Title : Steering Systems (Automobile Engineering)

Date: 23/03/2020 (09:30 am to 10:30 am)

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Lecture No : 01 (8^{th} sem MED)

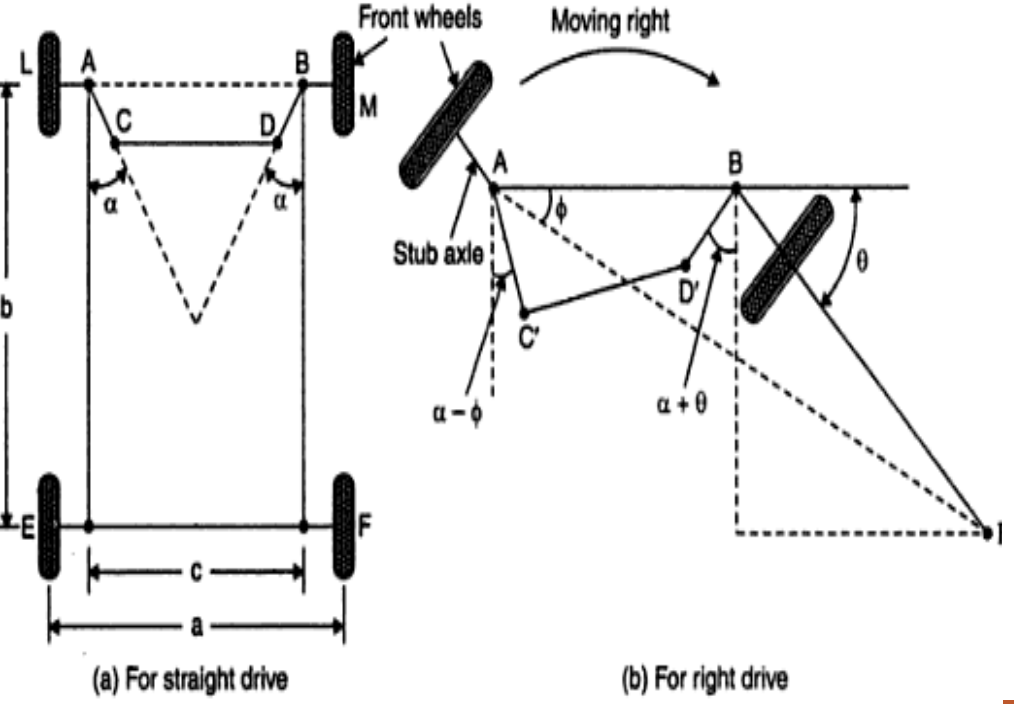
Source of information : Automobile Engineering / Tech-Max Publications, Page No. 4-25 to 4-29

Ackerman's principle of steering

2. Ackermann steering gear :

Refer to Fig. 8.17. It consists of a cross link *CD* connected to the short axles *AL* and *BM* of the two front wheels through the short arms *AC* and *BD*, forming bell crank lowers *LAC* and *MBD*, respectively.

When the wheel is running straight [Fig. 8.17 (*a*)], the cross-link *CD* is parallel to *AB*, the short arms *AC* and *BD* both make angle α to the horizontal axis of chassis. In order to satisfy the fundamental equation for correct steering, the links *AC* and *BD* are suitably proportioned and angle α is the suitably selected.



(a) For straight drive (b) For right drive

Fig. 8.17. Ackermann steering gear mechanism.

For correct steering, $\cot \phi - \cos \theta = \frac{c}{b}$

The angles ϕ and θ are shown in Fig. 8.17 (*b*).

The value of $\frac{c}{b}$ lies between 0.4 and 0.5, generally 0.455. The value of $\cot \phi - \cot \theta$ corresponds to the positions when steering is correct.

In fact there are *three* values of θ which give correct steering of the vehicle : *First*, while turning to 'right' ; *second*, while turning to left and *third* while it is running 'straight'.

