UNIT 2

STEERING AND SUSPENSION SYSTEMS

SYLLABUS

- Steering system; Principle of steering, Centre point steering, Steering linkages, Steering geometry and wheel alignment, power steering.
- Suspension system: its need and types, Independent suspension, coil and leaf springs, Suspension systems for multi-axle vehicles, troubleshooting and remedies.

Introduction of steering system

- Steering is the collection of components, linkages, etc. which allow a vessel (ship, boat) or vehicle (car, motorcycle, and bicycle) to follow the desired course.
- The most conventional steering arrangement is to turn the front wheels using a hand–operated steering wheel which is positioned in front of the driver, via the steering column, which may contain universal joints (which may also be part of the collapsible steering column design), to allow it to deviate somewhat from a straight line.

PURPOSE OF A STEERING SYSTEM

The **steering system** *allows the driver to guide the car along the road and turn left or right as desired.*

The system includes the following :

(*i*) *The steering wheel* ..... which the driver controls.

(*ii*) *The steering gear* ..... which changes the rotary motion of the wheel into straight line motion, and

(*iii*) *The steering linkages* ..... which transmit the steering gear movement to the front wheels.

- The steering system configuration depends on vehicle design (the drive train and suspension system used, whether it is a passenger car or a commercial vehicle etc.). At present, the rack-and-pinion type and the recirculating-ball types are in use.
- Most steering systems were *manual* until a few year back. Then *power steering* became popular. It is now installed on almost all costly cars.

Basic Principles

- The steering system, along with the suspension system, allows the driver to safely and easily control the vehicle's direction while driving. To accomplish these goals the steering system works with components of the suspension to provide for the turning movement of the wheels.
- In addition to connecting the driver to the wheels, the steering system also provides feedback to the driver from the front tires. This feedback, called road feel, is used by the driver to determine how the vehicle is handling.

The Steering System

- The steering system consists of the components that allow the driver to turn the front wheels of the vehicle, and for a few vehicles, provides for a limited amount of steering by the rear wheels. The overall function of the steering system has not changed much since the earliest days of the automobile.

Functions of the Steering System

- **Primary function:** to achieve angular motion of the front wheels to negotiate a turn. This is achieved through linkages & steering gear which convert the rotary motion of the steering wheel into angular motion of the front road wheels.
- **Secondary functions are:**

1. Provide directional stability of the vehicle when going straight ahead.
2. Provide perfect steering condition. i.e. perfect rolling of all wheels at all times.
3. Facilitate straight ahead recovery after completing a turn.
4. To minimize tyre wear.
5. Absorb most of the road shocks going to the steering wheel.

Requirements of a good steering system

1. Steering system should be very accurate & easy to handle.
2. Effort required to steer should be minimal & must not be tiresome to the driver.
3. Steering mechanism should provide directional stability.
4. The vehicle should have a tendency to return to its straight ahead position after turning.
5. High rigidity.
6. Low friction resulting in high efficiency.

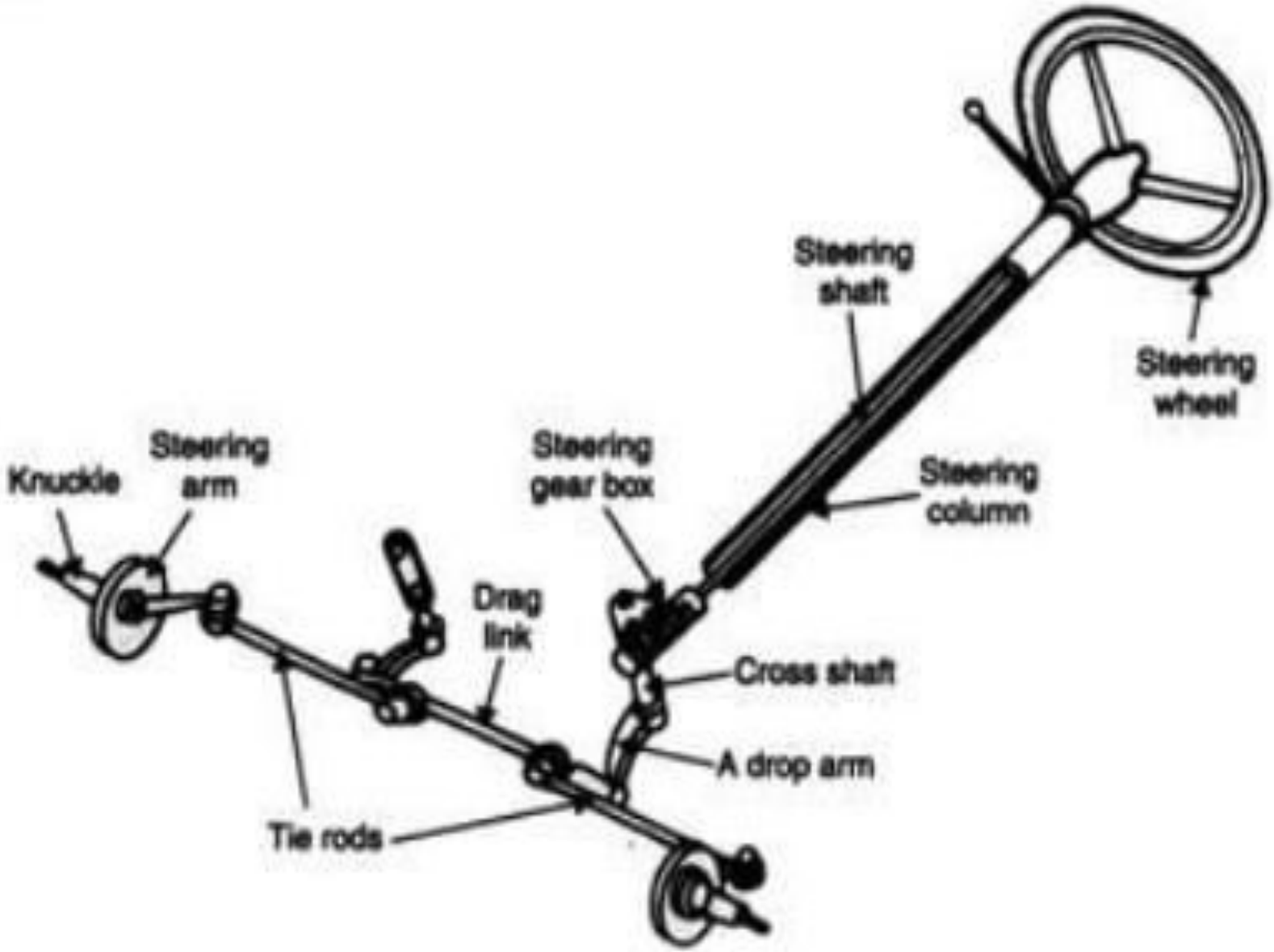
GENERAL ARRANGEMENT OF A STEERING SYSTEM

Fig. shows the general arrangement of a steering system. The layout of steering system is shown in Fig.

The *main parts of a steering system* are :

1. Steering wheel.
2. Steering column.
3. Steering shaft.
4. Steering gear box.
5. Steering drop arm (Pitman arm).
6. Pull and push rod (Drag link).
7. Knuckle arm.
8. Tie rod and tie rod end.

General arrangement of steering system



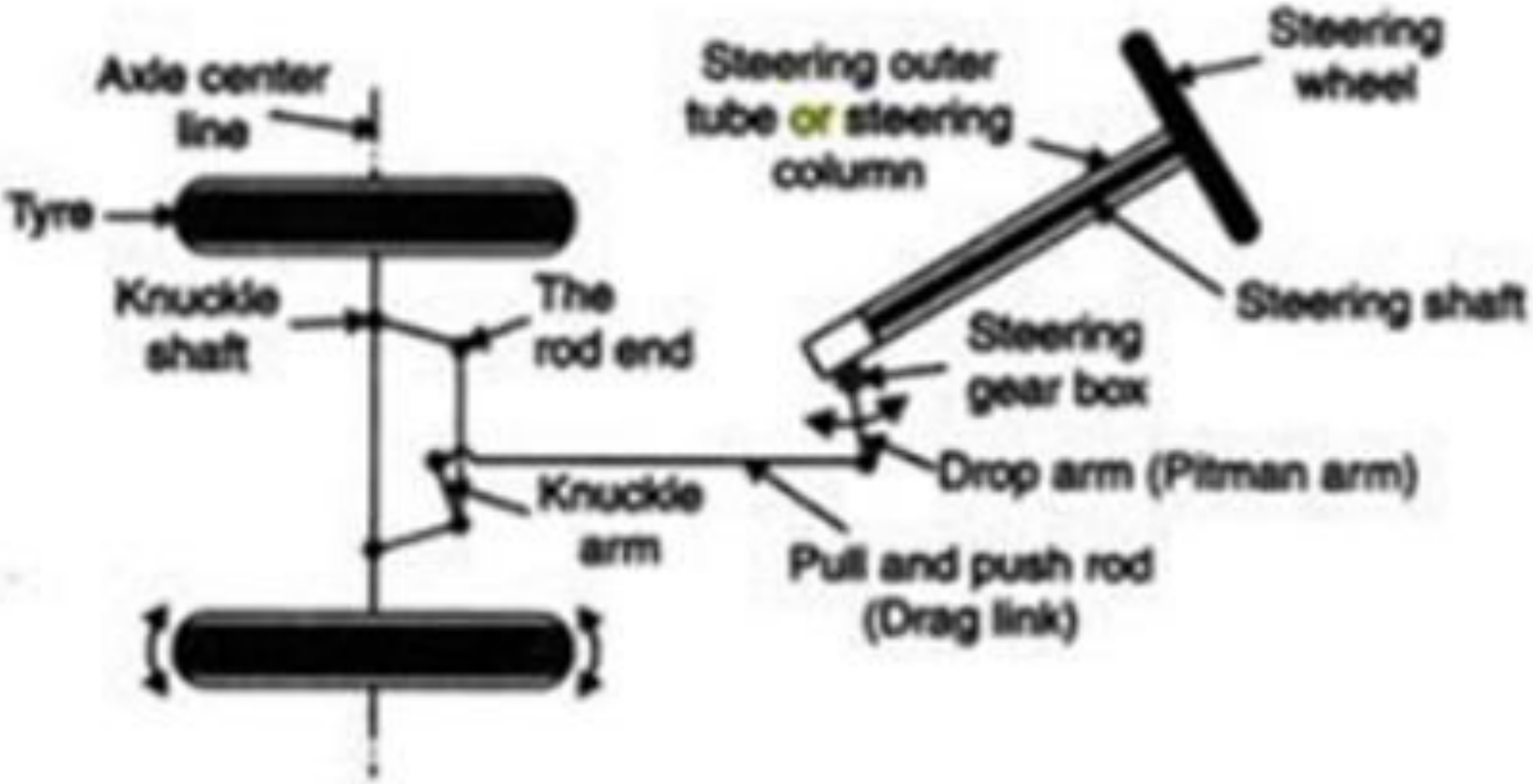


Fig. Layout of steering system.

Working of steering mechanism :

- The *steering wheel* rotates the *steering column*. The *steering gear box* is fitted to the end of this column. Therefore, when the wheel is rotated, the *cross shaft* in the gear box oscillates. The cross shaft is connected to the *drop arm*. This arm is linked by means of a *drag link* to the *steering arms*. The steering arms on both wheels are connected by the *tie rods* to the drag link.
- When the steering wheel is operated, the knuckle moves to and fro, moving the wheels to the right or left. The ends of the tie rod and steering knuckle are connected to each other. One end of the drag link is connected to the tie rod. The other end is connected to the end of the drop arm. A ball and a socket joint gives the required movement to the joints between the tie rod, drag link and drop arm. When the vehicle is moving, the drop arm develops vibration. Shock springs are used in ball and socket system to absorb this vibration.

Steering Parts

- Steering wheel
- Steering column or steering outer tube
- Steering shaft
- Steering gear box
- Drop arm
- Steering linkage

STEERING SYSTEMS

1. Manual steering system – relies solely on the driver to provide steering force
2. Power assist (power steering) – uses hydraulic or electric power to help the driver apply steering force.

STEERING SYSTEM – COMPONENTS



Steering wheel: used by the driver to rotate a steering shaft that passes through the steering column.



Steering shaft: Transfers turning motion from the steering wheel to the steering gear box.

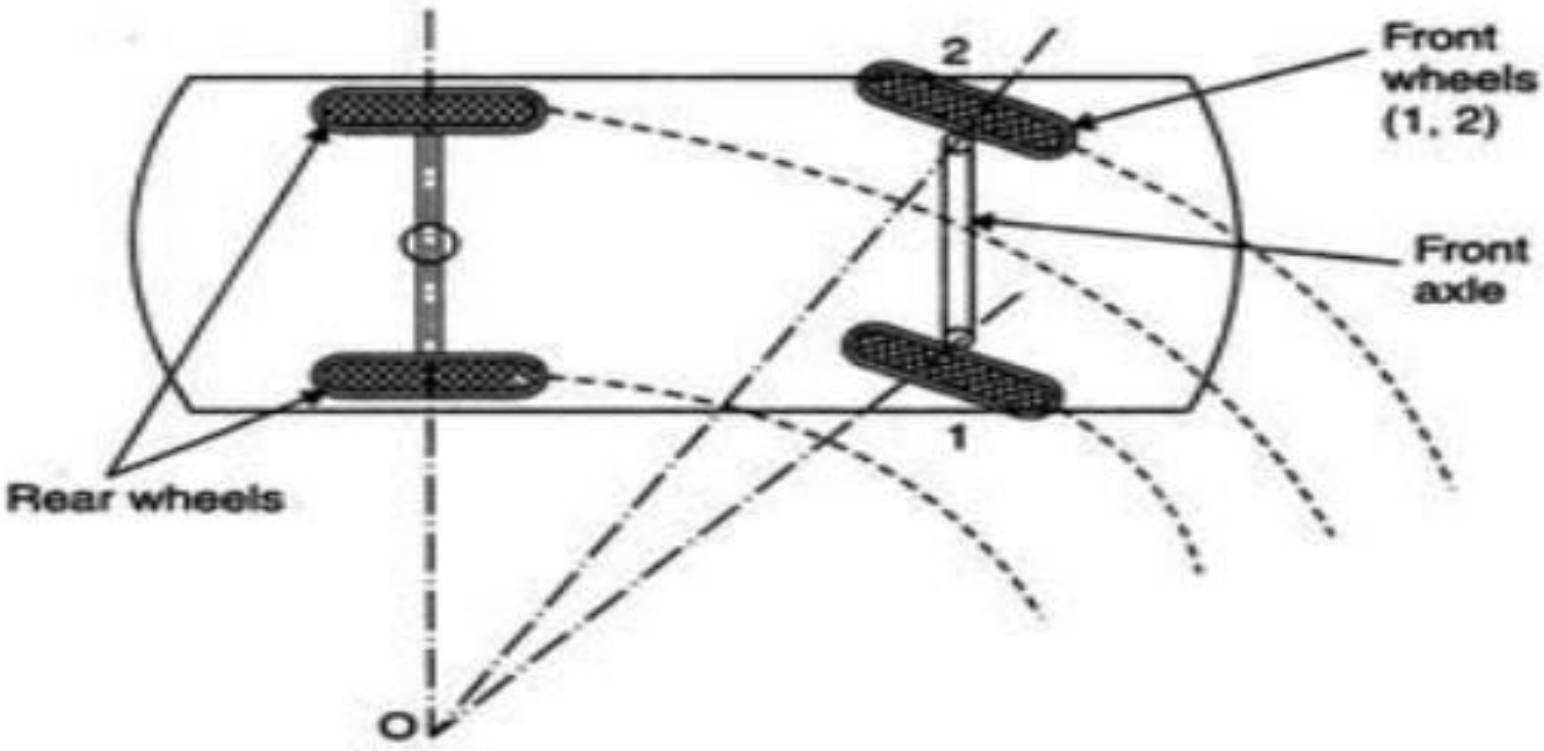


Steering Column: Supports the steering wheel & steering shaft



STEERING GEOMETRY

When a car is moving along a curve, all its wheels should *roll truly without any lateral slip*. This can be achieved if the axes of all four wheels intersect at one point. This point will be the centre about which the vehicle will be turning at that instant. Fig. shows the steering geometry of the four wheels of a vehicle. The rear wheels rotate along two circles. The centres of both these circles are at O. The front wheels 1 and 2 have different axes. They rotate along two other circles with the *same centre point. For correct functioning of any steering system, the centres of the wheels of the rear axles and of wheels 1, 2 should coincide.*



Steering Linkages

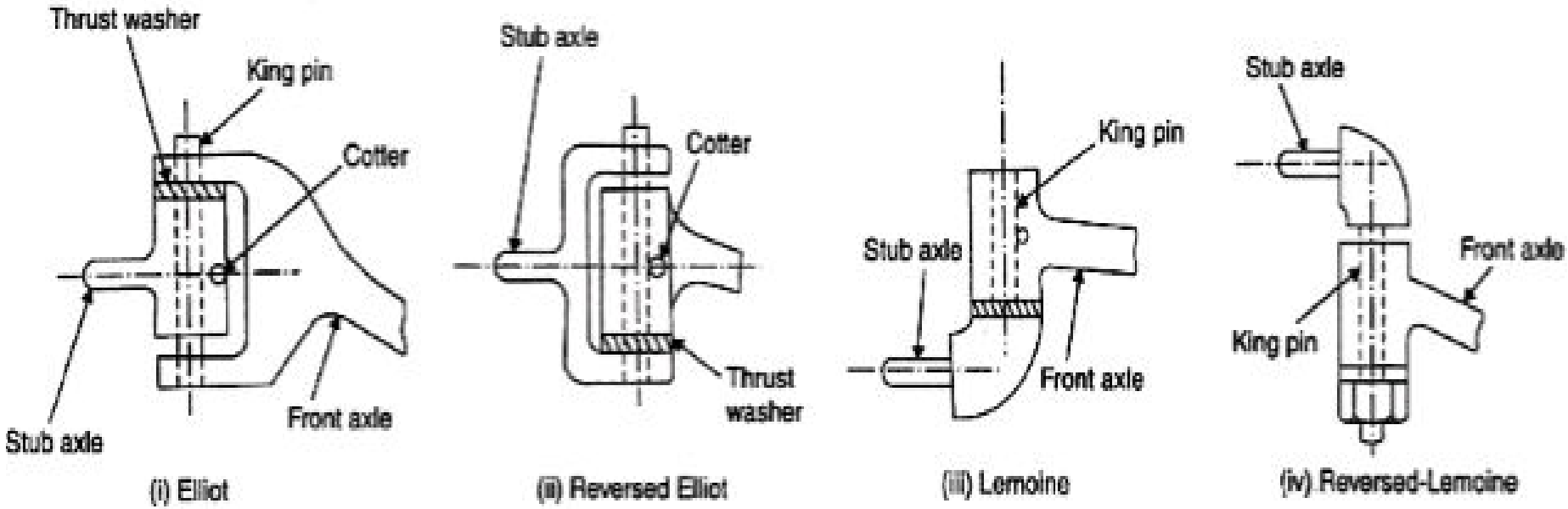
- Connects the steering gear box to steering knuckles & wheels.
- Steering linkage depends on the type of the vehicle, whether it's a car which has independent front suspension or a commercial vehicle having a rigid axle front suspension.

