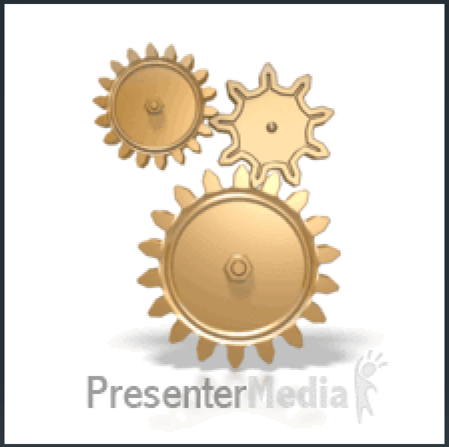
Power transmission



Introduction

- Rotating elements which possess mechanical energy has to be utilized at required place by transmitting.
  - From prime mover to machine
  - From one shaft to another

Transmission system

- The system that is used to transmit power from one mechanical element to another mechanical element.

Types of transmitting system

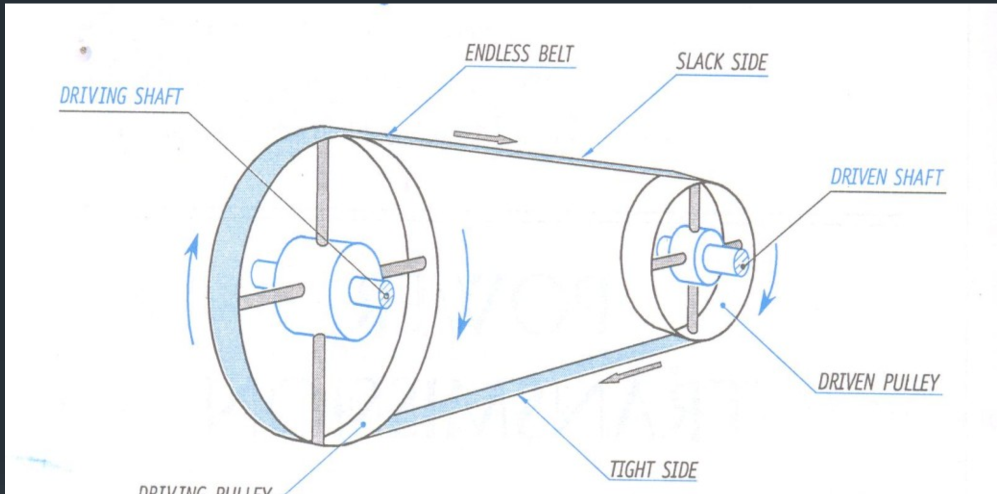
- Belt drives
- Rope drives
- Chain drives
- Gear drives

Factors to select transmission system

- Distance between driver and driven pulley shaft.
- Operational speed.
- Power to be transmitted.

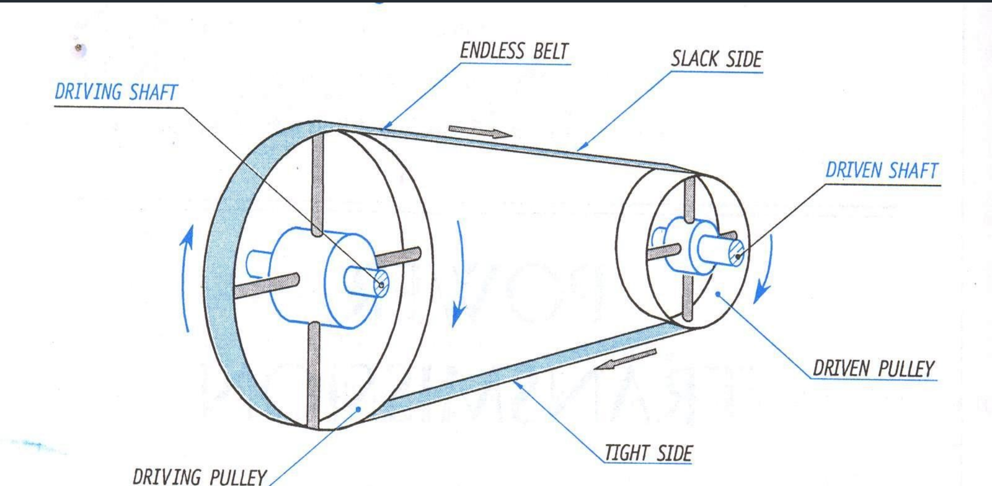
Belt drive

- Power is to be transmitted between the parallel shaft.
- Consists of two pulleys over which a endless belt is passed encircling the both.
- Rotary motion is transmitted from driving pulley to driven pulley.



