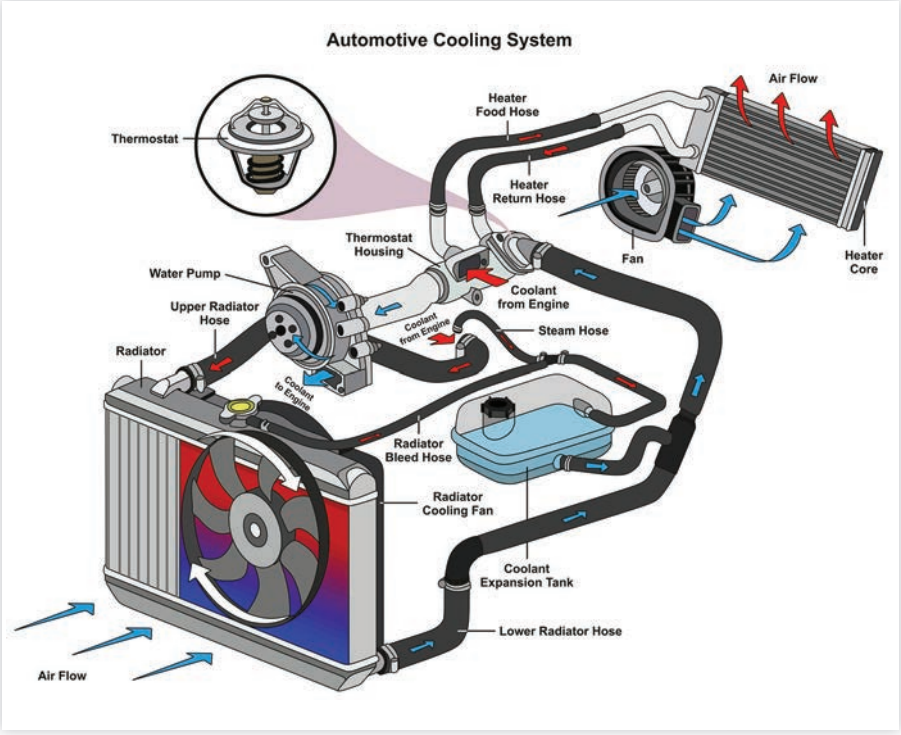
Engine cooling fans are used to draw air through the radiator while the vehicle is at idle or moving at a slow speed. When the vehicle is moving at sufficient speed, air is being forced through the radiator at greater CFM (cubic feet per minute) than the cooling fan is capable of, making the fan somewhat excessive. There are three individual types of engine cooling fans: flex, viscous clutch, and electric [13].

Cooling System

In an ICE, the coolant circulates through the engine to absorb excess heat through the convection process. The major components of a cooling system:

water pump, thermostat, radiator, coolant recovery or expansion tank, radiator fan, hoses, and heater core. When designing an engine cooling system, the selection of these components is very important for engine life and performance. The cooling system can be closed or open. In a closed system the engine coolant has no contact with the outside air. In an open system the coolant has contact with the outside atmosphere. All current systems are a combination of the two, where the coolant, while circulating through the engine, has no contact with the outside air, but at the radiator pressure cap, there is contact through the vacuum or air valve, which allows the entrance of atmospheric pressure [13].

FIGURE C.22 ICE cooling system used to remove the heat of combustion.



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COP (Coil-On-Plug) Ignition System

An ignition system that does not use a distributor or a central ignition coil. Each spark plug has its own ignition coil. This system is also called coil-by-plug, coil-near-plug, or coil-over-plug ignition. For more information on this, see **J139_202002** [14].

Core-Out Plug
Seals the holes in the engine block used during the manufacturing process. This component is also referred to as freeze plugs.

Corrosion
Wear by chemical or electrochemical reaction.

Corrosion Inhibitors
Prevents the formation of rust and protect metal parts.

Corrosion Test
Various metals and wheel cylinder cups are submerged in the brake fluid for a specified time.

Corrosive
A material that burns the skin or dissolves metal and other materials.

Cotter Pin
A soft metal pin that is used to secure components in place. Sometimes referred to as cotter keys. A metal loop used to retain castle nuts by installation through a hole. Size is measured by the diameter and length of the pin (e.g., 1/8 in. × 1 1/2 in.).

Co-solvent
Another substance (usually another alcohol) that is soluble in both methanol and gasoline and is used to reduce the tendency of the liquids to separate.