1. Steering linkage for vehicle with rigid axle suspension
2. Steering linkage for vehicle with independent suspension.

Front Axle



Stub Axles



Types of Stub Axles

Steering Linkage for Vehicle with Rigid Axle Front Suspension

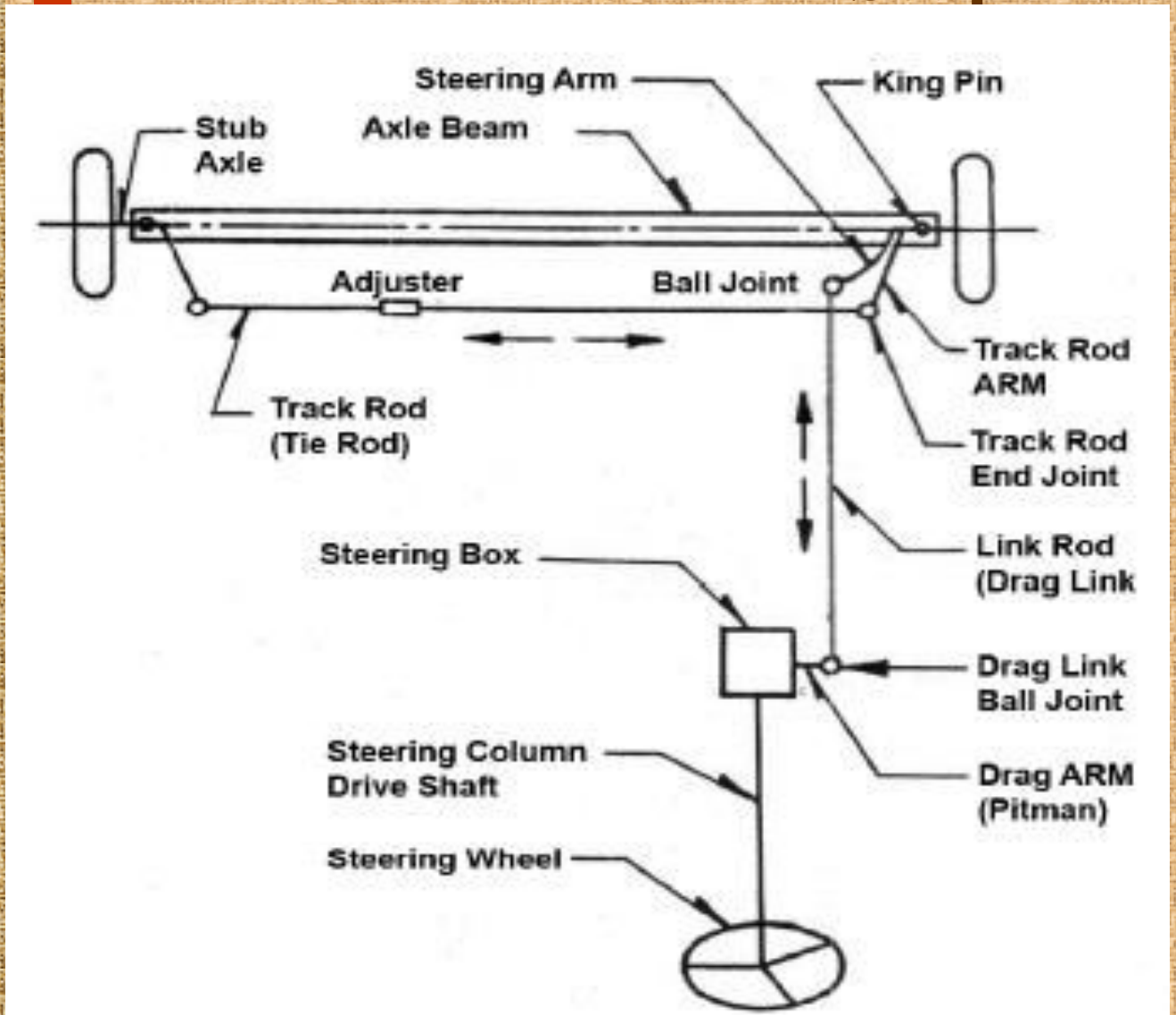


Fig. Steering Linkage for rigid axle suspension (line diagram)

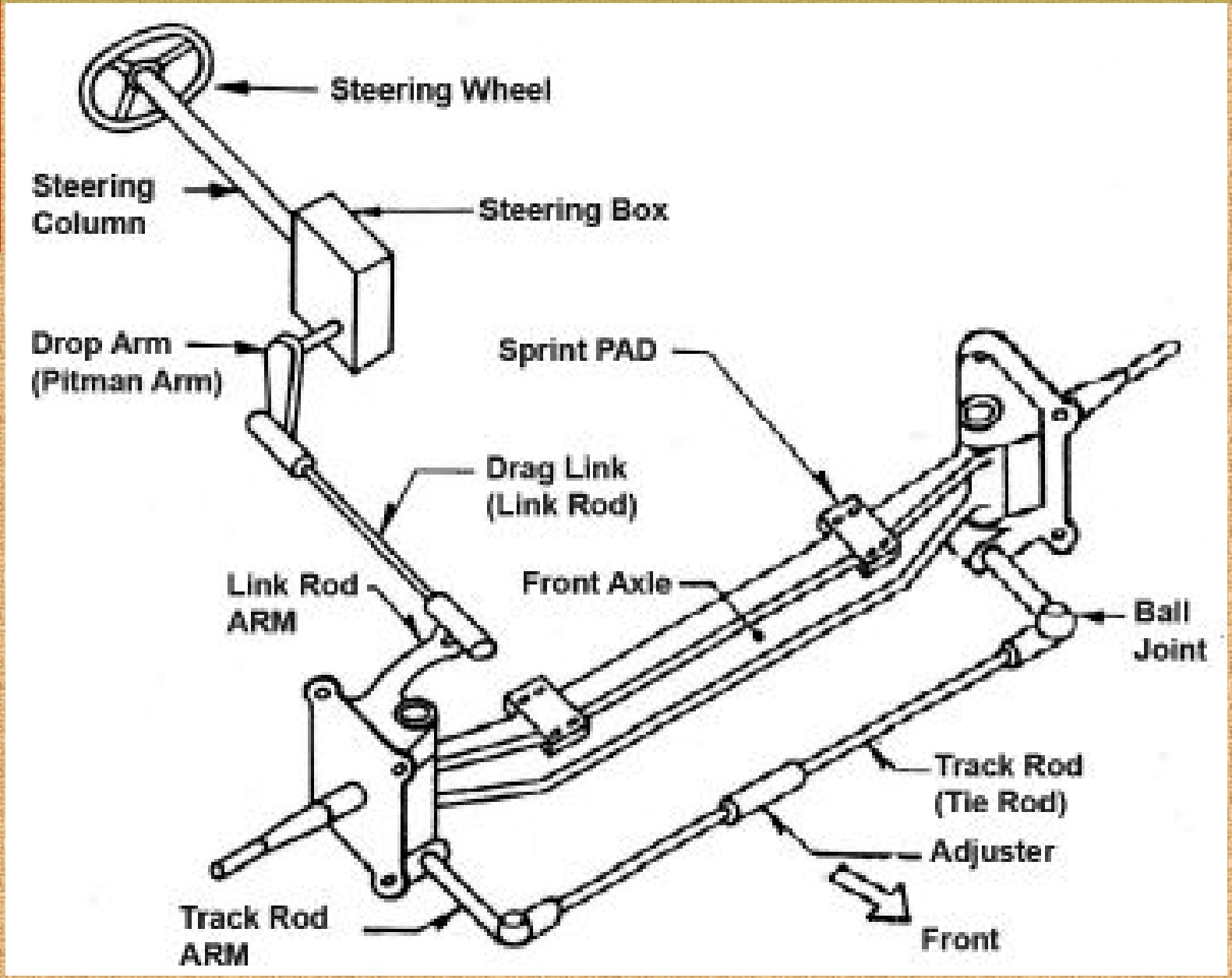


Fig. Steering Linkage for rigid axle suspension

Steering Linkage for Vehicle with Independent Front Suspension System

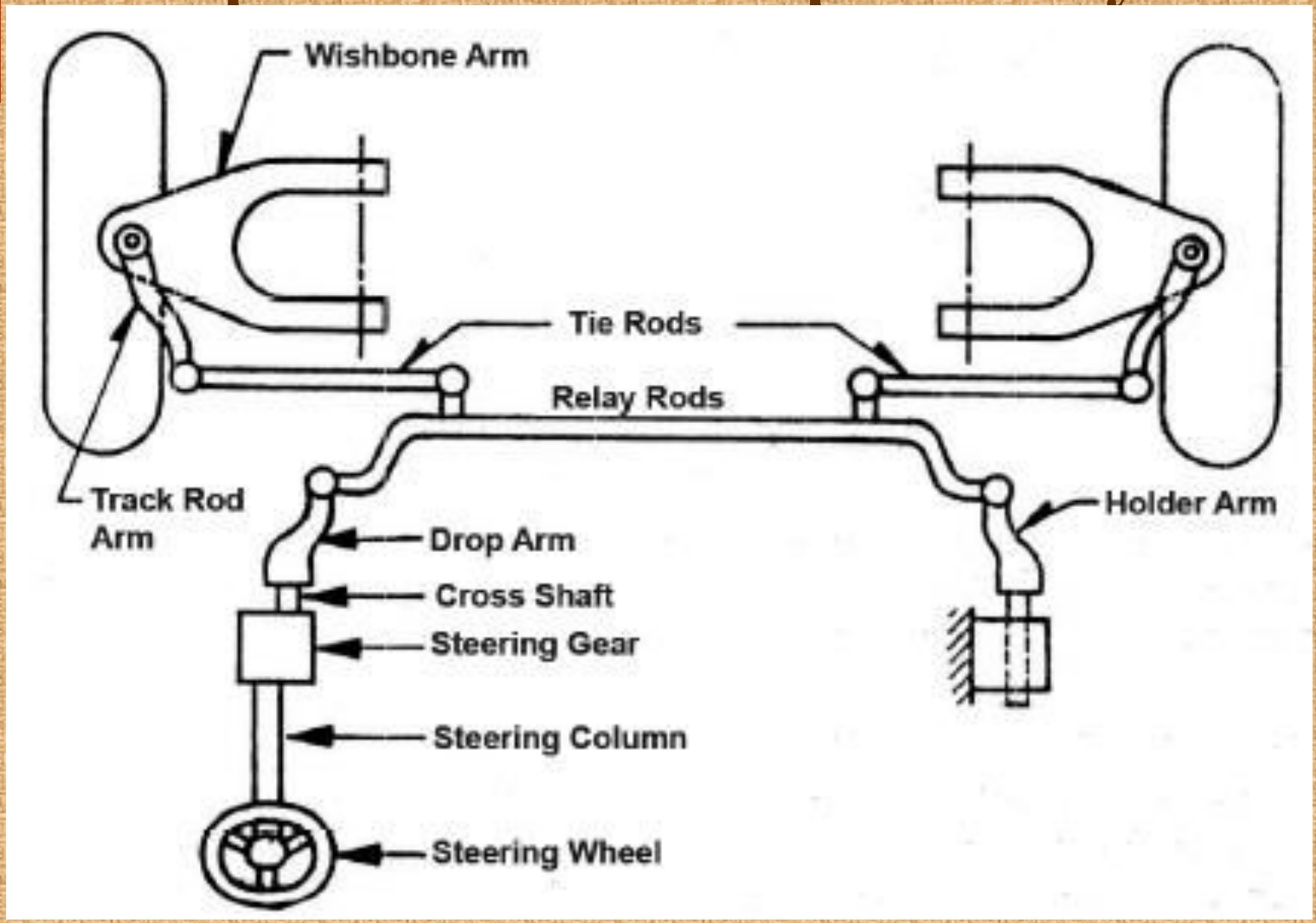


Fig. Steering linkage for vehicle with independent front suspension system

WHEEL ALIGNMENT

Positioning the steered wheels in order to achieve the following is termed wheel alignment.

- Directional stability during straight ahead position
- Perfect rolling condition on steering
- Recovery after completing the turn

Three different types of alignments can be done.

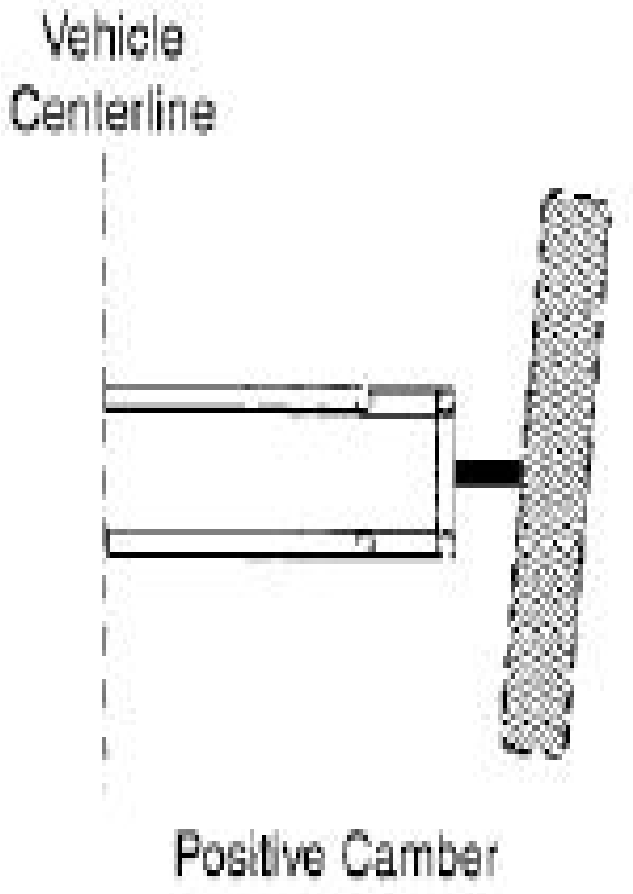
1. The front-end alignment – front axle's angles are measured & adjusted.
2. Thrust angle alignment – confirms that the rear tyres are positioned directly behind the front tyres.
3. Four-wheel alignment

- An important design factor for the vehicle is the wheel alignment. Four parameters are set by the designer, and these must be checked regularly to ensure they are within the original vehicle specifications. The four parameters discussed here are as follows:

Automotive Engineering Fundamentals

1. Camber
2. Steering axis inclination (SAI)
3. Toe
4. Caster

Camber



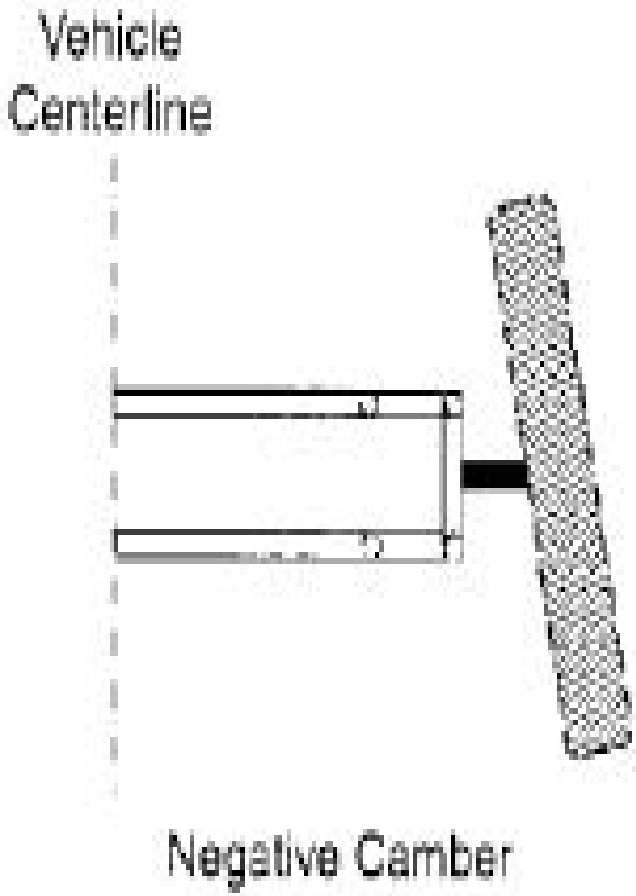


Fig. Positive & Negative camber (view from the front of the vehicle)

Steering axis inclination (SAI)

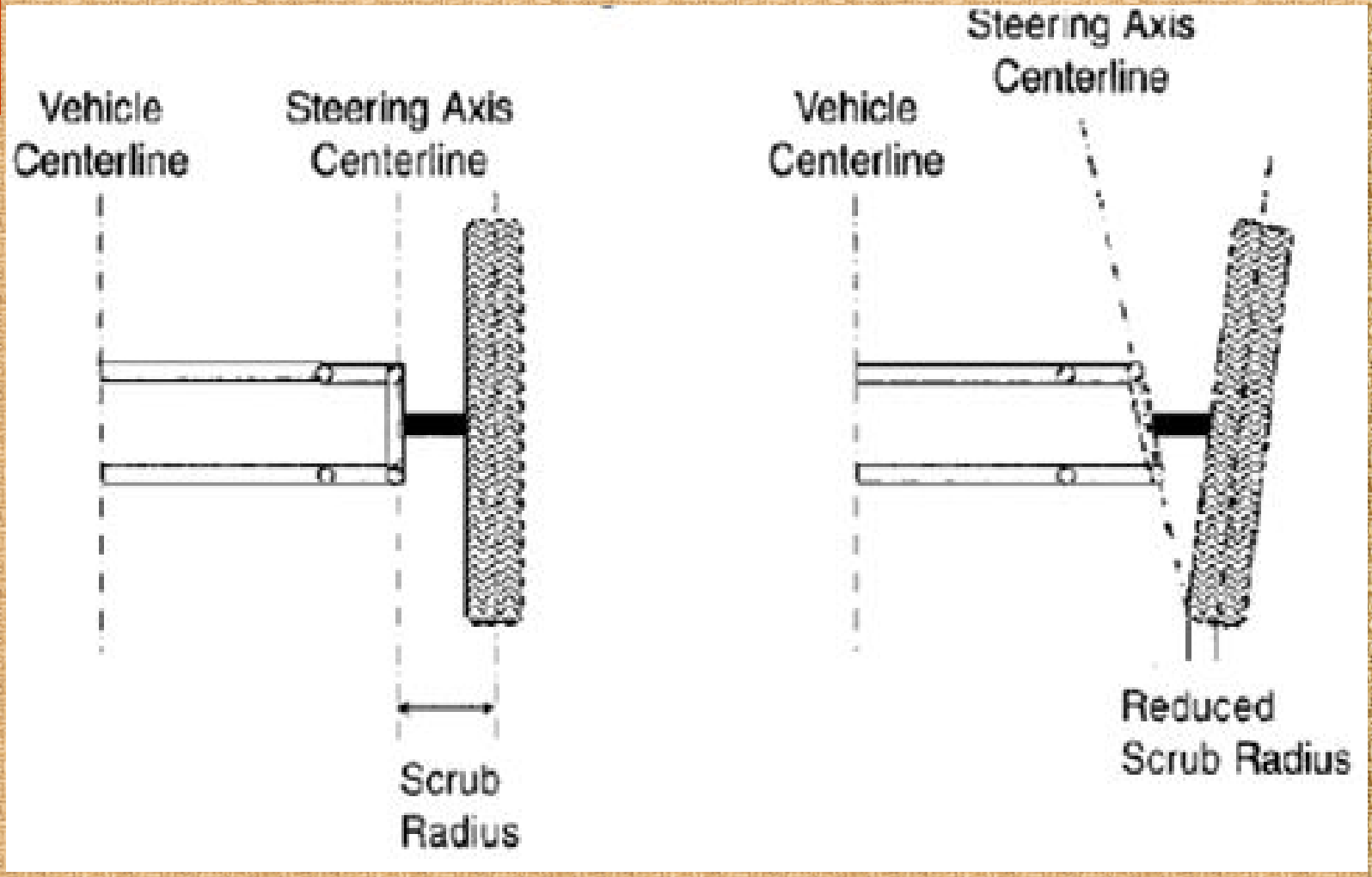
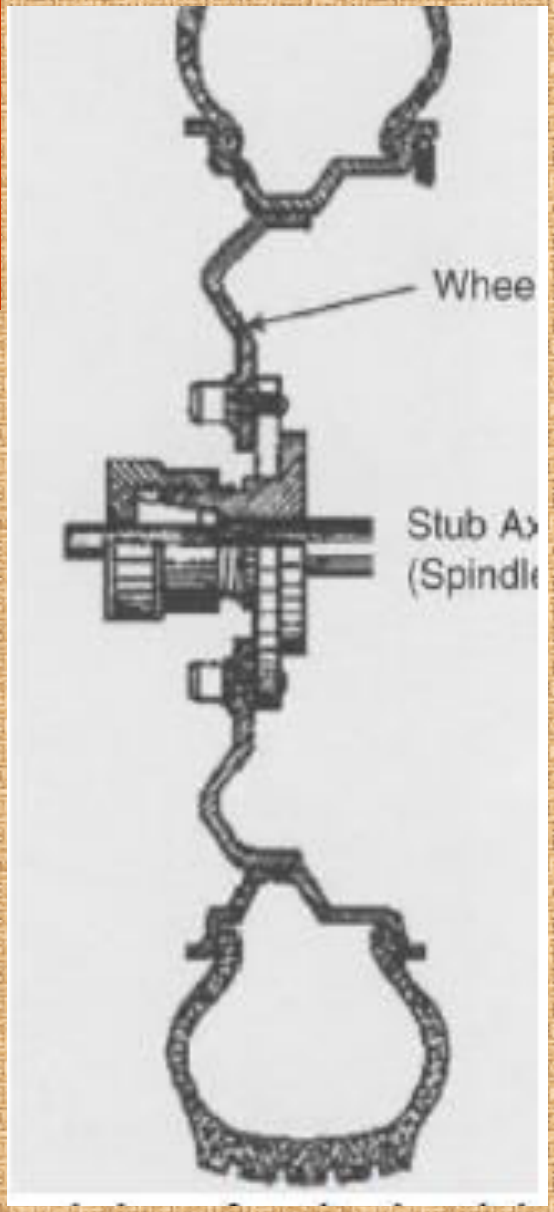