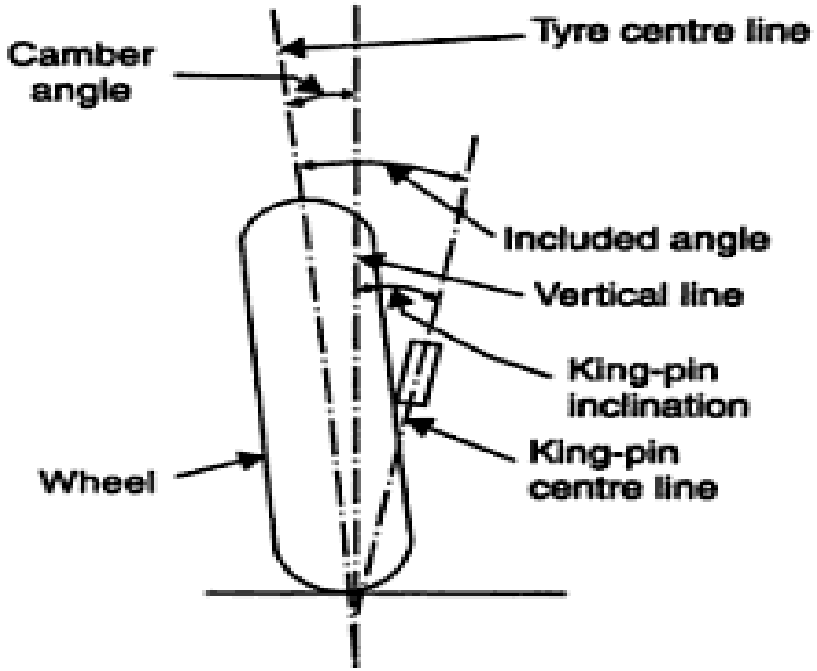
Definitions

1. Camber
2. King pin inclination
3. Caster
4. Toe-in
5. Toe-out

1. Camber

***Camber** is the tilting in or out of the front wheels from the vertical when viewed from the front of the vehicle.* If the top of the wheel tilts *out*, it has "*positive*" camber (Fig. 8.10). If the top of the wheel tilts *in*, it has "*negative*" camber. *The amount of tilt measured in degrees from the vertical, is called "camber angle".*

Any amount of camber, positive or negative, *tends to cause uneven or more tyre wear on one side than on the other side.* Camber should *not exceed two degrees.*



2. King pin inclination

The ***king-pin inclination*** *(or steering axle inclination) is the angle between the vertical line and centre of the kingpin or steering axle, when viewed from the front of the vehicle (Fig. 8.6).*

The king-pin inclination is absolutely necessary due to the following reasons :

(*i*) It helps the car to have steering stability.

(*ii*) It makes the operation of the steering quite easy particularly when the vehicle is stationary.

(*iii*) It helps in reducing the wear on the tyre.

Included angle :

The *combined camber and king-pin inclination is called the "**included angle**".*

This angle is important because it determines the point of intersection of the wheel and king pin centre lines. This in turn determines whether the wheel will tend to toe-out or toe-in.

— If the point of intersection is *above the ground*, the wheel *tends to toe-in*.

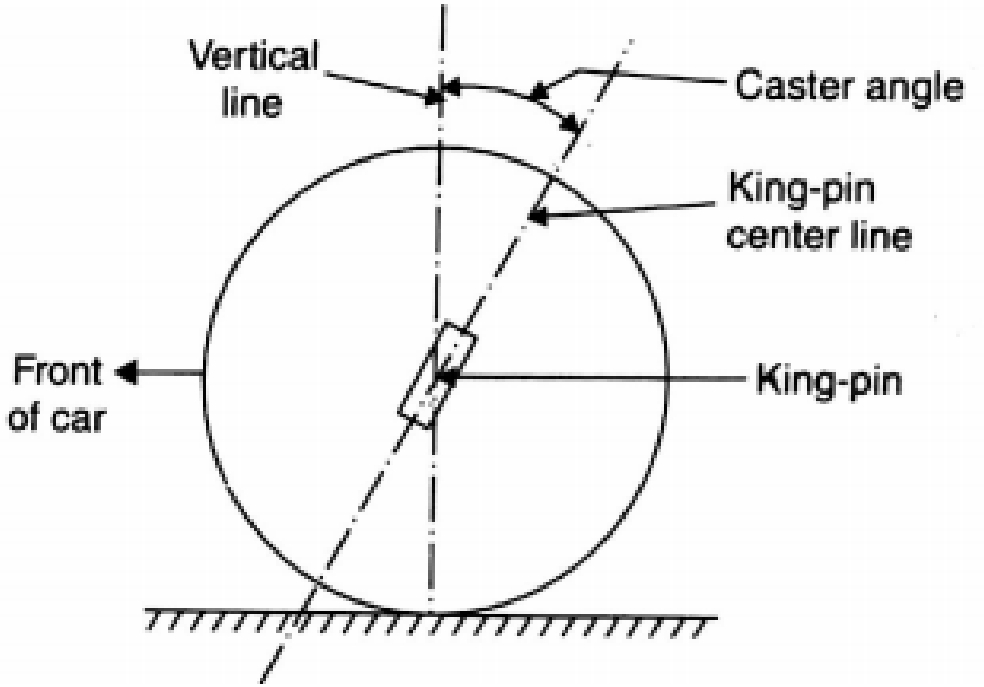
— If it is *below the ground*, the wheel tends to *toe-out*.

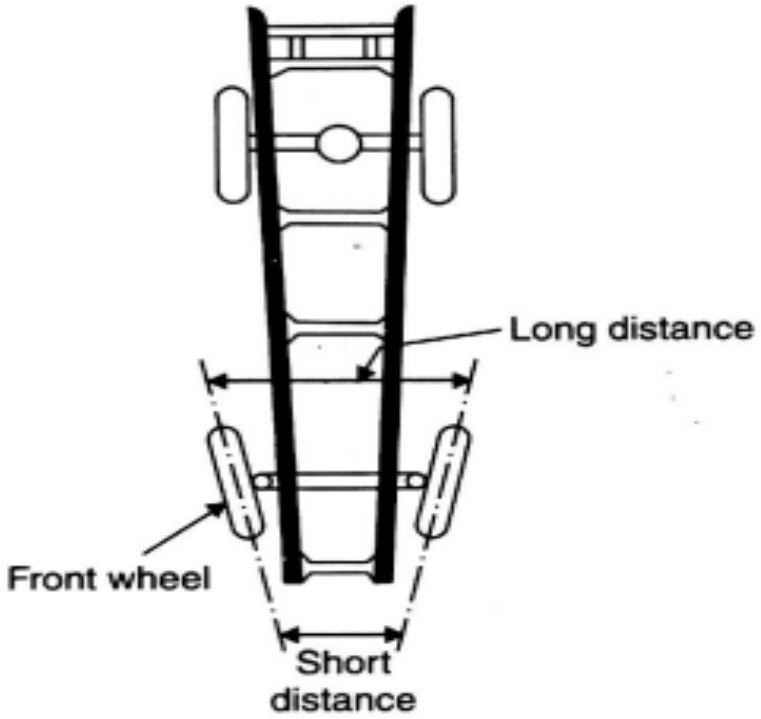
— If it is at the ground, the wheel keeps its straight position without any tendency to toe-in or toe-out. In this position the steering is called *centre point steering*.