CPI (Continuous Port Fuel Injection)
A form of multipoint fuel injection, or MFI, that uses a central injector that feeds a poppet valve at each cylinder for fuel delivery. The central injector is controlled by the engine management computer.

CPU (Central Processing Unit)
The microprocessor is the central processing unit (CPU) of a computer that does the required mathematical operations and logic decisions that does the processing function. It can be the heart of a computer.

Cracking

Cracking is the crude oil refining process where hydrocarbons with higher boiling points could be broken down (cracked) into lower boiling hydrocarbons by treating them to very high temperatures. This is called thermal cracking. Currently catalytic cracking is used where a catalyst is used to speed up the process without undergoing a permanent chemical change itself. It produces a higher quality gasoline than cracking. For more information on this, see **J312_201902** [15].

Crankcase

The bottom portion of an ICE cylinder block that houses the crankshaft and connecting rods.

Crankcase Ventilation

Blowby gases enter the crankcase from the combustion chambers. Because the combustion chamber gases are under very high pressure, they increase the pressure within the crankcase. If the crankcase is not vented, the pressure will force oil out of the engine. To prevent this, the crankcase is ventilated using the PCV (positive crankcase ventilator) valve on a gasoline fuel engine or a CDR (crankcase depression regulator) valve on a diesel engine.

Cranking Circuit

Electrical components and connections required to crank the engine to start.

Cranking Motor

See **Starter Motor**.

Crankshaft

The rotating member of an ICE. It converts the reciprocating (translating) motion of the engine piston into rotating motion to drive the ICE. Connecting rods are fastened to the crankshaft that connect with the pistons. The crankshafts is additionally either forged or nodular cast iron. Forged crankshafts are stronger than the cast crankshaft and have an oversized separation line. The wide separation line is the result of a grinding process to remove the metal that was extruded from the forging die during the forging process. Most forged crankshafts are made from SAE 4340 or a similar type of steel. The crankshaft is made from a hot steel billet through the use of a series of forging dies. Each die changes slightly the shape of the billet. The crankshaft blank is formed with the last die. The blanks are then machined. Forging makes a dense crankshaft with the metal grain structure running parallel to the principal direction of stress.

Crankshaft configuration may be either cross-plane or flat plane. The flat-plane crankshaft incorporates a 180° angle between crank throws. It is basically two four-cylinder engines connected at the crank. They are utilized in V-engines with eight cylinders. Cadillac first introduced a V8 flat-plane crank engine in 1923. Currently, GM uses a flat-plane crankshaft within the 5.6L V8 engine employed in the mid-engine Chevrolet Corvette.

FIGURE C.23 ICE crankshaft with connecting rods and pistons.

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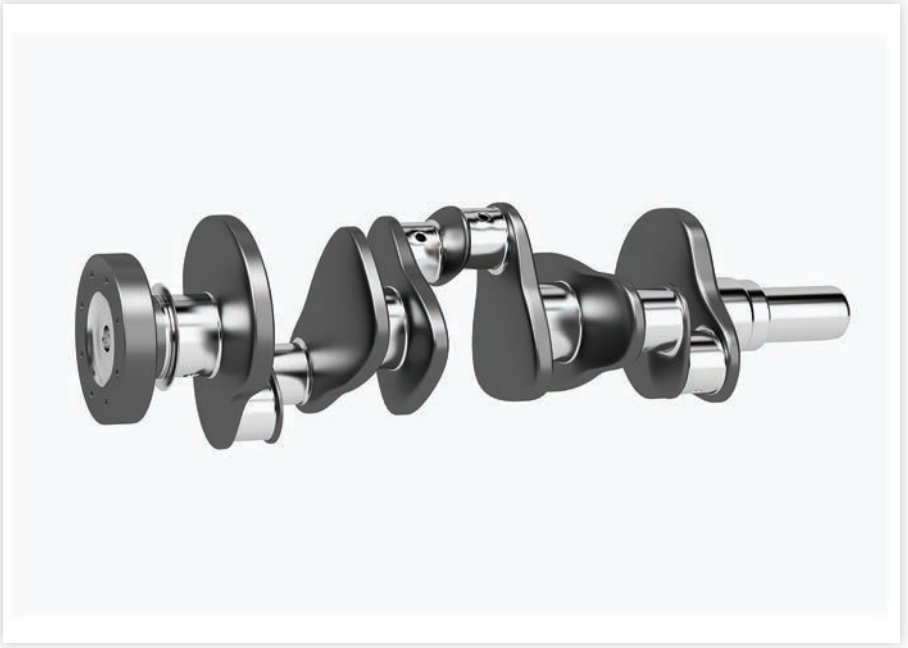
Crank Web

The part of the crankshaft between the crankpin and the shaft or between adjacent crankpins, which is also called the crank arm or throw.