Fig. Interaction of positive camber with steering axis inclination (SAI)

TOE



Cross-sectional view of a wheel and tire assembly

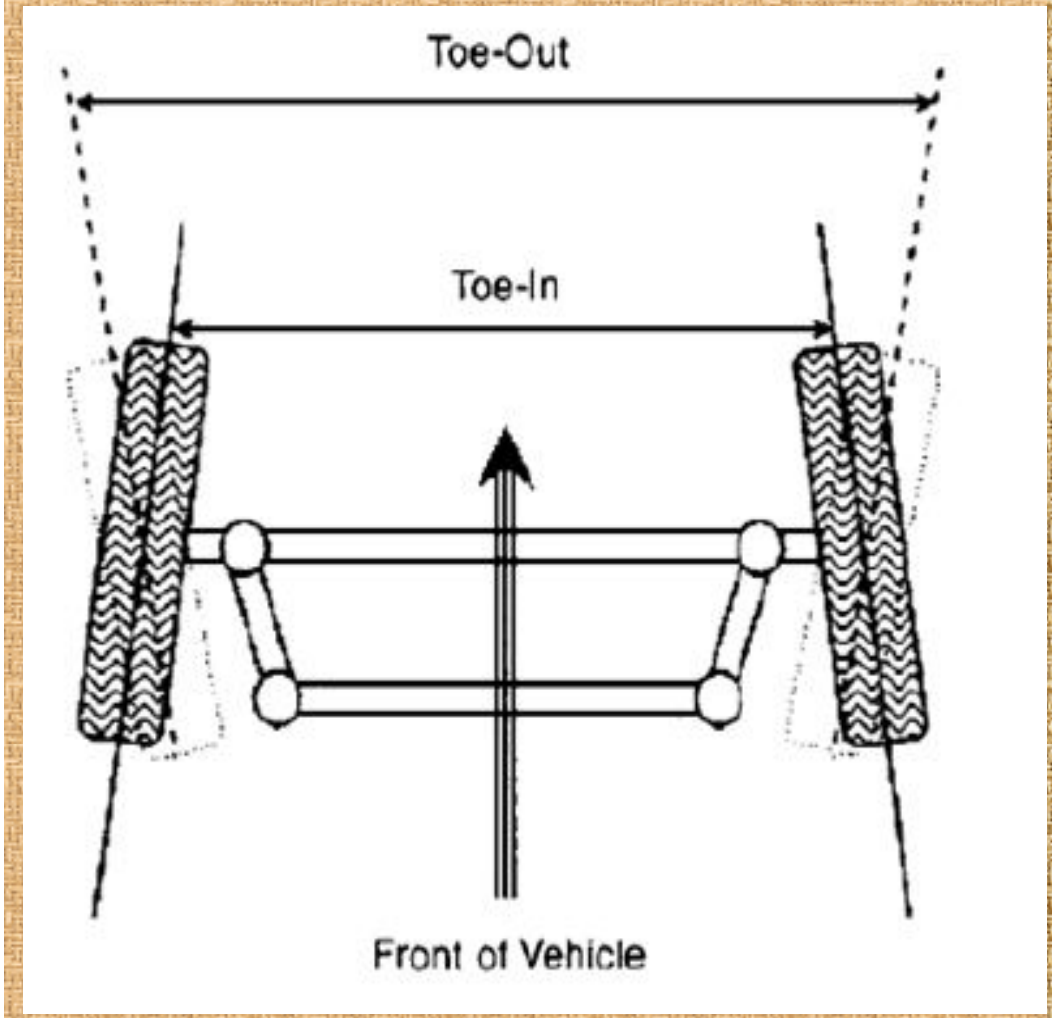
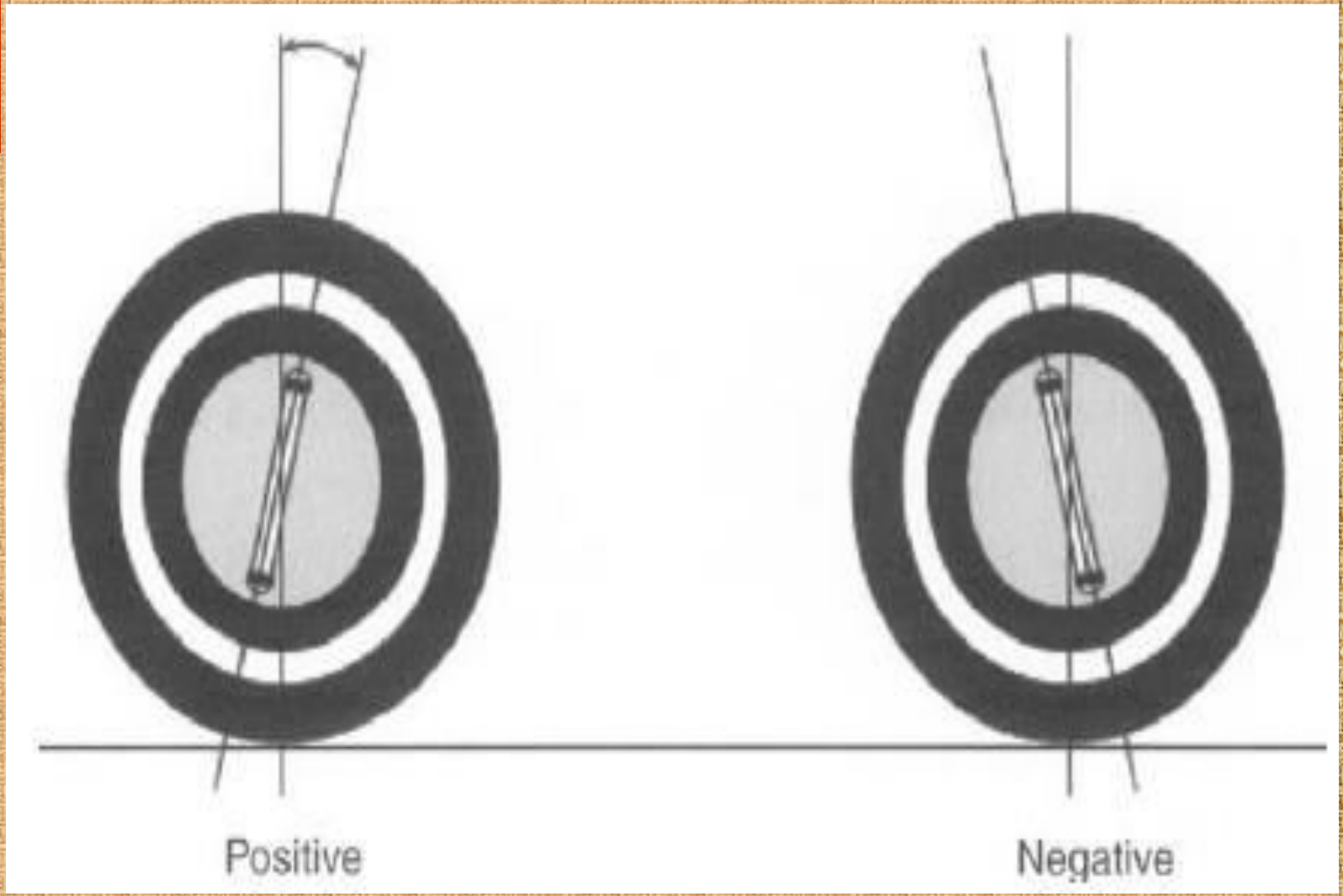


Fig. Toe-in versus toe-out

CASTER



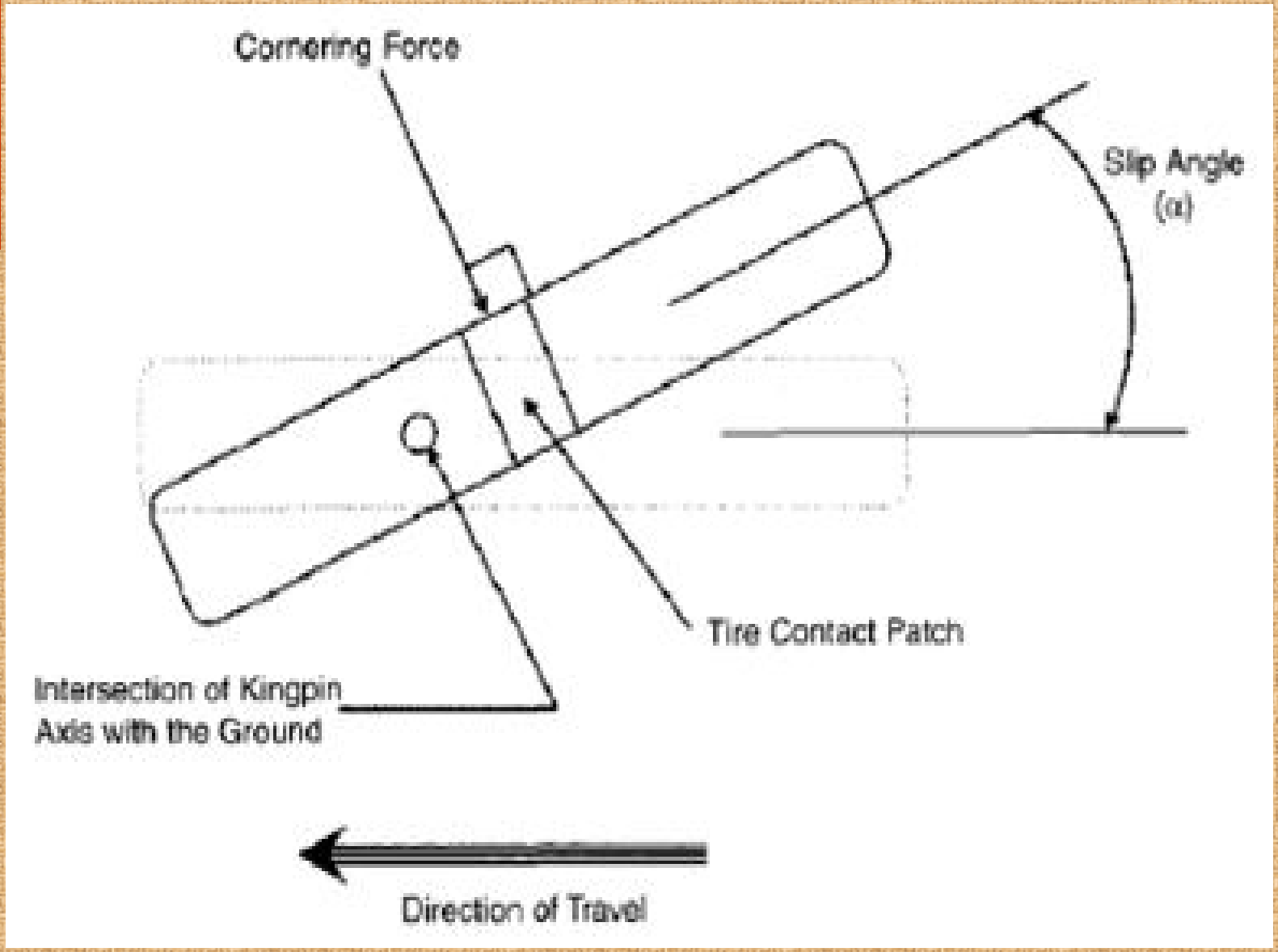


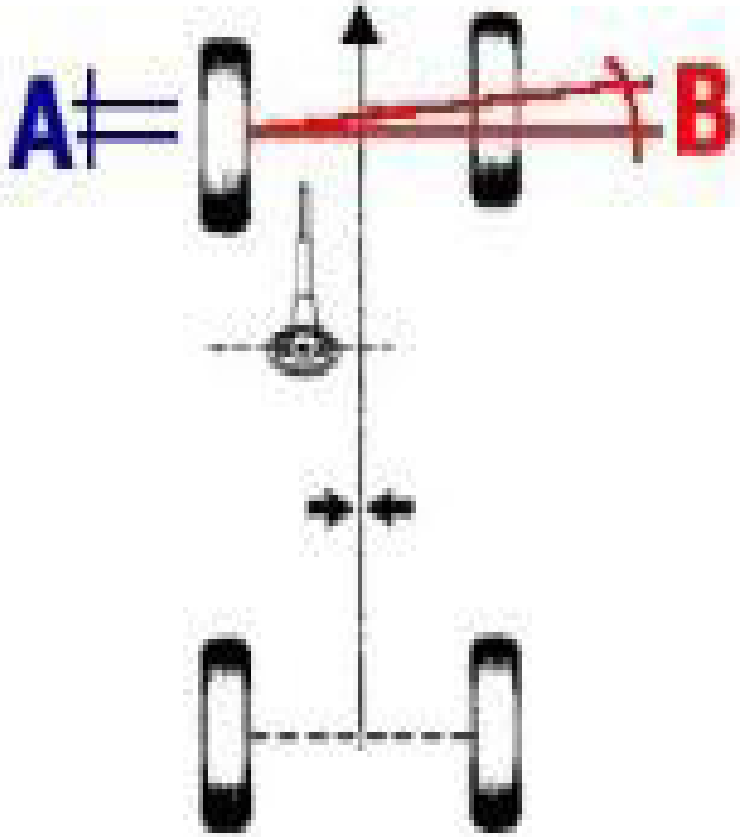
Fig. Self aligning generated by positive caster

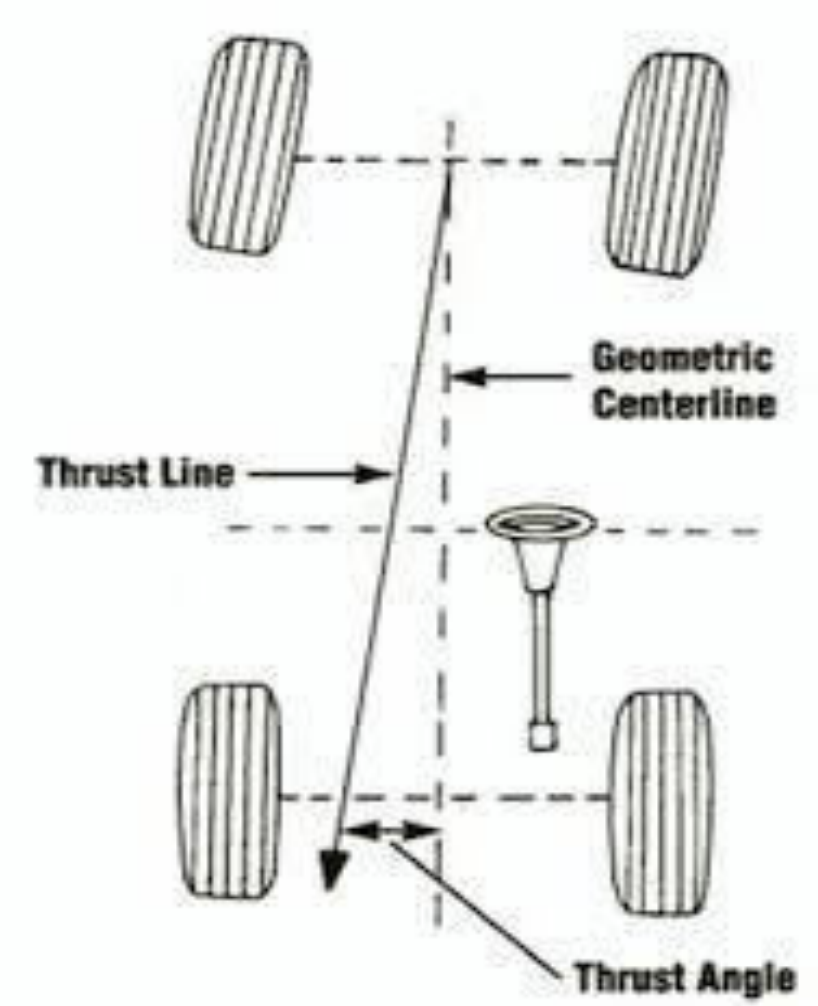
Checking of wheel alignment :

Before checking the wheel alignment, king-pin inclination, camber and caster angles and toe-in need to be checked.

The king-pin inclination and the camber angle are fixed in those vehicles which have axle beam. But the caster angle is adjustable by a caster plate. In those vehicles having independent suspension system, these angles are adjusted by a shim between the lower and upper arm brackets or by eccentric clamping bolts of the arm.