3. Caster

3. Caster :

The angle between the king-pin centre line (or steering axis) and the vertical, in the plane of the wheel is called ***Caster angle.*** If the king-pin centre line meets the ground at a point ahead of the vertical centre line, as is shown in Fig. 8.11 it is called *positive* caster while if it is behind the vertical, wheel centre line it is called *negative* caster. The caster angle in modern vehicles range from 2° to 8°.



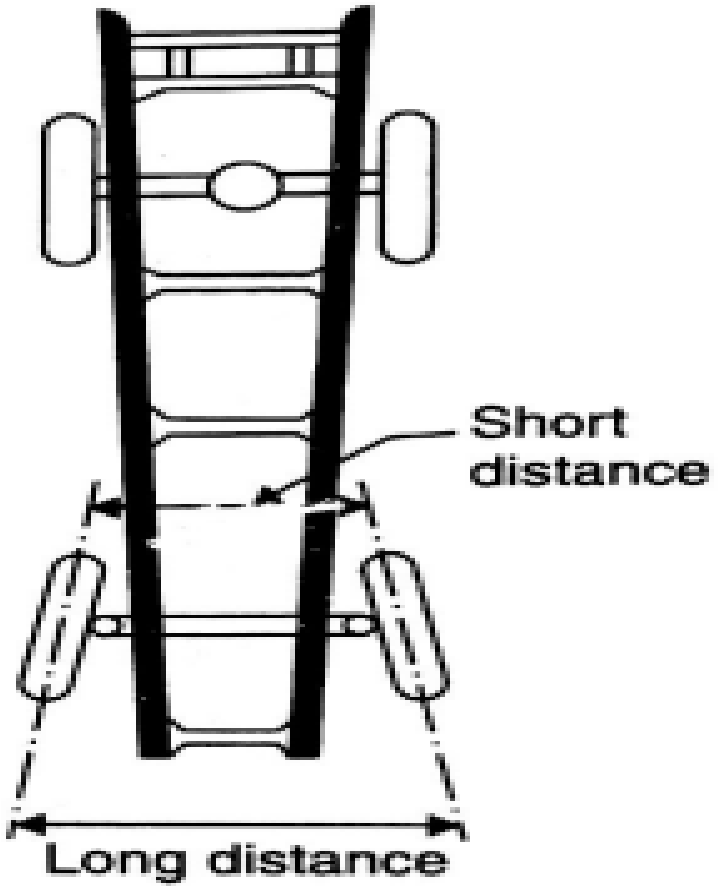


4. Toe-in

The position of toe-in of a vehicle is shown in Fig. 8.12. The distance at the front end between the front wheels is *less* than the distance between them at the rear. The front wheels point inward. The actual amount of toe-in in only a few millimetres (usually 3 to 5 mm).

4. Toe-out

In Fig. 8.13 the distance between front wheels at front end is *greater* than the distance between them at the rear. When car is stationary, this position of the front wheel is called *toe-out*.



The *ratio of side force sustained and slip angle* is *called the* ***cornering power***. The cornering power depends largely upon the *design of the tyre and its inflation pressure.*