FIGURE C.24 Crank web.



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Crate Engine

A complete replacement ICE that includes all components except accessories. It is a fully assembled, ready-to-run engine delivered in a crate. Most crate engines will include the block, rotating assembly, and cylinder heads.

Cross Camber

Difference in vehicle camber between both sides of a car or truck. Vehicle will pull to the side with the most positive camber. If the left front camber is 1° positive and the right front camber is 1° positive, the effects of pull cancel each other. If the front left camber is 1° negative and the right front 1° positive, the vehicle will pull to the right side.

Cross Caster

Difference in caster between both sides of a vehicle. Caster can cause a vehicle pull, where the vehicle will pull to the side with the most negative caster. When the front left wheel has 2° positive caster and the right front wheel has 2° negative caster, the vehicle pulls to the right. Caster is not a tire wearing angle, so caster is often set 0.5° more negative (less positive) on the left side to create a small pull to the left if a vehicle is driven on highly sloped roads. A difference in caster

between one side and the other of more than half a degree may cause a pull or lead toward the side with the least positive caster.

Cross Weight

Weight of the right-rear and left-front and right-front and left-rear wheels. It is used mostly in circle track racing cars. Drag racers are concerned with the front and rear weights, total weight, and the right-rear-wheel weight compared to the left-rear wheel.

Crossfire

Ignition voltage jumping from the distributor rotor on a distributor-type ignition to the wrong spark plug electrode inside the distributor cap or ignition voltage jumping from one spark plug cable to another cable due to defective insulation.

Crossflow Cylinder Head

Cylinder head design with the inlet manifold on one side and the exhaust manifold on the other side of the head so that the inlet and exhaust valves are arranged on opposite sides of the combustion chamber, giving a wider engine but better gas flow.

Cruise Control

A vehicle system that may maintain a preset vehicle speed even on gentle inclines. Some vehicles are programmed to downshift the transmission to maintain vehicle speed on downhill gradients if the speed increases above 5 mph (7 km/h) faster than the preset speed. The typical control system will be set provided that the vehicle speed is 25 mph (40 km/h) or more. Older systems use a throttle actuator to manage the throttle opening, control switches for driver control of controller functions, and electrical brake and clutch (if equipped) pedal-release switches. The actuator uses a stepper motor to maneuver the throttle linkage supported commands from the control module, which is commonly inside the control assembly.

Cruise Control Resume/Increase Switch

The resume/increase switch is used to extend the determined vehicle speed when adaptive control is active. The selected vehicle speed can be increased from the resume/increase switch depending on how long the switch is pressed. The presence of a slower moving vehicle in the path of the adaptive control vehicle will limit the extent to which the determined vehicle speed are often achieved. If there is no preceding vehicle ahead limiting the adaptive control

vehicle acceleration, then the vehicle speed that is achieved is the new determined vehicle speed. This determined vehicle speed is displayed by the motive force information center. Acceleration is terminated when the resume/increase switch is released. Momentarily pressing and releasing the resume/increase switch will allow the chosen vehicle to accelerate at 1 mph increments for every time the resume/increase switch is momentarily pressed.

Cruise Control Set/Decrease Switch

The resume/increase switch is used to extend the determined vehicle speed when adaptive control is active. The speed setting can be increased from the resume/increase switch depending on how long the switch is pressed. The presence of a slower moving vehicle in the path of the adaptive controller vehicle will limit the extent to which the determined vehicle speed is achieved. If there is no preceding vehicle before limiting the adaptive control vehicle acceleration, then the vehicle speed that is achieved is the new determined vehicle speed. The present determined vehicle speed is displayed by the driving force information center. Acceleration is terminated when the resume/increase switch is released. Momentarily pressing and releasing the resume/increase switch will allow the chosen vehicle to accelerate at 1 mph increments for every time the resume/increase switch is momentarily pressed.