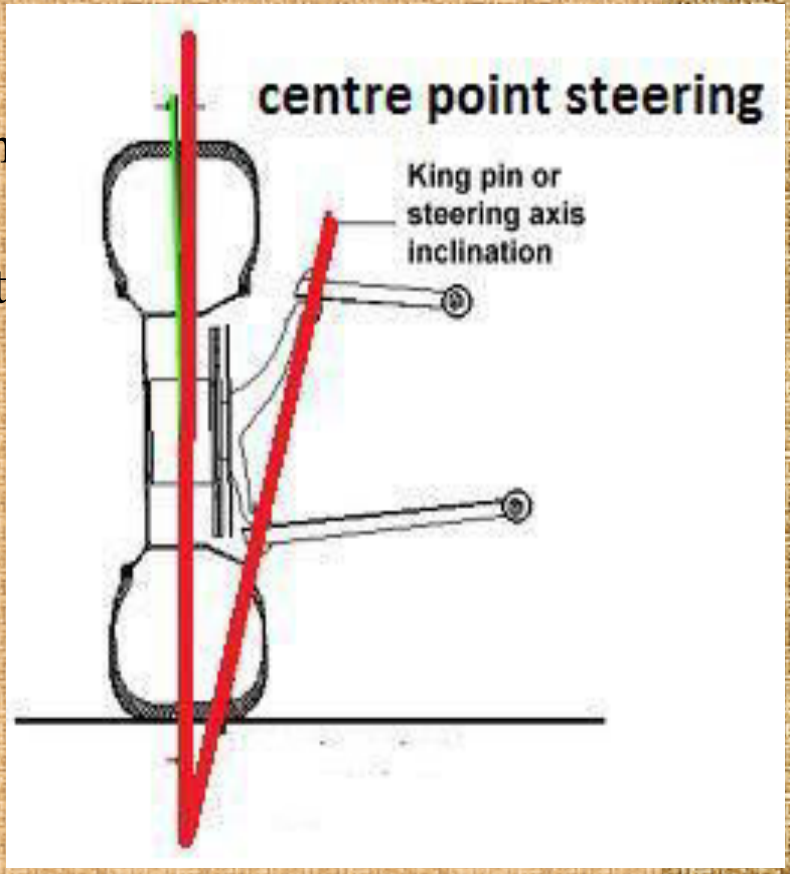
- The camber, caster king-pin inclination are checked by a particular type of gauge. This gauge consists of two parts : Level and angle gauge and turn table.
- For checking toe-in several gauges are available.
  - Optical gauge of Dunlop Tyre Company gives very accurate reading.
  - *Telescopic gauge* is commonly used in workshops. It consists of two pipes which can slide one inside the other. At the end of each pipe there is a rod which can be adjusted at any position on the pipe. Each rod has an adjustable pointer. To check the toe-in touch the pointers of the gauge with the front wheels and note the reading on the pipe. Similarly, touch the pointers of the gauge with the rear portion of the front wheels and note the reading. The *difference between the two readings is the toe-in.*

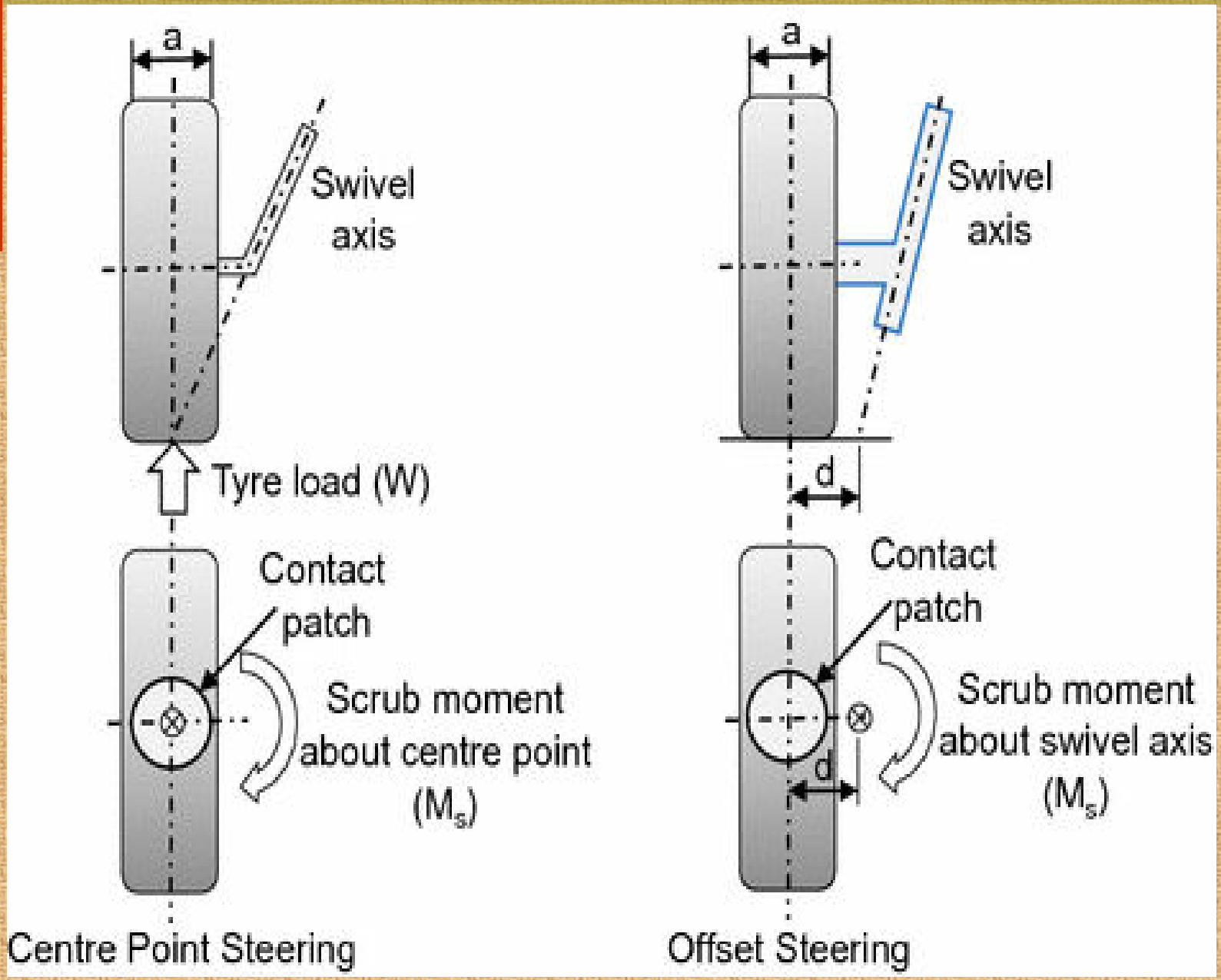

A
B


Geometric
Centerline
Thrust Line
Thrust Angle

CENTRE POINT STEERING:

- If the centre line of the wheel meets the imaginary king pin axis at the road surface, this condition is called Centre point steering.
- With a standard axle, the point of intersection of the king pin axis with ground is different from centre point steering.
- This results in heavy steering & larger bending stress on the stub axles & king pin
- In order to avoid this, the wheel & the king pin are arranged to reduce the king pin offset – Centre point Steering – reduces steering effort.




a
Swivel axis
Tyre load (W)
Contact patch
Scrub moment about centre point (M_s)
Centre Point Steering
a
Swivel axis
d
Contact patch
Scrub moment about swivel axis (M_s)
d
Offset Steering

Power Steering

- The power steering system is the system employed in automobiles to reduce the effort required to operate the steering wheel. This feature adds to the comfort while driving, as less effort is required to turn the steering by the driver.

Need of Power Steering

Drawbacks of Manual Steering :

- More effort is needed at low speeds, in tight turns & while parking.
- Doesn't work well for large/heavy vehicles.
- Can make a car more unsafe.
  - Power Steering helps drivers to steer vehicles with less effort by providing steering comfort.
  - Power steering (power assisted steering (PAS)) helps drivers steer by augmenting steering effort of the steering wheel.
- Hydraulic or electric actuators add controlled energy to the steering mechanism, so the driver can provide less effort to turn the steered wheels when driving at typical speeds, and reduce considerably the physical effort necessary to turn the wheels when a vehicle is stopped or moving slowly.
- Usual power steering systems for cars augment steering effort via an actuator, a hydraulic cylinder that is part of a servo system. These systems have a direct mechanical connection between the steering wheel and the linkage that steers the wheels.

- This means that power-steering system failure (to augment effort) still permits the vehicle to be steered using manual effort alone.
- Other power steering systems (such as those in the largest off-road construction vehicles) have no direct mechanical connection to the steering linkage; they require electrical power.
- Systems of this kind, with no mechanical connection, are sometimes called "drive by wire" or "steer by wire“. In this context, "wire" refers to electrical cables that carry power and data, not thin-wire-rope mechanical control cables.
- In other power steering systems, electric motors provide the assistance instead of hydraulic systems. As with hydraulic types, power to the actuator (motor, in this case) is controlled by the rest of the power-steering system.

- **Advantages:**

1. The power steering system reduces the number of turns of steering wheel required to move it from lock to lock (i.e. steering ratio on a vehicle having power steering us usually less).
2. Easy steering while parking, at low speeds or tight turns.

- **Disadvantages:**

The components used in the power steering assembly are more costly than the ones used in the normal steering. The most commonly power steering systems employed in automobiles are

1. Hydraulic power steering systems, and
2. Electrically assisted, electronic power steering systems (or simply electronic power steering systems).

Types of Power Steering:

There are two types of power steering system

- Hydraulic Power Steering
- Electronic Power Steering

Hydraulic Power Steering System: The hydraulic power steering, as discussed above, is the system having a hydraulic booster that reduces the force required to operate the steering wheel.

Components:

The hydraulic power steering system consists of the following major components, as shown in fig.

1. **Pump:** It generates hydraulic pressure.
2. **Control Valve:** It switches the oil passage to the power cylinder according to the rotational direction of the steering wheel.
3. **Power Cylinder:** It moves the piston in the cylinder to the right or left with hydraulic force and thereby assists the steering wheel operation.
4. **Fluid Reservoir:** The power steering fluid reservoir stores fluid and cleans it using a built in filter.

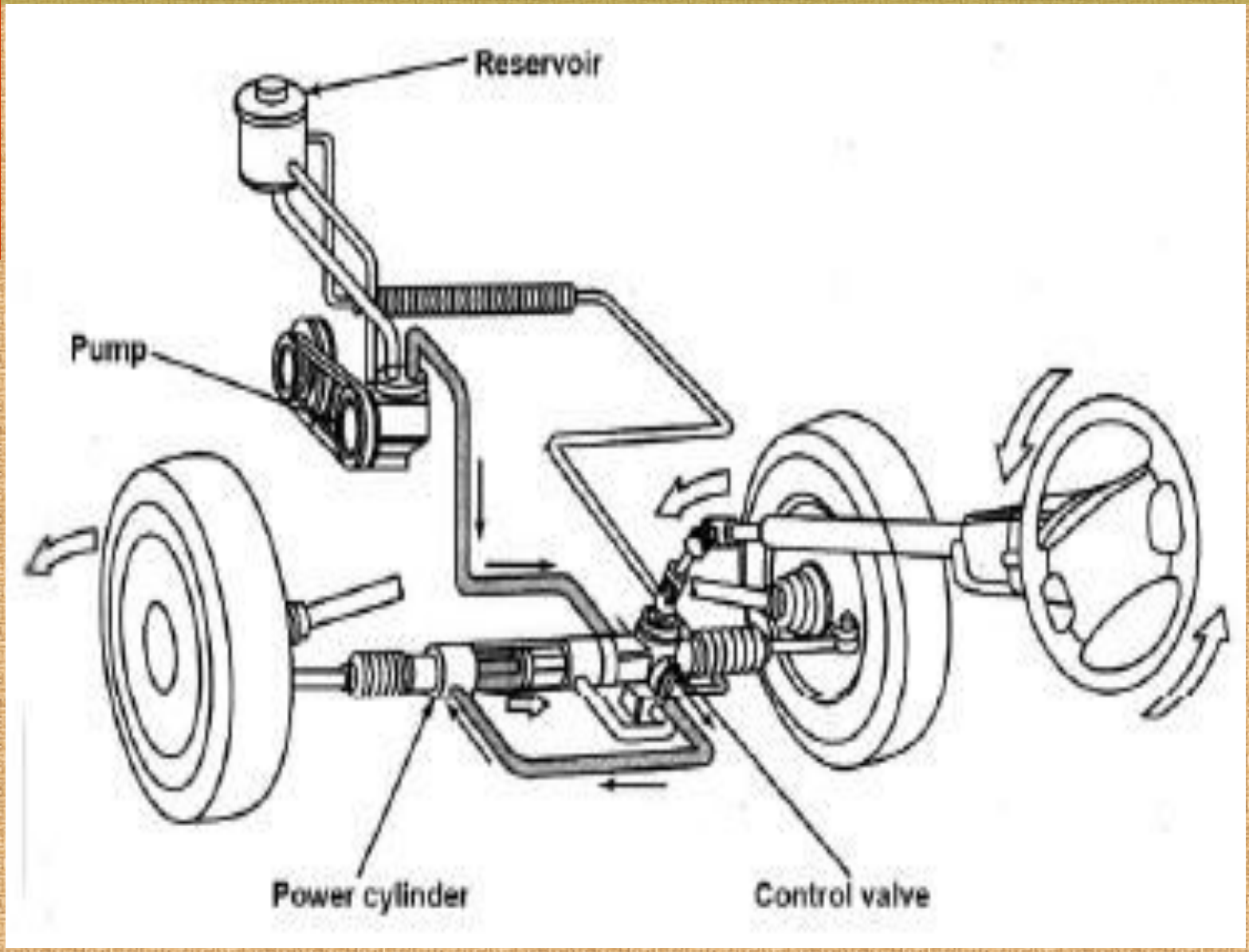
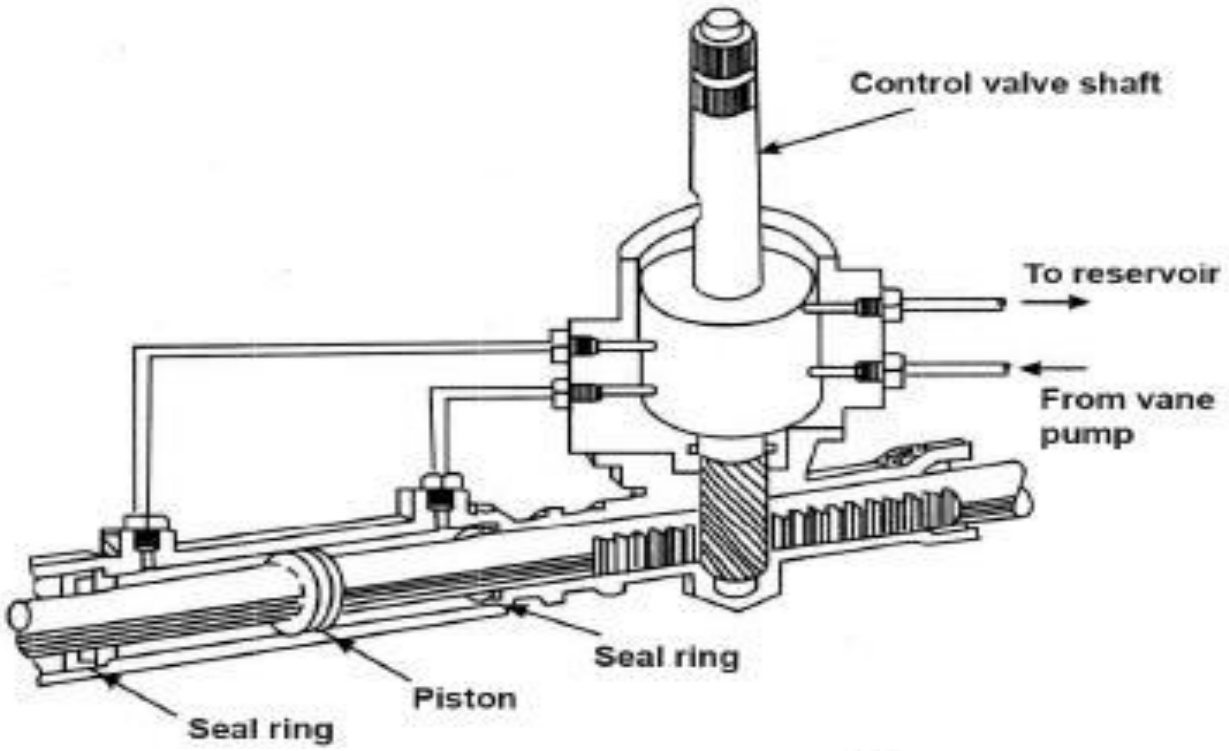


Fig. Hydraulic Power Steering system



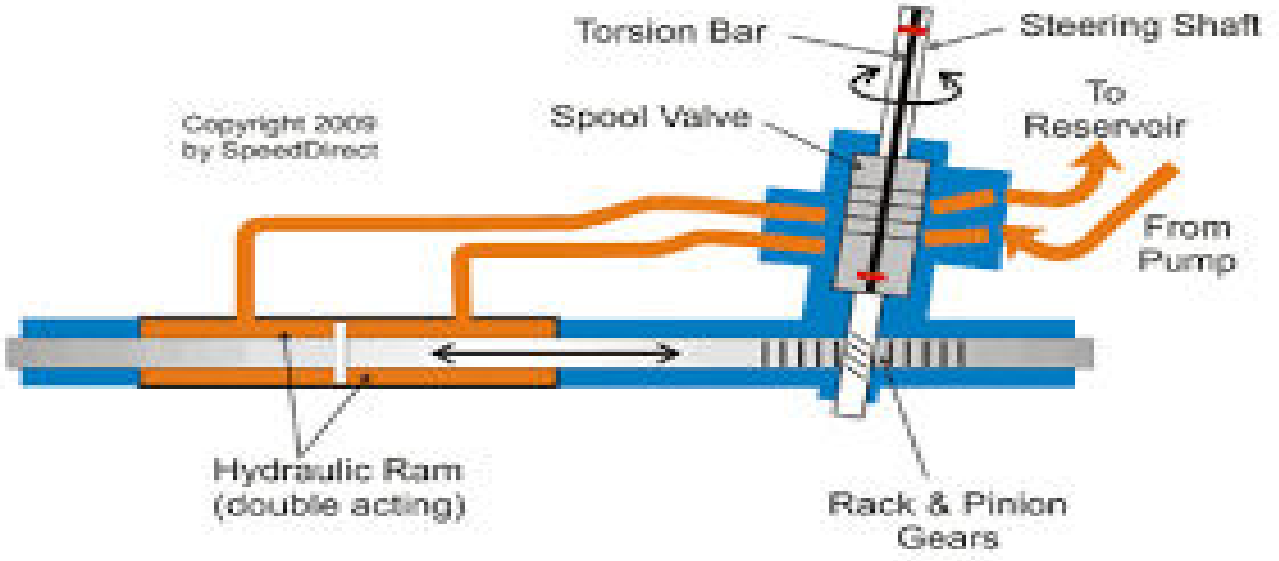
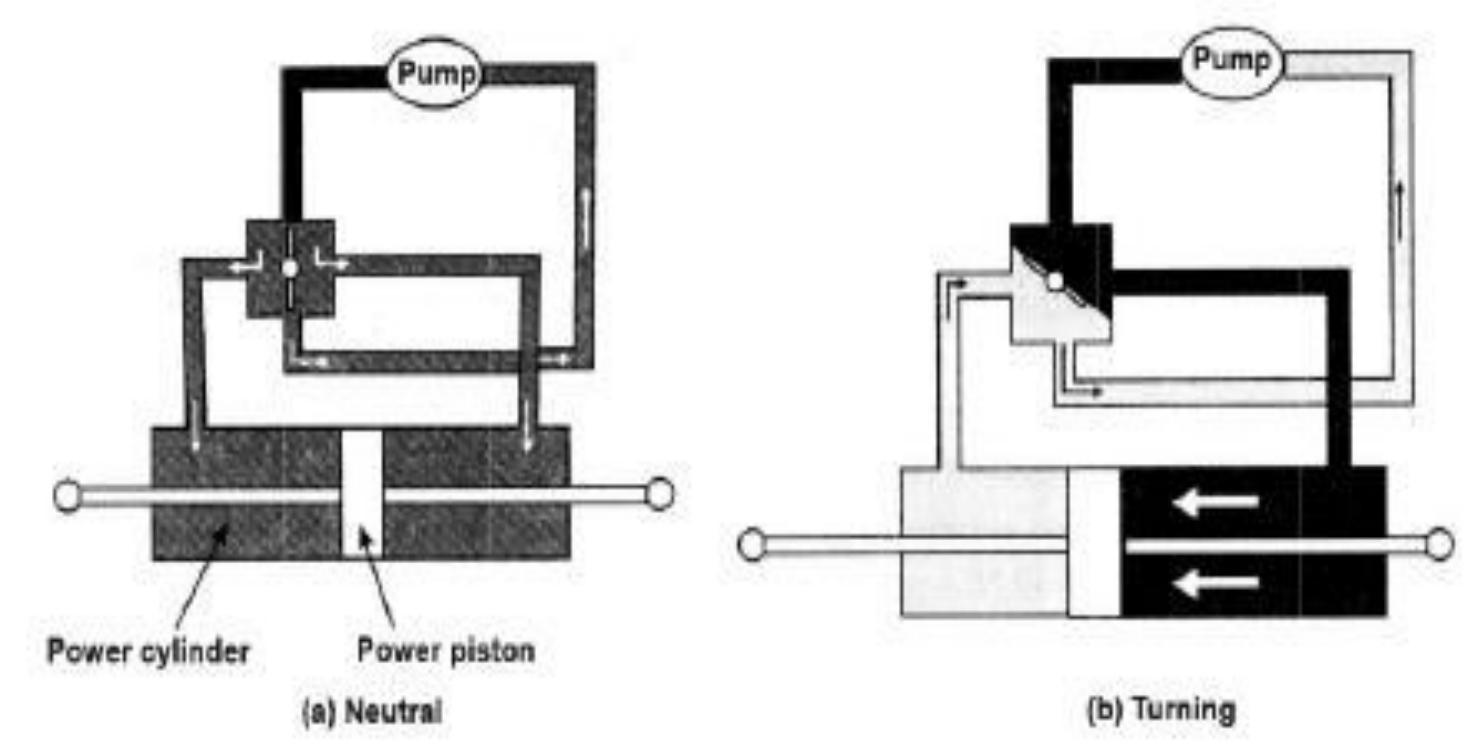