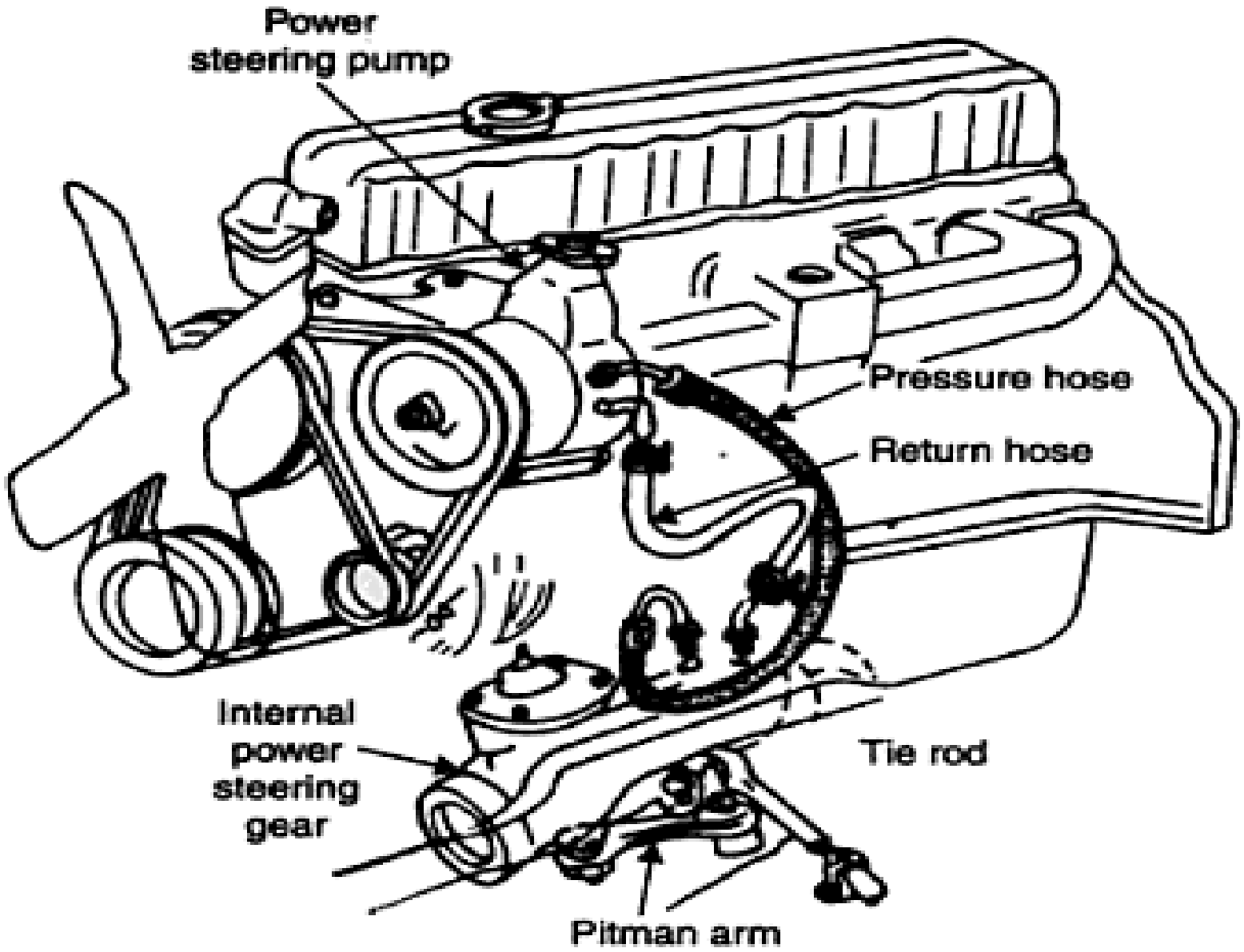
When the slip angle of the front wheel is *greater* than the rear wheel, the wheel turns at a radius *larger* than that intended and the driver has to keep steering into the turn. This condition is known as ***understeer.***

When the slip angle is greater at the rear wheel than the front, the vehicle tends to **oversteer,** that is to turn into the curve more than the driver intended.

When the front and rear slip angles are the same neutral steer occurs.

- Although both the understeer and oversteer are *unwanted*, yet *understeer is less undesirable* because the driver reacts naturally and positively by steering in the desired direction. In the case of oversteer, he is always conscious of losing the control and therefore greater care is needed. Owing to this reason, generally the vehicles are designed to provide understeer conditions at normal speeds. However, at higher speeds, the situation changes first to neutral steer and then to oversteer. The above explanation (of understeer and oversteer conditions) is equally valid even when the vehicle is going straight and is subjected to side force due to some cross-wind or camber.

Power steering



Power steering

- **When a car is steered manually, the driver supplies all the steering force. Then, through** the mechanical advantage of the steering gear and linkage, the front wheels are pointed to the right or left as desired by the driver. Large amount of torque is required to be applied by the driver for steering of medium and heavy vehicles. The *power steering system provides automatic hydraulic assistance to the turning effort applied to the manual steering*. The power system is designed to become operative when the effort at the wheel exceeds a predetermined value (say 10 N). The system is always so designed that in the event of the failure of the power system, the driver is able to steer the vehicle manually although with increased effort.
- In the **power-steering system,** *a continuously operating pump provides hydraulic pressure when needed* (Fig. 8.22). *At the steering wheel is turned, valves are operated to admit this hydraulic pressure to a cylinder that contains the power piston. Then the pressure causes the piston to move, and it provides most of the steering force.*

