

Automotive Design Technologies



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Chapter 1

Body-on-Frame and Chassis

Body-on-frame



Car frames.



2007 Toyota Tundra chassis.

Body-on-frame is an automobile construction technology. Mounting a separate body to a rigid frame that supports the drivetrain was the original method of building automobiles, and its use continues to this day. The original frames were made of wood (commonly ash), but steel ladder frames became common in the 1930s.

In the USA the frequent changes in automobile design made it necessary to use a ladder frame rather than monocoque to make it possible to change the design without having to change the chassis, allowing frequent changes and improvements to the car's bodywork and interior (where they were most noticeable to customers) while leaving the chassis and driveline unchanged, and thus keeping cost down and design time short. It was also easy to use the same chassis and driveline for several very different cars. Especially in the days before computer-aided design, this was a big advantage.

Most small passenger vehicles switched to monocoque construction in the 1960s, but the trend had started in the 1930s with cars like the Opel Olympia, and Citroen Traction Avant leaving just trucks, some bus manufacturers and large cars using conventional frames. The switch continued for several decades - even small SUVs typically use this construction method today. Body-on-frame remains the preferred construction method for heavy-duty commercial vehicles, especially those intended to carry or pull heavy loads, such as trucks.

A halfway house to full monocoque construction was the 'semi-monocoque' used by the Volkswagen Beetle and Citroen 2CV. These used a lightweight separate chassis made from pressed sheet steel panels forming a 'platform chassis', to give the benefits of a traditional chassis, but with lower weight and greater stiffness. Both of these chassis were used for several different models. Volkswagen made use of the bodyshell for structural strength as well as the chassis - hence 'semi-monocoque'.

The Lincoln Town Car dominates the American limousine market because it is the last American luxury car made with body-on-frame, and therefore easily lengthened for livery work.

Advantages and disadvantages compared to unibody

Advantages

- Easier to design, build and modify (less of an issue now that Computer-Assisted Design (CAD) is commonplace, but still an advantage for coach-built vehicles).
- More suited for heavy duty usage such as towing and off-roading; can be more durable.
- Easier to repair after accidents. Grand-Am allows tubular spaceframe cars to replace their monocoque counterparts, as the cars can easily be repaired with new clips.
- In an environment where roads are salted, it will not rust through as quickly.
- Could allow a manufacturer to easily sub-contract portions of work, e.g. as when Austin subcontracted the aluminum body work of the Austin A40 Sports to Jensen Motors.



Austin A40 Sports, ca 1951. During production, A40 Sports aluminum bodies were built by Jensen (of West Bromwich) and transported to Austin's Longbridge plant for final assembly.

Disadvantages

- Heavier than unibody - lower performance and/or higher fuel consumption.
- Less resistant to torsional flexing (flexing of the whole car in corners) - compromising handling and road grip.
- No crumple zone - higher rate of death and serious injury. Some cars have adopted a "front clip" and "rear clip" format similar to what is used in NASCAR race cars where the car is split into three sections, and the clips absorb the impact, allowing the "clip" to be replaced when repairing the car.

Chassis



Motor vehicle chassis with its suspension, exhaust system, and steering box

A **chassis** (plural: "chassis") consists of an internal framework that supports a man-made object. It is analogous to an animal's skeleton. An example of a chassis is the under part of a motor vehicle, consisting of the frame (on which the body is mounted) with the wheels and machinery.

Examples of use

Vehicles



1950s Jeep FC cowl and chassis for others to convert into finished vehicles

In the case of vehicles, the term chassis means the frame plus the "running gear" like engine, transmission, driveshaft, differential, and suspension. A body (sometimes referred to as "coachwork"), which is usually not necessary for integrity of the structure, is built on the chassis to complete the vehicle. For commercial vehicles chassis consists of an assembly of all the essential parts of a truck (without the body) to be ready for operation on the road. The design of a pleasure car chassis will be different than one for commercial vehicles because of the heavier loads and constant work use. Commercial vehicle manufacturers sell "chassis only", "cowl and chassis", as well as "chassis cab" versions that can be outfitted with specialized bodies. These include motor homes, fire engines, ambulances, box trucks, etc.

In particular applications, such as school busses, a government agency like National Highway Traffic Safety Administration (NHTSA) in the U.S. defines the design standards of chassis and body conversions.

An armoured fighting vehicle's chassis comprises the bottom part of the AFV that includes the tracks, engine, driver's seat, and crew compartment. This describes the lower hull, although common usage of might include the upper hull to mean the AFV without the turret. A chassis serves as basis for platforms on tanks, armored personnel carriers, combat engineering vehicles, etc.

Electronics



PowerMac G4 chassis opened to expose computer components

A chassis in a television, radio, or other electronic device consists of the metal frame on which the circuit boards and other electronics are mounted.

In the absence of a metal frame the chassis refers to the circuit boards and components themselves, not the physical structure.

In computers, the chassis refers to the rigid framework onto which the motherboard, memory, disk drives, and other equipment are mounted. It also supports the shell-like *case*: the housing that protects all of the vital internal equipment from dust, moisture, and

tampering. The term "case modding" refers to the artistic styling of otherwise rather functional and plain computer encasings.

Chapter 2

Fender (Vehicle) and Fender Skirts

Fender (vehicle)



1938 Chrysler, fenders highlighted in red.

Fender is the US English term for the part of an automobile, motorcycle or other vehicle body that frames a wheel well (the fender underside). Its primary purpose is to prevent sand, mud, rocks, liquids, and other road spray from being thrown into the air by the rotating tire. Fenders are typically rigid and can be damaged by contact with the road surface. Instead flexible mud flaps are used close to the ground where contact may be possible.

Sticky materials such as mud may adhere to the smooth outer tire surface, while smooth loose objects such as stones can become temporarily embedded in the tread grooves as the tire rolls over the ground. These materials can be ejected from the surface of the tire

at high velocity as the tire imparts kinetic energy to the attached objects. For a vehicle moving forward, the top of the tire is rotating upward and forward, and can throw objects into the air at other vehicles or pedestrians in front of the vehicle.

In British English, the fender is called the **wing** (this usually only refers to the panels over the front wheel arches, in modern cars, since the rear 'fenders' are more an integral part of the car's body shape). The equivalent component of a bicycle or motorcycle, or the "cycle wing" style of wing fitted to vintage cars which is not integral with the bodywork, is called a **mudguard** in Britain, as it *guards* other road users - and in the case of a bicycle or motorcycle, the rider as well - from *mud*, and spray, thrown up by the wheels.

In the United States, a minor car accident is often called a "fender bender".

Trucks and automobiles



Lotus 7 Series 1, 1957 to 1960

In current US auto industry nomenclature, usually only the panels over the front wheels are called fenders. The auto industry changed from rear fenders bolted onto a quarter panel to an enlarged welded on quarter panel that fulfilled both functions. There then was only one piece where there had previously been two, and name of the larger welded piece, the quarter panel, survived the consolidation.

The bolted panel which covers the wheel on dual rear wheel pickup trucks is called a fender. A pickup truck with a separate bed but without bolt on fenders has a bedside, which performs the function of a fender. When the side of the bed is welded to the cab, as with the Cadillac Escalade and Chevrolet Avalanche, it is called a quarter panel.

While the standard of bolted versus welded normally applies, there are some exceptions. Although attached by welding, the panels over the front wheels on cars such as the early 60s Lincoln Continental, the Corvair, and the early 60s Chrysler Imperial are called fenders. Similarly, even though bolted on, the panels covering the rear wheels on the Saturn S series are called quarter panels.

A common accessory on pick up trucks are fender flares, which blocks mud and stones and/or covers rust. They are sometimes used by manufacturers on models that have wider tires than basic models. Using this method, the manufacturer can provide the needed tire coverage without having to stamp a different metal fender, bed side, or quarter panel for what may be a relatively low production model.

The terms have evolved to be determined mostly based on location. Fenders are at the front. Quarter panels are at the rear, with an exception made for dual rear wheel trucks, where the panel at the rear is called a fender.

For vehicles with a narrow car body that exposes the tire, the fender is an exposed curve over the top of the tire. For wide body vehicles that cover the tire, the fender forms the **wheel well** surrounding the tire, and is not directly visible from above the car body.

Wheel wells tend to be much larger than the diameter of the tire, because they do not move with the tire suspension and consequently must be large enough to allow the full range of tire motion on the suspension without touching the interior of the wheel well. More elaborate designs include fender skirts for enclosing the outside edge of the wheel well, and stylized pontoon fenders for exposed fenders.

Certain types of cars with narrow bodies, such as the Lotus Seven, Allard, and Caterham Seven, use what are called **cycle fenders** in the US or **cycle wings** in Britain, for their resemblance to those used on bicycles. They are attached to the wheel suspension and remain at a fixed distance from the tire regardless of wheel motion, and can therefore be much closer to the tire than fixed wheel wells. This was popular on early Classic Trials cars because the fenders were lightweight and allowed for a thin streamlined body. They persist on cars wanting a "vintage" look.

Bicycles and motorcycles



A bicycle fender

There are generic fenders for bicycles that can be fitted to most bicycle frames. These catch and redirect road spray thrown up by the tires, allowing the rider to remain relatively clean. They are relatively uncommon on bicycles in the more car dependent English-speaking countries, as bikes in these countries tend to be sports-oriented, with minimal clearance between tires and frame tubes for fenders, or are only ridden in clement conditions, although there are a few fenders that are designed to be attached to the seat post. However, European utility bicycles, traditional roadsters used in developing countries, serious touring bicycles, and beach cruisers are nearly always fitted with fenders, universally known in British English as mudguards. They are also fitted to motorcycles.

In the UK it is a legal requirement that a motorcycle should be fitted with mudguards. While motorcycles are invariably fitted with mudguards, only touring cycles generally have fully functional mudguards. Some machines can be seen with a stub of a mudguard only a few inches long, which satisfies the legal requirements but does not actually provide any protection from thrown mud and spray.

Sporty-styled or racing motorcycles sometimes come with, or have added as an aftermarket accessory, a "hugger" rear fender, attached to the rear swingarm and very

close to the tire, rather than attached to the rear subframe and away from the tire. Conversely, the practice of removing the front fender and reducing the size of the rear fender produced the bobber customization style of the 1950s onwards.

Fender skirts



Rear wheel partially covered by a detachable fender skirt on 1969 Buick Electra 225



1952 Nash Rambler non-detachable front and rear fender skirts



1986 Citroën CX



Los Angeles Bus

Fender skirts, known in Australia and the United Kingdom as **spats**, are pieces of bodywork on the fender that cover the upper portions of the rear tires of an automobile.

Functions

Fender skirts are implemented for both aesthetic and aerodynamic reasons. Rather than air flowing into and being trapped in the rear wheel well, it flows smoothly over the bodywork. They are typically detachable to allow for tire changes. Automakers have also experimented with front wheel fender skirts, as on the 1950-1954 Nash Rambler, but with success limited by the fact that the front wheels must pivot for steering, extending out from the side of the vehicle slightly.

History

First described as "pants", they were used for the streamlining effect by Frank Lockhart on a 1928 Stutz land speed record attempt car. Factory production of fender skirts began with the 1932 Graham-Paige. Aesthetically streamlined designs were copied to mass-produced models. The innovations introduced by Amos Northup, such as the V'd radiators, fender skirts, and sloping beaver-tails, became common after 1933. However, by the 1970s, fender skirts began to disappear from mass market automobiles. Fender skirts remained for some time longer on a few cars, particularly large American luxury cars.

Fender skirts were often paired with whitewall tires. The extent of the skirt also varied, before the 1950s it was common for all but the very bottom of the rear tire to be covered, while by the 1960s fender skirts only covered some of the top of the tire, and were largely absent on cars other than top line models. For example up until 1976, the Chevrolet Caprice, Oldsmobile 98, Buick Electra, Pontiac Bonneville and the Cadillac Fleetwood, DeVille and Calis models used fender skirts. Starting in 1977 only the Pontiac Bonneville retained the use of fender skirts on General Motors downsized cars. In 1980 the Oldsmobile returned the fender skirts to the 98 model. By 1985 fender skirts would disappear from all standard General Motors cars. In 1993 Cadillac again incorporated fender skirts into the design of the re-styled Fleetwood, this design would last until 1996. The General Motors EV1 had fender skirts later.

In European automobile design, Citroën notably used fender skirts on nearly all models produced between 1950 and 1990, most prominently in the DS, 2CV, Ami, GS, SM, BX and CX.

As of 2009, the last car produced with fender skirts was the 1999-2006 Honda Insight, although they are available for some new cars as aftermarket accessories.

Some cities, such as Los Angeles, have fender skirts on municipal buses for safety purposes, as they can prevent items in the road from slipping under the tires.

Chapter 3

Vehicle Canopy



Lifting canopy on a Sterling Nova.

A **vehicle canopy** is a rarely used type of door for cars. It has no official name so it is also known as an **articulated canopy**, **bubble canopy**, **cockpit canopy**, **canopy door**, or simply a **canopy**. A canopy is a type of door which sits on top of a car and lifts up in some way, to provide access for passengers. It is similar to an aircraft canopy. There are no set rules to canopies, so they can be hinged at the front, side, or back, although hinging at the front is most common. Canopy doors are rarely used on production cars, and are sometimes used on concept cars.

Advantages

- Normal car doors open out of the car's track, so they can obstruct the road or pavement when opened. This is not an issue with canopies as they open vertically.
- A-pillars aren't necessary as there are no side doors, so the windscreen can extend from the front to the back of the car, giving the driver a field of vision of more than 180 degrees and minimising blind spots. A-pillars are sometimes still added, like with the Sterling Nova, to give the car a more conventional look.

Disadvantages

- Air-conditioning or climate control is necessary with an all-glass canopy or with a wrap-around windscreen because the canopy provides substantial 'glasshouse effect'.
- If the car rolled over during fast cornering, exiting the vehicle would be impossible, short of breaking the glass.
- Entering and exiting the vehicle can be hard with a high sill and awkward roof positioning. This problem was overcome with the Saab Aero X, which has a 3 part canopy to fully open the interior.
- In situations of bad weather such as snow, rain, or hail, it is impossible to enter or exit the vehicle without getting the interior wet, unless under cover.

Cars that use canopies

This is not a full list of cars that use canopies, but just a few examples.

Messerschmitts



Messerschmitt KR175

Messerschmitt, the notable aeroplane manufacturer, weren't allowed to produce aircraft after World War II. Instead, they produced cars. These were designed by the aircraft engineer Fritz Fend. A vehicle canopy was a new concept that is believed to be invented by Messerschmitt; this originated from their aircraft design. They quickly adopted the canopy as this was a simple solution that they had experience in. Unlike most canopies, the Messerschmitt canopies are hinged on the side. A problem with side hinging, is that if driving on the other side of the road, the canopy opens the wrong way. For that reason, after this, canopies were usually hinged at the front or back.

1953 Messerschmitt KR175

The KR175 was the first car, and the first production car to have a canopy. In 1956, the model was changed to the Messerschmitt KR200.

1956 Messerschmitt KR200

The most noticeable thing about the KR200 is its distinctive bubble canopy. The KR200 continued Messerschmitt's side-hinged canopies. These were usually transparent acrylic ("Plexiglas" or "Perspex"), though reproductions are car-safe polymethyl methacrylate.

1970 Ferrari Modulo concept car

The Ferrari Modulo was one of the first cars to have a canopy. At this time they were a new concept and were thought to be the future in automotive design.

1970 Bond Bug

The Bond Bug is a small 3-wheeled sports car and was the first production car to use a front-hinged canopy.

1971 Nova kit car



Lifting canopy on a Sterling Nova.

Other than the Purvis Eureka (a licensed copy of the Nova) and the Bond Bug, the Nova is the only production car to date to use a front-hinged canopy door. The windscreen has small A-pillars so it looks like a conventional car when the canopy is closed.

1985 Buick Wildcat concept car

The 1985 Buick Wildcat concept car had a canopy. The style of canopy it used is an extended canopy, as it is composed of much of the front bodywork, and not just the passenger compartment. A canopy was used in this concept car as it was thought to be futuristic.

2005 Maserati Birdcage 75th concept car

The Maserati Birdcage 75th lacks conventional doors, instead, it uses an extended canopy system. The demonstrator model lacks air-conditioning and so journalists (including Evo Magazine's Harry Metcalfe) experienced the previously-mentioned 'glasshouse effect' and so whilst driving the vehicle were reportedly forced to keep the bubble slightly open on hot days to cool the car's interior.

2006 Saab Aero-X concept car



The 3 part canopy on a Saab Aero-X.

The Aero X's top canopy is styled on the one of the Saab aeroplanes, and this was their inspiration for using a canopy. The canopy opens by remote control, and there is a lever to close it again.

The three-piece canopy eliminates the problems like a high sill and awkwardly angled roof, although the mechanisms are more complex and so heavier, and more likely to fail; leaving an occupant stranded inside a car. The canopy includes a wrap-around windscreen and a glass roof, side windows and body panels (which lift upwards, lowering the sills), and the top roof section of the interior fascia (which moves inwards so it doesn't obstruct entry/exit). These sections intricately manoeuvre themselves into a position where they take up as little space as possible. This construction eliminates the need for doors and A-pillars and so the windscreen extends from B-pillar to B-pillar, which has the important benefit of improving overall visibility.

2002 Volkswagen 1-litre car

The concept car, VW 1L, uses a canopy door. A limited number of these cars are planned to go on sale in 2010, making this one of the few production cars with a canopy.

Batmobile

Various models of the Batmobile used in the production of the Batman films make use of the canopy door.

Custom Cars

Bubble canopies are popular on some custom cars, most notably those by Ed Roth, such as the Orbitron, Road Agent and Beatnik Bandit.

Chapter 4

Scissor Doors and Bumper (Automobile)

Scissor doors



The Lamborghini Murciélago

Scissor doors (also **beetle-wing doors**, **jack-knife doors**, **switchblade doors**, **Lamborghini doors**, and **Lambo doors**) are automobile doors that rotate vertically at a fixed hinge at the front of the door, rather than outwardly as with a conventional door.