Fig. Rack and Pinion Hydraulic Power Steering

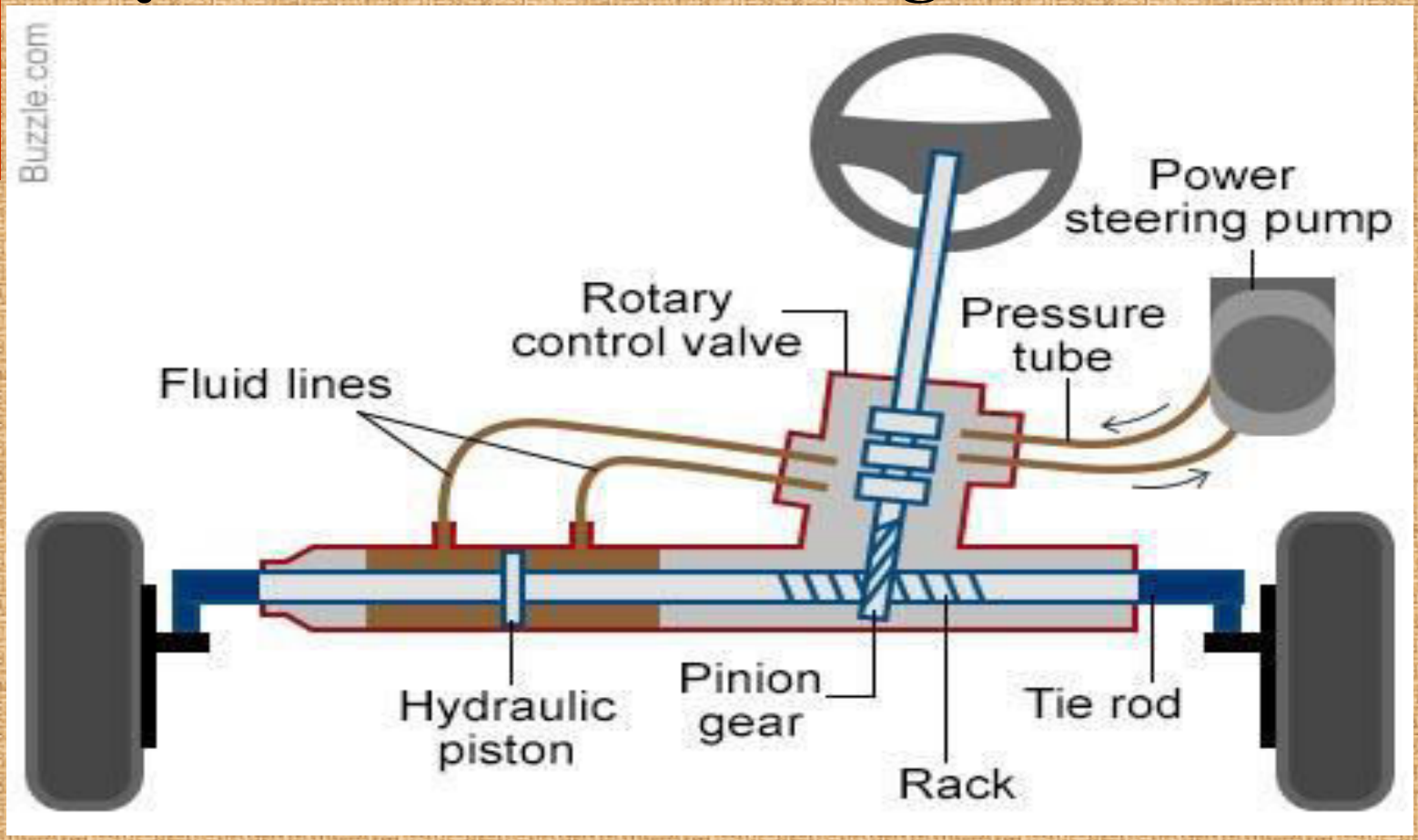
Working Principle

- **Neutral (Straight-Ahead) Position:**



- **While Turning:**

- **Hydraulic Power Steering:**



Hydraulic Power Steering System:

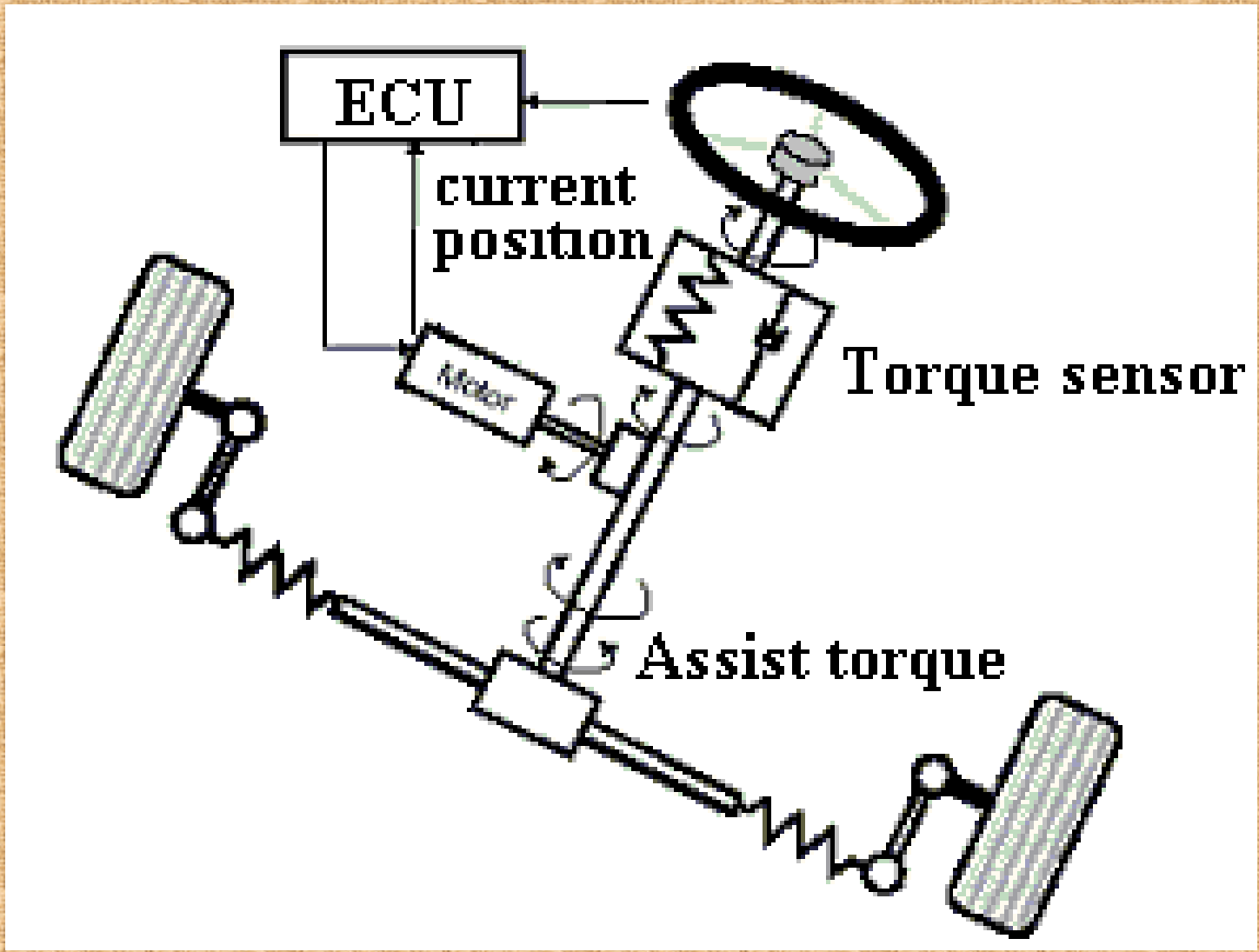


Power Steering Fluid Reservoir & Pulley Driven Pump:

Electro-Hydraulic Power Steering:

- 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 comes from a pump driven by an electric motor instead of a drive belt at the engine.
- This means that the power steering would still operate while the engine was stopped 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.

Electronic Power Steering



Electronic Power Steering

Limitations of Power Steering:

- Parasitic loss to the engine. (However, it is nearly negligible in most cases.)
- Tends to be oversensitive (follows ruts in road, false inputs from harsh bumps)
- Depending on suspension settings, power steering can make the car feel light, particularly at high speeds.
- Added weight and complexity.

SUSPENSION SYSTEM

- **INTRODUCTION:**
- To isolate the vehicle body from the road shocks the automobile chassis is mounted on the axle through some form of springs, shock absorber, etc. All the parts which perform the function of isolating the automobile from the road shocks are collectively called a suspension system.
- •The automobile chassis is mounted on the axles, not directly but through some form of springs.
- •This is done to isolate the vehicle body from road shocks which may be in the form of pitch, bounce, roll or sway.
- •These tendencies give rise to an uncomfortable ride & also cause additional stress in the frame & body.
- •All the parts which perform the function of isolating the automobile from the road shocks – ***Suspension System.***

NEED/OBJECTIVES OF SUSPENSION SYSTEM

1. Protects the passengers from road shocks & provide a comfortable ride.
2. Prevents the vehicle body from tipping while traveling over rough ground or when turning. This helps to minimize the tendency of rolling, pitching, or vertical movement.
3. Provides cushioning effect. Thus, minimizes the effects of stress on vehicle components and mechanisms.
4. Maintains the vehicle body at a perfect level while traveling over rough, uneven ground. This enables the up and down movement of the wheels relative to the body.
5. Insulates the vehicle structure from shocks and vibrations due to irregularities of the road surface without affecting its stability.
6. Provides required height to the body structure as well as bears the torque and braking reactions.
7. Suspension system maximizes the friction between road surface & the tyres during acceleration, cruising & braking.

- **Principle**:
- When a tire hits an obstruction, there is a reaction force. The size of this reaction force depends on the unsprung mass at each wheel assembly.
- In general, the larger the ratio of sprung weight to unsprung weight, the less the body and vehicle occupants are affected by bumps, dips, and other surface imperfections such as small bridges. A large sprung weight to unsprung weight ratio can also impact vehicle control. No road is perfectly flat i.e. without irregularities. Even a freshly paved highways have subtle imperfections that can be interact with vehicle's wheels. These are the imperfections that apply forces on wheels.

- According to **Newton‘s law of motion** all forces have both magnitude and direction. A bump in the road causes the wheel to move up and down perpendicular to the road surface. The magnitude of course, depends on whether the wheel is striking a giant bump or a tiny speck. Thus, either the wheel experiences a vertical acceleration as it passes over an imperfection. The suspension of a car is actually part of the chassis, which comprises all of the important systems located beneath the car's body. These systems include:
- Frame
- Suspension system
- Steering system
- Tires or Wheels

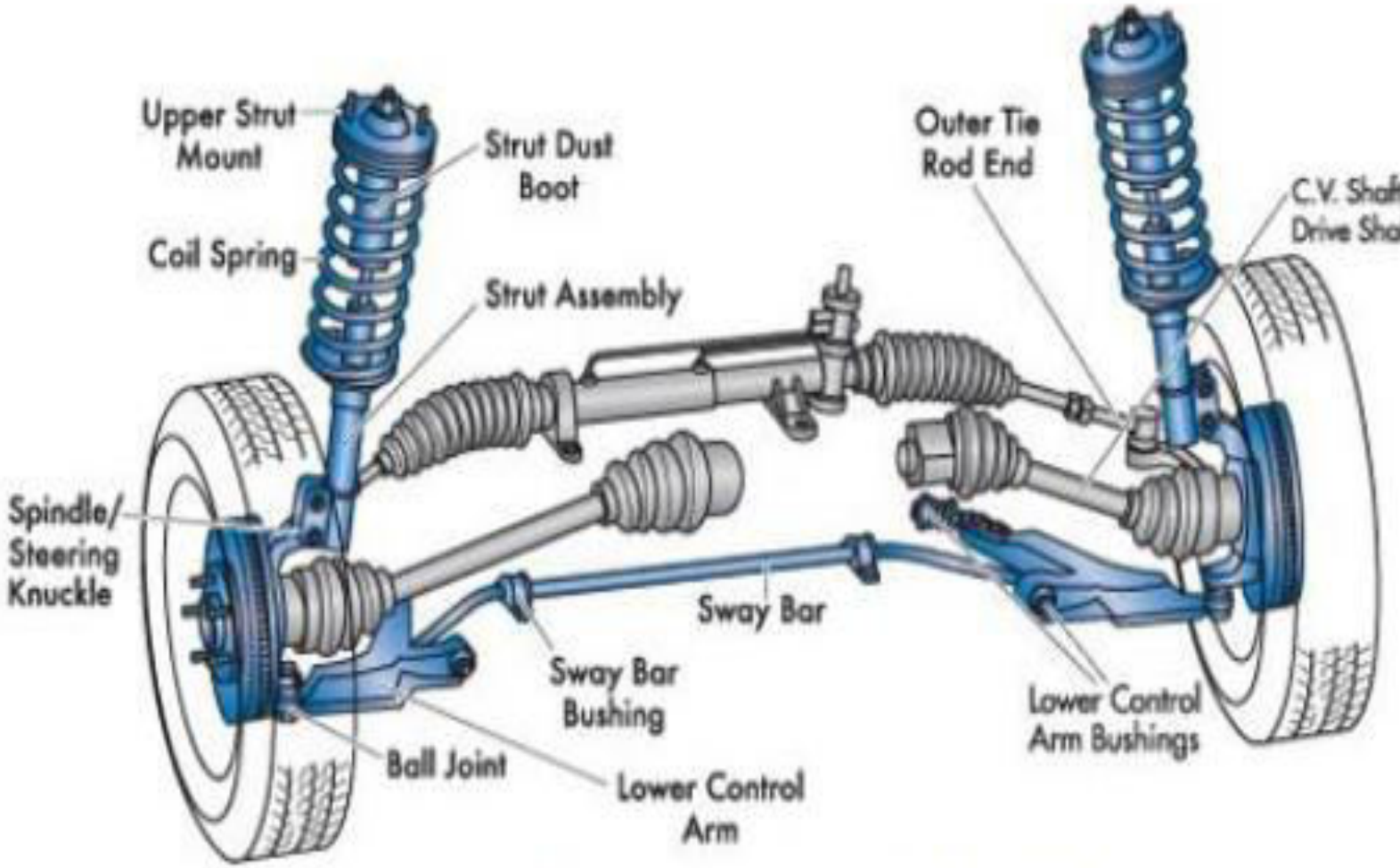
The suspension system serves the following functions:

- It connects the vehicle body and the wheels, and thus supports the weight of the vehicle.
- During running it acts together with the tyres to absorb and damp the various vibrations, oscillations and shocks received by the vehicle due to irregularities of the road in order to protect the passengers and cargo, and improve driving stability.
- It transmits the driving and braking forces, which are generated due to friction between the road surface and the wheels, to the chassis and body.

- **Requirements of a suspension system:**
- Low initial cost.
- Minimum weight.
- Minimum tyre wear.
- Minimum deflection consistent with required stability.

- **Components of Suspension system:**
- There are three fundamental components of any suspension system.
- **Springs**
- 1. Coil spring
- 2. Leaf springs
- 3. Air springs
- **Dampers**
- Shock Absorbers
- Struts:-
- Anti-sway Bars
- Anti sway bars.