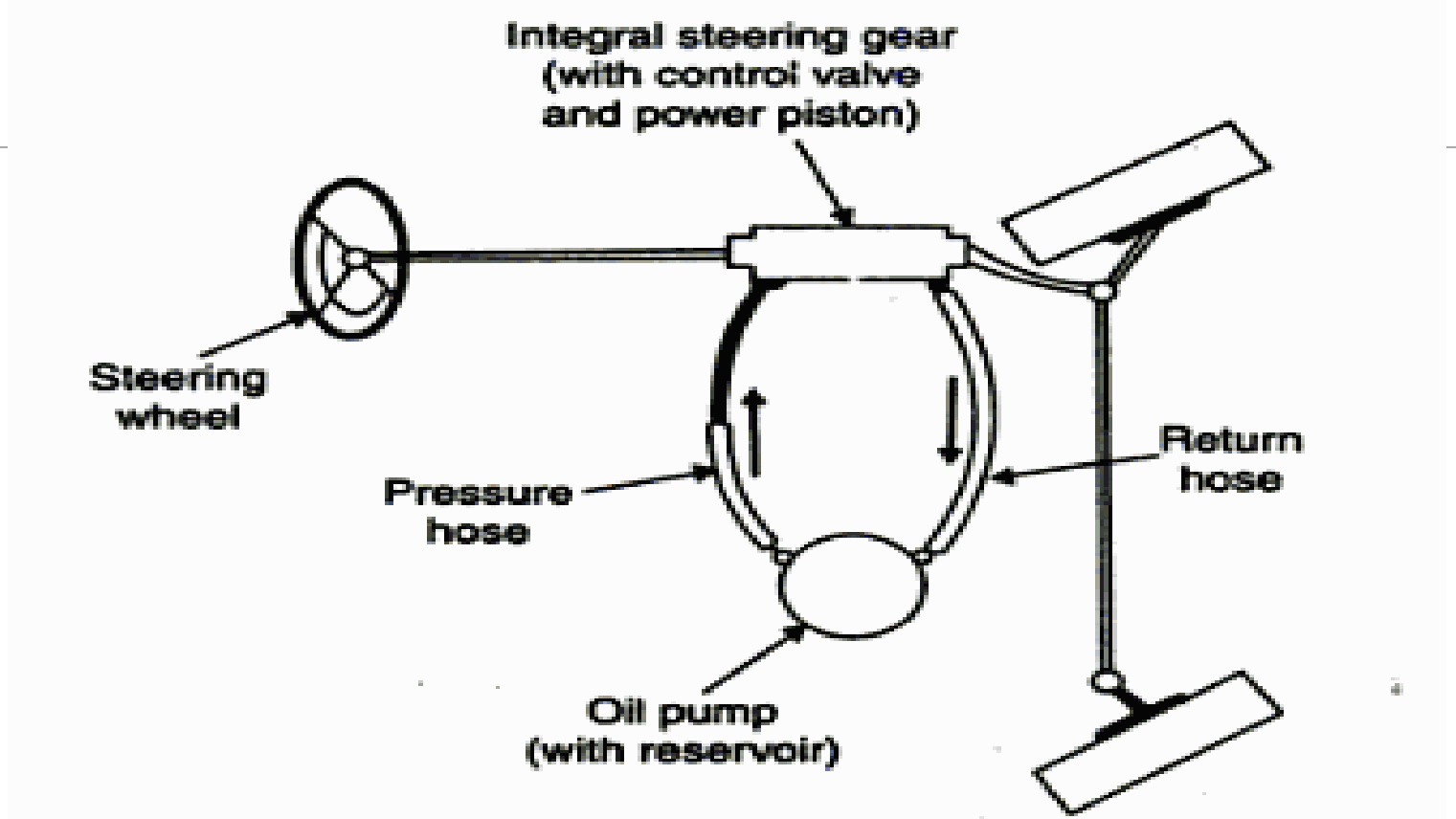
Types of power steering

In automobiles, the following two general types of power-steering systems are found

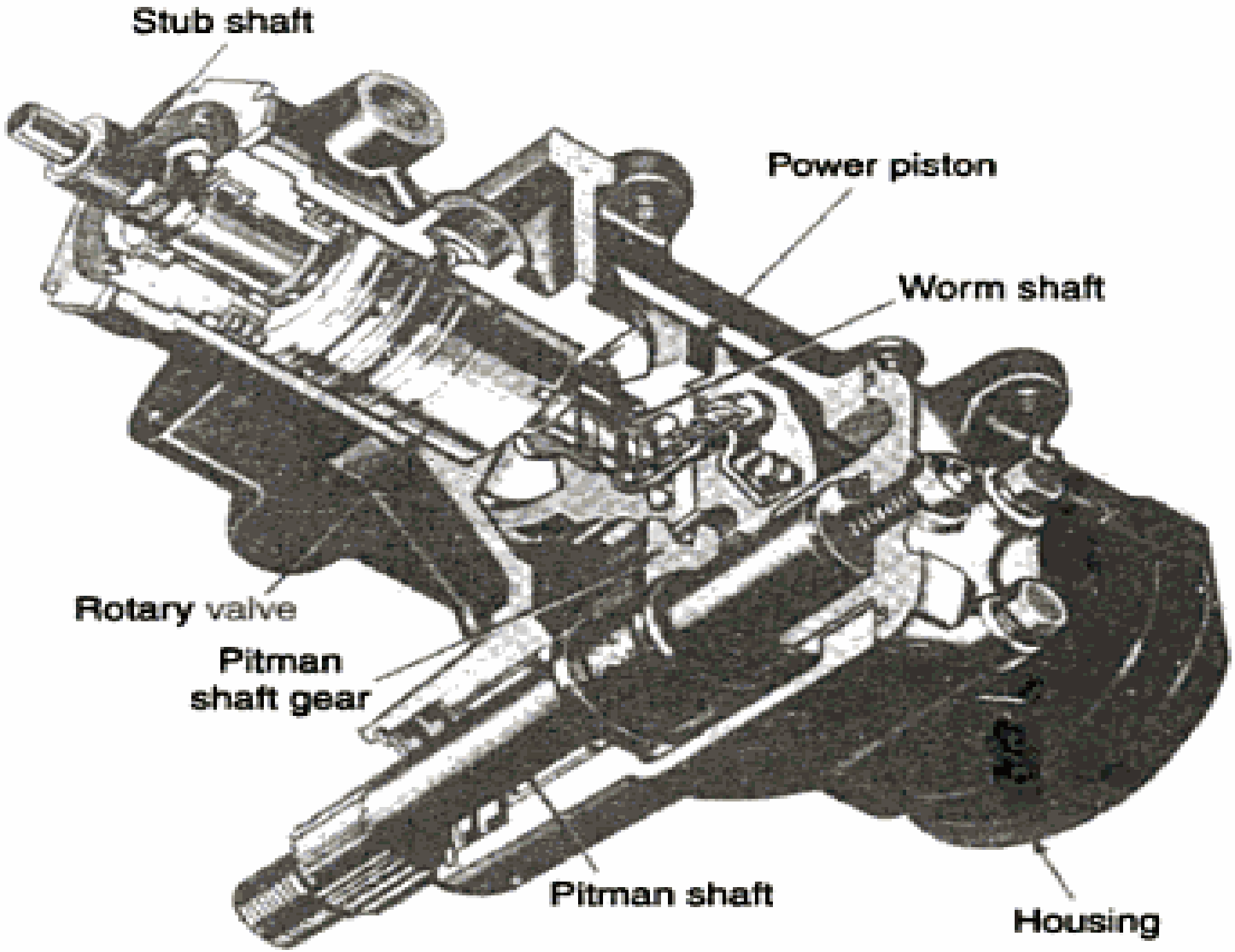
1. Integral power steering.
2. Linkage power steering.