Belt Drive
Fig. 9.1

- Friction is a helpful agent.
- Tension in one side of the belt
  - Portion of the belt having less tension is called slack side.
  - Portion of the belt having high tension is called tight side.

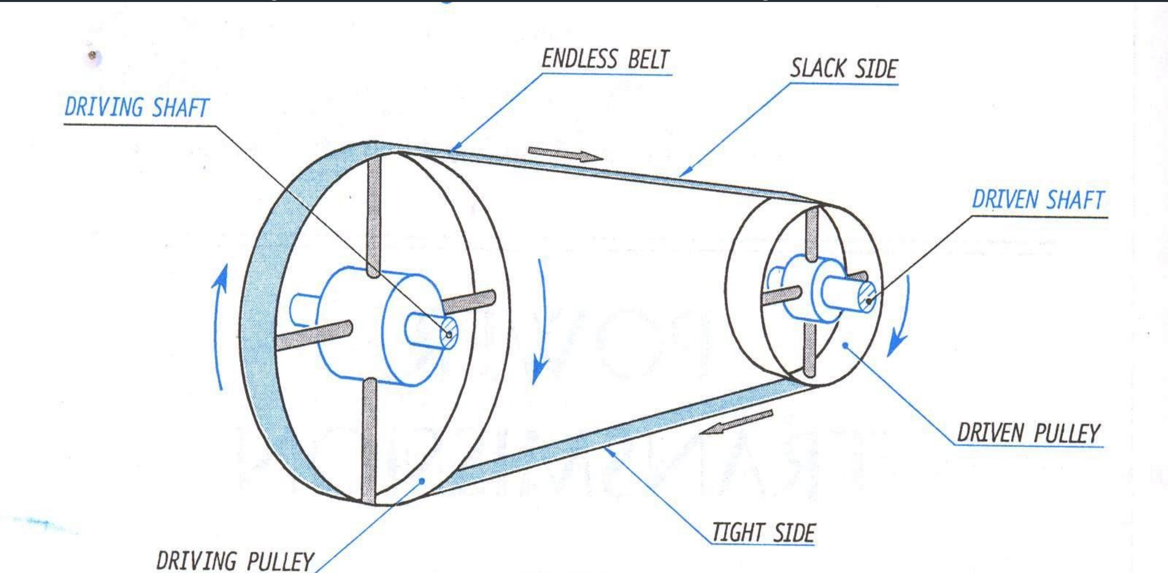


Belt Drive
Fig. 9.1

Terminology of a belt drive

- Driver : in a transmission system the one which drives or supplies power to other mechanical element.
- Driven : in a transmission system the one which follows the driver or receives power from driver.
- Tight side : the portion of the belt in maximum tension. Denoted by T1 Newton.
- Slack side : the portion of the belt in minimum tension. Denoted by T2 Newton.