SUSPENSION GEOMETRY

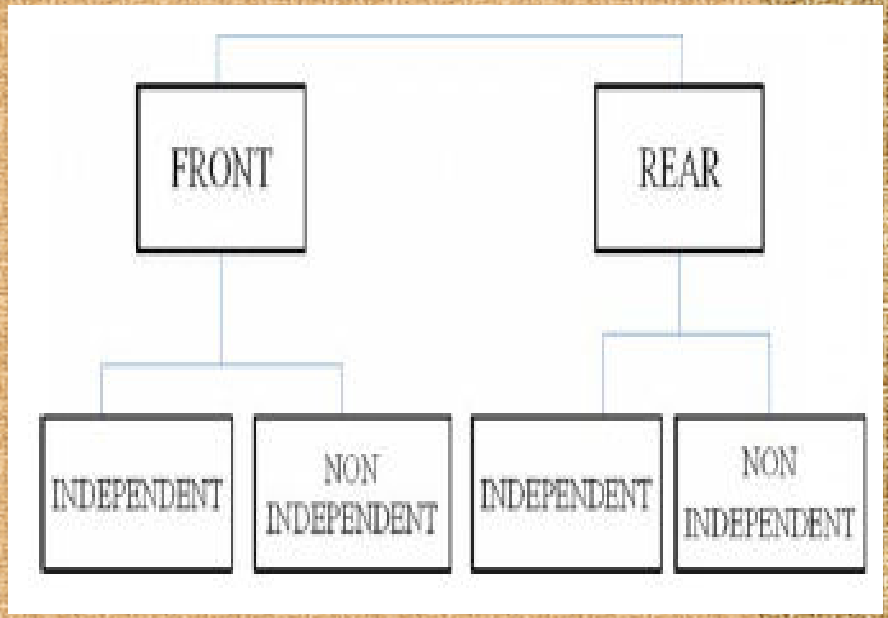


Suspension of a Front Wheel

SUSPENSION TERMINOLOGY:

- •King pins (or) Swivel Joints: It's the main part in the steering mechanism of a vehicle.
- •Pivot Centre: It's the point where the king pin axis projects & intersects the ground.
- •Contact Patch: The flattened crown area of a tyre which contacts the ground.
- •Track: Distance b/w both steering wheel contact centres

Types of Suspension system

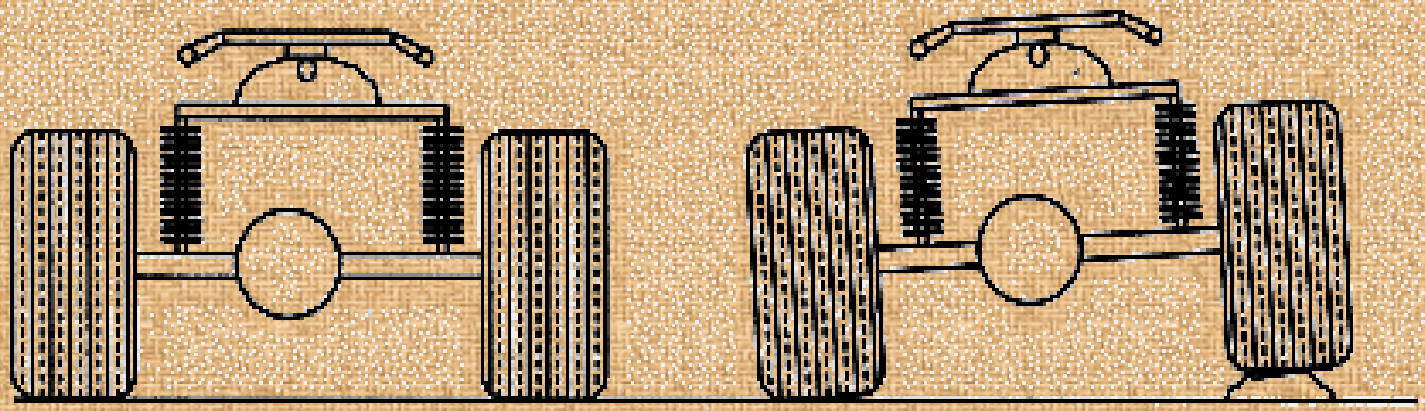


- Conventional suspension system
- Independent suspension system
- Air suspension system
- Hydro elastic suspension system
- Non-independent suspension:

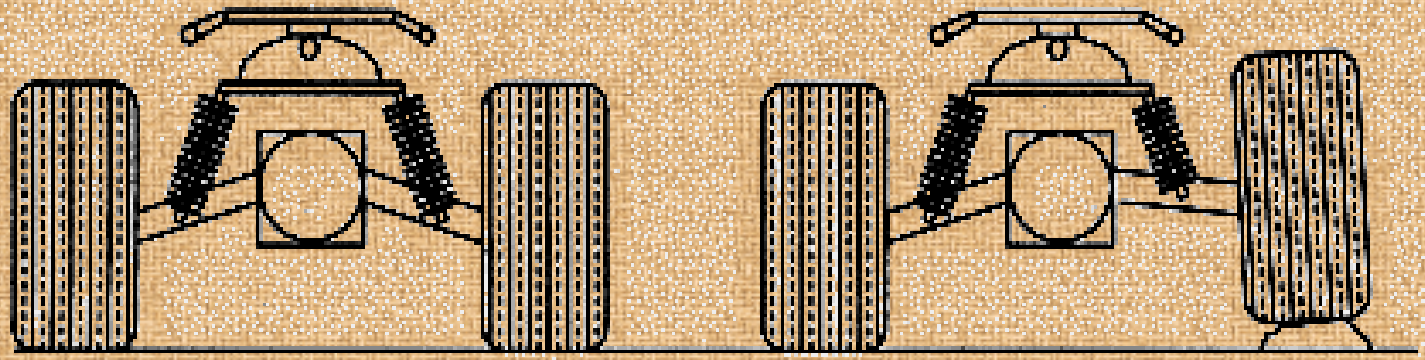
- It has both right and left wheel attached to the same solid axle. When one wheel hits a bump in the road, its upward movement causes a slight tilt of the other wheel.

- Independent suspension:- Independent suspension is a broad term for any automobile suspension system that allows each wheel on the same axle to move vertically independently of each other

LOW SPEED BUMP WITH THE PATENTED LEHMAN "NO LEAN SUSPENSION"



LOW SPEED BUMP WITH INDEPENDENT SUSPENSION



- **Rigid Suspension (Conventional suspension system):**
- Two wheels are mounted on either side of the rigid axle
- When one wheel encounters the bump, both the wheel do not execute parallel up and down motion
- So it gives rise to gyroscopic effect and wheel wobble
- Rear driving wheels mounted on live axle suspended by laminated leaf springs and shock absorbers

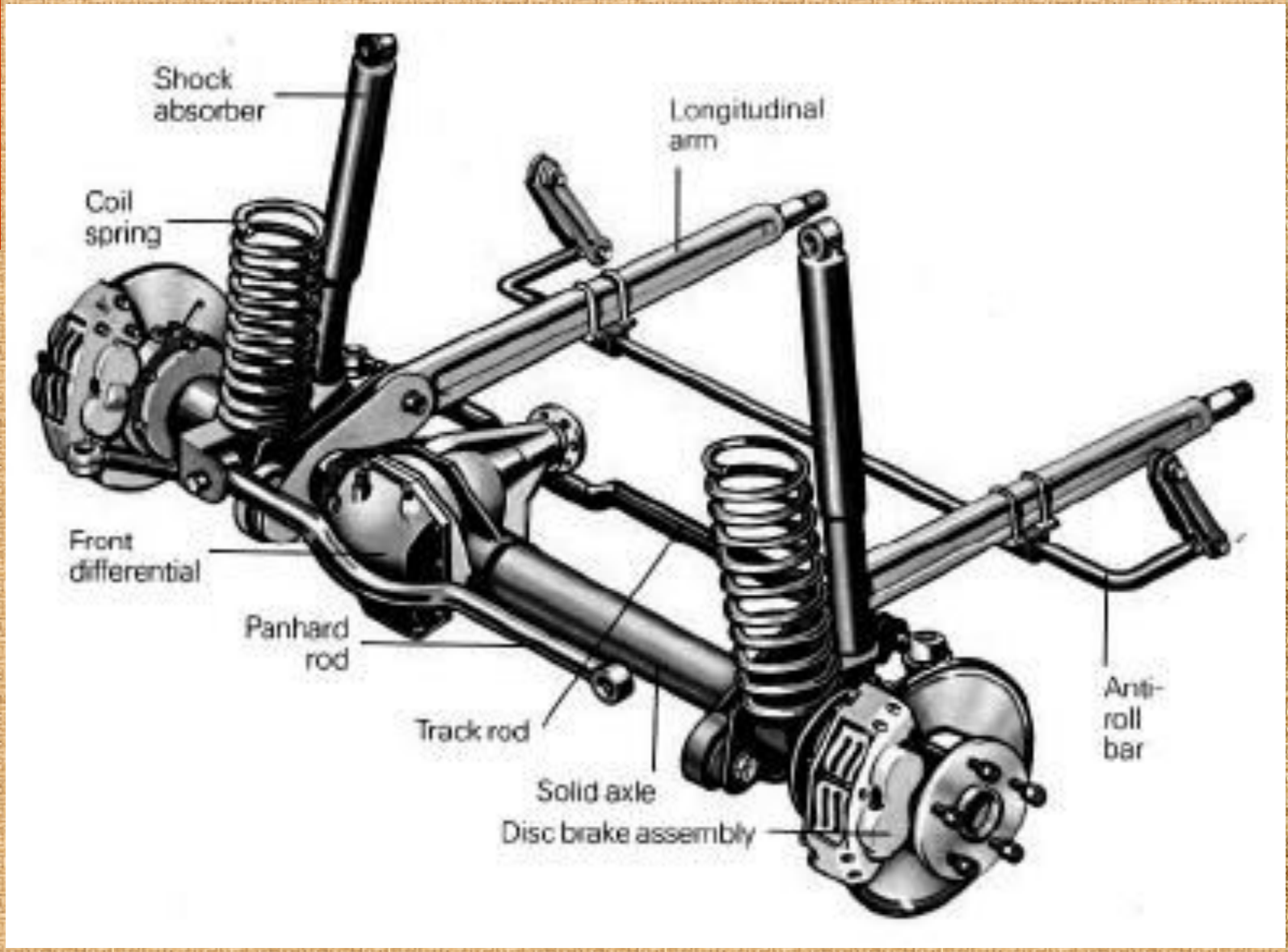


Fig. Rigid Axle Suspension System with coil springs and shock absorber

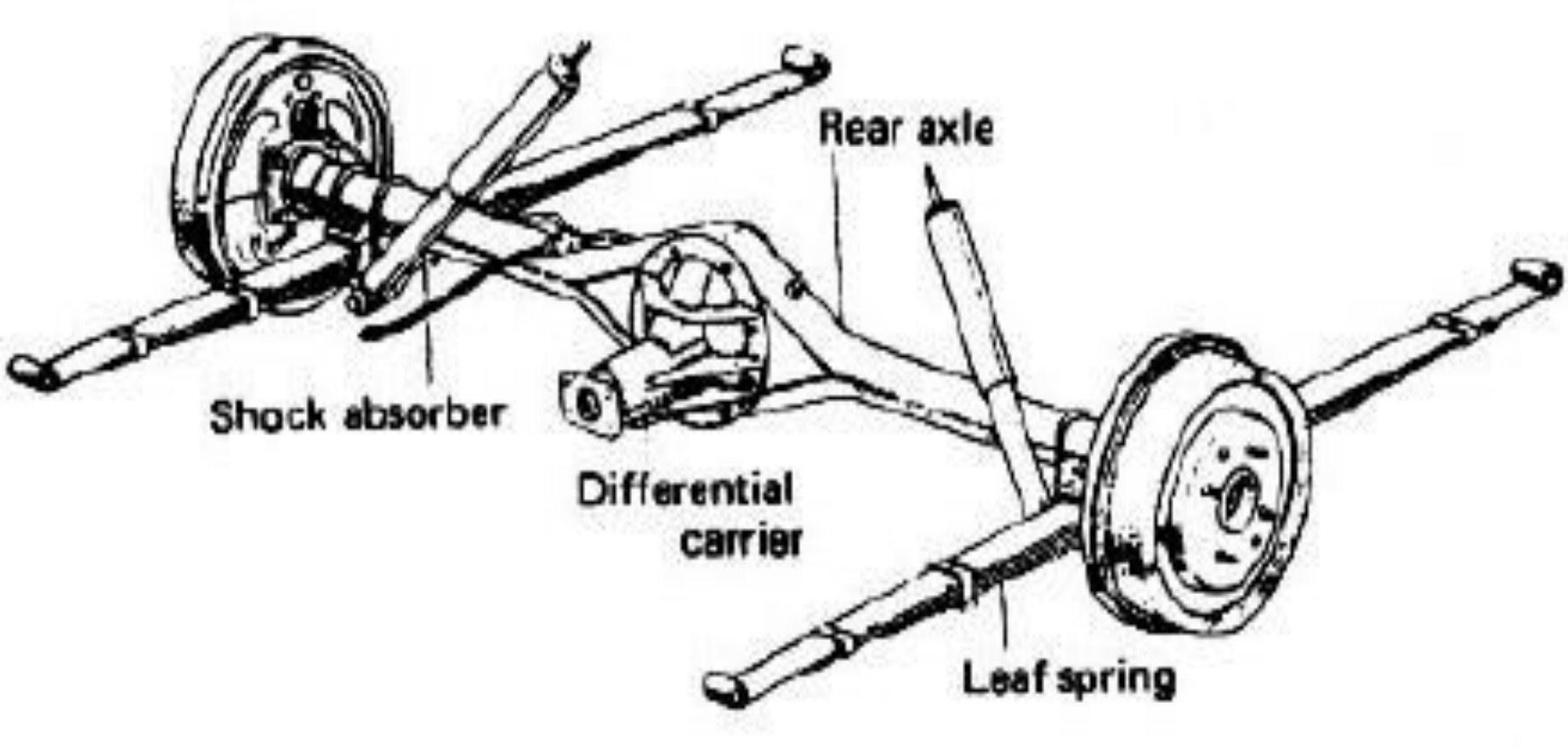
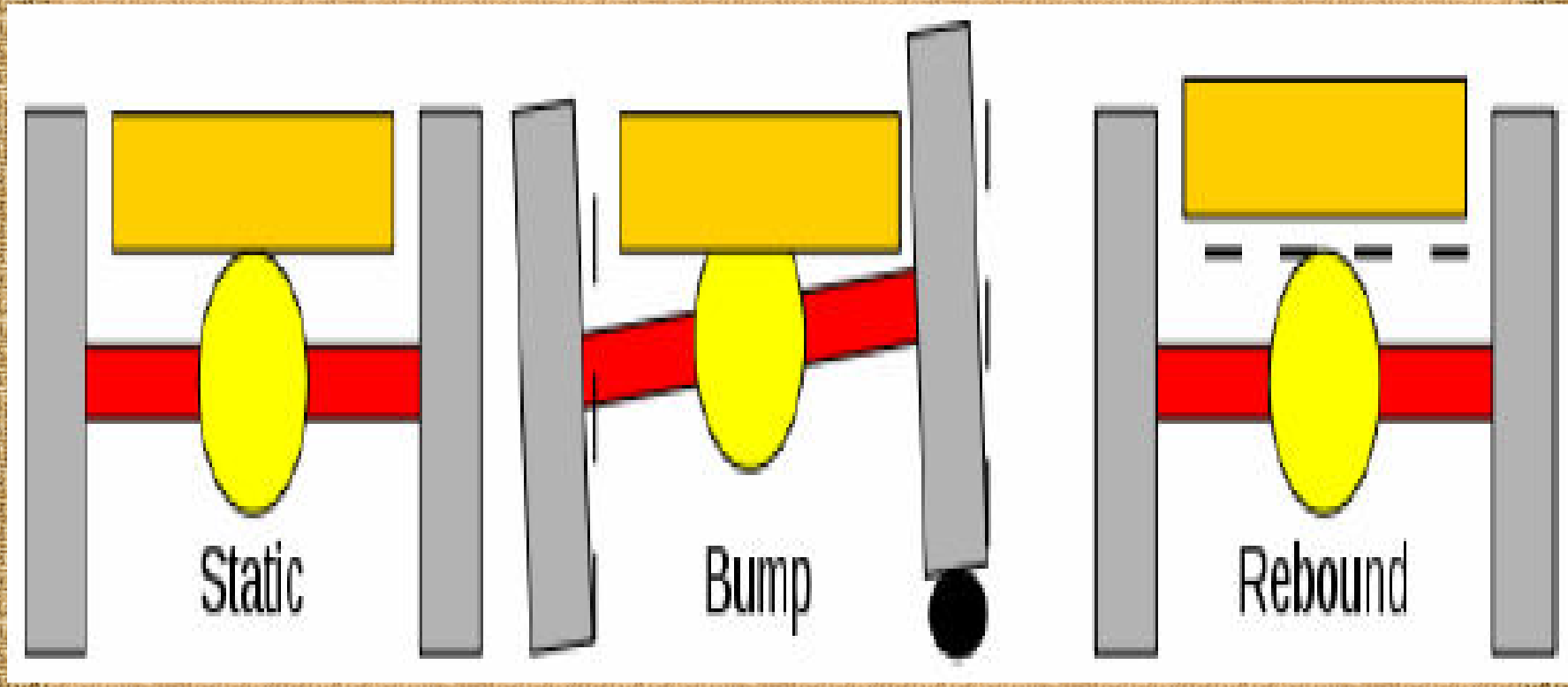


Fig. Rigid Axle Suspension System with leaf springs and shock absorber

There cannot be any independent movement of the two stub axles in a rigid axle beam suspension.

With a beam axle, the camber angle between the wheels is the same no matter where it is in the travel of the suspension.



ADVANTAGES:

- The principal advantage is its simplicity.
- Very space-efficient and relatively cheap to manufacture.
- Provide better vehicle articulation and durability in a high load environment
- They are universally used in buses and heavy-duty trucks.
- Most light and medium duty pickup trucks, SUVs, and vans also use a beam axle, at least in the rear.

DISADVANTAGES

- It does not allow each wheel to move independently in response to bumps.
- Mass of the beam is part of the unsprung weight of the vehicle, which can further reduce ride quality.
- Also the cornering ability is typically worse than other suspension designs.
- Can cause a side-to-side oscillation of steering at certain speeds (typically 40-50 mph).

Independent Suspension

Following figure shows the principle of independent suspension system.

- Both the front and the rear wheel are utilized
- Design incorporated in the front wheels
- One wheel goes down ,the other wheel does not have much effect

Basic classification of the design

- Macpherson Strut
- Double Wishbone
- Multi link

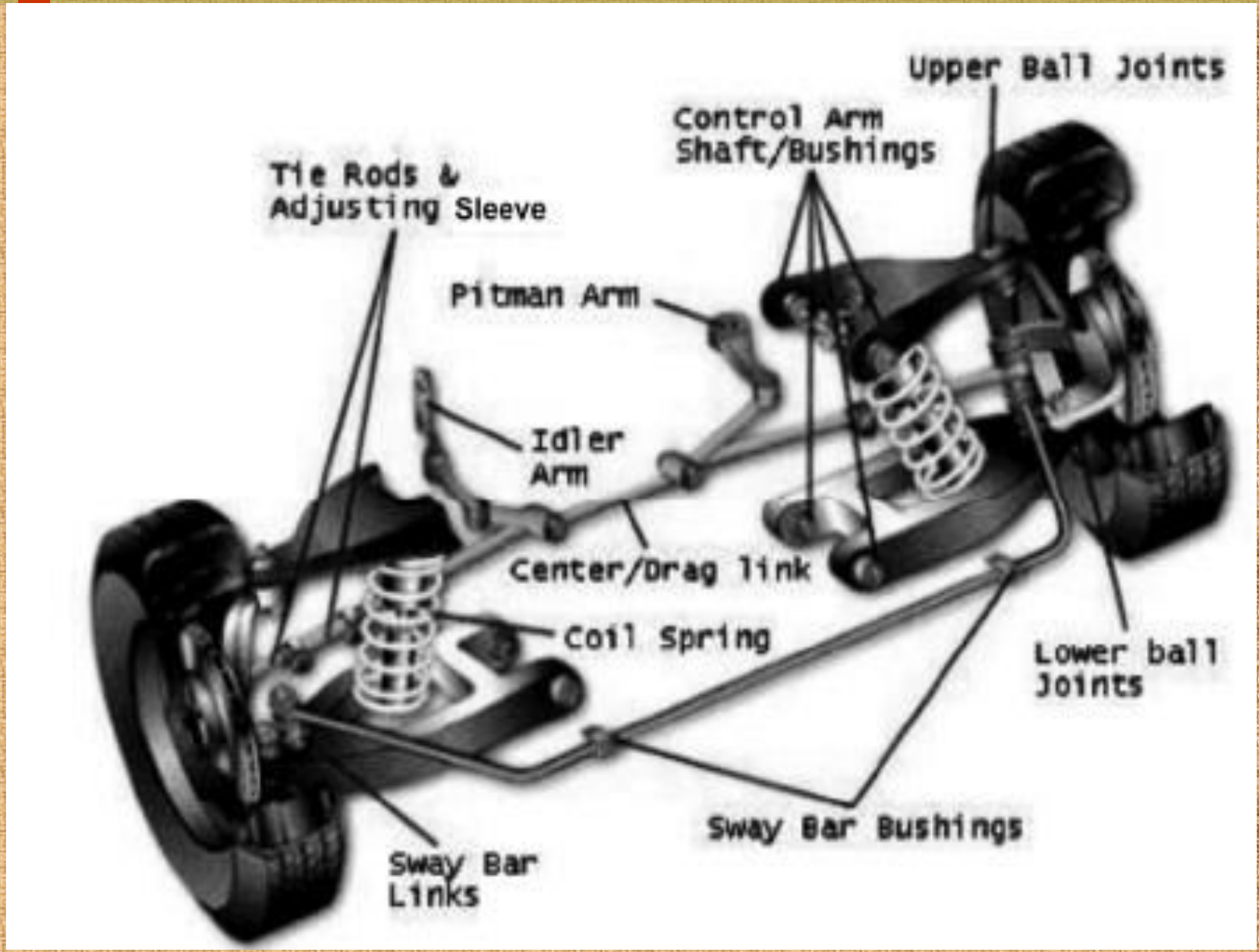


Fig. Independent Suspension System

The different variations of independent front wheel and rear wheel suspensions may be of following categories;

- With Coil Spring
- With Leaf Spring
- With Torsion Bar Spring
- Shock Absorber with any of the above

Advantages:

1. Comfort to passengers
2. Good handling
3. Shields the vehicle from damage
4. Increases life of vehicle
5. Keeps the tires pressed firmly to ground.