Cruise Control Switch

A common control switch that is shared between the adaptive cruise control system and the standard cruise control system. The adaptive cruise control system will not operate if one of the cruise switches fails in the circuit. The cruise control switch has the following function switches:

- ON/OFF switch
- Set/decrease switch
- Resume/increase switch

The cruise control system is engaged when the adaptive cruise control ON/OFF switch is turned ON and the set/decrease switch is momentarily pressed and released. When the set/decrease switch is pressed, the selected vehicle speed is set to the current vehicle speed by the engine management computer. The vehicle speed must be near or greater than 25 mph. The selected vehicle speed is displayed by the driver information center. While in the engaged state, the selected vehicle speed and distance can be adjusted. Pressing and holding the set/decrease switch when the adaptive cruise control system is engaged will decrease the selected vehicle speed without deactivating the adaptive cruise control. Momentarily pressing and releasing the set/decrease switch, when the

adaptive cruise control is engaged, decreases the selected vehicle speed by 1 mph for each time that the set/decrease switch is pressed.

Curb Weight

The inertia weight (also known as unladen weight or wet weight), which is the total weight of a vehicle with standard equipment, driver, and full tank of fuel, without passengers or cargo.

Current

A movement of electrons in a circuit is the flow of electricity. Another name for the flow of electricity is current. Current flow is measured in amperes (A). This unit expresses the percentage electrons move through a circuit in one second. A current flow of 6.28 pico (billion/billion) (6.28 × 1018) electrons per second is adequate to one ampere.

Current Limiting Hump

Portion of an ICE ignition waveform that indicates the exact point in the dwell when a current limiting device is switched on used with transistor switched ignition coils.

Customary Measuring System

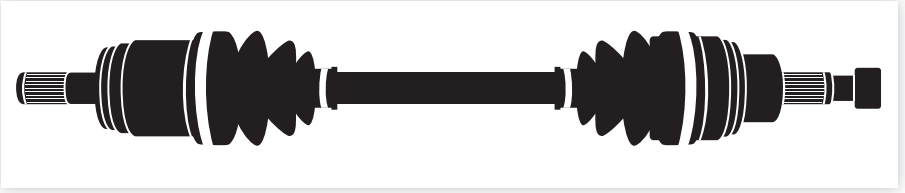
A measuring system established about 1100 AD in then England, now the United Kingdom during the reign of King Henry I. It established the standard measurements such as foot, yard, mile, and the temperature scale using Fahrenheit. Also known as the English system of measurement or FPS, for foot pound, second.

CV (Constant Velocity) Joint

A driveline connection between a driven and drive axle that allows the two shafts to show a near-constant velocity. These joints permit angularity, in and out, and up and down movement. They also permit for unequal axle length, the angles at the CV joints are different, which also leads to the pulling concern and possibility of creating vibration. To combat this condition, many OEMs use an intermediate shaft. The intermediate shaft may be a short section of shaft that typically contains a bearing pressed onto it (similar to a carrier bearing). The intermediate shaft makes it possible that both half-shafts are the identical

length from left to right. In some cases the manufacturer uses an extended half-shaft on one side, and a rubber dynamic damper could also be fitted to assist in absorbing vibrations, although this does not reduce torque steer issues. CV joints afford more torque transfer than U-joints because of their larger bearing surfaces and equal angles at both the input and output of the joint. CV joints can operate at greater angles than U-joints. Rzeppa fixed CV joint has an inner race, six steel ball bearings, a sway cage, and an outer race. A sliding spline or a plunge-type joint is used because the inner half-shaft joint accommodates changes in shaft length when traveling over differing kinds of terrain. Plunge-type joints allow smooth power flow while allowing the joint to slip in and out, effectively increasing and decreasing the length of the axle shaft during up and down suspension travel. One kind of plunge CV joint is the tulip tripod joint. The tulip/tripod joint uses three equally spaced fingers shaped like a star. On the ends of the star are three round bearing surfaces that sit on needle bearings on each finger. The round bearing surfaces advance the fingers by needle bearings. The outer race has three straight grooves that run from side to side. This configuration allows in- and-out movement of the shaft while allowing flexing. The fixed-type joint does not slide to permit for shaft lengthening or shortening; it simply allows for angle changes because of the suspension moves. The fixed joint is usually used on the outboard side of the half-shaft.

FIGURE C.25 Constant velocity drive axle joint or connection.