History



The Carabo concept car was the first vehicle to use scissor doors

The first vehicle to feature scissor doors was the 1968 Alfa Romeo Carabo concept car, designed by Bertone's Marcello Gandini. The door style was dictated by Gandini's desire for an innovative design, and by his concern over the car's extremely poor rear visibility. In order to reverse the car, the driver would be able to lift the door and lean his upper body out of the hatch in order to see behind the car. The first production car to feature the doors was a Lamborghini, Gandini's Countach; the sports car's wide chassis created similar problems to those found on the Carabo, calling for the unusual door configuration. The doors were used on the Countach's successor, the Diablo, on its replacement, the Murciélago, and on a low-production run derivative of the Murciélago called the Reventón. Having used the exotic door style for several of its cars, the Italian manufacturer has become synonymous with the implementation of scissor doors, which are sometimes colloquially referred to as "Lambo doors".

Advantages

- Offers the possibility of operating the car with the door open, in a manner that would be difficult or impossible in a car with conventional doors.
- Because the doors stay within the car's track throughout their range of movement, they are useful when parking in tight spaces. A gullwing door style offers similar visibility, but the doors swing out from the car's area slightly.
- The hinge is placed in a similar location to a conventional door, so a convertible version of the car is possible with the same door style.
- Reduces the dooring hazard to cyclists.

Disadvantages

- The door still impedes access/egress much more than a gullwing and, in some cases, more than a conventional door.
- The manufacture cost of the door hinge can be more than that of a conventional door.
- If the height of the parking lot is not high enough, the door may make contact with the roof.
- In the event of a rollover, emergency egress may be more difficult than with conventional doors, if not impossible.

Types

There are different types of scissor doors. The conventional type rotates to 90 degrees. Scissor doors can be powered and they usually are.

VLS

VLS doors have a scissor door configuration. The biggest difference is that they are designed to initially open slightly outward before opening upward to allow the top edge of the door to clear the door frame and A-pillar. Although butterfly doors also move upwards and outwards, VLS doors are not butterfly doors, this is because VLS doors move outwards to a very small degree compared to the angle of butterfly doors.

130 Degrees

Although conventional scissor doors rotate to 90 degrees, some can rotate up to 130 degrees; these are commonly used for modified cars. These have the benefit that they

don't obstruct the entrance or exit to the car as much as conventional scissor doors. VLS doors also can rotate to 130 degrees.

Scissor-conventional door hybrid

Some aftermarket example scissor doors are also designed so they can open vertically, and horizontally like a conventional car door. These are used so the user can get the benefits of both types of door and open the door in whichever style is best suited to the situation.

Bumper (automobile)



A BMW front bumper (highlighted in red)

An automobile's **bumper** is the front-most or rear-most part, ostensibly designed to allow the car to sustain an impact without damage to the vehicle's safety systems. They are not capable of reducing injury to vehicle occupants in high-speed impacts, but are increasingly being designed to mitigate injury to pedestrians struck by cars.

Presence

In most jurisdictions, bumpers are legally required on all vehicles. The height and placement of bumpers may be legally specified as well, to ensure that when vehicles of different heights are in an accident, the smaller vehicle will not slide under the larger vehicle.

North America



Front and rear bumpers on Chrysler A platform cars before (left, 1971) and after (right, 1974) the U.S. 5-mph bumper standard took effect. The 1974 bumpers are larger, heavier, and mounted farther away from the body, and they no longer contain the taillamps.

USA



Freestanding 5-mph shock-absorbing zero-damage bumper, 1976 AMC Matador.

First standards

In 1971, the U.S. National Highway Traffic Safety Administration (NHTSA) issued the country's first regulation applicable to passenger car bumpers. **Federal Motor Vehicle Safety Standard No. 215 (FMVSS 215)**, "Exterior Protection," took effect on 1 September 1972 — when most automakers would begin producing their model year 1973 vehicles. The standard prohibited functional damage to specified safety-related components such as headlamps and fuel system components when the vehicle is subjected to barrier crash tests at 5 miles per hour (8 km/h) for front and 2.5 miles per

hour (4 km/h) for rear bumper systems. In October 1972, the U.S. Congress enacted the Motor Vehicle Information and Cost Saving Act (MVICS), which required NHTSA to issue a bumper standard that yields the "maximum feasible reduction of cost to the public and to the consumer". Factors considered included the costs and benefits of implementation, the standard's effect on insurance costs and legal fees, savings in consumer time and inconvenience, and health and safety considerations.

The 1973 model year passenger cars sold in the U.S. used a variety designs. They ranged from non-dynamic versions with solid rubber guards, to "recoverable" designs with oil and nitrogen filled telescoping shock-absorbers. The standards were further beefed up for the 1974 model year passenger cars with standardized height front and rear bumpers that could take angle impacts at 5-mile-per-hour (8 km/h) with no damage to the car's lights, safety equipment, and engine. This often meant additional overall vehicle length, as well as new front and rear designs to incorporate the stronger energy absorbing bumpers.

Strengthening standards

The requirements promulgated under MVICS were consolidated with the requirements of Federal Motor Vehicle Safety Standard Number 215 (FMVSS 215, "Exterior Protection of Vehicles") and promulgated in March 1976. This new bumper standard was placed in the United States Code of Federal Regulations at 49CFR581, separate from the Federal Motor Vehicle Safety Standards at 49CFR571. The new requirements, applicable to 1979-model passenger cars, were called the **Phase I** standard. At the same time, a zero-damage requirement, **Phase II**, was enacted for bumper systems on 1980 and newer cars. The most rigorous requirements applied to 1980 through 1982 model vehicles; 5 miles per hour (8 km/h) front and rear barrier and pendulum crash tests were required, and no damage was allowed to the bumper beyond a $\frac{3}{8}$ in (10 mm) dent and $\frac{3}{4}$ in (19 mm) displacement from the bumper's original position.

Weakening standards



Different Bumper Designs on a BMW 5 Series (E28): Euro-spec left and US-

spec right.

Facing pressure from automakers, and operating under the Reagan administration's pledge to reduce regulatory burdens on industry, NHTSA most recently amended the bumper standard in May 1982, halving the front and rear crash test speeds for 1983 and newer car bumpers from 5 miles per hour (8 km/h) to 2.5 miles per hour (4 km/h), and the corner crash test speeds from 3 miles per hour (5 km/h) to 1.5 miles per hour (2 km/h). In addition, the zero-damage Phase II requirement was rolled back to the damage allowances of Phase I. At the same time, a passenger car bumper height requirements of 16 to 20 inches (41–51 cm) was established for passenger cars. At that time, NHTSA promised to conduct research and testing to provide consumers with accurate information on the quality of new car bumpers, but no such information has been provided.

Consumer and insurance groups have decried the weakened bumper standard, saying it has increased consumer costs without any attendant benefits except to automakers.

In 1986, Consumers Union petitioned NHTSA to return to the Phase II standard and disclose bumper strength information to consumers. In 1990, NHTSA rejected that petition.

The weakened regulations permitted automakers to design bumpers with emphasis on style and low cost; protection dropped substantially and repair costs rose. In 1990, IIHS conducted four crash tests on three different-year examples of the Plymouth Horizon. The results illustrated the effect of the changes to the U.S. bumper regulations (repair costs quoted in 1990 United States dollars):

- 1983 Horizon with Phase-II 5-mph bumpers: \$287
- 1983 Horizon with Phase-I 2.5-mph bumpers: \$918
- 1990 Horizon: \$1,476

Canada

Canada's bumper standard, first enacted at the same time as that of the United States, was generally similar to the U.S. regulation. However, the Canadian standard was not weakened from 8 km/h (5 mph) to 4 km/h (2.5 mph) in accord with the weakened U.S. standard of 1983. Some automakers chose to provide stronger Canadian-specification bumpers throughout the North American market, while others chose to provide weaker bumpers in the U.S. market, which hampered private importation of vehicles from the U.S. to Canada.

In early 2009, Canada's regulation shifted to harmonize with U.S. Federal standards and international ECE regulations. Consumer groups are upset with the change, but Canadian

regulators assert that the 4 km/h (2.5 mph) test speed is used worldwide and is more compatible with improved pedestrian protection in vehicle-pedestrian crashes.

Effect on design



Different Bumper Designs on a Audi 90 convertible: Euro-spec left and US-spec right.

Cars were equipped with bulky, massive, heavy, protruding bumpers to comply with the bumper standards of the 1970s and early 1980s. By the late 1980s most bumpers were concealed by a painted thermoplastic fascia.

Chapter 5

Hood Ornament



Mercedes-Benz



1913 Boyce MotoMeter



Ford Model 48



1949 Kaiser Virginian



1967 AMC Marlin



Home-made hood ornament on pick-up truck in Texas

A hood/bonnet ornament or car mascot is a specially crafted model of something which symbolizes a car company like a badge, located on the front center portion of the hood. It has been used as an adornment since almost the inception of automobiles.

History

In the early years automobiles had their radiator caps outside of the hood and on top of the grille which also served as an indicator of the temperature of the engine's coolant fluid. The Boyce Motormeter Company was issued a patent in 1912 for radiator cap that incorporated thermometer that was visible to the driver with a sensor that measured the heat of the water vapor, rather than the water itself. This became useful gauge for the driver because many early engines did not have water pumps, but a circulation system based on the "thermo-syphon" principle as in the Ford Model T. Many automakers wanted their own emblems displayed on their vehicles' hoods and Boyce Motormeter accommodated them with corporate logos or mascots, as well as numerous organizations that wanted custom cap emblems to identify their members. The company had over 300 such customers at one time during the mid-1920s, for car, truck, tractor, boat, airplane and motorcycle manufacturers, and in 1927, had 1,800 employees in six countries: U.S., England, Canada, Australia, France, and Germany. The hundreds of motor vehicle manufacturers before 1929 meant many customers for their customized emblems.

The radiator cap was transformed into an art form and became a way of individualizing the car, "representing a company's vision of the automobile", or "speaking volumes about the owner" of the vehicle.

Hood ornaments (or car mascots as they are known in the UK) were popular in the 1920s, 1930s, 1940s, and 1950s with many automakers fitting them to their vehicles. Moreover, a healthy business was created in the supply of accessory mascots available to anyone who wanted to add a hood ornament or car mascot to their automobile. Most companies like Desmo and Smiths are now out of business with only Louis Lejeune in England surviving.

Hood ornaments are usually cast in brass, zinc, or bronze and finished in a chrome plated finish. In the years when chrome plate was unavailable, they were plated in either silver or nickel. Some also incorporated other materials, such as plastic, while others incorporated a light bulb for illumination at night.

There is now a strong collectors market for hood ornaments and car mascots. Sculptors such as Bazin, Paillet, Sykes, Renevey, and Lejeune all created finely detailed sculptures in miniature.

The best-known glass mascots were made by René Lalique in France, but other sellers or producers of glass mascots include Sabino in France, Red Ashay in England, and Persons Majestic in the U.S. The latter two had their products made in Czechoslovakia. The Lalique company, like Louis Lejeune, is one of the few survivors from this era of motoring.

Examples

Along with the grille, the hood ornament is often a distinctive styling element and many marques use it as their primary brand identifier.

Examples of hood ornaments include:

- Archer on Pierce-Arrow cars
- Crest and Wreath on Cadillac cars
- Leaping jaguar on Jaguar cars
- Lion rampant on Peugeot cars
- Rocky Mountain big horn ram's head on Dodge cars and trucks
- Rocket on Oldsmobile cars
- Spirit of Ecstasy on Rolls-Royce Motors cars
- Trishields on Buick cars
- Three-pointed star surrounded by a circle on most Mercedes-Benz sedans and wagons, (not on sport coupe models, which instead tend have a grille with horizontal bars and a large centre-mounted star)

Additionally, many vehicle models such as Buick's Regal, the Chevrolet Impala, or Chrysler's Cordoba had their own unique emblem and accompanying distinctive standup hood ornament.

Chapter 6

Daytime Running Lamp

A **daytime running lamp (DRL)**, also **daylight running lamp** or **daytime running light**) is an automotive lighting device on the front of a roadgoing motor vehicle, installed in pairs, automatically switched on when the vehicle is moving forward, emitting white, yellow, or amber light to increase the conspicuity of the vehicle during daylight conditions.

Implementations



full-voltage vs. reduced-voltage (DRL) operation of low beam headlamp on European-market Volkswagen

Depending on prevailing regulations and vehicle equipment, the daytime running light function may be implemented by functionally-specific lamps, by operating the low-beam headlamps or fog lamps at full or reduced intensity, by operating the high-beam headlamps at reduced intensity, or by steady-burning operation of the front turn signals. Compared to any mode of headlamp operation to create the daytime running light, functionally-dedicated DRLs maximize the potential benefits in safety performance and minimize fuel consumption, glare, motorcycle masking, and other potential drawbacks.



LED DRLs on an Audi R8

Safety performance

Numerous studies done worldwide since the 1970s have tended to conclude that daytime running lights improve safety. A 2008 study by the U.S. National Highway Traffic Safety Administration analysed the effect of DRLs on frontal and side-on crashes between two vehicles and on vehicle collisions with pedestrians, cyclists, and motorcyclists. The analysis determined that DRLs offer no statistically-significant reduction in the frequency or severity of the collisions studied, except for a reduction in light trucks' and vans' involvement in two-vehicle crashes by a statistically-significant 5.7%.

Effect of ambient light

The Daytime Running Light was first mandated, and safety benefits first perceived, in Scandinavian countries where it is frequently and persistently dark during daytime hours in winter time. As ambient light levels increase, the potential safety benefit decreases while the DRL intensity required for a safety improvement increases. The safety benefit produced by DRLs in relatively dark Nordic countries is roughly triple the benefit observed in relatively bright Israel, Palestine and America.

Effect on motorcycle safety

In many countries, every motorcycle's low beam headlamp has been wired to illuminate whenever the engine is running, either as a matter of law or of voluntary industry practice. Some motorcycling advocacy groups are concerned over the potential for reduced motorcycle conspicuity with the introduction of headlamp-based DRLs on cars and other dual-track vehicles, since it means motorcycles are no longer the only vehicles displaying headlamps during the day. Some researchers have suggested that amber DRLs be reserved for use exclusively on motorcycles, in countries where amber is not presently a permissible color for DRLs on any vehicles, while other research has concluded there is a safety disbenefit to two 90 mm x 520 cd DRLs on motorcycles in comparison to one 190 mm x 270 cd dipped beam headlight. The latter result suggests that DRL luminous area may have an important influence on its effectiveness.

Environmental impact



LED daytime running lights on Audi A4

DRL power consumption varies widely depending on the implementation. Current production DRL systems consume from 8 watts (dedicated LED system) to over 200 W (headlamps and all parking, tail, and marker lights on). International regulators, primarily in Europe, are working to balance the potential safety benefit offered by DRL with the increased fuel consumption due to their use. Because the power to run the DRLs must be produced by the engine, which in turn requires burning additional fuel, high-power DRL systems increase CO₂ emissions sufficiently to affect a country's compliance with the

Kyoto protocol on greenhouse gas emissions. For that reason, low-power solutions are being encouraged and headlamp-based systems are not allowed when DRLs become mandatory in Europe at the beginning of 2011. LEDs and low-power, high-efficacy, long-life light bulbs produce appropriate amounts of light for an effective DRL without significantly increasing fuel consumption or emissions. Fuel consumption reductions of up to 0.5 mpg may be found when comparing a 55 W DRL system to a 200 W DRL system. In 2006, the UK's Department of Transport also found significant reductions in emissions and fuel consumption when comparing a 42 W DRL system to a 160 W full headlight DRL systems. DRL fuel consumption can be reduced to insignificant levels by the use of 8 to 20 W DRL systems based on LEDs or high-efficacy filament bulbs.

Worldwide

European Union

As a result of European Union Directive 2008/89/EC coming into force on the 7 of February 2011 all new passenger cars and small delivery vans through out the EU will have to come equipped with Daytime Running Lights. This will also be the case for Trucks and busses in August 2012.

Individual States within the European Union



Hella 6w halogen-bulb DRLs for retrofit. Other retrofit DRLs use LEDs

Germany, Spain, France and others have encouraged or required daytime use of low-beam headlamps on certain roads at certain times of year, Ireland encourages and Bulgaria requires the use of low-beam headlights at all times during winter, Italy, Hungary and Romania require daytime running lamps outside populated areas, and Czech Republic, Estonia, Latvia, Lithuania, Poland, Slovakia and Slovenia require the use of full or reduced voltage low-beam headlights at all times. Most EU states no longer significantly disagree over whether DRLs should be required, permitted, or prohibited; by member-state consensus, from 2011, ECE R48 will require DRLs conforming to ECE R87 on all new motor vehicles. DRLs compliant with R87 emit white light of between 400 and 1200 candelas.

Scandinavia



Hella DRL retrofit kit offered in Sweden in the 1970s. Package text reads "Install Hella perception lights so you are seen in traffic".

DRLs were first mandated in Scandinavian countries, where ambient light levels in the winter are generally low even during the day. Sweden was the first country to require widespread DRLs in 1977. At the time, the function was known as *varselljus* ("perception light" or "notice light"). The initial regulations in these countries favored devices incorporating 21-watt signal bulbs identical to those used in brake lamps and turn signals, producing yellow or white light of approximately 400 to 600 candelas on axis, mounted at the outer left and right edges of the front of the vehicle. Finland adopted a daytime-light requirement in 1972 on rural roads in wintertime, and in 1982 on rural roads in summertime and 1997 on all roads all year long; Norway in 1986, Iceland in 1988, and Denmark in 1990. To increase manufacturer flexibility in complying with the requirement for DRLs, the daytime illumination of low-beam headlights was added as an optional implementation. Given the ECE headlamp specifications in use in those countries, such an implementation would produce approximately 450 cd axially.

United Kingdom

United Kingdom national regulations required vehicles first used on or after 1 April 1987 to be equipped with a *dim-dip* device or daytime running lamps, except such vehicles as comply fully with ECE Regulation 48 regarding installation of lighting equipment. A dim-dip device operates the low beam headlamps (also called "dipped beam" in the UK)

at between 10 percent and 20 percent of normal low-beam intensity when the side lamps are switched on, the primary aim being to prevent drivers using only position lamps at night.

UK specifications for functionally-dedicated DRLs called for at least 200 candelas straight ahead, and no more than 800 candelas in any direction. These regulatory provisions were based on ILPE research and recommendations. In practice, most vehicles were equipped with the dim-dip option, rather than DRLs. Subsequently, the UK's Dim-Dip requirement was quashed by the European Commission.