Advantages (independent front):

- Bigger deflection of front wheels, no reaction on steering
- Greater distance for resisting rolling action
- Front axle (small-stub), improves road holding tendency of tyres.
- Minimum vibrations

Disadvantages:

- Better shock absorber required.
- Expensive
- Tyre wear increases due to transmission of torque.

Advantages (independent rear suspension):

- Lesser unsprung weight – improves ride, reduces tyre wear
- Increased passenger space
- Rear wheels remain stable

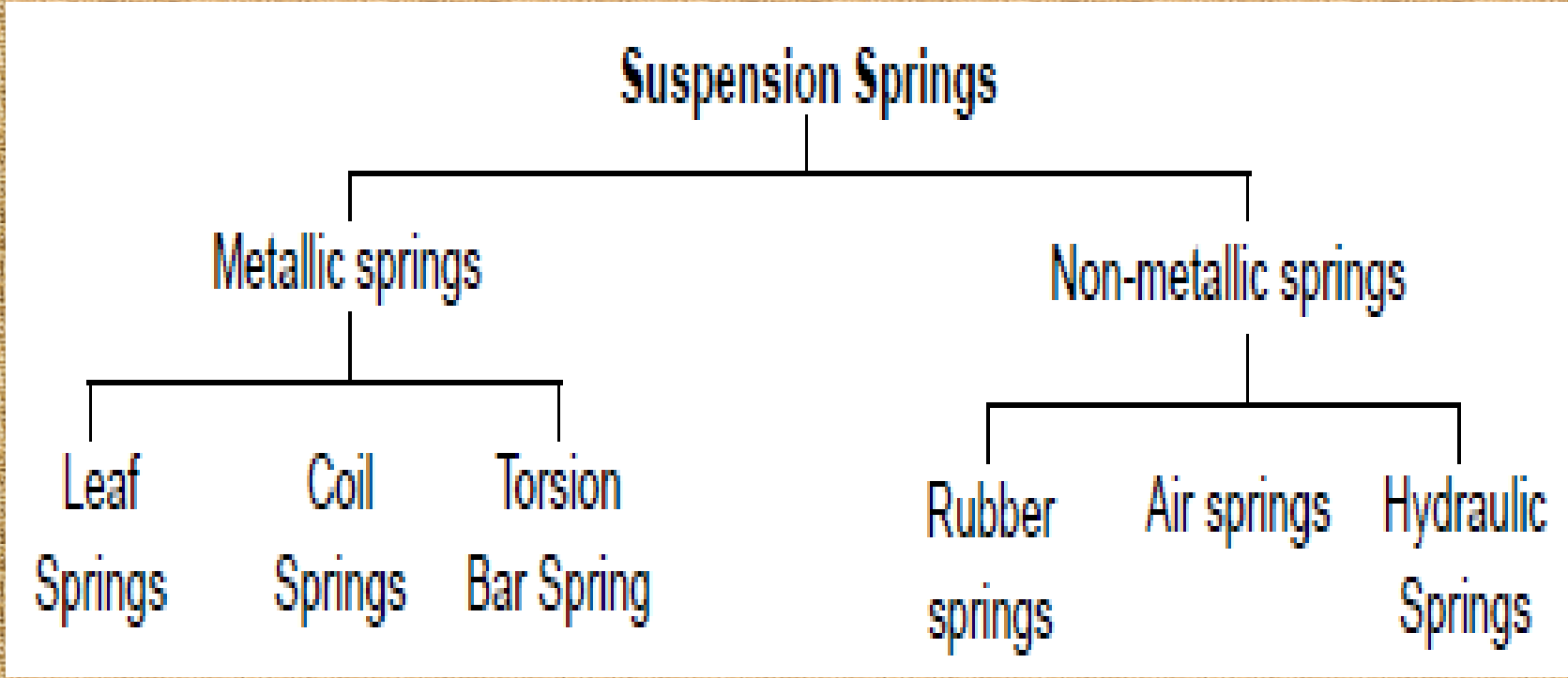
Disadvantages:

- Increased cost
- Complicated design
- Steering action is not proper

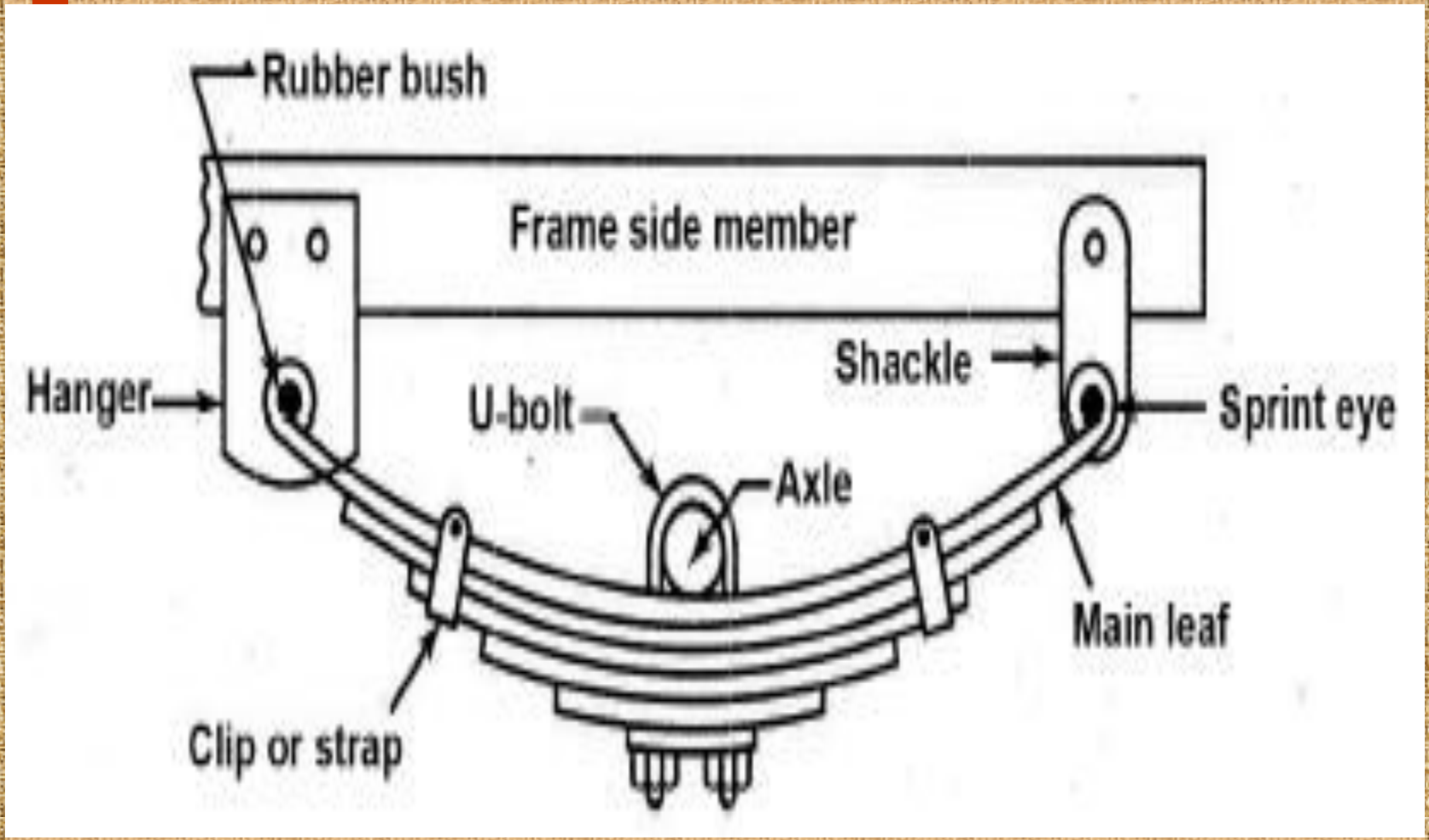
Components of a Suspension system:

- It consists of the following principle components:
- 1. Springs, which neutralize the shocks from the road surface?
- 2. Shock absorbers (dampers), which act to improve riding comfort by limiting the free oscillation of the springs.
- 3. Stabilizer (sway or anti roll bar), which prevents lateral swaying of the car.
- 4. A linkage system, which acts to hold the above components in place and to control the longitudinal and lateral movements of the wheels.

Suspension Spring



Leaf Spring


Rubber bush
Frame side member
Hanger
U-bolt
Shackle
Sprint eye
Axle
Main leaf
Clip or strap

Types of Leaf Springs:

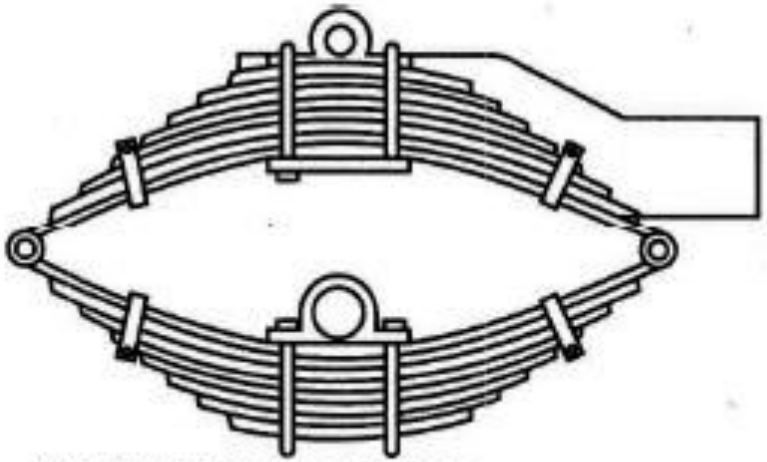
a. **Full elliptical leaf spring:** This type of leaf spring refers to two semi-elliptical springs connected at their ends, to form the shape of an ellipse as shown in Fig. (a).

b. **Three quarter elliptical leaf spring:** This type of leaf spring refers to one semi-elliptical spring connected over a quarter elliptical springs as shown in Fig. (b).

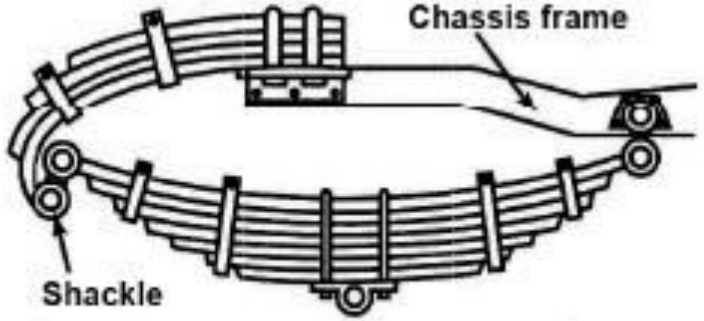
c. **Semi-elliptical leaf spring:** This type of leaf spring refers to forming the shape of half ellipse as shown in Fig. (c). It is most commonly used in all types of heavy vehicles.

d. **Quarter elliptical leaf springs:** This type of leaf spring refers to forming the shape of half of semi-elliptical spring as shown in Fig. (d). this type of system is also called as cantilever spring system, the thick end of which is bolted rigidly to the frame.

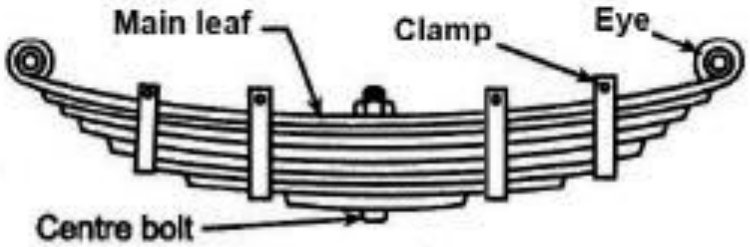
e. **Transverse leaf Spring:** This type of leaf spring refers to a semi elliptical spring mounted in a inverted manner, and has saddle at above forming a bow and is attached parallel to the wheel axle as shown in Fig. (e).



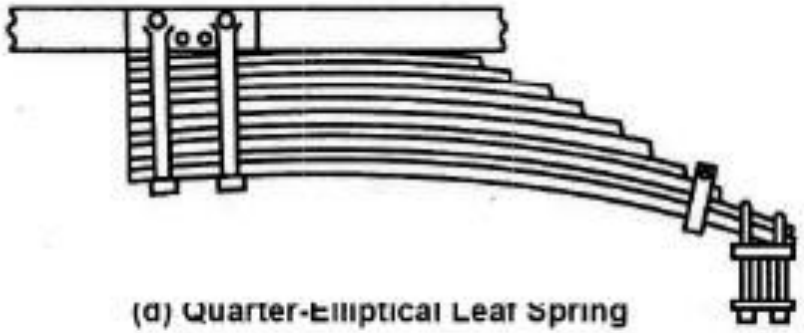
(a) Full Elliptical Leaf Spring



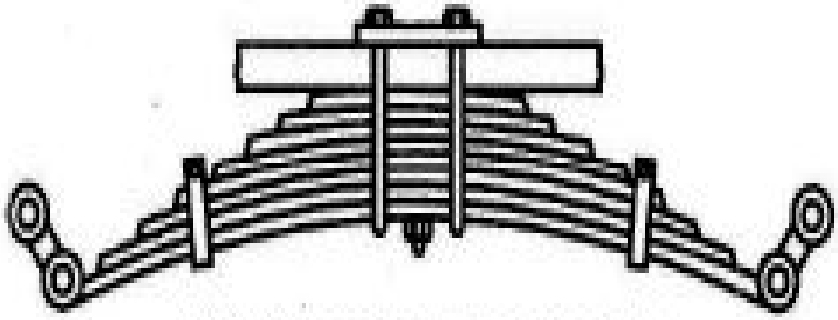
(b) Three Quarter Elliptical Leaf Spring



