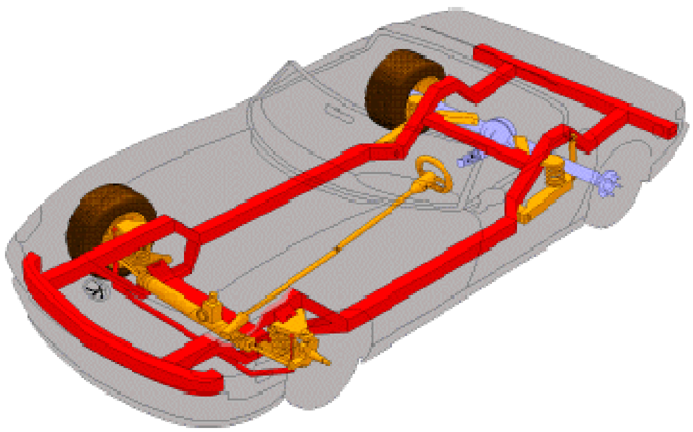
Suspension and Steering Systems Operation



Below is an overview of the suspension and steering systems

The Steering/Suspension System (Overview)

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

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

Cadillac allegedly produced the first American car to use a steering wheel instead of a tiller.

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

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

Steering Systems

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

In Pittman arm systems, the movement inside the steering box causes the Pitman shaft and arm to rotate, applying leverage to the relay rod, which passes the movement to the tie rods.

Power steering systems add a hydraulic pump; fluid reservoir; hoses; lines; and either a power assist unit mounted on, or integral with, a power steering gear assembly.

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

The steering wheel and column are a major source of injury to the driver, and a range of energy-absorbing and non-intrusion designs have been developed. There is great variation in these designs, some of which are now thought to be not fully effective.

Energy-absorbing columns have to serve two functions. First, they must stop the steering wheel and column from being pushed to the rear as the front of the car is crushed in an impact. Before such designs were invented, a common feature of driver injury was for the chest to be impaled by the steering column. The energy-absorbing column must also provide the driver with a tolerable impact as he moves forward and strikes the wheel with his chest. At that point in the crash, the column should build up the load on the driver's chest to a tolerable level, and then deform under that load to give a "ride-down" for the driver.

Several design problems are presented in providing this system. One major problem is that collapse of the column due to the frontal crush of the car should not hinder its performance for providing ride-down for the driver's chest. The system must also be so designed that under crash conditions, the wheel stays in such a position that it will strike the driver's chest and not move upwards into the region of his face, or downwards into his abdomen.

Steering Linkage

The steering linkage is made of interconnected parts which move every time the steering wheel is turned. The rotating movement of the steering column activates mechanisms inside the steering box. Tie rod ends, which join the key parts, pass on the steering wheel's motion no matter what the angle of the linkage or the vibration from the road. In a pitman arm steering setup, the movement inside the steering box causes the Pitman shaft and arm to rotate, applying leverage to the relay rod, which passes the movement to the tie rods. The steering arms pick up the motion from the tie rods and cause the steering knuckles to turn the wheels. The steering linkages need regular maintenance for safe operation, such as lubrication and inspection. Faulty steering links can cause tire wear at the least, and complete loss of control of the vehicle at worst. "Popping" noises (when turning the wheels) usually indicate worn out steering linkages.

Manual Rack and Pinion Steering

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

Manual Recirculating Ball Steering

With the manual recirculating ball steering gear, turning forces are transmitted through ball bearings from a "worm gear" on the steering shaft to a sector gear on the pitman arm shaft. A ball nut assembly is filled with ball bearings, which "roll" along grooves between the worm teeth and grooves inside the ball nut. When the steering wheel is turned, the worm gear on the end of the steering shaft rotates, and movement of the recirculating balls causes the ball nut to move up and down along the worm. Movement of the ball nut is carried to the sector gear by teeth on the side of the ball nut. The sector gear then moves with the ball nut to rotate the pitman arm shaft and activate the steering linkage. The balls recirculate from one end of the ball nut to the other through ball return guides.