Russia

Russian national regulations which come into operation from 23 September 2010 required use of lowbeam or DRL anytime anywhere. DRL should have intensity from 400 to 800 cd and lighted surface square 40 cm². Currently only lowbeam are required outside of the towns (so DRL couldn't be used instead lowbeam).

Canada

Canada Motor Vehicle Safety Standard 108 requires DRLs on all new vehicles made or imported after January 1, 1990. Canada's proposed DRL regulation was essentially similar to regulations in place in Scandinavia, with an axial luminous intensity limit of 1,500 candelas, but automakers objected, claiming it was too expensive to add a new front lighting device, and would increase warranty costs (by dint of increased bulb replacements) to run the low beams. After a pitched regulatory battle, the standard was rewritten to permit the use of reduced-voltage high beam headlamps producing up to 7,000 axial candelas, as well as permitting any light color from white to amber or selective yellow. These changes to the regulation permitted automakers to implement a less-costly DRL, such as by connecting the high beam filaments in series to supply each filament with half its rated voltage, or by burning the front turn signals full time except when they are actually flashing as turn indicators.



Reduced-voltage high beam DRL on a US/Canada 2002 Lexus RX300

United States

General Motors, interested in reducing the build variations of cars for the North American market, began lobbying the DOT (United States Department of Transportation) to permit DRLs in the United States shortly after Canada required them. A prolonged regulatory battle was fought, with the DOT objecting on grounds of potential safety drawbacks and glare issues. Eventually, however, these objections were set aside and DRLs of the same types allowed in Canada (save for fog lamp DRLs) were legalized but not mandated effective with the 1995 model year. General Motors immediately equipped most (and, in following years, all) of its vehicles with DRLs beginning with the Chevrolet Corsica. Saab, Volkswagen, Volvo, Suzuki and Subaru gradually introduced DRLs in the U.S. market beginning in 1995. In recent years, Lexus has installed high-beam or turn signal based DRLs on US models. Some Toyota models come with DRLs as standard or optional equipment, and with a driver-controllable on/off switch. Starting in the 2006 model year, Honda began equipping their U.S. models with DRLs, mostly by reduced-intensity operation of the high beam headlamps.

Public reaction to DRLs, generally neutral to positive in Canada, is decidedly mixed in the U.S. Thousands of complaints regarding glare from DRLs were lodged with the DOT shortly after DRLs were permitted on cars, and there was also concern that headlamp-

based DRLs reduce the conspicuity of motorcycles, and that DRLs based on front turn signals introduce ambiguity into the turn signal system. In 1997, in response to these complaints and after measuring actual DRL intensity well above the 7,000 cd limit on vehicles in use, DOT proposed changes to the DRL specification that would have capped axial intensity at 1,500 candelas, a level nearly identical to the European 1,200 cd and identical to the initially-proposed Canadian limit. During the open comment period, thousands of public comments were received by DOT in support of lowering the intensity (or advocating the complete elimination of DRLs from U.S. roads). Automaker sentiment generally ran along predictable lines, with European automakers experienced at complying with European DRL requirements voicing no objection to the proposal, and North American automakers vociferously repeating the same objections they raised in response to Canada's initial proposal. The DOT proposal for DRL intensity reduction was rescinded in 2004.

Australia

DRLs are permitted but not required in Australia, though Australian automotive authorities are interested in introducing DRL requirements.

Chapter 7

Trafficators and Parking Sensors

Trafficators



Trafficator in the "on" position



Trafficator in the "on" position

Trafficators are semaphore signals which, when operated, protrude from the bodywork of a motor vehicle to indicate its intention to turn in the direction indicated by the pointing signal. Trafficators are often located at the door pillar.

History

They first appeared in the 1900s when they were actuated either mechanically or pneumatically. In 1908 Alfredo Barrachini in Rome had added electric lights inside the arms that turned on as they extended but operation was still by a cable system. Electric operation came in 1918 when the Naillik Motor Signal Company of Boston added electric motor drive. This system was superseded by two French inventors, Gustave Deneef and Maurice Boisson, who used a linear solenoid in 1923. The final complete system came in 1927 when Berlin-based Max Ruhl and Ernst Neuman combined internal illumination and solenoid operation.

The shape of the Trafficator arm is closely based upon the shape of the semaphore signal arm used by the Royal Bavarian Railway beginning in 1890. The only difference from the railway arm is that it is halved down its length so as to fit flush with the vehicle's exterior.

They were common on vehicles until the introduction of the flashing amber or red indicators at or near the corners of the vehicle (and often along the sides as well). They have been increasingly rare since the 1950s, as ever-tightening legislation has prescribed the need for the modern type of flashing signal. Many historic vehicles that are used on

today's roads have had their trafficators supplemented or replaced with modern indicators to aid visibility and to meet legislative requirements.

Turn indicator stalk

Turn indicator stalk or **turn signal lever** is the control lever which operates the turn signal or indicator lights on the front, sides and rear of the vehicle.

Since the majority of the world's vehicles are left hand drive, the turn indicator stalks are located on the left of the steering column. This is true for all left hand drive vehicles manufactured by European and North American manufacturers.

For most right-hand-drive (RHD) motor vehicles, the indicator stalk is located on the right of the steering column. This is assumed to be the correct design for right hand drive cars. The indicator stalk should be placed closest to the driver's door. The reason is when the driver intends to turn, the person has their right hand on the steering column and activating the turn indicator and the left hand using the gear shift simultaneously.

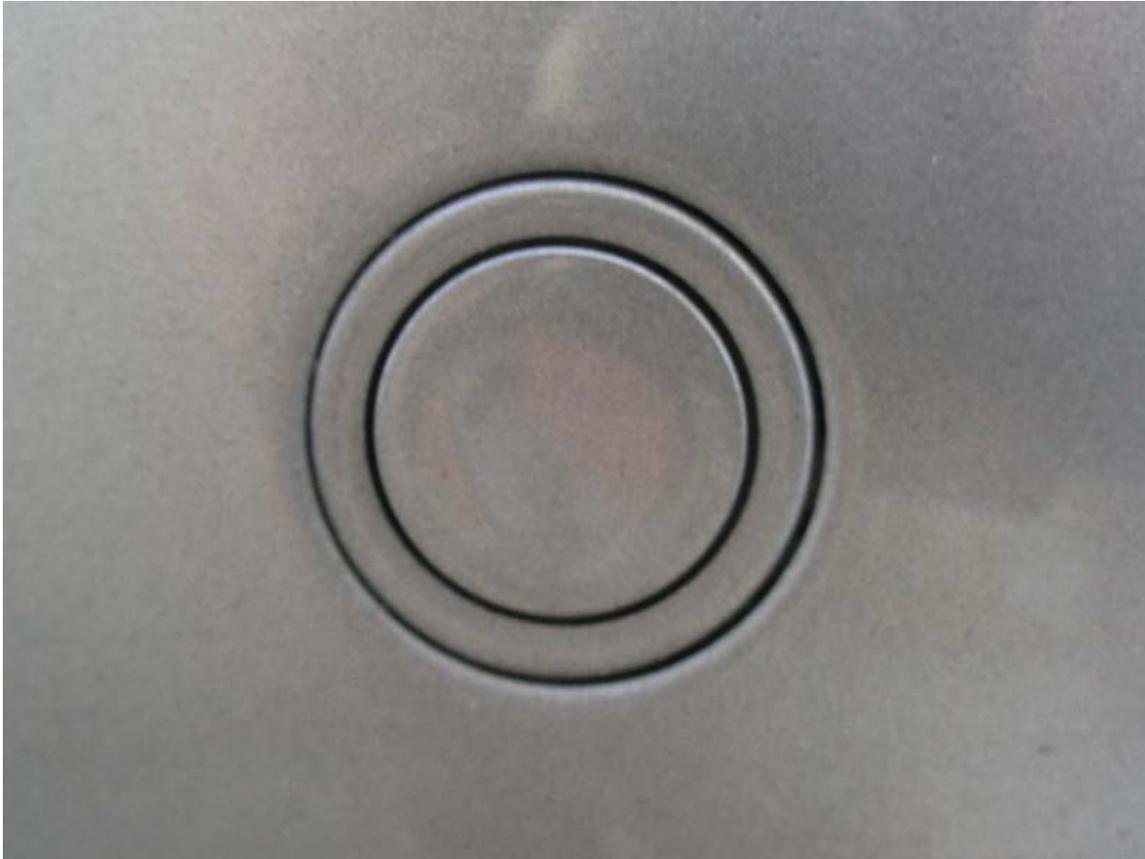
However, European manufacturers used to develop steering columns for both LHD and RHD motor vehicles. Due to cost cutting, these manufacturers assemble the steering column for LHD into their RHD motor vehicle models.

This has the effect of making one perceived the car as European. Some Japanese manufacturers such as Subaru will have variation in the model line up to where the turn indicator stalk is located.

Innovations

Many other functions have been added to the turn signal stalk. Frequently headlamps and high beam controls are integrated into the turn signal control.

Parking sensors



Parking sensor

Parking sensors are proximity sensors for road vehicles which can alert the driver to unseen obstacles during parking manoeuvres.

The ultrasonic sensors are currently available in several brands of cars, with a variety of brand names such as Parktronic and Parking Aid. Some systems are also available as additional upgrade kits for later installation.

Description

Parking sensor systems use ultrasonic proximity detectors embedded in the front and/or rear bumpers, to measure the distances to nearby objects at low level. The sensors measure the time taken for each sound pulse to be reflected back to the receiver.

Depending on the speed of the vehicle and the distance to the obstacle, the system will warn the driver by visual and/or audible means about the risk of collision. The feedback

to the driver will generally indicate the direction and proximity of the obstacle. Warnings are deactivated when the vehicle exceeds a certain speed, and can be switched off for situations such as stop-and-go traffic.

Audible feedback

The most common form of feedback to the driver in a car with parking sensors is audible "beeps" and/or tones. Generally, the frequency of the beep indicates distance from an obstruction, with the beeps becoming faster the closer the vehicle moves to an object. A continuous tone may be heard when the vehicle is extremely close, often warning a driver to stop immediately to avoid collision.

Visual feedback

Some systems use visual aids as well as or instead of audible tones, such as LED or LCD readouts to indicate distance from an object. The direction and distance to the obstacle is indicated by the location and strength of the warning symbols.

Shortcomings

Since the system relies on the reflection of sound waves, it may not detect some items that are not flat or large enough to reflect sound, for example a narrow pole or a longitudinal object pointed directly at the vehicle or near an object.

Chapter 8

Wing Mirror



Dual-contour wing mirror. Large inboard convex surface is separated by visible line from small outboard aspheric surface



Fender mirror on a Toyota Celsior

A wing mirror (also **fender mirror**, **door mirror**, **side mirror** or **side-view mirror**) is a mirror found on the exterior of motor vehicles for the purposes of helping the driver see areas behind and to the sides of the vehicle, outside of the driver's peripheral vision (in the 'blind spot').

Although almost all modern cars mount their side mirrors on the doors, normally at the "A" pillar, rather than the wings (fenders – portion of body above the wheel well), the "wing mirror" term is still frequently used. However, wing mirrors continue to be relatively common in the Japanese domestic market. The mirrors on bicycles and motorcycles are usually mounted to the handlebars, and there are usually two of them.

The side mirror is equipped for manual or remote vertical and horizontal adjustment so as to provide adequate coverage to drivers of differing height and seated position. Remote adjustment may be mechanical by means of bowden cables, or may be electric by means of geared motors. The mirror glass may also be electrically heated, often in conjunction with the vehicle's rear window defogger, to thaw accumulated snow and ice. Increasingly, the side mirror incorporates the vehicle's turn signal repeaters. There is evidence to suggest mirror-mounted repeaters may be more effective than repeaters mounted in the previously predominant fender side location.



Side-view mirror with warning legend



Driver's control for Wing mirrors, with tiny curb-view button (saab 9-5).

Planar, convex, aspheric

U.S. Federal Motor Vehicle Safety Standard 111 and the analogous Canada Motor Vehicle Safety Standard 111 require the driver side mirror to provide "unit magnification", i.e., an undistorted 1:1 reflection achieved with a flat mirror. However, unit magnification limits the field of view that can be provided by a mirror of size compatible with the vehicle body. The ECE regulations in use throughout most of the world except North America permit the driver side mirror to have a planar, convex, and/or aspheric surface; an aspheric section is often combined with a larger convex section, and the two sections are separated by a visible line to alert the driver to the two sections' different perspective shifts.

Because of the distance from the driver's eye to the *passenger* side mirror, a useful field of view can only be achieved with a convex or aspheric mirror. However, the convexity also minifies the objects shown. Since minified objects seem farther away than they actually are, a driver might make a maneuver such as a lane change assuming an adjacent vehicle is a safe distance behind, when in fact it is quite a bit closer. In the United States, Canada, and Australia, passenger-side mirrors are etched or printed with the warning legend OBJECTS IN MIRROR ARE CLOSER THAN THEY APPEAR. In Canada, this warning is often supplemented by a transparent decal on the passenger side window repeating the

warning in French: LES OBJETS DANS LE RETROVISEUR SONT PLUS PROCHE QU'ILS NE SE PARAISSENT. Warnings of this nature are not required in Europe, where the proliferation of languages would make it difficult to implement a universally-comprehensible warning.



Side mirrors are easily damaged



Wing mirror retraction control (Saab 9-5)

Some side mirrors may be manually or electrically folded in, to protect them when the car is parked. Passing cars can easily clip protruding wing mirrors; the folding capability helps protect them from harm.

Specifications

U.S. Federal Motor Vehicle Safety Standard 111 requires that convex side view mirrors must have a curvature radius of between 889 mm and 1651 mm. Canada Motor Vehicle Safety Standard 111 stipulates a range of between 890 mm and 1800 mm. Neither the U.S. nor the Canadian standard allows for aspheric mirrors. The European ECE Regulation 46 used throughout most of the world permits planar, convex, and/or aspheric mirrors on either side of the vehicle. American research suggests non-planar driver side mirrors may help reduce crashes.

ECE Regulation 46 also requires that side mirrors be mounted such that they swing away when struck by a test cylinder meant to represent a pedestrian.

Chapter 9

Fuel Gauge and Automotive Night Vision

Fuel gauge



A fuel gauge



The empty fuel indicator displaying on the fuel gauge for a 2003 Honda Civic.

A **fuel gauge** (or **gas gauge**) is an instrument used to indicate the level of fuel contained in a tank. Commonly used in cars, these may also be used for any tank including underground storage tanks.

As used in cars, the gauge consists of two parts:

- The sensing unit
- The indicator

The sensing unit usually uses a float connected to a potentiometer. As the tank empties, the float drops and slides a moving contact along the resistor, increasing its resistance. In addition, when the resistance is at a certain point, it will also turn on a "low fuel" light on some vehicles.

Meanwhile, the indicator unit (usually mounted on the dashboard) is measuring and displaying the amount of electrical current flowing through the sending unit. When the tank level is high and maximum current is flowing, the needle points to "F" indicating a full tank. When the tank is empty and the least current is flowing, the needle points to "E" indicating an empty tank.

The system is fail-safe; a fault that opens the electrical circuit causes the indicator to show the tank as being empty (which will provoke the driver to refill the tank (in theory)) rather than full (which would allow the driver to run out of fuel with no prior notification). However this system has a potential risk associated with it. An electric current is sent through the variable resistor to which a float is connected, so that the value of resistance depends on the fuel level. In most of automotive fuel gauges such resistors are on the inward side of gauge i.e inside fuel tank. Sending current through such a resistor has fire hazard (and an explosion risk) associated with it. Therefore there is demand for another safer (and cheaper) method to be invented.

Systems that measure large fuel tanks (including underground storage tanks) may use the same electro-mechanical principle or may make use of a pressure sensor, sometimes connected to a mercury manometer.

Many aircraft use a different fuel gauge design principle. An aircraft may use a number (around 30 on an A320) of low voltage tubular capacitor probes where the fuel becomes the dielectric. At different fuel levels, different values of capacitance are measured and therefore the level of fuel can be determined. In early designs, the profiles and values of individual probes were chosen to compensate for fuel tank shape and aircraft pitch and roll attitudes. In more modern aircraft, the probes tend to be linear (capacitance proportional to fuel height) and the fuel computer works out how much fuel there is (slightly different on different manufacturers). This has the advantage that a faulty probe may be identified and eliminated from the fuel calculations. In total this system can be more than 99% accurate. Since most commercial aircraft only take on board fuel necessary for the intended flight (with appropriate safety margins), the system allows the fuel load to be preselected, causing the fuel delivery to be shut off when the intended load has been taken on board.

Automotive night vision

An **automotive night vision** system is a system to increase a vehicle driver's perception and seeing distance in darkness or poor weather beyond the reach of the vehicle's headlights. They are currently offered as optional equipment on certain premium vehicles.

Display type

- instrument cluster using a high resolution liquid-crystal display (LCD), newest type
- navigation system or information screen, least expensive and with display's location further away from driver's field of vision (used exclusively by BMW, and the W212 E-class)
- windshield via head-up display, earliest type, dimmer knob can reduce brightness, display nearest to driver's line of sight

There are two types of systems, either passive or active systems, both have advantages and disadvantages when compared to the other.

Active systems

There are two kinds of active systems gated and non- gated. the gated system uses a pulser light source and a synchronized camera that enable long ranges (250m) and high performance at rain and snow. Active systems use an infrared light source built into the car to illuminate the road ahead with light that is invisible to humans.

- Pros: higher resolution image, superior picture of inanimate objects, works better in warmer conditions, smaller sensor can be mounted to rearview mirror.
- Cons: does not work as well in fog or rain, lower contrast for animals, shorter range of 150-200 meters or 500-650 feet

Mercedes-Benz

In late-2005, Mercedes-Benz introduced their **Night View Assist** system on the redesigned S-class. It was the first system to use the instrument cluster's LCD as a display. In 2009, Mercedes added a pedestrian detection function calling the revised system **Night View Assist Plus** and offered it on the redesigned E-class and refreshed S-class, however, the E-class uses the navigation screen's display.

Toyota



Night View system on the 2003 Lexus LX 470

In 2002, Toyota introduced the first production automotive active night vision system or **Night View** on the Lexus LX 470 and Landcruiser Cygnus. This system uses the headlight projectors emitting near infrared light aimed like the car's highbeam headlights and a CCD camera then captures that reflected radiation, this signal is then processed by computer which produces a black-and-white image which is projected on the lower section of the windshield. In 2008 Toyota added a feature to the Crown Hybrid which highlights pedestrians and presents them in a box on an LCD display in front of the driver, this was the first pedestrian detection feature for an active system.