(c) Semi-Elliptical Leaf Spring



(d) Quarter-Elliptical Leaf Spring



(e) Transverse Leaf Spring

Helper Springs

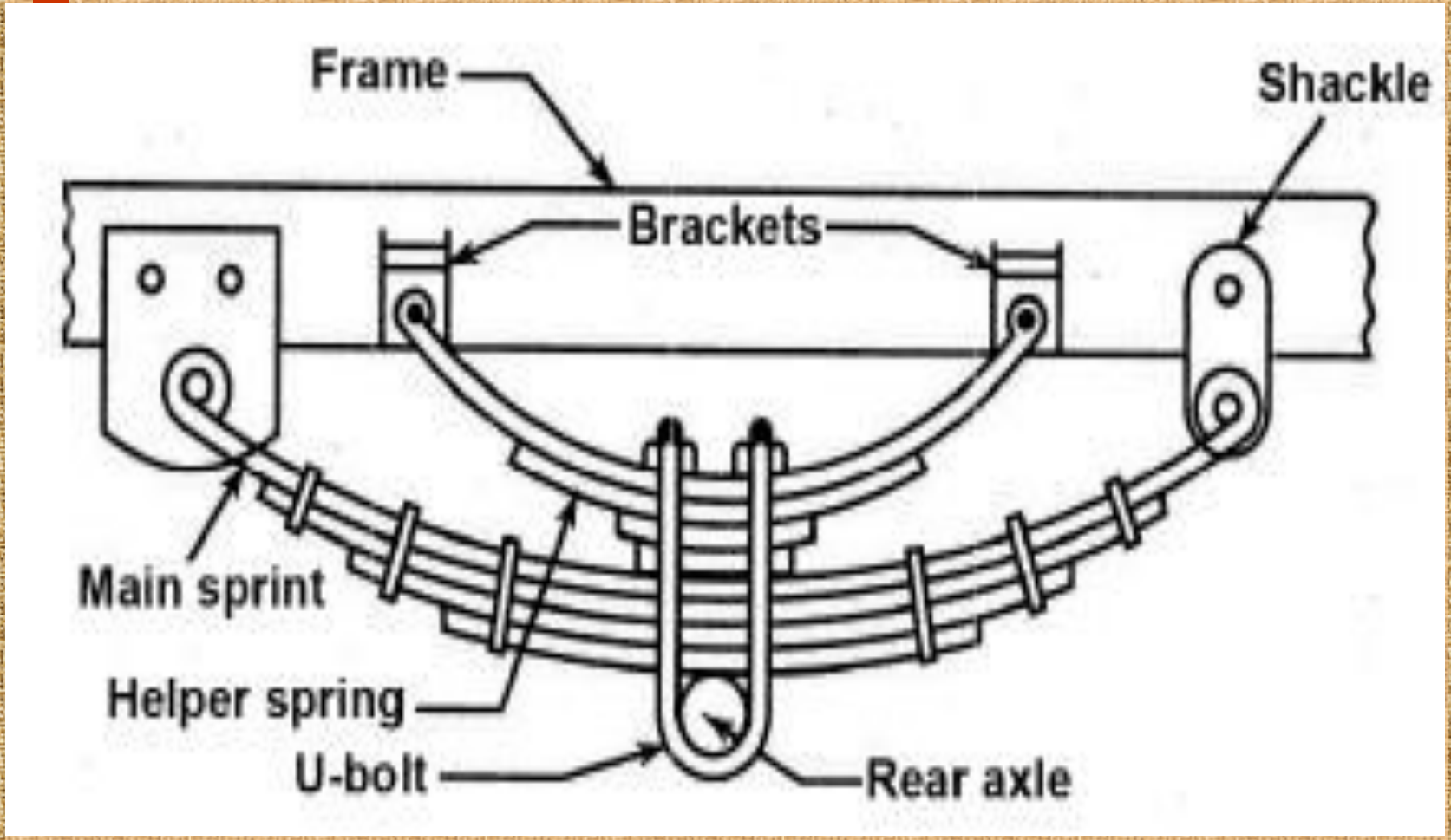


Fig. Helper Springs

Features of Leaf Springs

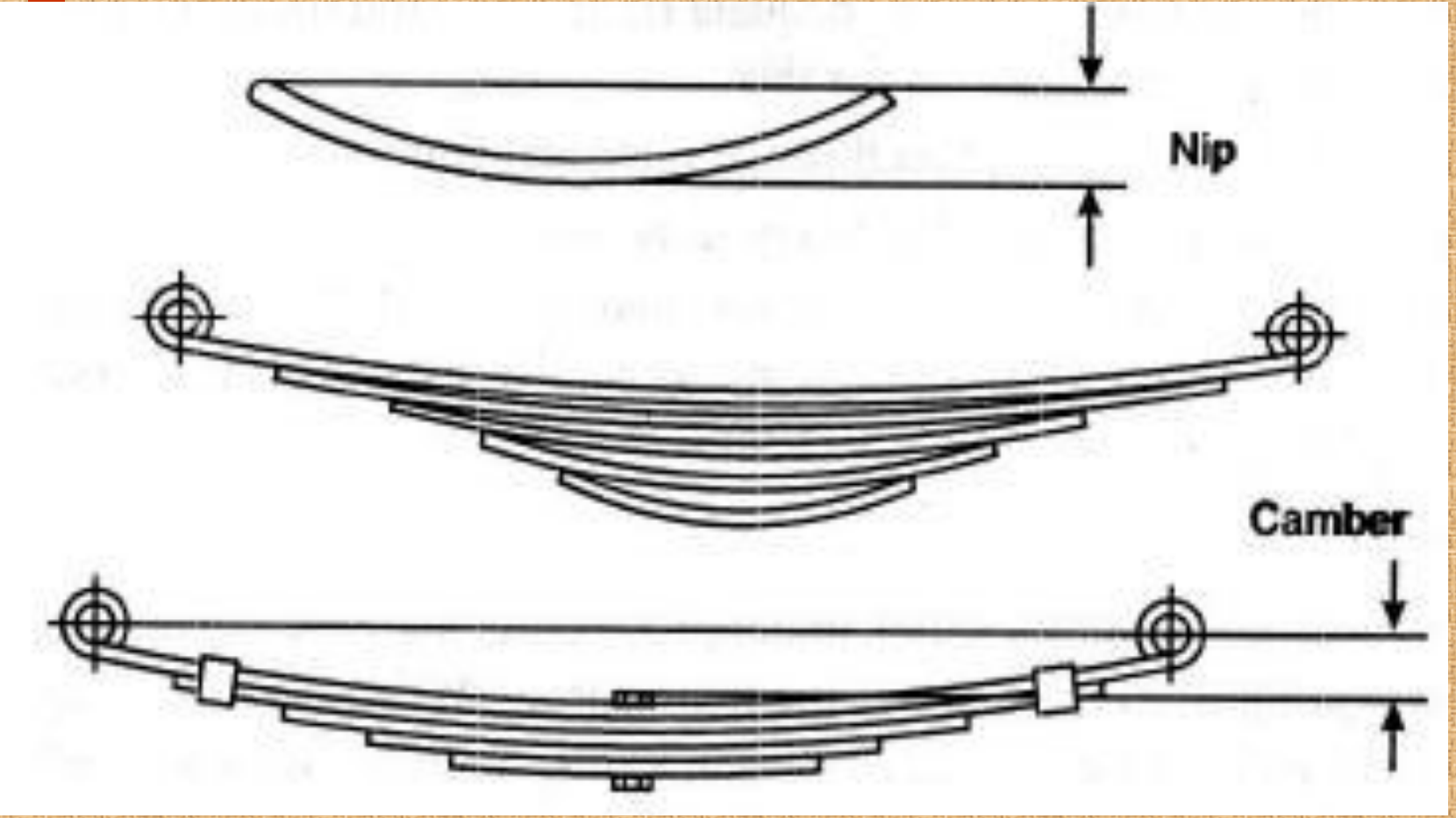
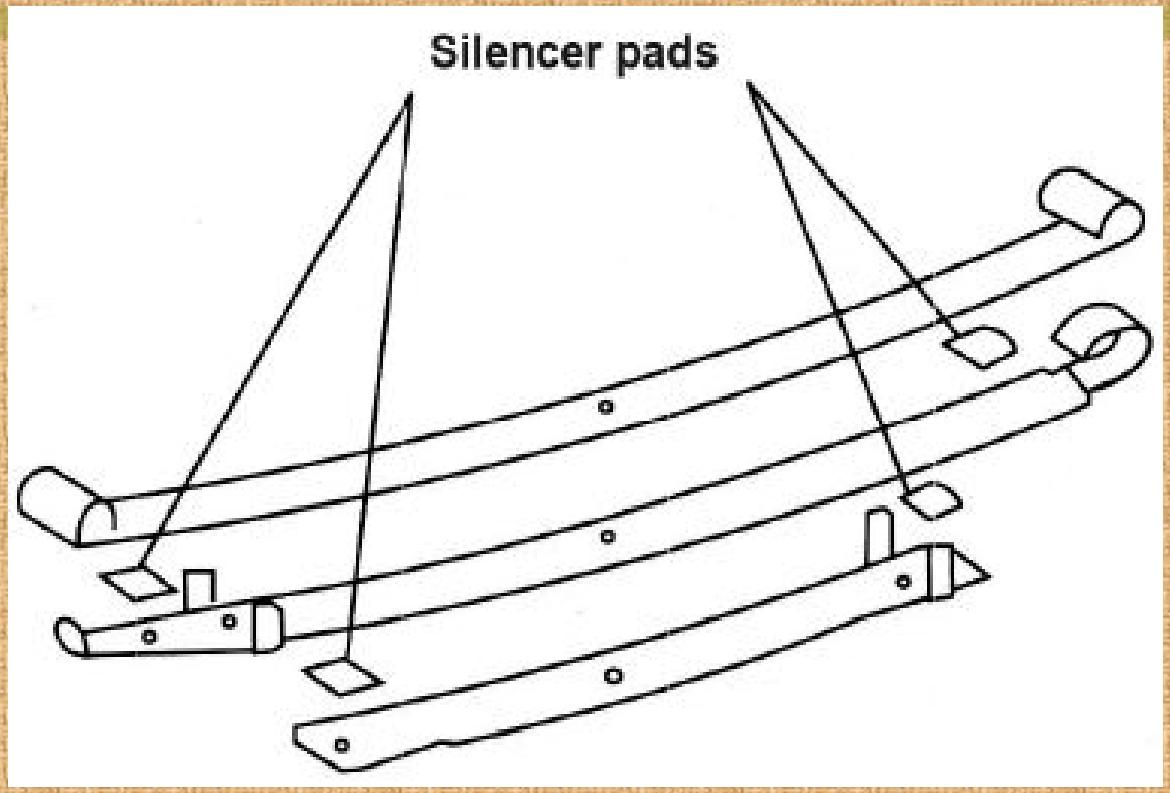


Fig. Springs Nip and Camber

- **Techniques to reduce inter leaf friction**
- Since riding comfort deteriorates if the inter-leaf friction is great, measures are taken in actual leaf springs to reduce this friction. Silencer pads are inserted between each of the leaves at their ends to improve the sliding of the leaves against each other.



Each of the leaves is also tapered at the ends so that they exert the proper amount of pressure when they come in contact with each other.

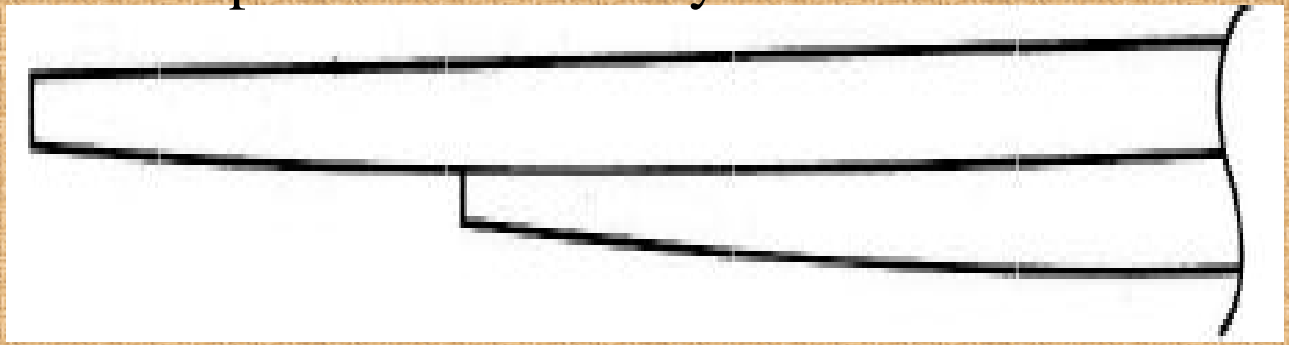


Fig. Tapered at the ends of each Leaf

- **Characteristics of Leaf Springs:**

1. Since the springs themselves have adequate rigidity to hold the axle in the proper position, it is not necessary to use linkages for this.
2. They control their own oscillation through inter-leaf friction.
3. They have sufficient durability for heavy-duty use.
4. Due to inter-leaf friction, it is difficult for them to absorb the minute vibrations from the road surface. Therefore, leaf springs are generally used for large commercial vehicles which carry heavy loads.

Coil Springs

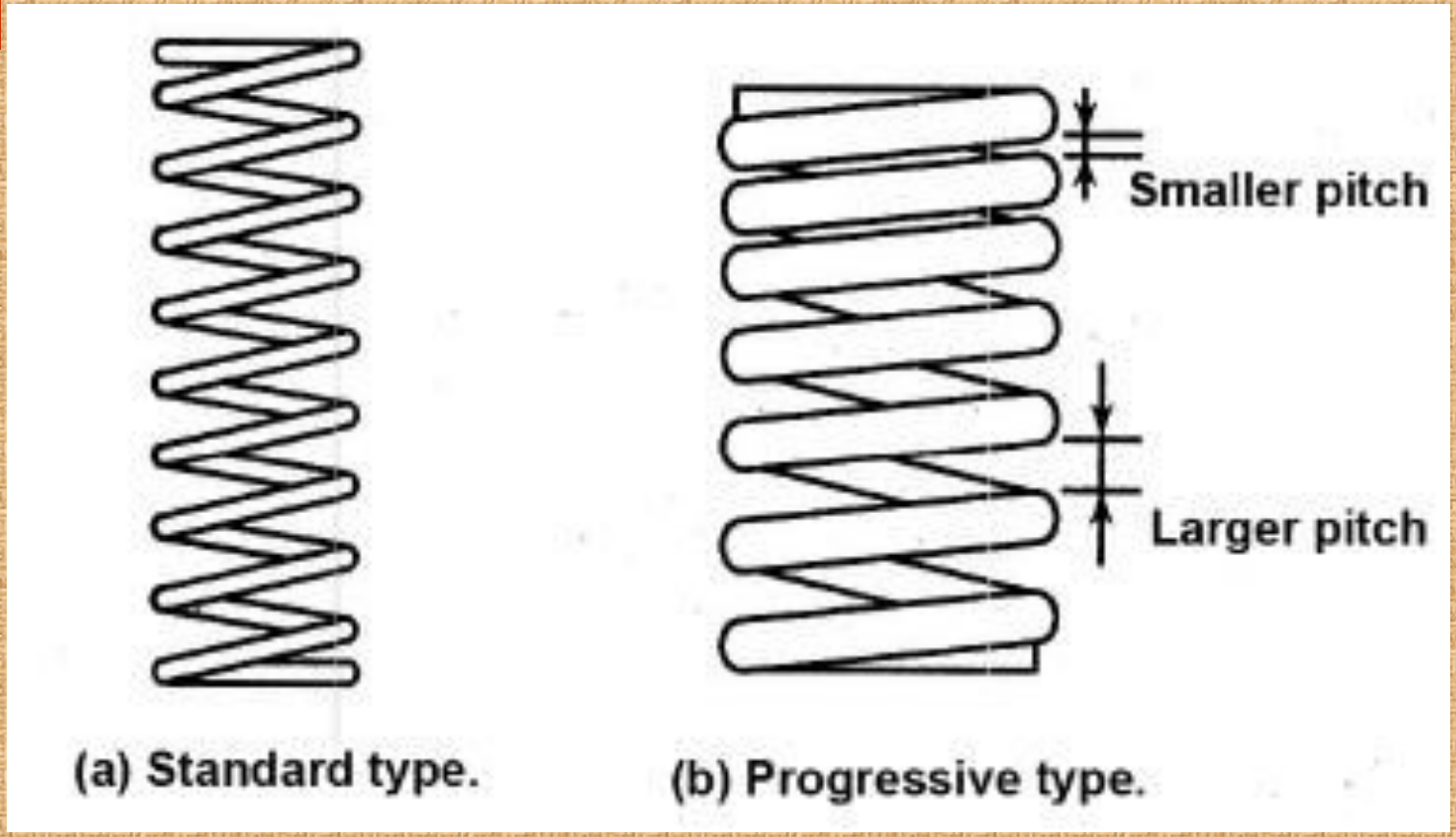


Fig. Coil Spring

- **Characteristics of Coil Springs**

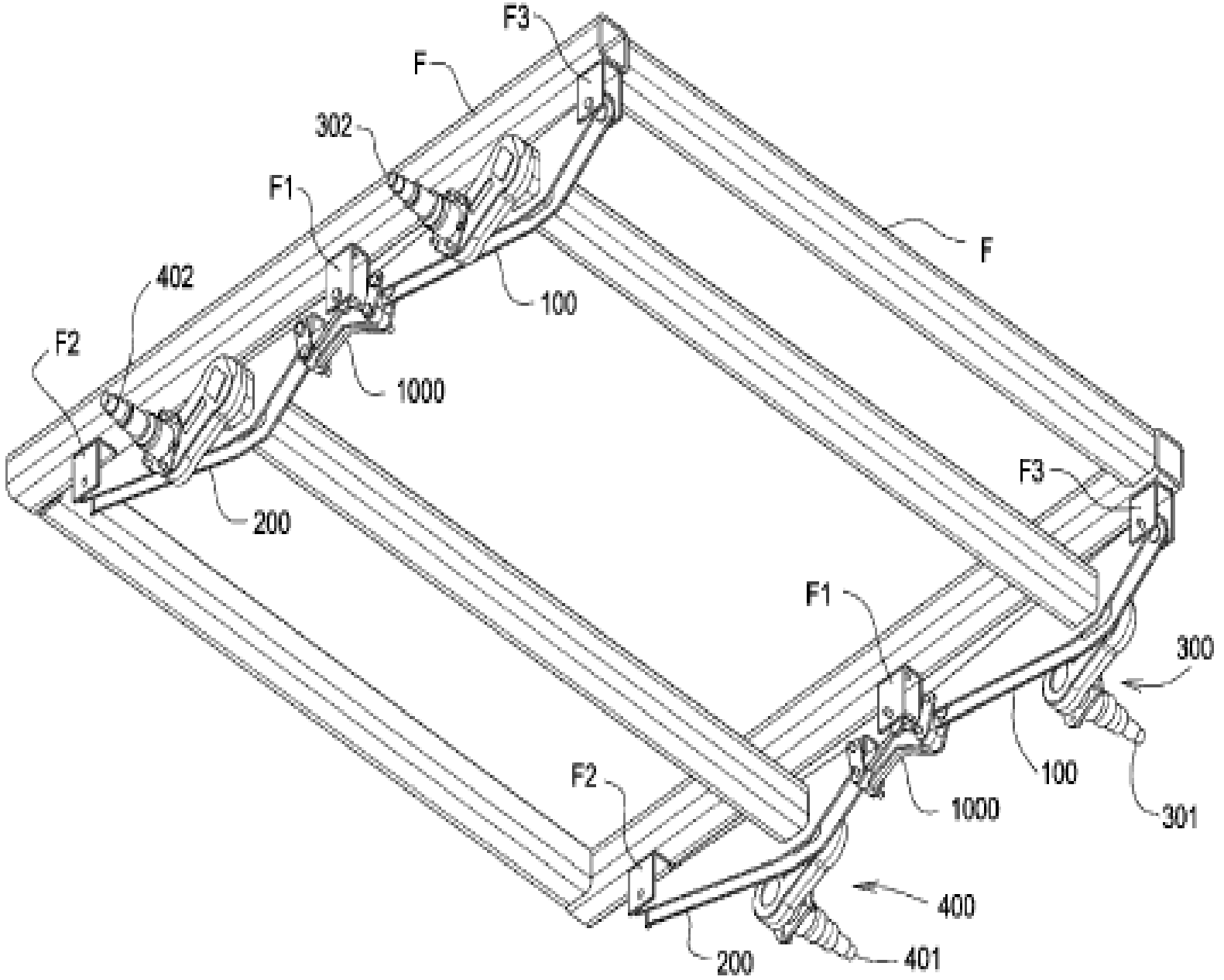
  1. The energy absorption rate per unit of weight is greater in comparison with leaf springs.

  2. Soft springs can be made.

  3. Since there is no inter-leaf friction, there is no control of oscillation by the spring itself. So it is necessary to use shock absorbers along with them.

  4. Since there is no resistance to lateral forces, linkage mechanisms to support the axle (suspension arms, lateral control rod, etc.) are necessary.

- **Suspension systems for multi-axle vehicles:**
- A multi-axle vehicle Suspension system comprising a first torsion axle mounted to a first Suspension pivot member, the first Suspension pivot member pivotally coupled to a vehicle frame, a second torsion axle mounted to a second Suspension pivot member, the second Suspension pivot member pivotally coupled to the vehicle frame, a pivot member pivotally Publication Classification coupled to the vehicle frame, the first Suspension pivot member pivotally coupled to the pivot member, and the second Suspension pivot member pivotally coupled to the pivot member.


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- The primary aspect of the invention is to provide a multi-axle vehicle Suspension system having at least two torsion axles, each torsion axle coupled to a vehicle frame, and further having a pivotal member pivotally coupled to the vehicle frame and pivotally coupled to each torsion axle. Other aspects of the invention will be pointed out or made obvious by the following description of the invention and the accompanying drawings.
- The invention comprises a multi-axle vehicle suspension system comprising a first torsion axle mounted to a first Suspension pivot member, the first Suspension pivot member pivotally coupled to a vehicle frame, a second torsion axle mounted to a second Suspension
- pivot member, the second Suspension pivot member pivotally coupled to the vehicle frame, a pivot member pivotally coupled to the vehicle frame, the first suspension pivot member pivotally coupled to the pivot member, and the second Suspension pivot member pivotally coupled to the pivot member.

Trouble shooting Chart for Suspension System

Complaint	Causes	Remedies
1. Suspension too flexible	a. The manufacturer might have indicated that the springs should not be lubricated. By mistake, these springs are lubricated against this precaution. Then the friction in the springs may decrease	Clean the springs completely
	b. A few leaves of the springs may be broken	Replace the springs
	c. Some defects may be noted in the shock absorber	Replace the shock absorber
	d. The springs may become weak due to constant use	Replace the spring
2. Rough ride	**A. In the conventional rigid axle suspension:**	
	a. The leaves of the spring may be rusted. This will result in excessive friction	The spring should be lubricated to reduce friction
	b. The pins in the shackles may be seized	This defect should be set right
	c. Defect will be in the shock absorber.	Replace the shock absorber
	B. In the independent suspension:	
	a. The pivots on the suspension arms may be seized.	Lubricate the pivots
	b. The adjustment in the torsion bars may not be correct.	Adjust the torsion bars properly
3. The vehicle may sag on one side due to the sagging springs.	a. Due to constant use, the spring on the sagging side may be weak	Replace the weak spring
	b. A few leaves of the sagging spring may be broken	Replace the spring
	c. The coil spring may be adjusted incorrectly in case of independent suspension	Adjust the coil spring correctly
4. Squeaking or rattling noises	a. Lubrication may not be sufficient. This may develop spring noise.	Lubricate the springs
	b. Shackles may have side play	Rectify the side play
	c. U-bolts may be loose	Tighten the U-bolts correctly
	d. The shackle pins and the bushes may be loose	Rectify suitably
	e. Shock absorbers may have some defect	Replaced the shock absorber

Thank You

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