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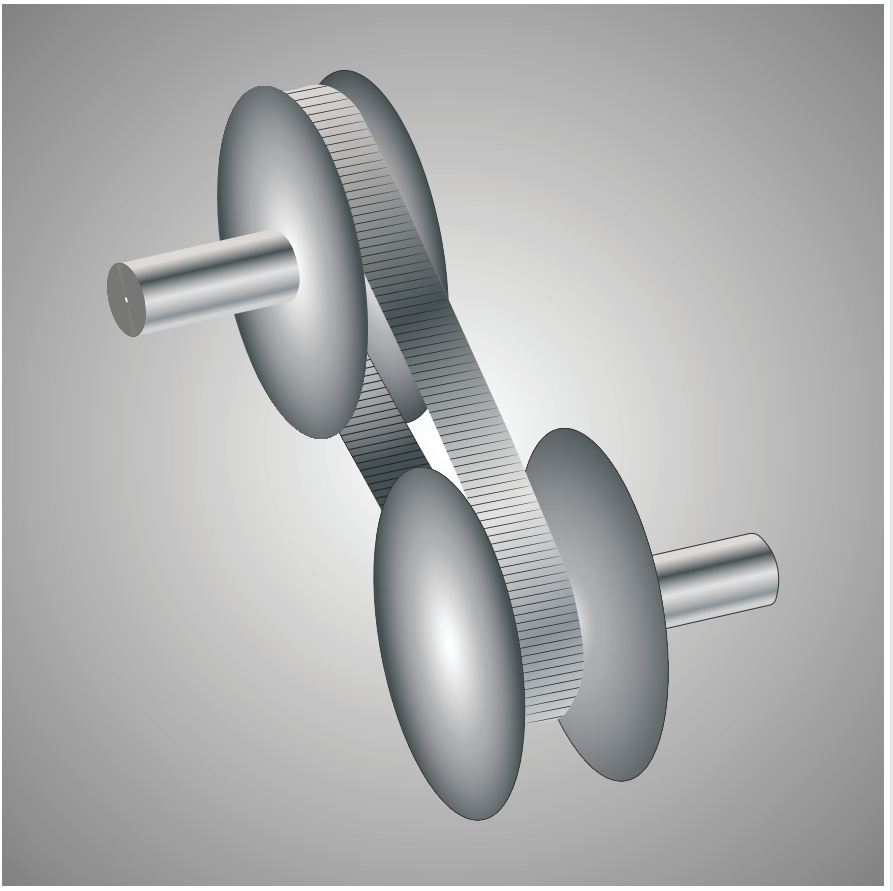
CVT (Continuously Variable Transmission)

An automatic transmission that can change through a series gear ratios continuously using two moving pulleys that move in and out changing the gear ratio.

FIGURE C.26 CVT vector.



fariz guliyev/Shutterstock.com.

Cycle

One complete positive curve and negative curve of a sine wave. The term cycle comes from the word circle that begins and ends at the same point, as does a cycle.

Cylinder Block (CASE)

Central casting of an ICE that houses the crankshaft, connecting rods, pistons, and bearings. In the case of an in-block camshaft, the camshaft is also housed with the cylinder block.

Cylinder Deck

The top of the cylinder case or block that the cylinder head rests on. The first inspection you do on the cylinder deck is with your eyes and hands. You look for excessive scoring, corrosion, erosion, threading pulling up around bolt holes, cracks, dents, and scratches. Run your fingernail across any irregularities you find. If a scratch can catch your fingernail, then it probably is deep enough to be corrected.

Cylinder Head

The cylinder head in an ICE sits on top of the cylinder block above the cylinders and generally forms the combustion chamber. It uses a head gasket to seal the passage between the head and the cylinder block. It also provides passages to feed air and fuel into the cylinder, which allows the exhaust to escape, and contains the valve train and valves, spark plugs, and fuel injectors.

Cylinder Hone

A tool that uses an abrasive tool driven by a drill to smooth out and bring to exact measurement in the ICE cylinder bores.

Cylinder Liner

Diesel engine cylinders use two types of cylinder: dry and wet liners. The dry liner is a thin wall sleeve, while a wet liner is installed in the coolant jacket surrounded by engine coolant. Dry liners are installed into the block bore usually with a marginally loose fit and retained by the cylinder head. The dry sleeve does not transfer heat as well as a wet liner, but they are easily replaced and do not present coolant-sealing problems. Air-cooled engines used finned liners that are cooled using the fins on the liner, like in motorcycle and VW/Porsche boxer engines.

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