Passive systems

Passive systems do not use an infrared light source, instead they capture existing thermal radiation emitted by the objects which using a thermographic camera.

- Pros: greater range of about 300 meters or 1,000 feet, higher contrast for living objects
- Cons: grainy, lower resolution image, works poorly in warmer weather conditions, larger sensor

Audi

The **Night Vision Assistant** was introduced in 2010 on the Audi A8. It uses a thermal imaging camera behind the four rings at the front of the car which can "see" 300 meters (984 ft) ahead. The display in the instrument cluster highlights humans with yellow markings. More importantly, the computer can determine if the person on the road moves in a way that could lead to a collision with the car. In that case the pedestrian is being marked in red color and the driver of the car receives an audible warning.

BMW

In fall 2005, BMW introduced **BMW Night Vision** on the 7-series. This system processes far infrared radiation, which minimizes non-essential information placing a greater emphasis on pedestrians and animals, allows for a range of 300 meters or nearly 1,000 feet, and avoids "dazzle" from headlights, road lights and similar intense light sources. In the fall of 2008, on the redesigned 7-series, BMW added a pedestrian detection system which flashes a caution symbol on the navigation/information screen and head-up-display when it detects pedestrians.

General Motors

In 2000, General Motors introduced **Night Vision** on the Cadillac Deville which became the first vehicle sold with such a system, however it was discontinued in 2004. This system was developed with Raytheon and worked by using an infrared sensing camera mounted behind the vehicle's grille. Infrared radiation is picked up by the sensor, processed by computer and then displayed on the windshield using a head-up display. Information is displayed as a black and white image with warmer objects in white, while cooler objects appear black.

Honda

In the fall of 2004, Honda introduced the redesigned Legend with an optional **Intelligent Night Vision** system. This system detected far infrared radiation and was also the first system to offer pedestrian detection. The pedestrian detection feature alerted the driver with an audio warning and visually enclosed the pedestrian in a box on the display which was presented via head-up display.

Automobiles

Active

- 2002-2007 Lexus LX 470 (windshield)
- 2009 Lexus LS (instrument cluster)¹
- 2006 Mercedes CL-class (instrument cluster)
- 2009 Mercedes E-class (navigation screen)¹
- 2005 Mercedes S-class (instrument cluster)

- 2009 Mercedes S-class (instrument cluster)¹
- 2008 Toyota Crown Hybrid (instrument cluster)¹
- 2002 Toyota Landcruiser Cignus (windshield)
- 2011 Under development BrightEye Gated long range system

Passive

- 2010 Audi A8, Audi A7 (instrument cluster)¹
- 2005 BMW 5-series (navigation screen)
- 2005 BMW 7-series (navigation screen)
- 2008 BMW 7-series (navigation screen)¹
- 2000-2004 Cadillac (windshield)
- 2004 Honda Legend (windshield)¹

Chapter 10

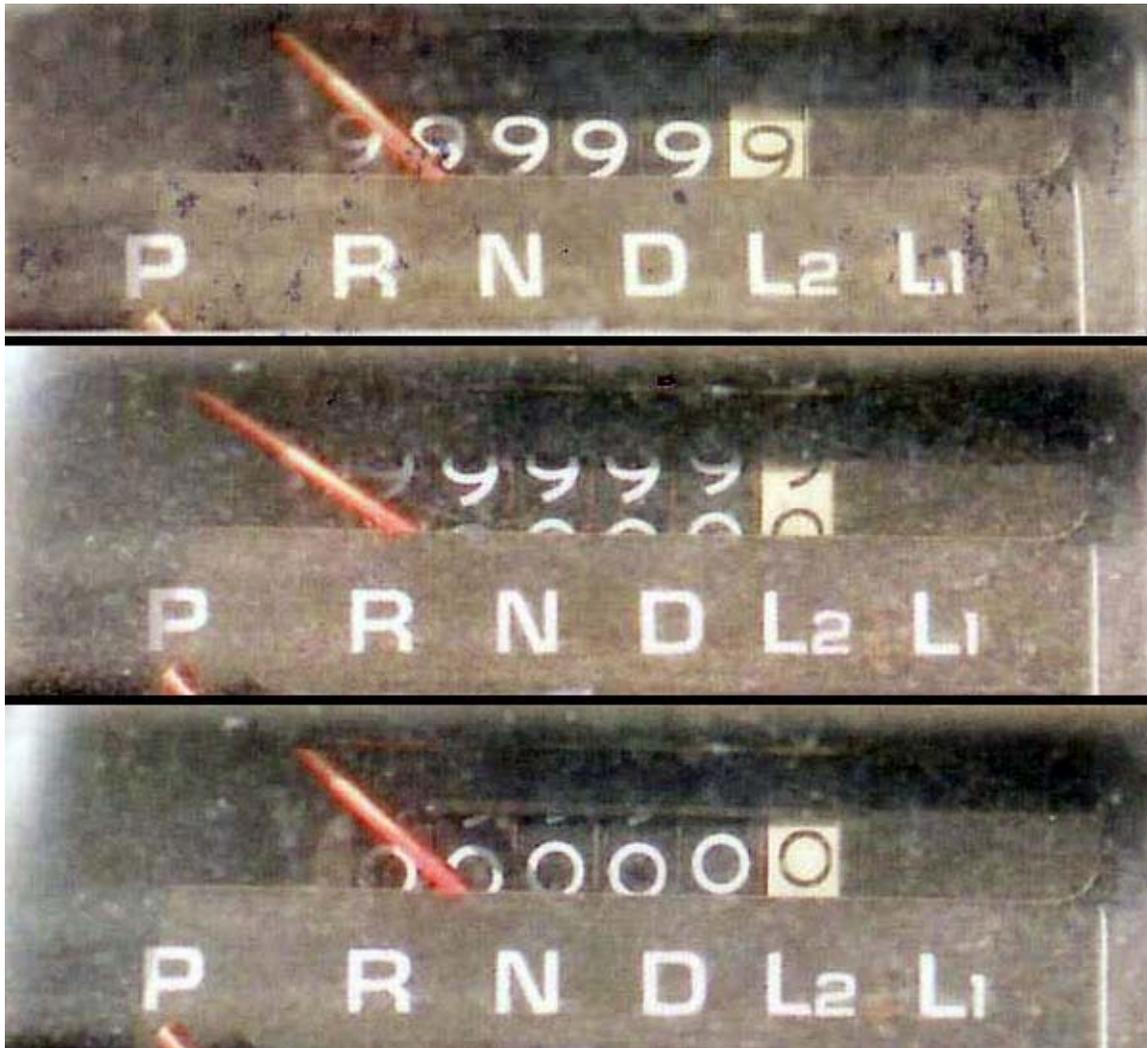
Odometer



A mechanical odometer with trip meter below.

An **odometer** (**mileometer**, **milometer**) indicates distance travelled by a bicycle, automobile, or other vehicle. The device may be electronic, mechanical, or a combination of the two. The word derives from the Greek words *hodós*, meaning "path" or gateway and "métron", "measure".

Description

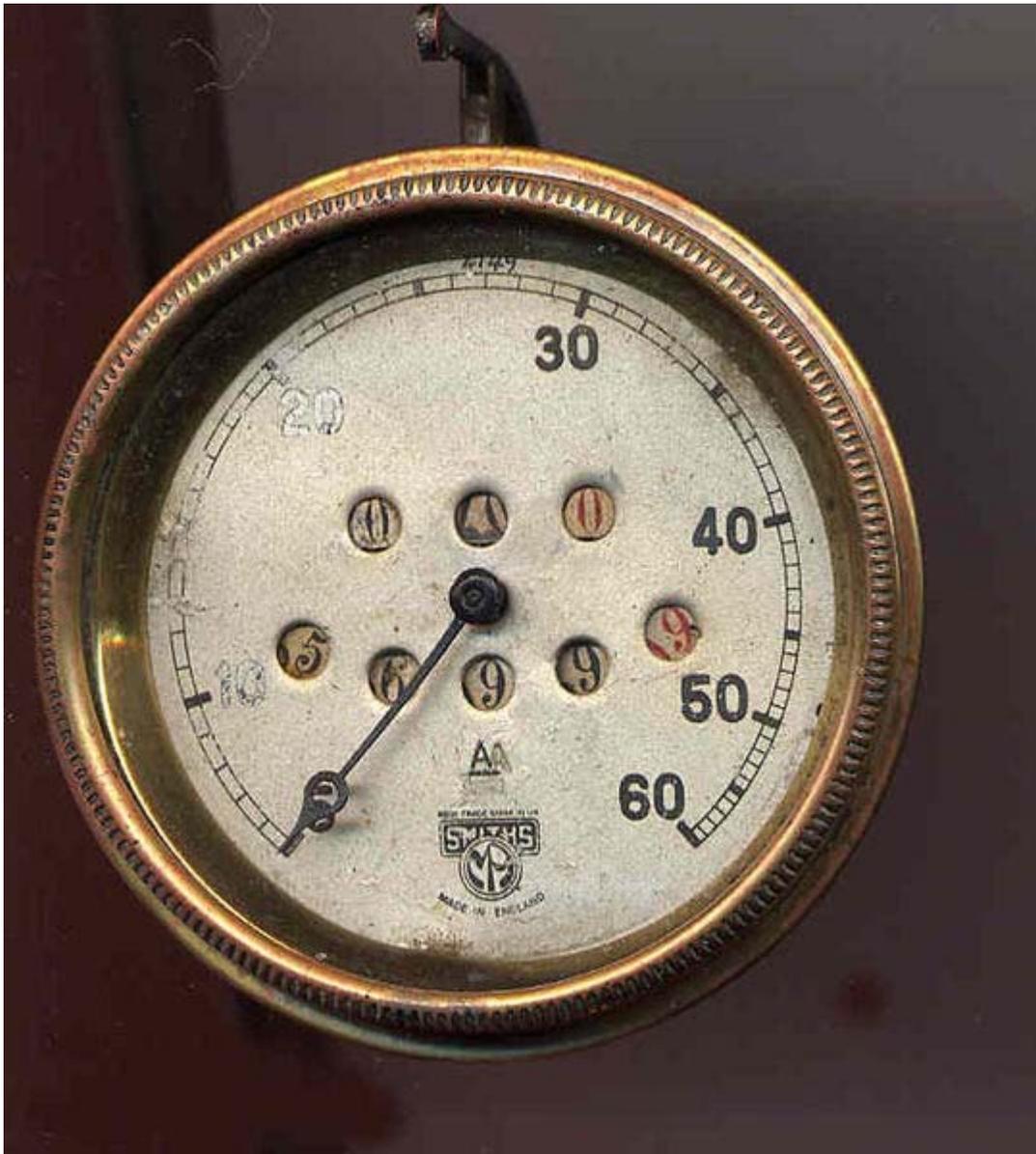


Odometer rollover.

In the early cars a top reading of 99,999 was enough. With improvements, modern vehicles need an extra digit. At the top reading, an odometer restarts from zero (odometer rollover).

Most modern cars include a **trip meter (trip odometer)**. Unlike the odometer, a trip meter is reset at any point in a journey, making it possible to record the distance travelled in any particular journey or part of a journey. It was traditionally a purely mechanical device but, in most modern vehicles, it is now electronic. Luxury vehicles often have multiple trip meters. Most trip meters will show a maximum value of 999.9. The trip meter may be used to record the distance travelled on each tank of fuel, making it very easy to accurately track the energy efficiency of the vehicle; another common use is resetting it to zero at each instruction in a sequence of driving directions, to be sure when one has arrived at the next turn.

History



A Smiths speedometer from the 1920s showing odometer and trip meter.



An electronic odometer with digital display

Classical Era

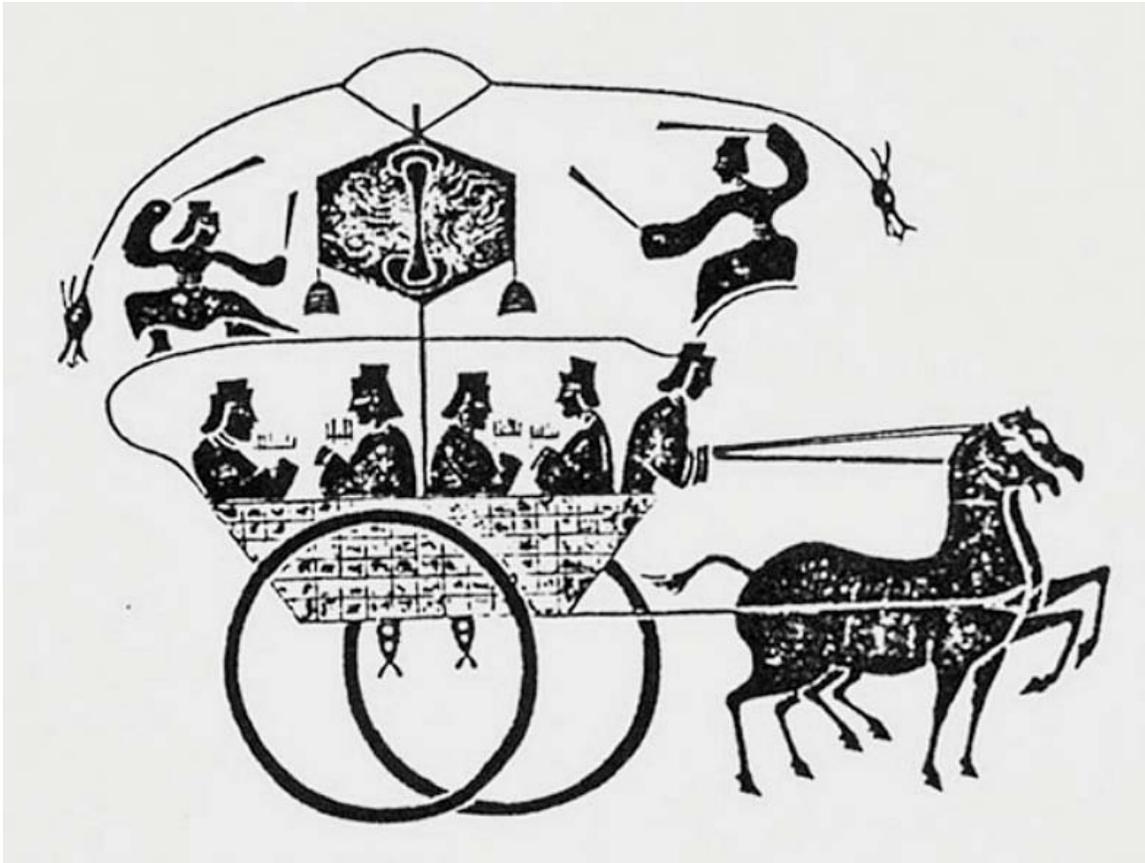
Possibly the first evidence for the use of an odometer can be found in the works of Pliny (NH 6. 61-62) and Strabo (11.8.9). Both authors list the distances of routes travelled by Alexander the Great (r. 336-323 BC) as measured by his bematists Diognetus and Baeton. However, the high precision of the bematists's measurements rather indicates the use of a mechanical device. For example, the section between the cities Hecatompylos and Alexandria Areion, which later became a part of the silk road, was given by Alexander's bematists as 529 English miles long, that is with a deviation of 0.4% from the actual distance (531 English miles). From the nine surviving bematists' measurements in Pliny's *Naturalis Historia* eight show a deviation of less than 5% from the actual distance, three of them being within 1%. Since these minor discrepancies can be adequately explained by slight changes in the tracks of roads during the last 2300 years, the overall accuracy of the measurements implies that the bematists already must have used a sophisticated device for measuring distances, although there is no direct mentioning of such a device.

An odometer for measuring distance was first described by Vitruvius around 27 and 23 BC, although the actual inventor may have been Archimedes of Syracuse during the First Punic War. Hero of Alexandria describes a similar device in chapter 34 of his *Dioptra*.

The machine was also used in the time of Roman Emperor Commodus (c. 192 AD), although after this point in time there seems to be a gap between its use in Roman times and that of the 15th century in Western Europe. Some researchers have speculated that the device might have included technology similar to that of the Greek Antikythera mechanism.

The odometer of Vitruvius was based on chariot wheels of 4 feet (1.2 m) diameter turning 400 times in one Roman mile (about 1400 m). For each revolution a pin on the axle engaged a 400 tooth cogwheel thus turning it one complete revolution per mile. This engaged another gear with holes along the circumference, where pebbles (*calculus*) were located, that were to drop one by one into a box. The distance travelled would thus be given simply by counting the number of pebbles. Whether this instrument was ever built at the time is disputed. Leonardo da Vinci later tried to build it himself according to the description, but failed. However, in 1981 engineer Andre Sleewyck built his own replica, replacing the square-toothed gear designs of da Vinci with the triangular, pointed teeth found in the *Antikythera mechanism*. With this modification, the Vitruvius odometer functioned perfectly.

Ancient China



A Han Dynasty stone rubbing of a horse-drawn odometer cart.

The odometer was also later invented in ancient China, possibly by the profuse inventor and early scientist Zhang Heng (78–139 AD) of the Han Dynasty (202 BC–220 AD). Zhang Heng is often accredited with the invention of the first odometer device in China, an achievement alongside earlier contemporaries Archimedes and Heron of Alexandria from the Hellenized West. By the 3rd century (during the Three Kingdoms Period), the Chinese had termed the device as the 'jì lǐ gǔ chē' (記里鼓車), or 'li-recording drum carriage' (Note: the modern measurement of li = 500 m/1640 ft). Chinese texts of the 3rd century tell of the mechanical carriage's functions, and as one li is traversed, a mechanical-driven wooden figure strikes a drum, and when ten li is traversed, another wooden figure would strike a gong or a bell with its mechanical-operated arm.

Despite its association with Zhang Heng or even the later Ma Jun (c. 200–265), there is evidence to suggest that the invention of the odometer was a gradual process in Han Dynasty China that centered around the *huang men* court people (i.e. eunuchs, palace officials, attendants and familiars, actors, acrobats, etc.) that would follow the musical procession of the royal 'drum-chariot'. The historian Joseph Needham asserts that it is no surprise this social group would have been responsible for such a device, since there is already other evidence of their craftsmanship with mechanical toys to delight the emperor and the court. There is speculation that some time in the 1st century BC (during the Western Han Dynasty), the beating of drums and gongs were mechanically-driven by working automatically off the rotation of the road-wheels. This might have actually been the design of one Loxia Hong (c. 110 BC), yet by 125 AD the mechanical odometer carriage in China was already known (depicted in a mural of the Xiao Tang Shan Tomb).