1. Integral power steering

In integral power steering the power piston is built into the steering gear



It consists of a *spool valve*, *rotary valve*, and a *torsion bar*. The torsion bar is attached to the end of the worm shaft. When the steering wheel is turned, the torsion bar twists. This moves the spool valve slightly, opening passages which move fluid to the side of the piston where hydraulic assist is required. When there is no power-assist action, the spool valve is in the neutral or straight-ahead position.


Stub shaft
Power piston
Worm shaft
Rotary valve
Pitman shaft gear
Pitman shaft
Housing

2. Linkage power steering

In this type of steering (Fig. 8.25) the *power system is attached between the frame of the vehicle and the steering linkage*. Usually it must be installed at the factory as the vehicle is built. The integral type is *more widely used*.

The *linkage type is widely used on trucks*.

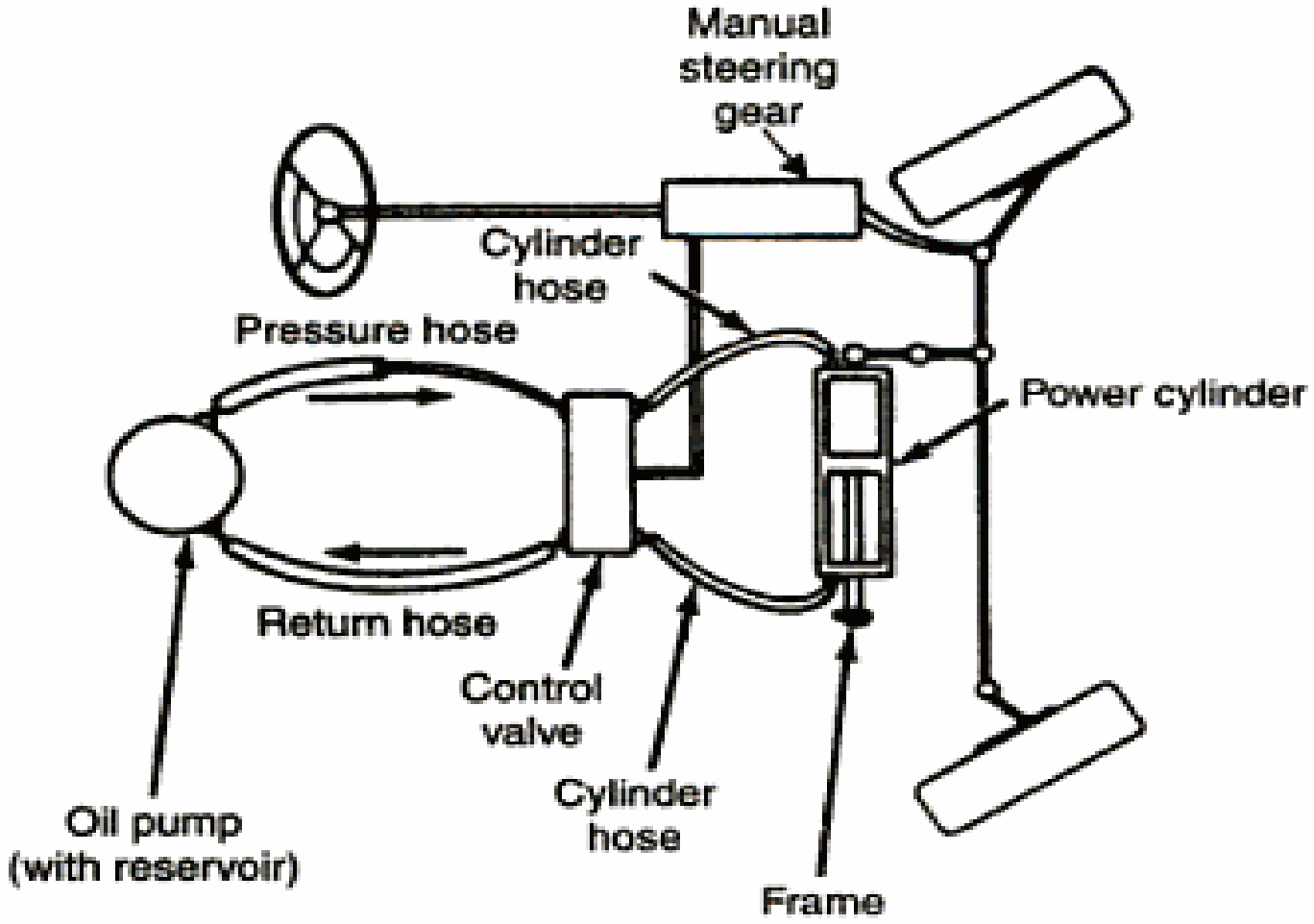


Fig. 8.26 shows a typical linkage power steering (Ford Motor)