Manual Worm and Sector Steering

The manual worm and sector steering gear assembly uses a steering shaft with a three-turn worm gear supported and straddled by ball bearing assemblies. The worm meshes with a 14-tooth sector attached to the top end of the pitman arm shaft. In operation, a turn of the steering wheel causes the worm gear to rotate the sector and the pitman arm shaft. This movement is transmitted to the pitman arm and throughout the steering train to the wheel spindles.

Worm and Tapered Peg Steering

The manual worm and tapered peg steering gear has a three-turn worm gear at the lower end of the steering shaft supported by ball bearing assemblies. The pitman shaft has a lever end with a tapered peg that rides in the worm grooves. When the movement of the steering wheel revolves the worm gear, it causes the tapered peg to follow the worm gear grooves. Movement of the peg moves the lever on the pitman shaft which in turn moves the pitman arm and the steering linkage.

Manual Worm and Roller Steering

The manual worm and roller steering gear is used by various manufacturers. This steering gear has a three-turn worm gear at the lower end of the steering shaft. Instead of a sector or tapered peg on the pitman arm shaft, the gearbox has a roller assembly (usually with two roller teeth) that engages the worm gear. The assembly is mounted on anti-frictional bearings. When the roller teeth follow the worm, the rotary motion is transmitted to the pitman arm shaft, pitman arm and into the steering linkage.

Power Steering

Over the years, power steering has become a standard equipment item on many automobiles. The demand for this system has caused power steering to be installed on over 90%% of all domestic new car production. All systems require a power steering pump attached to the engine and driven by a belt, a pressure hose assembly, and a return line. Also, a control valve is incorporated somewhere in the hydraulic circuit. "Power steering" is really "power assisted steering." All systems are constructed so that the car can be steered manually when the engine is not running or if any failure occurs in the power source.

Most power steering pumps contain a flow control valve, which limits fluid flow to the power cylinder to about two gallons per minute, and a relief valve which limits pressure according to system demands.

Power Rack and Pinion

Power rack and pinion steering assemblies are hydraulic/ mechanical unit with an integral piston and rack assembly. An internal rotary valve directs power steering fluid flow and controls pressure to reduce steering effort. The rack and pinion is used to steer the car in the event of power steering failure, or if the engine (which drives the pump) stalls.

When the steering wheel is turned, resistance is created by the weight of the car and tire-to-road friction, causing a torsion bar in the rotary valve to deflect. This changes the position of the valve spool and sleeve, thereby directing fluid under pressure to the proper end of the power cylinder. The difference in pressure on either side of the piston (which is attached to the rack) helps move the rack to reduce turning effort. The fluid in the other end of the power cylinder is forced to the control valve and back to the pump reservoir. When the steering effort stops, the control valve is centered by the twisting force of the torsion bar, pressure is equalized on both sides of the piston, and the front wheels return to a straight ahead position.

Integral Power Steering Gears

A representative of an integral power steering gear is used on certain General Motors rear-wheel drive cars and on American Motors four-wheel drive. This power steering gear uses a recirculating ball system in which steel balls act as rolling threads between the steering worm shaft and the rack piston. The key to its operation is a rotary valve that directs power steering fluid under pressure to either side of the rack piston. The rack piston converts hydraulic power to mechanical force. The rack piston moves up inside the gear when the worm shaft turns right. It moves down when the worm shaft turns left. During these actions, the steel balls recirculate within the rack piston, which is power assisted in movement by hydraulic pressure. (See also Manual Recirculating Ball Steering)

Power Steering Hoses

The power steering hoses are used to transmit hydraulic fluid under pressure from the pump to the power cylinder and to return. Besides this, the hoses must provide the proper amount of expansion to absorb any shock surge and offer enough restriction to the fluid flow to keep the pump cavity full of fluid at all times.

Power steering hoses are specially designed rubber hoses with metal fittings at each end which screw together with your power steering system. They contain power steering fluid at high pressures, and allow the system to circulate the fluids between the pump and the power cylinders.