The odometer was used also in subsequent periods of Chinese history. In the historical text of the *Jin Shu* (635 AD), the oldest part of the compiled text, the book known as the *Cui Bao* (c. 300 AD), recorded the use of the odometer, providing description (and interestingly enough attributing it to the Western Han era, from 202 BC–9 AD). The passage in the *Jin Shu* expanded upon this, explaining that it took a similar form to the mechanical device of the South Pointing Chariot invented by Ma Jun. As recorded in the *Song Shi* of the Song Dynasty (960-1279 AD), the odometer and South Pointing Chariot were combined into one wheeled device by engineers of the 9th century, 11th century, and 12th century (refer to South Pointing Chariot). The *Sun Tzu Suan Ching* (Master Sun's Mathematical Manual), dated from the 3rd century to 5th century, presented a mathematical problem for students involving the odometer. It involved a given distance between two cities, the small distance needed for one rotation of the carriage's wheel, and the posed question of how many rotations the wheels would have in all if the carriage was to travel between point A and B.

Song Dynasty odometer

The historical text of the *Song Shi* (1345 AD), recording the people and events of the Chinese Song Dynasty (960–1279), also mentioned the odometer used in that period. However, unlike written sources of earlier periods, it provided a much more thoroughly detailed description of the device that harkens back to its ancient form (Wade-Giles spelling):

The odometer. [The mile-measuring carriage] is painted red, with pictures of flowers and birds on the four sides, and constructed in two storeys, handsomely adorned with carvings. At the completion of every li, the wooden figure of a man in the lower storey strikes a drum; at the completion of every ten li, the wooden figure in the upper storey strikes a bell. The carriage-pole ends in a phoenix-head, and the carriage is drawn by four horses. The escort was formerly of 18 men, but in the 4th year of the Yung-Hsi reign-period (987 AD) the emperor Thai Tsung increased it to 30. In the 5th year of the Thien-Sheng reign-period (1027 AD) the Chief Chamberlain Lu Tao-lung presented specifications for the construction of odometers as follows:

What follows is a long dissertation made by the Chief Chamberlain Lu Daolong on the ranging measurements and sizes of wheels and gears, along with a concluding description at the end of how the device ultimately functions:

The vehicle should have a single pole and two wheels. On the body are two storeys, each containing a carved wooden figure holding a drumstick. The road-wheels are each 6 ft in diameter, and 18 ft in circumference, one revolution covering 3 paces. According to ancient standards the pace was equal to 6 ft and 300 paces to a li; but now the li is reckoned as 360 paces of 5 ft each.

The vehicle wheel (li lun) is attached to the left road-wheel; it has a diameter of 1.38 ft with a circumference of 4.14 ft, and has 18 cogs (chhih) 2.3 inches apart. There is also a lower horizontal wheel (hsia phing lun), of diameter 4.14 ft and circumference 12.42 ft, with 54 cogs, the same distance apart as those on the vertical wheel (2.3 inches). (This engages with the former.)

Upon a vertical shaft turning with this wheel, there is fixed a bronze "turning-like-the-wind wheel" (hsuan feng lun) which has (only) 3 cogs, the distance between these being 1.2 inches. (This turns the following one.) In the middle is a horizontal wheel, 4 ft in diameter, and 12 ft circumference, with 100 cogs, the distance between these cogs being the same as on the "turning-like-the-wind wheel" (1.2 inches).

Next, there is fixed (on the same shaft) a small horizontal wheel (hsiao phing lun) 3.3 inches in diameter and 1 ft in circumference, having 10 cogs 1.5 inches apart. (Engaging with this) there is an upper horizontal wheel (shang phing lun) having a diameter of 3.3 ft and a circumference of 10 ft, with 100 cogs, the same distance apart as those of the small horizontal wheel (1.5 inches).

When the middle horizontal wheel has made 1 revolution, the carriage will have gone 1 li and the wooden figure in the lower story will strike the drum. When the upper horizontal wheel has made 1 revolution, the carriage will have gone 10 li and the figure in the upper storey will strike the bell. The number of wheels used, great and small, is 8 in all, with a total of 285 teeth. Thus the motion is transmitted as if by the links of a chain, the "dog-teeth" mutually engaging with each other, so that by due revolution everything comes back to its original starting point (ti hsiang kou so, chhuan ya hsiang chih, chou erh fu shih).

Subsequent Developments

Odometers were first developed in the 1600s for wagons and other horse-drawn vehicles in order to measure distances traveled. In 1645 Blaise Pascal invented the *pascaline*. The *pascaline* utilized gears to compute measurements. Each gear contained 10 teeth. The first gear advanced the next gear one position when moved one complete revolution, the same principle employed on modern mechanical odometers.

Odometers were developed for ships in 1698 with the odometer invented by the Englishman Thomas Savery. Benjamin Franklin, U.S. statesman and the first Postmaster General, built a prototype odometer in 1775 that he attached to his carriage to help measure the mileage of postal routes. In 1847, William Clayton, a Mormon traveller, invented the *Roadometer*, which he attached to a wagon used by American settlers heading west. The *Roadometer* recorded the distance travelled each day by the wagon trains.

In 1895 Curtis Hussey Veeder invented the *Cyclometer*. The *Cyclometer* was a mechanical device that counted the number of rotations of a bicycle wheel. A flexible cable transmitted the number of rotations of the wheel to an analog odometer visible to the rider, which converted the wheel rotations into the number of miles traveled according to a predetermined formula.

In 1903 Arthur P. and Charles H. Warner, two brothers from Beloit, Wisconsin, introduced their patented *Auto-meter*. The *Auto-Meter* used a magnet attached to a rotating shaft to induce a magnetic pull upon a thin metal disk. Measuring this pull provided accurate measurements of both distance and speed information to automobile drivers in a single instrument. The Warners sold their company in 1912 to the Stewart & Clark Company of Chicago. The new firm was renamed the Stewart-Warner Corporation. By 1925, Stewart-Warner magnetic speedometers were standard equipment on the vast majority of automobiles and motorcycles manufactured in the United States.

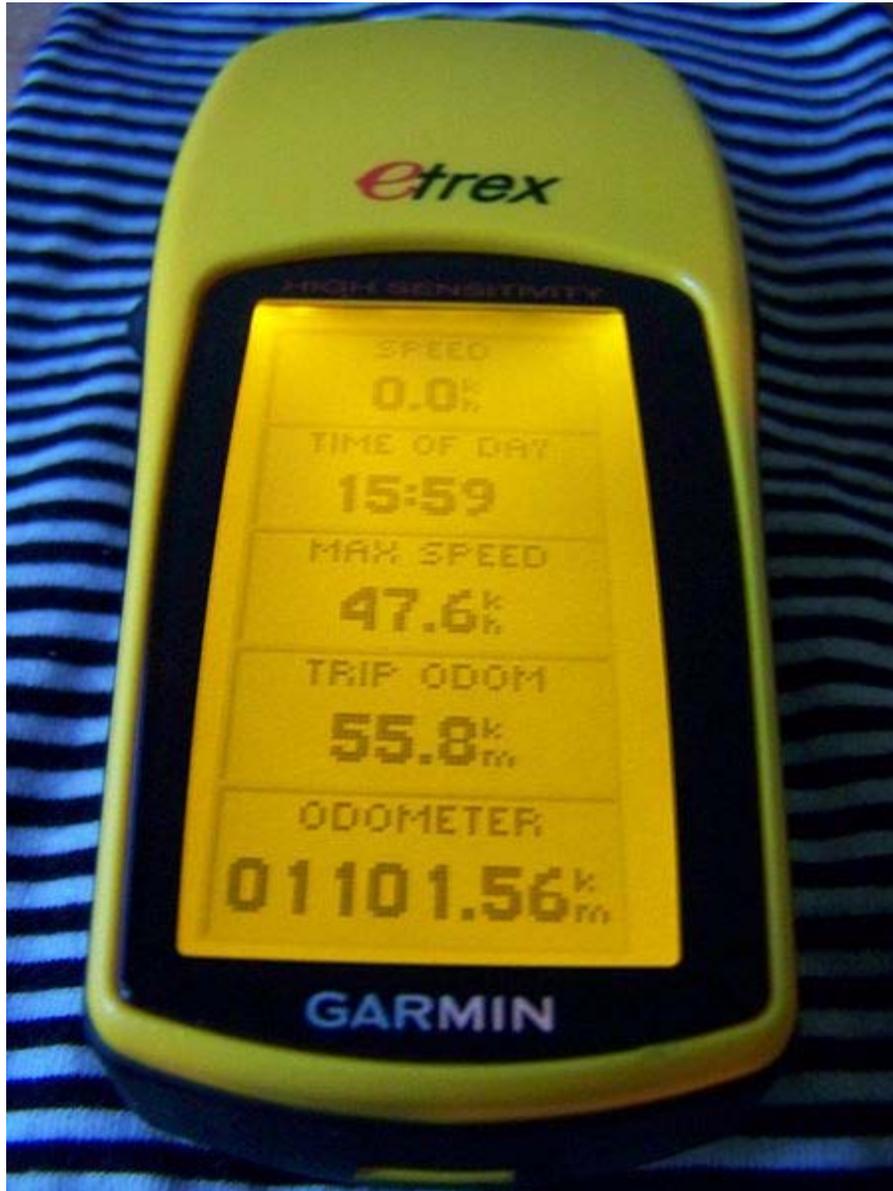
Clocking and legality

A common form of fraud is to tamper with the reading on an odometer; this is often referred to as clocking. This is done to make a car appear to have been driven less than it really has been, and thus increase its apparent market value. Many new cars sold today use digital odometers that store the mileage in the vehicle's engine control module making it difficult (but not impossible) to manipulate the mileage electronically. With mechanical odometers, the speedometer can be removed from the car dash board and the digits wound back, or the drive cable can be disconnected and connected to another odometer/speedometer pair while on the road. Modern odometers now add mileage driven in reverse to the total as if driven forward, to accurately reflect the true total wear and tear on the vehicle (older vehicles could be driven in reverse to subtract mileage).

The resale value of a vehicle is often strongly influenced by the number of miles or kilometres a passenger vehicle has on the odometer, yet odometers are inherently

insecure because they are under the control of their owners. Many jurisdictions have chosen to enact laws which penalize people who are found to commit odometer fraud. In the US (and many other countries), vehicle mechanics are also required to keep records of the odometer any time a vehicle is serviced. Companies such as Carfax then use this data to help potential car buyers detect whether odometer rollback has occurred.

GPS used as odometer



A Garmin etrex H GPS receiver, showing an odometer, trip odometer as well as speed related information

Recently, exercise enthusiasts have observed that an advanced Global Positioning System receiver (GPSr) with an odometer mode serves as a very accurate pedometer for outdoor

activities. While not truly counting steps (no pendulum is involved) an advanced GPS odometer can accurately reveal the distance traveled to within 1/100 of a mile (depending on the model, perhaps 1/1000 of a mile). 1/1000 of a mile is approximately the distance of a single pace or 2 steps (1.609 m). Precise metric odometers have a precision of 1/100 or 1/1000 km, 10 or 1 metre(s) respectively.

A GPS with odometer mode is also an excellent and inexpensive means to verify proper operation of both the speedometer and odometer mounted in a vehicle.

Odometer tax

This would be a road vehicle tax collected per distance unit of travel. This may become increasingly important with the increasing presence of gas burning vehicles & very fuel efficient electric models.

Chapter 11

Trip Computer and Cruise Control

Trip computer



Interior in a Saab GT850. A Halda Tripmaster can be seen in the middle at the bottom of the dashboard.

A **trip computer** is an onboard computer device fitted to cars which can generally record distance travelled, average speed, average fuel consumption, and display real time fuel consumption information. This computer can be found in various vehicles.



Trip computer function showing fuel and trip distance information.

The first mechanical trip computers such as the "Halda Speedpilot", produced by a Swedish taximeter manufacturer, were made in the 1950s as a car accessory to enable the driver to maintain a given time schedule, particularly useful in rallying. One was installed as standard in the 1958 Saab GT750. In 1978, General Motors Cadillac division introduced the "Cadillac Trip Computer" available on the Cadillac Seville. Electronic ones were fitted in General Motors products, and are still usually reserved for more upscale cars, although some lower-end models are fitted with them often as an option. They can range from basic to complex. The most basic varieties of the trip computer incorporate average fuel mileage and perhaps an outside temperature display. Middle-of-the-road versions will often incorporate trip information into a bundle and include information on fuel, speed, distance, cardinal heading (compass), and elapsed time. The most advanced trip computers are reserved for high-end cars and often feature average calculations for two drivers, a stop watch, tire pressure information, an over-speed warning tone, as well as a multitude of other features.

Sometimes the trip computer display will be incorporated into the gauge cluster, into the dashboard or navigation system screen, or in an overhead console. Some vehicles will convey maintenance information to the driver to inform them of scheduled maintenance. The current Acura TL does this in stages, first alerting the driver with a 'Due Soon' message. Once the programmed mileage is reached, it alerts 'Due Now'. If the vehicle is driven past a certain point, the message will change to 'Past Due'. Mercedes-Benz vehicles constantly monitor the quality of the oil and alert the driver of the need of a change when the oil degrades to a certain extent.

Some trip computers can display the diagnostic codes mechanics use. This is specially useful when the mechanic wants to see what the codes are while driving the car. In 2004 Linear Logic developed the ScanGauge which at the time was the only easily installed (via OBDII) accessory that works as a trip computer, 4 simultaneous digital gauges, and a diagnostic trouble code reader. This device has available 12 different measurements which can be used as the 4 digital gauges. The units of measure can be independently selected between miles/km, gallons/liters, Celsius/Fahrenheit, and PSI/KPA.

In 2008, the OBDuino project announced a low cost DIY trip computer design using the OBDII interface and the Arduino hobbyist microcontroller platform, released under the GPL open source license.

Cruise control



Cruise control mounted on a 2000 Jeep Grand Cherokee Steering Wheel

Cruise control (sometimes known as **speed control** or **autocruise**) is a system that automatically controls the speed of a motor vehicle. The system takes over the throttle of the car to maintain a steady speed as set by the driver.

History

Speed control with a centrifugal governor was used in automobiles as early as the 1910s, notably by Peerless. Peerless advertised that their system would "maintain speed whether up hill or down". The technology was invented by James Watt and Matthew Boulton in 1788 to control steam engines. The governor adjusts the throttle position as the speed of the engine changes with different loads.

Modern cruise control (also known as a speedostat) was invented in 1945 by the blind inventor and mechanical engineer Ralph Teetor. His idea was born out of the frustration of riding in a car driven by his lawyer, who kept speeding up and slowing down as he

talked. The first car with Teetor's system was the Chrysler Imperial in 1958. This system calculated ground speed based on driveshaft rotations and used a solenoid to vary throttle position as needed.

Theory of operation

In modern designs, the cruise control may need to be turned on before use — in some designs it is always "on" but not always enabled, others have a separate "on/off" switch, while still others just have an "on" switch that must be pressed after the vehicle has been started. Most designs have buttons for "set", "resume", "accelerate", and "coast" functions. Some also have a "cancel" button. Alternatively, depressing the brake or clutch pedal will disable the system so the driver can change the speed without resistance from the system. The system is operated with controls easily within the driver's reach, usually with two or more buttons on the steering wheel spokes or on the edge of the hub like those on Honda vehicles, on the turn signal stalk like in many older General Motors vehicles or on a dedicated stalk like those found in, particularly Toyota and Lexus. Earlier designs used a dial to set speed choice.

The driver must bring the vehicle up to speed manually and use a button to set the cruise control to the current speed. The cruise control takes its speed signal from a rotating driveshaft, speedometer cable, wheel speed sensor from the engine's RPM or from internal speed pulses produced electronically by the vehicle. Most systems do not allow the use of the cruise control below a certain speed (normally around 25 mph). The vehicle will maintain that speed by pulling the throttle cable with a solenoid, a vacuum driven servomechanism or by using the electronic systems built into the vehicle (fully electronic) if it uses a 'drive-by-wire' system.

All cruise control systems must be capable of being turned off both explicitly and automatically, when the driver depresses the brake and often also the clutch. Cruise control often includes a memory feature to resume the set speed after braking and a coast feature to disengage the system without braking. When the cruise control is engaged, the throttle can still be used to accelerate the car, but once the pedal is released the car will then slow down until it reaches the previously set speed.

On the latest vehicles fitted with electronic throttle control, cruise control can be easily integrated into the vehicle's engine management system. Modern "adaptive" systems include the ability to automatically reduce speed when the distance to a car in front, or the speed limit, decreases. This is an advantage for those driving in unfamiliar areas.

The cruise control systems of some vehicles incorporate a "speed limiter" function, which will not allow the vehicle to accelerate beyond a pre-set maximum; this can usually be overridden by fully depressing the accelerator pedal. (Note that most systems will prevent the vehicle accelerating beyond the chosen speed, but will not apply the brakes in the event of overspeeding downhill.)

Electronic Cruise Control

Daniel Aaron Wisner invented Automotive Electronic Cruise Control in 1968 as an engineer for RCA's Industrial and Automation Systems Division in Plymouth, Michigan. His invention described in two patents filed that year (#3570622 & #3511329), with the second modifying his original design by debuting digital memory, was the first electronic gadgetry to play a role in controlling a car and ushered in the computer-controlled era in the automobile industry. Two decades lapsed before an integrated circuit for his design was developed by Motorola Inc. as the MC14460 Auto Speed Control Processor in CMOS. As a result, cruise control was eventually adopted by automobile manufacturers as standard equipment and nearly every car built and many trucks are fitted with a configuration of the circuitry and hardware nearly identical to his prototype. The advantage of electronic speed control over its mechanical predecessor, which was featured on luxury models but never gained wide acceptance, was that it could be easily integrated with electronic accident avoidance and engine management systems.