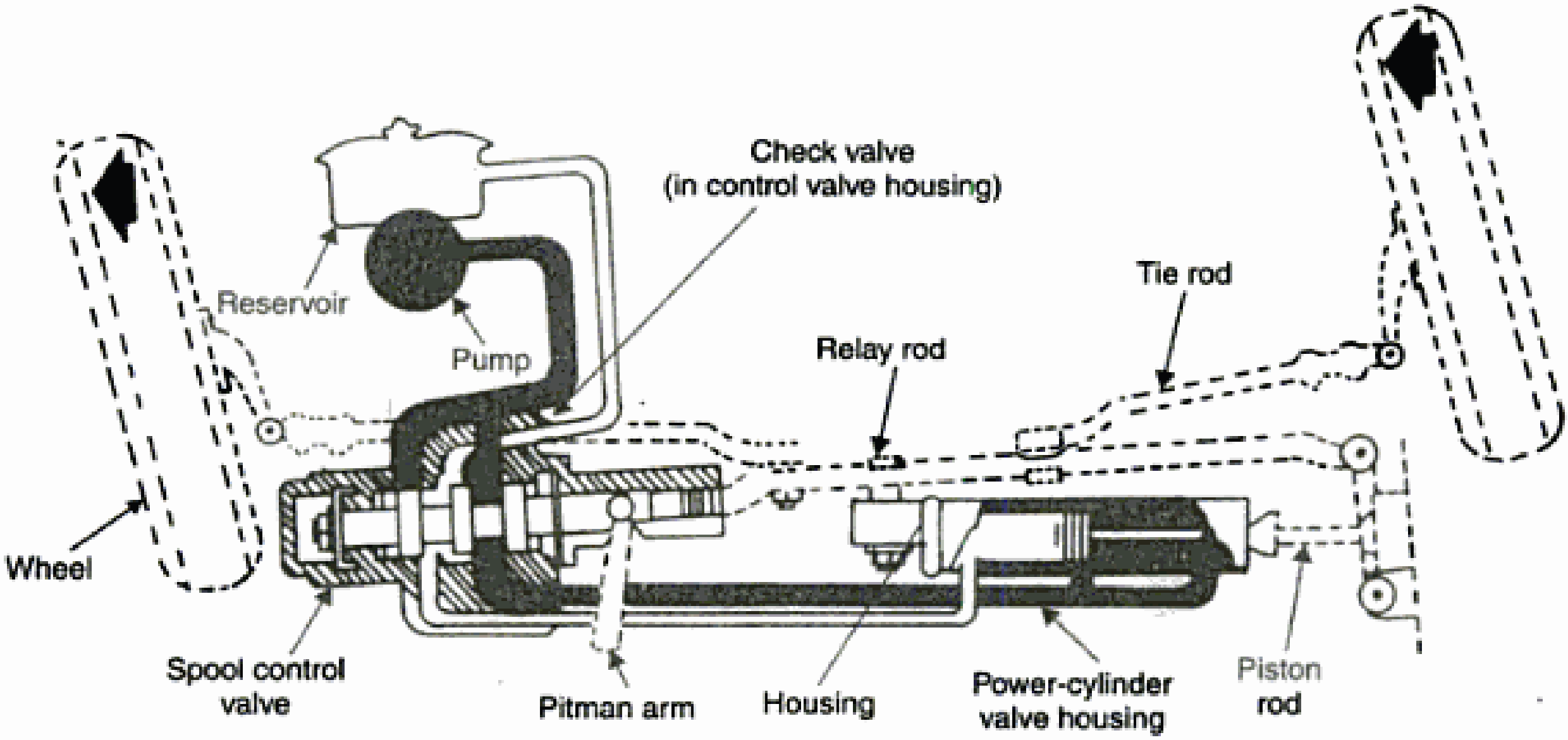


Fig. 8.26. Linkage power steering (Ford Motor Co.)

- When the vehicle is running "*straight ahead*" (*i.e.* in neutral position), a spool valve in the control valve assembly is held in the centre position by means of a centring spring. Oil flows to both sides of the piston in the power cylinder and around the valve bands and returns to the pump reservoir.
- While the vehicle is taking "*left turn*", and the force on the wheel exceeds about 20 N, the pitman arm moves the spool control valve with sufficient force to overcome the pressure of the centring spring so that the valve slides to the right hand side of the valve body. In this position it connects the left-hand side of power cylinder to return line leading to the pump reservoir and directs oil pressure to the right hand side of the power cylinder. This causes the cylinder housing to move to the right, which moves the relay rod to the right in order to turn the wheels to the left.
- In case of the wheel taking a "*right turn*", the conditions are reversed and the relay rod is forced to turn the wheels to the right.