Advantages and disadvantages

Some of those advantages include:

- Its usefulness for long drives (reducing driver fatigue, improving comfort by allowing positioning changes more safely) across Interstate highways and sparsely populated roads. This usually results in better fuel efficiency.
- Some drivers use it to avoid unconsciously violating speed limits. A driver who otherwise tends to unconsciously increase speed over the course of a highway journey may avoid a speeding ticket. Such drivers should note, however, that a cruise control may go over its setting on a downhill which is steep enough to accelerate with an idling engine. Note however, that in many jurisdictions, officers cannot write a ticket for a violation of a speed limit due to a steep hill.

However, cruise control can also lead to accidents due to several factors, such as:

- The lack of need to maintain constant pedal pressure, which can help lead to accidents caused by highway hypnosis or incapacitated drivers; future systems may include a dead man's switch to avoid this.
- When used during inclement weather or while driving on wet or snow- and/or ice-covered roads, the vehicle could go into a skid (although this may be somewhat mitigated by cars equipped with Electronic Stability Control). Stepping on the brake — such as to disengage the cruise control — often results in the driver losing control of the vehicle.

Driving over "rolling" terrain, with gentle up and down portions, can usually be done more economically (using less fuel) by a skilled driver viewing the approaching terrain, by maintaining a relatively constant throttle position and allowing the vehicle to accelerate on the downgrades and decelerate on upgrades, while reducing power when cresting a rise and adding a bit before an upgrade is reached. Cruise control will tend to

overthrottle on the upgrades and retard on the downgrades, wasting the energy storage capabilities available from the inertia of the vehicle. The inefficiencies from cruise control can be even greater relative to skilled driving in hybrid vehicles.

Many countries establish that it is illegal to drive within city limits with the cruise control feature activated.

Adaptive cruise control

Some modern vehicles have **adaptive cruise control (ACC)** systems, which is a general term meaning improved cruise control. These improvements can be automatic braking or dynamic set-speed type controls.

Automatic Braking Type: The automatic braking type use either a radar or laser setup to allow the vehicle to keep pace with the car it is following, slow when closing in on the vehicle in front and accelerating again to the preset speed when traffic allows. Some systems also feature forward collision warning systems, which warns the driver if a vehicle in front - given the speed of both vehicles - gets too close (within the preset headway or braking distance).

Dynamic Set Speed Type: The dynamic set speed uses the GPS position of speed limit signs, from a database. Some are modifiable by the driver.

Chapter 12

Steering Wheel



A modern road car's steering wheel (Volvo S70)



Steering wheels from different periods

A **steering wheel** (also called a **driving wheel** or **hand wheel**) is a type of steering control in vehicles and vessels (ships and boats).

Steering wheels are used in most modern land vehicles, including all mass-production automobiles as well as light and heavy trucks. The steering wheel is the part of the steering system that is manipulated by the driver; the rest of the steering system responds to such driver inputs. This can be through direct mechanical contact as in recirculating ball or rack and pinion steering gears, without or with the assistance of hydraulic power steering, HPS, or as in some modern production cars with the assistance of computer controlled motors, known as Electric Power Steering. With the introduction of federal vehicle regulation in the United States in 1968, FMVSS 114 required the impairment of steering wheel rotation, to hinder motor vehicle theft; in most vehicles this is accomplished when the ignition key is removed from the ignition lock.

History



Rigid steering column and wheel in a Packard from 1920s



Steering wheel in a Chrysler Airflow from the 1930s



Steering wheel on a collapsible column in an AMC Matador from the 1970s

The first automobiles were steered with a tiller, but in 1894 Alfred Vacheron took part in the Paris-Rouen race with a Panhard 4 hp model which he had fitted with a steering wheel. That is believed to be one of the earliest employments of the principle.

From 1898 the Panhard et Levassor cars were equipped as standard with steering wheels. C S Rolls introduced the first car in Britain fitted with a steering wheel when he imported a 6 hp Panhard from France in 1898. Arthur Constantin Krebs replaced the tiller with an inclined steering wheel for the Panhard car he designed for the Paris-Amsterdam race which ran 7–13 July 1898. In 1899 Packard used a steering wheel on the second car they built.

In 1898, Thomas B. Jeffery and his son, Charles T. Jeffery, developed two advanced experimental cars featuring a front-mounted engine, as well as a steering wheel that was mounted on the left-hand side. However, the early automaker adopted a more “conventional” rear-engine and tiller-steering layout for its first mass-produced Ramblers in 1902. The following year, the Rambler Model E was largely unchanged, except that it came equipped with a tiller early in the year, but with a steering wheel by the end of 1903. By 1904, all Ramblers featured steering wheels. Within a decade, the steering wheel had entirely replaced the tiller in automobiles. At the insistence of Thomas B. Jeffery, the position of the driver was also moved to the left-hand side of the car during

the 1903 Rambler production. Most other car makers began offering cars with left-hand drive in 1910. Soon after, most cars in the U.S. convert to left hand drive.

Passenger cars

Steering wheels for passenger automobiles are generally circular, and are mounted to the steering column by a hub connected to the outer ring of the steering wheel by one or more spokes (single spoke wheels being a rather rare exception). Other types of vehicles may use the circular design, a butterfly shape, or some other shape. In countries where cars must drive on the left side of the road, the steering wheel is typically on the right side of the car (right-hand drive or RHD); the converse applies in countries where cars drive on the right side of the road (left-hand drive or LHD).

In addition to its use in steering, the steering wheel is the usual location for a button to activate the car's horn. Modern automobiles may have other controls, such as cruise control and audio system controls built into the steering wheel to minimize the extent to which the driver must take their hands off the wheel.

The steering wheels were rigid and mounted on non-collapsible steering columns. This arrangement increased the risk of impaling the driver in case of a severe crash. The first collapsible steering column was invented in 1934 but was never successfully marketed. In 1968, United States regulations (FMVSS Standard No. 204) were implemented concerning the acceptable rearward movement of the steering wheel in case of crash. Collapsible steering columns were required to meet that standard.

Power steering gives the driver an easier means by which the steering of a car can be accomplished. Modern power steering have almost universally relied on a hydraulic system, although electrical systems are steadily replacing this technology. Mechanical power steering systems (ex. Studebaker, 1952) have been invented, but their weight and complexity negate the benefits that they provide.

While other methods of steering passenger cars have resulted from experiments, for example the "wrist-twist instant steering" Mercury Park Lanes controlled by two 5-inch (127 mm) rings, none have yet been deployed as successfully as the conventional large steering wheel.

Other designs

The steering wheel is centrally located on certain high-performance sports cars, such as the McLaren F1, and in the majority of single-seat racing cars.

As a driver may have his hands on the steering wheel for hours at a time these are designed with ergonomics in mind. However, the most important concern is that the driver can effectively convey torque to the steering system; this is especially important in vehicles without power steering or in the rare event of a loss of steering assist. A typical design for circular steering wheels is a steel or magnesium rim with a plastic or

rubberized grip molded over and around it. Some drivers purchase vinyl or textile steering wheel covers to enhance grip or comfort, or simply as decoration. Another device used to make steering easier is the brodie knob.

A similar device in aircraft is the yoke. Water vessels not steered from a stern-mounted tiller are directed with the ship's wheel, which may have inspired the concept of the steering wheel.

Early Formula One cars used steering wheels taken directly from road cars. They were normally made from wood (necessitating the use of driving gloves), and in the absence of packaging constraints they tended to be made as large a diameter as possible, to reduce the effort needed to turn. As cars grew progressively lower and cockpits narrower throughout the 1960s and 1970s, steering wheels became smaller, so as to fit into the more compact space available.

Spokes in steering wheel



Banjo steering wheel

The number of spokes in the steering wheel has continuously changed. Most early cars had four-spoke steering wheels.

A Banjo Steering Wheel was an option on many early automobiles. Banjo Wheels predate power steering. The wire spokes were a buffer or absorber between the driver's hands and the drum of the road. Most were 3 or 4 spokes made of four or five wires in each spoke, hence the name "Banjo".

Adjustable steering wheels

Tilt Wheel

The original Tilt Wheel was developed by Edward James Lobdell in the early 1900s. The seven position Tilt Wheel was made available in several General Motors products in 1963. Originally a luxury option on cars, the **tilt** function helps to adjust the steering wheel by moving the wheel through an arc in an up and down motion. Tilt Steering Wheels rely upon a ratchet joint located in the steering column just below the steering wheel. By disengaging the ratchet lock, the wheel can be adjusted upward or downward while the steering column remains stationary below the joint. Some designs place the pivot slightly forward along the column, allowing for a fair amount of vertical movement of the steering wheel with little actual tilt, while other designs place the pivot almost inside the steering wheel, allowing adjustment of the angle of the steering wheel with almost no change in its height.

Telescope Wheel

Developed by General Motors Saginaw Steering Gear Division (now Nexteer Automotive), the telescoping wheel can be adjusted to an infinite number of positions in a 3-inch range. The Tilt *and* Telescope steering wheel was introduced as an exclusive option on Cadillac automobiles in 1965.

Adjustable Steering Column

In contrast, an adjustable steering column allows steering wheel height to be adjusted with only a small, useful change in tilt. Most of these systems work with compression locks or electric motors instead of ratchet mechanisms; the latter may be capable of moving to a memorized position when a given driver uses the car, or of moving up and forward for entry or exit.

Swing-away Steering Wheel

Introduced on the 1961 Ford Thunderbird, and made available on other Ford products throughout the 1960s, the Swing-away steering wheel allowed the steering wheel to move nine inches to the right when the transmission selector was in Park, so as to make driver exit and entry easier.



A steering wheel with the airbag module removed

Usage

The steering wheel should be used with strategic movements of the hand and wrist in spinning motions. Caution and care should be used to ensure safety of the extremities. The constant motions used must be performed with caution. "Proper posture of the hand-arm system while using hand tools is very important. As a rule the wrist should not be bent, but must be kept straight to avoid overexertion of such tissues as tendons and tendon sheaths and compression of nerves and blood vessels."

The act of turning the steering wheel while the vehicle is stationary is called dry steering. It is generally advised to avoid dry steering as it puts strain on the steering mechanism and causes undue wear of the tires.

Buttons and controls on the steering wheel



A modern Formula One car's steering wheel has buttons and knobs to control various functions as well as gauges and other important items normally found on a dashboard.

The first button added to the steering wheel was a switch to activate the car's electric horn. Traditionally located on the steering wheel hub or center pad, the horn switch was sometimes placed on the spokes or activated via a decorative horn ring which obviated the necessity to move a hand away from the rim. A further development, the Rim Blow steering wheel, integrated the horn switch into the steering wheel rim itself.

When speed control systems were introduced in the 1960s, some automakers located the operating switches for this feature on the steering wheel. In the 1990s, a proliferation of new buttons began to appear on automobile steering wheels. Remote or alternate adjustments for the audio system, the telephone and voice control, acoustic repetition of the last navigation instruction, stereo system, and on board computer functions can be operated comfortably and safely using buttons on the steering wheel. This ensures a high standard of additional safety since the driver is able in this way to control and operate many systems without even taking hands off the wheel or eyes off the road.

The scroll buttons can be used to set volume levels or page through menus.

Steering wheel audio control can use universal interfaces, wired or wirelessly.

The buttons can be adjusted manually for reach and height.

Gaming imitations

Certain game controllers available for arcade cabinets, personal computers and console games are designed to look and feel like a steering wheel and intended for use in racing games. The cheapest ones are just paddle controllers with a larger wheel, but most today's examples employ force feedback to simulate the tactile feedback a real driver feels from a steering wheel. This contributes to steering "feel" and is one of the hallmarks of a true "driver's car" or sports car.

Chapter 13

Automatic Vehicle Location

Automatic vehicle location (AVL or ~locating; telelocating in EU) is a means for automatically determining the geographic location of a vehicle and transmitting the information to a requester.

Most commonly, the location is determined using GPS, and the transmission mechanism is SMS, GPRS, a satellite or terrestrial radio from the vehicle to a radio receiver. GSM and EVDO are the most common services applied, because of the low data rate needed for AVL, and the low cost and near-ubiquitous nature of these public networks. The low bandwidth requirements also allow for satellite technology to receive telemetry data at a moderately higher cost, but across a global coverage area and into very remote locations not covered well by terrestrial radio or public carriers. Other options for determining actual location, for example in environments where GPS illumination is poor, are dead reckoning, i.e. inertial navigation, or active RFID systems or cooperative RTLS systems. With advantage, combinations of these systems may be applied. In addition, terrestrial radio positioning systems utilizing an LF (Low Frequency) switched packet radio network were also used as an alternative to GPS based systems.

Applications

Application with vehicles

Automatic vehicle locating is a powerful concept for managing fleets of vehicles, as service vehicles, emergency vehicles, and especially precious construction equipment, also public transport vehicles (buses and trains). It is also used to track mobile assets, such as non wheeled construction equipment, non motorized trailers, and mobile power generators.

Application with vehicle drivers and crews

The other purpose of tracking is to provide graded service or to manage a large driver and crewing staff effectively. For example, suppose an ambulance fleet has an objective of arriving at the location of a call for service within six minutes of receiving the request. Using an AVL system allows to evaluate the locations of all vehicles in service with driver and other crew in order to pick the vehicle that will most likely arrive at the destination fastest, (meeting the service objective).

Types of systems

Simple direction finding

Amateur radio and some cellular or PCS wireless systems use **direction finding or triangulation** of transmitter signals radiated by the mobile. This is sometimes called **radio direction finding or RDF**. The simplest forms of these systems calculate the bearing from two fixed sites to the mobile. This creates a triangle with endpoints at the two fixed points and the mobile. Trigonometry tells you roughly where the mobile transmitter is located. In wireless telephone systems, the phones transmit continually when off-hook, making continual tracking and the collection of many location samples possible. This is one type of location system required by Federal Communications Commission Rules for wireless Enhanced 911.

Former LORAN-based locating

Motorola offered a 1970s-era system based on the United States Coast Guard LORAN maritime navigation system. The LORAN system was intended for ships but signal levels on the US east- and west-coast areas were adequate for use with receivers in automobiles. The system may have been marketed under the Motorola model name *Metricom*. It consisted of an LF LORAN receiver and data interface box/modem connected to a separate two-way radio. The receiver and interface calculated a latitude and longitude in degrees, decimal degrees format based on the LORAN signals. This was sent over the radio as MDC-1200 or MDC-4800 data to a system controller, which plotted the mobile's approximate location on a map. The system worked reliably but sometimes had problems with electrical noise in urban areas. Sparking electric trolley poles or industrial plants which radiated electrical noise sometime overwhelmed the LORAN signals, affecting the system's ability to determine the mobile's geolocation. Because of the limited resolution, this type of system was impractical for small communities or operational areas such as a pit mine or port.

Signpost systems

To track and locate vehicles along fixed routes, a technology called **Signpost transmitters** is employed. This is used on transit routes and rail lines where the vehicles to be tracked continually operated on the same linear route. A transponder or RFID chip along the vehicle route would be polled as the train or bus traverses its route. As each

transponder was passed, the moving vehicle would query and receive an ack, or handshake, from the signpost transmitter. A transmitter on the mobile would report passing the signpost to a system controller. This allows supervision, a call center, or a dispatch center to monitor the progress of the vehicle and assess whether or not the vehicle was *on schedule*. These systems are an alternative inside tunnels or other conveyances where GPS signals are blocked by terrain.

Today's GPS-based locating

The low price and ubiquity of Global Positioning System or GPS equipment has lent itself to more accurate and reliable telelocation systems. GPS signals are impervious to most electrical noise sources and don't require the user to install an entire system. Usually only a receiver to collect signals from the satellite segment is installed in each vehicle and radio or GSM to communicate the collected location data with a dispatch point.

Large private telelocation or AVL systems send data from GPS receivers in vehicles to a dispatch center over their private, user-owned radio backbone. These systems are used for businesses like parcel delivery and ambulances. Smaller systems which don't justify building a separate radio system use cellular or PCS data services to communicate location data from vehicles to their dispatching center. Location data is periodically polled from each vehicle in a fleet by a central controller or computer. In the simplest systems, data from the GPS receiver is displayed on a map allowing humans to determine the location of each vehicle. More complex systems feed the data into a computer assisted dispatch system which automates the process. For example, the computer assisted dispatch system may check the location of a call for service and then pick a list of the four closest ambulances. This narrows the dispatcher's choice from the entire fleet to an easier choice of four vehicles.

Some wireless carriers such as Nextel have decided GPS was the best way to provide the mandated location data for wireless Enhanced 9-1-1. Newer Nextel radios have embedded GPS receivers which are polled if 9-1-1 is dialed. The 9-1-1 center is provided with latitude and longitude from the radio's GPS receiver. In centers with computer assisted dispatch, the system may assign an address to the call based on these coordinates or may project an icon depicting the caller's location onto a map of the area.

Sensor-augmented AVL

The main purpose of using AVL is not only to locate the vehicles, but also to obtain information about engine data, fuel consumption, driver data and sensor data from i.e. doors, freezer room on trucks or air pressure. Such data can be obtained via the CAN-bus, via direct connections to AVL systems or via open bus systems such as UFDEX that both sends and receives data via SMS or GPRS in pure ASCII text format. Because most AVL consists of two parts, GPS and GSM modem with additional embedded AVL software contained in a microcontroller, most AVL systems are fixed for its purposes unless they connect to an open bus system for expansion possibilities.

With an open bus system the users can send invoices based on goods delivered with exact location, time and date data where if connected to scale, RFID or barcode readers, can make a fairly good automated system to avoid human errors.

In countries with high prices on gasoline external fuel sensors are used to prevent cases of fuel theft.

Logbook functions

Another scenario for sensor functions is to connect the AVL to driver information, to collect data about driving time, stops, or even driver absence from the vehicle. If the driver/worker conditions is such as the hourly rates for driving and working outside is not the same, this can be monitored by sensors, by using iButton or other personal identification devices. Later by analyzing log-file it is possible to get reports on any kind of events, like stops, visited streets, speed limits violations, etc.

Differentiating between Automatic Vehicle Location and Events Activated Tracking Systems

It might be helpful to draw a distinction between vehicle location systems which track automatically and event activated tracking systems which track when triggered by an event. There is increasingly crossover between the different systems and those with experience of this sector will be able to draw on a number of examples which break the rule.

A.V.L (Automatic Vehicle Location) This type of vehicle tracking is normally used in the fleet or driver management sector. The unit is configured to automatically transmit it's location at a set time interval, e.g. every 5 minutes. The unit is activated when the ignition is switched on/off.

E.A.T.S (Events Activated Tracking system) This type of system is primarily used in connection with vehicle or driver security solutions. If, for example a thief breaks into your car and attempts to steal it, the tracking system can be triggered by the immobiliser unit or motion sensor being activated. A monitoring bureau, will then be automatically notified that the unit has been activated and begin tracking the vehicle.

Some products on the market are a hybrid of both AVL and EATS technology. However industry practice has tended to lean towards a separation of these functions. It is worth taking note that vehicle tracking products tend to fall in to one, not both of the technologies.

AVL technology is predominately used when applying vehicle tracking to fleet or driver management solutions. The use of Automatic Vehicle Location is given in the following scenario; A car breaks down by the side of the road and the occupant calls a vehicle recovery company. The vehicle recovery company has several vehicles operating in the area. Without needing to call each driver to check his location the dispatcher can pinpoint

the nearest recovery vehicle and assign it to the new job. If you were to incorporate the other aspects of vehicle telematics into this scenario; the dispatcher, rather than phoning the recovery vehicle operative, could transmit the job details directly to the operative's mobile data device, who would then use the in-vehicle satellite navigation to aid his journey to the job.

EATS technology is predominately used when applying vehicle tracking to vehicle security solutions. An example of this distinction is given in the following scenario; A construction company owns some pieces of plant machinery that are regularly left unattended, at weekends, on building sites. Thieves break onto one site and a piece of equipment, such as a digger, is loaded on the back of a flat bed truck and then driven away. Typically the ignition wouldn't need to be turned on and as such most of the AVL products available wouldn't typically be activated. Only products that included a unit that was activated by a motion sensor or GeoFence alarm event, would be activated.

Both AVL and EATS systems track, but often for different purposes.

Special applications of automatic vehicle locating

Vehicle location technologies can be used in the following scenarios:

- **Fleet management:** when managing a fleet of vehicles, knowing the real-time location of all drivers allows management to meet customer needs more efficiently. Vehicle location information can also be used to verify that legal requirements are being met: for example, that drivers are taking rest breaks and obeying speed limits.
- **Passenger Information:** Real-time Passenger information systems use predictions based on AVL input to show the expected arrival and departure times of Public Transport services.
- **Asset tracking:** companies needing to track valuable assets for insurance or other monitoring purposes can now plot the real-time asset location on a map and closely monitor movement and operating status. For example, haulage and logistics companies often operate trucks with detachable load carrying units. In this case, trailers can be tracked independently of the cabs used to drive them. Combining vehicle location with inventory management that can be used to reconcile which item is currently on which vehicle can be used to identify physical location down to the level of individual packages.
- **Field worker management:** companies with a field service or sales workforce can use information from vehicle tracking systems to plan field workers' time, schedule subsequent customer visits and be able to operate these departments efficiently.

- **Covert surveillance:** vehicle location devices attached covertly by law enforcement or espionage organizations can be used to track journeys made by individuals who are under surveillance

Chapter 14

Automotive Navigation System



A taxi equipped with GPS navigation device

An **automotive navigation system** is a satellite navigation system designed for use in automobiles. It typically uses a GPS navigation device to acquire position data to locate the user on a road in the unit's map database. Using the road database, the unit can give directions to other locations along roads also in its database. Dead reckoning using distance data from sensors attached to the drivetrain, a gyroscope and an accelerometer can be used for greater reliability, as GPS signal loss and/or multipath can occur due to urban canyons or tunnels.

Some sorts can be taken out of the car and used hand-held while walking.

History

Automotive navigation systems were the subject of extensive experimentation, including some efforts to reach mass markets, prior to the availability of commercial GPS.

Most major technologies required for modern automobile navigation were already established when the microprocessor emerged in the 1970s to support their integration and enhancement by computer software. These technologies subsequently underwent extensive refinement, and a variety of system architectures had been explored by the time practical systems reached the market in the late 1980s. Among the other enhancements of the 1980s was the development of color displays for digital maps and of CD-ROMs for digital map storage.

However, there is some question about who made the first *commercially available* automotive navigation system. There seems to be little room for doubt that Etak was first to make available a digital system that used map-matching to improve on dead reckoning instrumentation. Etak's systems, which accessed digital map information stored on standard cassette tapes, arguably made car navigation systems practical for the first time. However, Japanese efforts on both digital and analog systems predate Etak's founding.

Steven Lobbezoo developed the first commercially available satellite navigation system for cars. It was produced in Berlin from start 1984 to January 1986. Publicly presented first at the Hannover fair in 1985 in Germany, the system was shown in operation on the evening news (item in the Hannover fair) from the first German television channel in that year. It used a modified IBM PC, a large disc for map data and a flat screen, built into the glove compartment. It was called Homer (after the device from a James Bond movie).

Alpine claims to have created the first automotive navigation system in 1981. However, according to the company's own historical timeline, the company claims to have *co-*developed an analog automotive navigation product called the Electro Gyrocator, working with Honda. This engineering effort was abandoned in 1985. Although there are reports of the Electro Gyrocator being offered as a dealer option on the Honda Accord in 1981, it's not clear whether an actual product was released, whether any customers took delivery of an Electro Gyrocator-equipped Accord, or even whether the unit appeared in any dealer showrooms; Honda's own official history appears to pronounce the Electro Gyrocator as not practical.

Honda claims to have created the first navigation system starting in 1983, and culminating with general availability in the 1990 Acura Legend. The original analog Electro Gyrocator system used an accelerometer to navigate using inertial navigation, as the GPS system was not yet generally available. However, it appears from Honda's concessions in their own account of the Electro Gyrocator project that Etak actually trumped Honda's analog effort with a truly practical digital system, albeit one whose effective range of operation was limited by the availability of appropriately digitized street map data.

[...] progress in digital technology would not stop simply because Honda had turned its attention to analog. In 1985, for example, the U.S. company ETAK introduced its own digital map navigation system. Although the system's effective range-the area of geographical coverage-was limited, the announcement was a dour one for Nakamura and his staff. Therefore, ultimately the development of a practical analog system was shelved. The staff experienced indescribable feelings of disappointment. The development of [Honda's] digital map navigation system resumed in 1987, following a three-year hiatus.

Both Mitsubishi Electric and Pioneer claim to be the first with a GPS-based auto navigation system, in 1990. Also in 1990, a draft patent application was filed within Digital Equipment Co. Ltd. for a multi-function device called PageLink that had real-time maps for use in a car listed as one of its functions.

Magellan, a GPS navigation system manufacturer, claims to have created the first GPS-based vehicle navigation system in the U.S. in 1995.

In 1995, Oldsmobile introduced the first GPS navigation system available in a production car, called GuideStar. There also was an Oldsmobile navigation system available as an option as early as 1994 called the Oldsmobile Navigation/Information System. It was an option on the Oldsmobile Eighty Eight.

However it was not until 2000 that the United States made a more accurate GPS signal available for civilian use.

Technology

Visualization

Navigation systems may (or may not) use a combination of any of the following:

- top view for the map
- top view for the map with the map rotating with the automobile (so that "up" on the map always corresponds to "forward" in the vehicle)
- bird's-eye view for the map or the next curve
- linear gauge for distance, which is redundant if a rotating map is used
- numbers for distance
- schematic pictograms
- voice prompts

Road database

Contents

The road database is a vector map of some area of interest. Street names or numbers and house numbers are encoded as geographic coordinates so that the user can find some desired destination by street address.

Points of interest (waypoints) will also be stored with their geographic coordinates. Point of interest specialties include speed cameras, fuel stations, public parking, and "parked here" (or "you parked here").

Contents can be produced by the user base as their cars drive along existing streets (Wi-Fi) and communicating via the internet, yielding a free and up-to-date map.

Map formats

Formats are almost uniformly proprietary; there is no industry standard for satellite navigation maps, although NAVTEQ are currently trying to address this with S-Dal.

The map data vendors such as Tele Atlas and NAVTEQ create the base map in a standard format GDF, but each electronics manufacturer compiles it in an optimized, usually proprietary format. GDF is not a CD standard for car navigation systems. GDF is used and converted onto the CD-ROM in the internal format of the navigation system.

CARiN

CARiN Database Format (CDF) is a proprietary navigation map format created by Philips Car Systems (this branch was sold to Mannesman VDO, VDO/Dayton in 1998, to Siemens VDO in 2002, and Continental in 2007.) and is used in a number of navigation-equipped vehicles. The 'CARiN' portmanteau is derived from **Car** Information and Navigation.

S-Dal

This is a proprietary map format published by NAVTEQ, who released it royalty free in the hope that it would become an industry standard for digital navigation maps. Vendors currently using this format include:

- Microsoft
- Magellan
- Pioneer
- Panasonic
- Clarion
- InfoGation

The format has not been very widely adopted by the industry.

Physical Storage Format

The Physical Storage Format (PSF) initiative is an industry grouping of car manufacturers, navigation system suppliers and map data suppliers whose objective is the standardization of the data format used in car navigation systems, as well as allow a map update capability. Standardization would improve interoperability, specifically by

allowing the same navigation maps to be used in navigation systems from 19 manufacturers. Companies involved include BMW, Volkswagen, Daimler, Renault, ADIT, Aisin AW, Alpine Electronics, Navigon, Bosch, DENSO, Mitsubishi, Harman Becker, Panasonic, PTV, Continental AG, Clarion, NAVTEQ, Tele Atlas and Zenrin.

Media

The road database may be stored in solid state read-only memory (ROM), optical media (CD or DVD), solid state flash memory, magnetic media (hard disk), or a combination. A common scheme is to have a base map permanently stored in ROM that can be augmented with detailed information for a region the user is interested in. A ROM is always programmed at the factory; the other media may be preprogrammed, downloaded from a CD or DVD via a computer or wireless connection (bluetooth, Wi-Fi), or directly used utilizing a card reader.

Some navigation device makers provide free map updates for their customers. These updates are often obtained from the vendor's website, which is accessed by connecting the navigation device to a PC.

Real-time data

Some newer systems can not only give precise driving directions, they can also receive and display information on traffic congestion and suggest alternate routes. These may use either TMC, which delivers coded traffic information using radio RDS, or by GPRS/3G data transmission via mobile phones.

One key type of real-time data is traffic information, which includes:

- Real-time data about free/full parkings;
- Nearest public transport lines and prices, to go to a destination, when there is a jam.

Other real-time data includes weather broadcasting, etc.

Integration and other functions

- The color LCD screens on some automotive navigation systems can also be used to display television broadcasts or DVD movies.
- A few systems integrate (or communicate) with mobile phones for hands-free talking and SMS messaging (i.e., using Bluetooth or Wi-Fi).
- Automotive navigation systems can include personal information management for meetings, which can be combined with a traffic and public transport information system.

Controversy

Safety features

Vehicles produced by Subaru and Lexus, as well as Lexus' parent company, Toyota, lock out many of the features when the vehicle is in motion. The manufacturers claim this is a safety feature to avoid the driver being distracted. Many users have complained that passengers are not able to enter destinations while in motion, even though it is safe to do so. Additionally, drivers have complained that it is often more dangerous to pull off a highway and stop than it would be to enter a destination into the system.

Misdirection

A number of road accidents in the UK have been attributed to misdirection by satellite navigation systems. On May 11, 2007, a driver followed satellite navigation instructions in the dark and her car was hit by a train on a rail crossing that was not shown on the system. In Exton, Hampshire, the County Council erected a sign warning drivers to ignore their "sat nav" system and to take another route, because the street was too narrow for vehicular traffic and property damage resulted from vehicles getting stuck.

On March 25, 2009, a man drove down a steep mountain path and almost off of a cliff after he was allegedly directed by his portable GPS system. He was finally stopped by a wire fence.

Misdirection can also occur when a road is altered either permanently or temporarily, such as during road re-construction.

GPS vs speed camera accuracy

In July 2007, an Australian man successfully overturned a speeding conviction after evidence from a GPS navigational track proved that he did not exceed the speed limit.

Other functions

- Golf Carts may have integrated GPS rangefinders tailored to specific golf courses, providing interactive course maps and live readings of distance measurements to the green.
- Many systems can give information on nearby points of interest (POIs), such as restaurants, cash machines and gas stations. Some navigation devices use this feature to store the location of known speed traps or speed cameras, and can alert the driver in much the same way as a radar detector. GPS may also be integrated into actual radar detection devices to enhance accuracy, and in some cases, implement a logic system where the system only alerts if the driver is traveling above the speed limit or in the direction to be 'caught.' Unlike radar detectors, GPS-based speed trap warnings are currently legal in many countries.

- Some systems feature internet connectivity, either via Bluetooth to a mobile phone (in which case the device can typically also be used for hands-free calling), or with a built in GSM SIM card. This connectivity can be used for up-to-date traffic information, to find fuel prices, as well as to search for local distances. Such devices include the TomTom LIVE series, and the Garmin nüvi 1690.
- The radio dispatching of taxicabs have been phased out in several countries in favor of GPS technology plus some form of mobile networking with on board computers. The central dispatch computer keeps track of all vehicles in its fleet, and automatically selects the nearest cab to respond to a passenger request.
- Advanced car security vehicle tracking systems can relay the vehicle's location via cellular phone services in case of loss or theft. The technology can also be used to manage fleet vehicles, in which case it's known as automatic vehicle location.
- In Taipei, GPS receivers have several applications on city buses. They enable automatic station approach announcements, provides ETA information for passengers waiting at bus stops or using mobile devices. Finally, GPS data is recorded along with video surveillance footage, which is helpful when investigating traffic incidents.

Retrofitting of GPS

A vehicle can be retrofitted with a GPS navigation device unit if it did not originally have one. There are three approaches that can be taken here:

Portable GPS

This type of GPS navigation device is not permanently integrated into the vehicle, having only a simple bracket to mount the device on the surface of the dashboard and powered via the car cigarette lighter. This class of GPS unit does not require professional installation and can typically be used as handheld device, too.

Benefits of this type of GPS unit include low cost as well as the ability to move them easily to other vehicles. Their portability means they are easily stolen if left inside the vehicle. Furthermore, not having a compass, accelerometer or inputs from the vehicle's speed sensors, means that they cannot navigate as accurately by dead reckoning as some built-in devices when there's no GPS signal. More modern portable devices such as the TomTom 920, have an inbuilt accelerometer to try to address this.

A portable automotive navigation system kit generally includes:

- Mini-USB sync cable
- AC adaptor
- Car charger
- Car mount kit
- Pouch
- Wrist band

- External antenna (optional by model)
- Stylus
- Battery pack
- Document kit
- SD card with preload map (sometimes capable of shuffling MP3 playlists)
- Companion CD-ROM
- Navigation software CD-ROM



Early Factory Navigation System (as fitted to 1997 UK Specification Ford Mondeo)

Original factory equipment

Many vehicle manufacturers offer a GPS navigation device as an option in their vehicles. Customers whose vehicles did not ship with GPS can therefore purchase and retrofit the original factory-supplied GPS unit. In some cases this can be a straightforward "plug-and-play" installation if the required wiring harness is already present in the vehicle. However, with some manufacturers, new wiring is required, making the installation more complex.



Modern Factory Navigation System (as fitted to a 2009 U.S. Honda Accord)

The primary benefit of this approach is an integrated and factory-standard installation. Many original systems also contain a gyrocompass or accelerometer and may accept input from the vehicle's speed sensors, thereby allowing them to navigate via dead reckoning when a GPS signal is temporarily unavailable. However, the costs can be considerably higher than other options. In some cases, it may even be more economical to buy a similar vehicle that already has a factory-fitted GPS.

Aftermarket

A number of manufacturers supply aftermarket GPS navigation devices that can be integrated permanently into the vehicle. A typical location for such an installation is the DIN slot for the radio/tape/CD. However, in extreme cases, the dashboard may also be remodeled to accommodate the unit.

This approach can be considered a trade off between the previous two options. Benefits include a more secure and better cosmetic finish than a portable device, and lower cost compared to the installation of an original factory-supplied GPS.

Alternatives

Smartphones with GPS, and other navigation devices, may also be used without installing in a car.

SMS

Establishing points of interest in real-time and transmitting them via GSM cellular telephone networks using the Short Message Service (SMS) is referred to as Gps2sms. Some vehicles and vessels are equipped with hardware that is able to automatically send an SMS text message when a particular event happens, such as theft, anchor drift or breakdown. The receiving party (e.g., a tow truck) can store the waypoint in a computer system, draw a map indicating the location, or see it in an automotive navigation system.

Example systems



Navigon

- Acer e300 series
- Clarion
- EB street director

- Garmin
- Gizmondo
- Hertz Neverlost
- iGo (software)
- MapmyIndia
- Kenwood DNX-5120
- Magellan Navigation
- Mio Technology
- Navigon
- NDrive
- Navman iCN series
- Ovi Maps
- Pioneer
- Teletype Software
- TomTom
- VDO Dayton
- Sygic Mobile Maps/Tele Atlas
- Wayfinder Navigator
- Waze

Chapter 15

Power Steering

The term **power steering** is usually used to describe a system that provides mechanical steering assistance to the driver of a land vehicle, for example, a car or truck. The power steering system in a vehicle is a type of servomechanism.

For many drivers, turning the steering wheel in a vehicle that doesn't have power steering requires more force (torque) than the driver finds comfortable, especially when the vehicle is moving at a very slow speed. Steering force is very sensitive to the weight of the vehicle, and nearly so much to its length, so this is most important for large vehicles. In a vehicle equipped with power steering, when the driver turns the steering wheel, he feels only a slight retarding force, so a vehicle equipped with power steering can be driven by any healthy driver, even when the vehicle is being parked. This is because the power steering system furnishes most of the energy required to turn the steered wheels of the car.

Most power steering systems in cars and light trucks today are hydraulic (that is, the force to turn the wheels is provided by a hydraulic piston, which is powered by high pressure hydraulic fluid), but in some cars and trucks, the steering force is provided by an electric motor.

History

A steam-powered ship's steering engine, similar in many ways to the power steering system used in modern cars and trucks, was first installed in the SS Great Eastern in 1866.

The earliest known patent for a power steering system for a land vehicle was granted to Frederick W. Lanchester in the UK in February 1902. His invention was to "cause the steering mechanism to be actuated by hydraulic power". R.E. Twyford included a mechanical power steering mechanism as part of his patent for the first four wheel drive

system (U.S. Patent 646,477 April 3, 1900). The next design was filed as recorded by the US Patent Office on August 30, 1932, by Klara Gailis, from Belmont, Massachusetts. There is another inventor credited with the invention of power steering by the name of Charles F. Hammond an American, born in Detroit, who filed similar patents, the first of which was filed as recorded by the Canadian Intellectual Property Office.