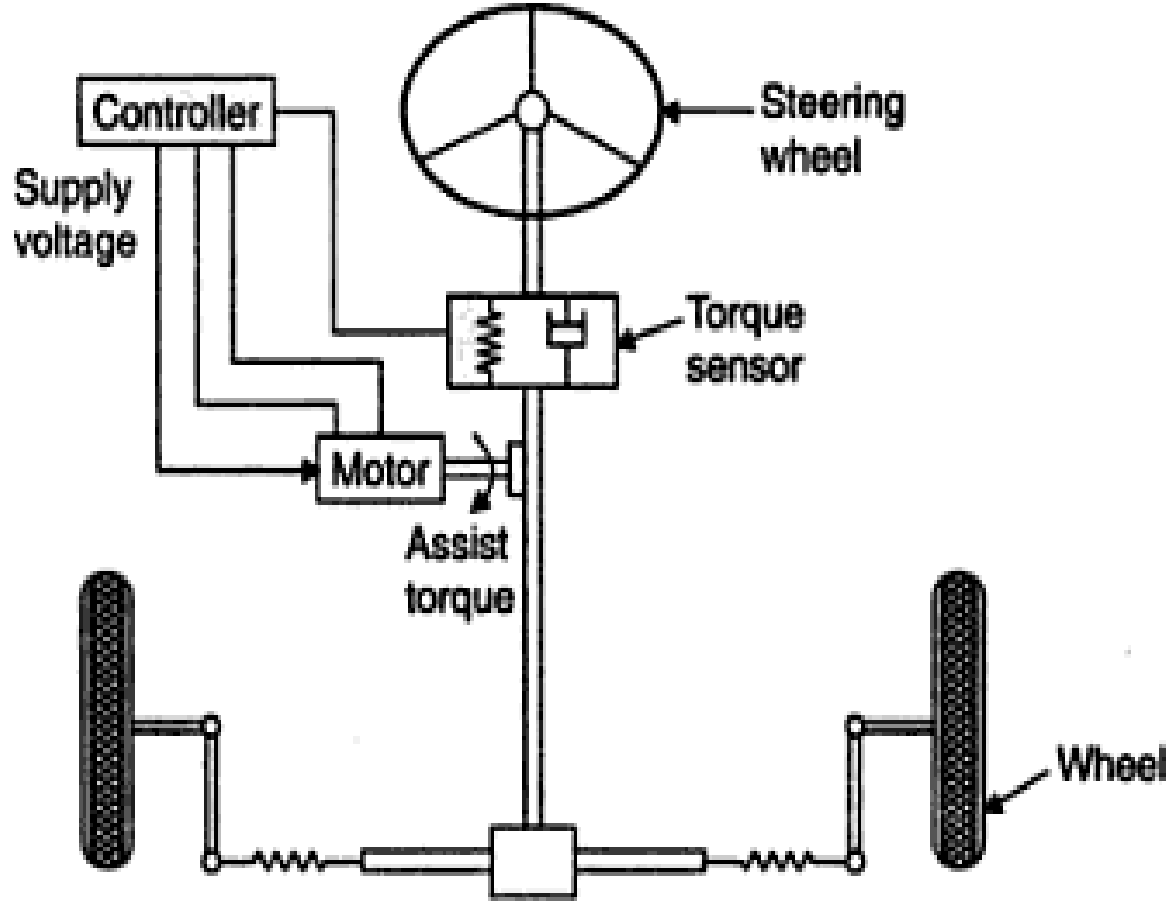
Electronic power steering :

In this type of steering system (Fig. 8.27), steering censor consists of two sensors : "*Torque sensor*" and "*Rotation sensor*".

'*Torque sensor*' converts the steering torque input and its direction into voltage signals.

'*Rotation sensor*' converts the rotation speed and direction into voltage signals and is located on the input shaft of the steering gear box.

The inputs from the steering sensor and the vehicle speed sponsor are sent to a *microprocessor control unit* where these are compared with a preprogrammed force assist map. The control unit then sends out the appropriate command signal to the current controller which supplies the appropriate current to the electric motor which pushes the rack to the right or left depending on in which direction the current flows. The amount of power assist increases with the increase in current. There is a provision to protect the electric motor from being overloaded and also from the voltage surges from a faulty alternator or charging problem. The electronic steering control unit is capable of self-diagonising faults by monitoring the system's inputs and outputs and the driving current of the electric motor. In case of a *problem, the control unit turns off the entire system by actuating a fail-safe relay in the power unit, the system reverts back to manual steering and warning light on the dash boads alerts the driver.*



Advantages :

Following are the *advantages of an electronic power steering over hydraulic power steering* :

1. Manual steering requires less force comparatively, since there is no fluid to be forced through the valves.

2. Energy is consumed only while steering.

3. Availability of steering assistance even when the engine is not running.

4. The problem of fluid leakage is eliminated.

Assignment No.02

1. Discuss in detail the Ackermann steering mechanism.
2. Explain briefly I. Caster angle II. King Pin inclination III. Camber Angle IV. Toe In V. Toe Out
3. What do you mean by under steering and over steering?
4. Write a short note on an Electronic power steering.

Note:- Kindly write the above assignment in Separate notebook which you have submit it on 31/3/2020.

- If any query regarding above topic kindly contact me on my mobile no.:-9998213196

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Thank You