Francis W. Davis, an engineer of the truck division of Pierce Arrow began exploring how steering could be made easier, and in 1926 demonstrated the first power steering system. Davis moved to General Motors and refined the hydraulic-assisted power steering system, but the automaker calculated it would be too expensive to produce. Davis then signed up with Bendix, a parts manufacturer for automakers. Military needs during World War II for easier steering on heavy vehicles boosted the need for power assistance on armored cars and tank-recovery vehicles for the British and American armies.

Chrysler Corporation introduced the first commercially available passenger car power steering system on the 1951 Chrysler Imperial under the name "Hydraguide". The Chrysler system was based on some of Davis' expired patents. General Motors introduced the 1952 Cadillac with a power steering system using the work Davis had done for the company almost twenty years earlier.

Most new vehicles now have power steering, owing to the trends toward front wheel drive, greater vehicle mass, and wider tires, which all increase the required steering effort. Heavier vehicles as common in some countries would be extremely difficult to maneuver at low speeds, while vehicles of lighter weight may not need power assisted steering at all.

Hydraulic systems



A power steering fluid reservoir and pulley driven pump

Most power steering systems work by using a hydraulic system to turn the vehicle's wheels. The hydraulic pressure is usually provided by a gerotor or rotary vane pump driven by the vehicle's engine. A double-acting hydraulic cylinder applies a force to the steering gear, which in turn applies a torque to the steering axis of the roadwheels. The flow to the cylinder is controlled by valves operated by the steering wheel; the more torque the driver applies to the steering wheel and the shaft it is attached to, the more fluid the valves allow through to the cylinder, and so the more force is applied to steer the wheels in the appropriate direction.

One design for measuring the torque applied to the steering wheel is to fix a torsion bar to the end of the steering shaft. As the steering wheel rotates, so does the attached steering shaft, and so does the top end of the attached torsion bar. Since the torsion bar is relatively thin and flexible and the bottom end is not completely free to rotate, the bar will soak up some of the torque; the bottom end will not rotate as far as the top end. The difference in rotation between the top and bottom ends of the torsion bar can be used to control the valve that allows fluid to flow to the cylinder which provides steering assistance; the greater the "twist" of the torsion bar, the more steering assistance will be provided.

Since the pumps employed are of the positive displacement type, the flow rate they deliver is directly proportional to the speed of the engine. This means that at high engine speeds the steering would naturally operate faster than at low engine speeds. Because this would be undesirable, a restricting orifice and flow control valve are used to direct some of the pump's output back to the hydraulic reservoir at high engine speeds. A pressure relief valve is also used to prevent a dangerous build-up of pressure when the hydraulic cylinder's piston reaches the end of the cylinder.

Some modern implementations also include an electronic pressure relief valve which can reduce the hydraulic pressure in the power steering lines as the vehicle's speed increases (this is known as variable assist power steering).

Some heavy machines use hydraulic-only systems where there is no backup if the pump motor fails.

DIRAVI

In the DIRAVI system invented by Citroën, the force turning the wheels comes from the car's high pressure hydraulic system and is always the same no matter what the road speed is. As the steering wheel is turned, the wheels are turned simultaneously to a corresponding angle by a hydraulic piston. In order to give some artificial steering feel, there is a separate hydraulically operated system that tries to turn the steering wheel back to centre position. The amount of pressure applied is proportional to road speed, so that at low speeds the steering is very light, and at high speeds it is very difficult to move more than a small amount from the centre position.

As long as there is pressure in the car's hydraulic system, there is no mechanical connection between the steering wheel and the roadwheels. This system was first introduced in the Citroën SM in 1970, and was known as 'VariPower' in the UK and 'SpeedFeel' in the U.S.

While DIRAVI is not the mechanical template for all modern power steering arrangements, it did innovate the now common benefit of speed sensitive steering. The force of the centering device increases as the car's road speed increases.

In the late 1960s, General Motors offered a variable ratio power steering system as an option on Pontiac and other vehicles.

Electro-hydraulic systems

Electro-hydraulic power steering systems, sometimes abbreviated EHPS, and also sometimes called "hybrid" systems, use the same hydraulic assist technology as standard systems, but the hydraulic pressure is provided by a pump driven by an electric motor instead of being belt-driven by the engine.

In 1965, Ford experimented with a fleet of "wrist-twist instant steering" equipped Mercury Park Lanes that replaced the conventional large steering wheel with two 5-inch (127 mm) rings, a fast 15:1 gear ratio, and an electric hydraulic pump in case the engine stalled.

In 1990, Toyota introduced its second-generation MR2 with electro-hydraulic power steering. This was to avoid running hydraulic lines from the engine (which were located behind the driver in the MR2) up to the steering rack. In 1994 Volkswagen produced the Mark 3 Golf Ecomatic, which utilized an electric pump so that the power steering could operate while the engine had been turned off by the computer to save fuel. Electro-hydraulic systems can be found in some cars by Ford, Volkswagen, Audi, Peugeot, Citroen, SEAT, Skoda, Suzuki, Opel, MINI, Toyota, Honda, and Mazda.

Servotronic

Servotronic offers true speed-dependent power steering, in which the amount of servo assist depends on road speed, and thus provides even more comfort for the driver. The amount of power assist is greatest at low speeds, for example when parking the car. The greater assist makes it easier to maneuver the car. At higher speeds, an electronic sensing system gradually reduces the level of power assist. In this way, the driver can control the car even more precisely than with conventional power steering. Servotronic is used by a number of automakers, including Audi, General Motors, BMW, Volkswagen, Volvo, SEAT and Porsche. Servotronic is a trademark of AM General Corp.

Electric systems

Electric power steering (EPS or EPAS) is designed to use an electric motor to reduce effort by providing steering assist to the driver of a vehicle. Sensors detect the motion and torque of the steering column, and a computer module applies assistive torque via an electric motor coupled directly to either the steering gear or steering column. This allows varying amounts of assistance to be applied depending on driving conditions. The system allows engineers to tailor steering-gear response to variable-rate and variable-damping suspension systems achieving an ideal blend of ride, handling, and steering for each vehicle. On Fiat group cars the amount of assistance can be regulated using a button named "CITY" that switches between two different assist curves, while most other EPS systems have variable assist, which allows for more assistance as the speed of a vehicle

decreases and less assistance from the system during high-speed situations. In the event of component failure, a mechanical linkage such as a rack and pinion serves as a back-up in a manner similar to that of hydraulic systems. Electric power steering should not be confused with drive-by-wire or steer-by-wire systems which use electric motors for steering, but without any mechanical linkage to the steering wheel.

Electric systems have a slight advantage in fuel efficiency because there is no belt-driven hydraulic pump constantly running, whether assistance is required or not, and this is a major reason for their introduction. Another major advantage is the elimination of a belt-driven engine accessory, and several high-pressure hydraulic hoses between the hydraulic pump, mounted on the engine, and the steering gear, mounted on the chassis. This greatly simplifies manufacturing and maintenance. By incorporating electronic stability control electric power steering systems can instantly vary torque assist levels to aid the driver in evasive manoeuvres.

The first electric power steering systems appeared on the Honda NSX in 1990, the FIAT Punto Mk2 in 1999, the Honda S2000 in 1999, and on the BMW Z4 in 2002. Today a number of manufacturers use electric power steering.

Reviews in the automotive press often comment that certain steering systems with electric assist do not have a satisfactory amount of "road feel". Road feel refers to the relationship between the force needed to steer the vehicle and the force that the driver exerts on the steering wheel. Road feel gives the driver the subjective perception that they are engaged in steering the vehicle. The amount of road feel is controlled by the computer module that operates the electric power steering system. In theory, the software should be able to adjust the amount of road feel to satisfy drivers. In practice, it has been difficult to reconcile various design constraints while producing a more pronounced road feel. The same argument has been applied to hydraulic power steering as well.

Variable gear ratios

In 2000, Honda launched the S2000 Type V equipped with the world's first electric power variable gear ratio steering (VGS) system. In 2002, Toyota introduced their own "Variable Gear Ratio Steering (VGRS)" system introduced on the Lexus LX 470 and Landcruiser Cygnus, and also incorporated the electronic stability control system to alter steering gear ratios and steering assist levels. In 2003, BMW introduced their "Active Steering" system on the 5-series.

This system should not be confused with variable assist power steering which varies steering assist torque not steering ratios, nor with systems where the gear ratio is only varied as a function of steering angle.

Glossary of Automotive Design

0-9

1-box form

A categorization based on overall form design using rough rectangle volumes. In the case of the 1-box, it is a single continuous volume. Slight wedge formed front or rear are still generally placed in this category. e.g., Bus, original Ford Econoline.

2-box form

A categorization based on overall form design using rough rectangle volumes. In the case of the 2-box form, there is usually a "box" representing a separate volume from the a-pillar forward and second box making up the rest. e.g., Station Wagon, Shooting-brake, Scion xB(2006)

3-box form

A categorization based on overall form design using rough rectangle volumes. In the case of the 3-box form, there is a "box" delineating a separate volume from the a-pillar forward, a second box comprising the passenger volume, and third box comprising the trunk area — e.g., a Sedan.

A

A-line

The line running over the car, from headlight to taillight, tracing the car's silhouette.

Axis-to-dash ratio

The critical relationship between front wheels and the windshield. The most notable differences can be seen between cars with front-engine, front-wheel drive layout and front mid-engine, rear-wheel drive layout: the former tend to have longer front overhangs with a smaller axis-to-dash ratios, while the latter have shorter front overhangs with much greater axis-to-dash ratios.

B

Backlight

The rear glass window glass.

Beltline

The line going from the hood which usually follows the bottom edge of the windows and continues to the trunk.

Bling

(contemporary) May also refer to the strong use of jeweled lighting. Comes from the term bling-bling.

Bonnet

The hood of the vehicle.

Boot

The trunk or liftgate of the vehicle.

Brightwork

Anything reflective added to a car to enhance appearance. May also be called chrome.

C

Cab

Short for cabin. The enclosed compartment of a vehicle which contains the driver and passengers.

Cab back

The cab of the vehicle is moved to the rear of the vehicle. Cars such as a 1970's Corvette could be considered cab back design.

Cab forward

The cab of the vehicle is pushed forward. This design aesthetic was popular with Chrysler in the 1990s with the introduction of their LH platform cars.

Character line

A line creased into the side of a car to give it visual interest. (interchangeable with swage line)

Chrome

Brightwork using chrome plating.

Cladding

Material (usually plastic) added to exterior of the car which isn't structurally necessary. May be functional to keep out dirt/debris as in underbody cladding, or may be cosmetic.

Control Panel

Generally used in a Car/Truck for heating and cooling inside car environment according to the passenger requirements. Basically it is divided in to Different modes, Blower speed functions, AC, Temperature, Fresh recirculation of air. World wide control panel manufacturers are BHTC, Delphi, Visteon, Valeo, etc.

Cowl

The base of the windshield.

D

Daylight Opening (DLO)

US DOT Term: For openings on the side of the vehicle, other than a door opening, the locus of all points where a horizontal line, perpendicular to the vehicle longitudinal centerline, is tangent to the periphery of the opening.

US DOT Term: For openings on the front and rear of the vehicle, other than a door opening, daylight opening means the locus of all points where a horizontal line, parallel to the vehicle longitudinal centerline is tangent to the periphery of the opening.

Dead Cat Hole

The space between a car's tire and the wheel well. Currently there is a trend towards smaller dead cat holes.

Deck

The horizontal surface at the rear of the car, which usually serves as the trunk lid.

Down Road Graphic

The styling of the front end of the car, which people will instantly recognize and associate with a manufacturer. For example, the grille, lights and sometimes the DLO.

Droptop

A convertible.

F

Fascia

The body-skin panel at the front of the car.

Fender (wings, UK)

Term for cowl covering the wheels of the vehicles. In more modern automobiles, this refers generally to the body panel or panels starting at the front "bumper" to the first door line excluding the engine hood. The opposite of the fender is the "quarter panel".

Frame-on-rail

A design used in older (pre-unibody) cars, trucks, and SUVs. The power train and body are mounted to a rigid structural framework called a rail.

G

Gill

A vent on the side of the fender that can be used as hot-air outlet, but usually decorative.

Greenhouse

The glassed-in upper section of the car's body. Daylight Opening (DLO) in turn describes the actual window areas only.

H

Hardtop

a coupe or sedan lacking a center window post between the front windshield post and the rearmost window post or body section.

Header

(1) The structural roof beam above the windshield. (2) The section of exhaust piping attached to the cylinder head.

Hofmeister kink

BMW's trademark reverse-sweep kick at the bottom of last roof pillar.

HP (Hip Point or H-point)

A conceptual plane parallel with ground that aligns to the vehicle passengers' hip/thigh joint. This helps to describe the "seat" height of a vehicle design, relative to either the ground or the vehicle floor.

Hood (Bonnet in English speaking countries outside North America with the exception of the Canadian Maritimes)

The engine cover on vehicles when the engine is located forward or aft of the passenger compartment.

I

IP

Instrument Panel. The Dashboard is termed as Instrument Panel in Automotive Industries, sometimes this term is confused with the Instrument Cluster that is the group of speedometer, odometer and similar devices generally behind the steering wheel.

N

NACA duct

A distinctively shaped inlet that is flush and begins with a narrow, shallow inset and becomes progressively wider and deeper.

O

Overhang

The distance which the car's body extends beyond the wheelbase at the front (front overhang) and rear (rear overhang). In car style design terms, this is the amount of body that is beyond the wheels or wheel arches.

P

Phaeton

An open vehicle, usually with 4 doors, with a removable and/or retractable cloth top and a windshield characterized by the lack of integrated glass side windows. Contemporary uses of this name do not always follow this original description or apply to an open vehicle.

Pillar

A structural member that connects the roof to the body of the car. Pillars are usually notated from front to back alphabetically (e.g. A-pillar joins the windshield to the frontmost side windows, B-pillar is next to the front occupants' heads, etc.).

US DOT Term: Means any structure, excluding glazing and the vertical portion of door window frames, but including accompanying molding, attached components such as safety belt anchorages and coat hooks, that (1) supports either a roof or any other structure (such as a roll-bar) above the driver's head or (2) is located along a side edge of a window.

Plenum

The area at the base of the windshield where the wipers are parked. Also refers to the main chamber in an intake manifold.

Ponton styling

a 1930s–1960s design genre when distinct running boards and fully articulated fenders became less common and bodywork began to enclose the full width and uninterrupted length of a car in a markedly bulbous, slab-sided fashion.

Plug-in hybrid electric vehicle

A hybrid vehicle that can be plugged into the electric grid to recharge its battery to reduce gasoline usage.

Powertrain

All the components that generate power and deliver it to the tires.

Q

Quarter-panel

(or rear quarter panel) refers to the panel at the back sides starting at the rear edge of the rearmost doors, bordered by at top by the trunk (boot) lid and at bottom by the rear wheel arches ending at the rear bumper. This is the opposite of the fender. Literally, the term originally referred to the rear quarter or the car's length.

R

Rake

The tilt of a windshield. An extremely low or flat rake angle is considered to be "fast", as in fastback. Note that a "steeply raked" windscreen is close to horizontal.

Roadster

An open vehicle, usually with 2 doors, with a removable and/or retractable cloth top and a windshield characterized by the lack of integrated glass side windows. Contemporary uses of this name do not always follow this original description.

Rocker

The body section below the base of the door openings sometimes called the "rocker panels".

Rocker Rail

Body armor protecting the Rocker, found mostly in off road vehicles. Term coined by engineers at MetalCloak.

S

Scoop

Inset or protusion that implies the intake of air. May be functional for cooling/ventilation or purely ornamental.

Scowling headlamps

Headlamps styled along a V-shape as viewed from the front, giving the impression of a scowl.

Shoulder line

The line or "shoulder" formed by the meeting of top and side surfaces extending from hood/fender shoulder to boot-lid/quarter-panel shoulder. The strongest example of this feature can be found on more modern of Volvo Cars.

Sill line

Imaginary line drawn following the bottom edge of the greenhouse glass.

Six line

A line extending from the C-pillar down and around the rear wheel well.

Softtop

a convertible top which is made out of flexible materials like PVC or textile.

Spoiler

A raised lip or wing which is used to 'spoil' unfavorable air movement across the body. Some designs are more functional than others.

Staggered wheel fitment

The front and rear wheels are different widths. On sporty rear wheel drive cars, the rear tires are usually wider than the front.

Strake

Crease in the sheet metal intended as a "speed line" styling feature. Exemplified in the doors of the Ferrari Testarossa.

Suicide door

rear-hinged type, opening from the front of the car. If accidentally opened while driving at a high speed, doors would be blown backward.

Swage line

Crease or curvature in the side of the body used to create visual drama. Sometimes the crease is functional and improves rigidity of the outer body (interchangeable with character line).

T

Track

The distance across the car between the base of the left and right wheels. (Like wheelbase, but side to side.)

Truck

A typically large vehicle built using frame-on-rail construction consisting of a cab and a separate bed for cargo.

Trunk

(Boot in UK) Compartment for storage of cargo which is separate from the cab.

Tube Fender

Replacement fenders found on off road vehicles designed as part of body armor for off road vehicles. Used to protect the thin sheet metal bodies from damage while off-roading.

Tumblehome (tumble home)

Generally refers to the way the sides of a car rounds inward toward the roof, specifically of the greenhouse above the beltline. This term is borrowed from nautical description of naval vessels.

Turn under

The shape of the rocker panel as it curves inward at the lower edge.

V

Valvetrain

The mechanisms and parts which control the operation of the valves.

W

Wedge

Shape of the car as seen in the side profile. May be positive, negative or neutral. If the front is lower than the rear, then it is wedge-positive. If the rear is lower it is wedge-negative. If the car appears level from front to rear, then it is wedge neutral.

Wheel arch

The visible opening in the side of a car allowing access to the wheel.

Wheelbase

The distance front to back measured from where the front and rear wheels meet the ground.

Wheel well (or bucket)

The enclosure or space for the wheel.

Windshield Trim

US DOT Term: Molding of any material between the windshield glazing and the exterior roof surface, including material that covers a part of either the windshield glazing or exterior roof surface.