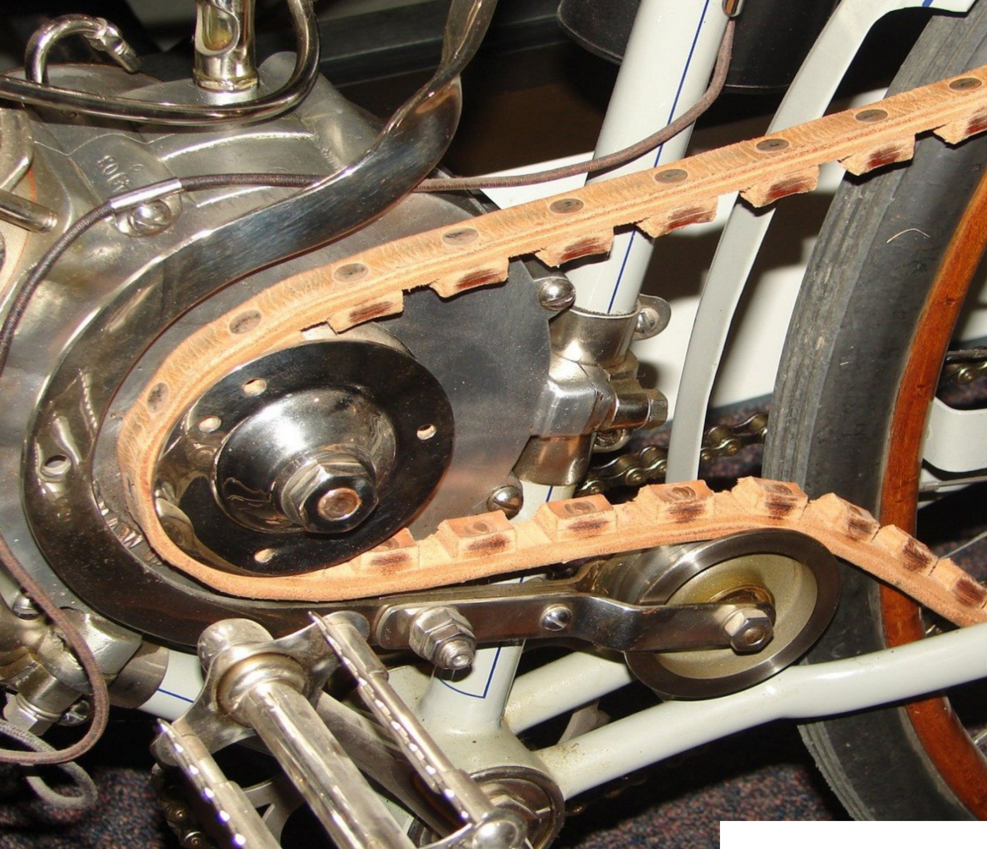
- Arc / angle of contact : it is the portion of the belt which is in contact with pulley surface. Denoted by



Belt Drive
Fig. 9.1

Belt materials

- Rubber
- Leather
- Canvas
- Cotton
- Steel

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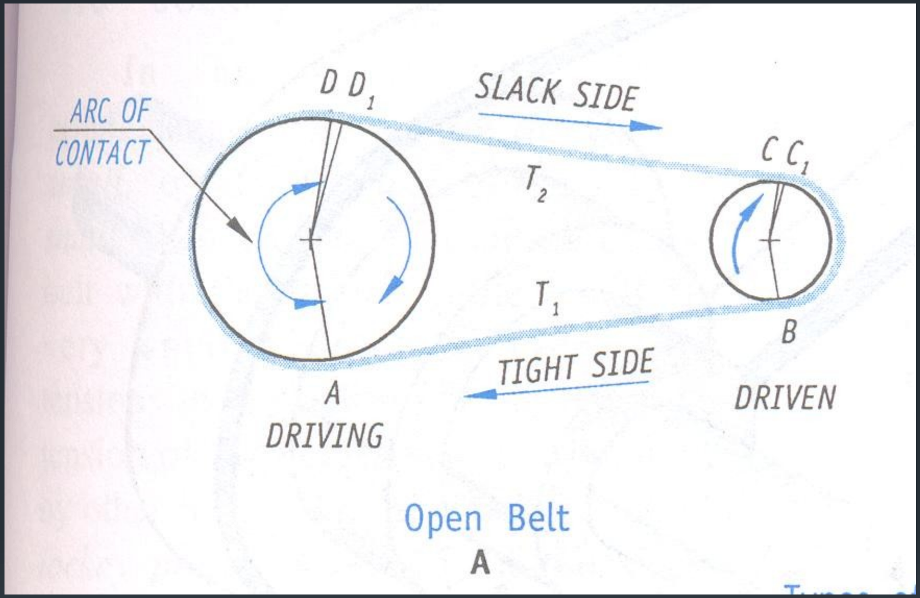
Classification

- Open belt drive
- Closed belt drive

Open belt drive

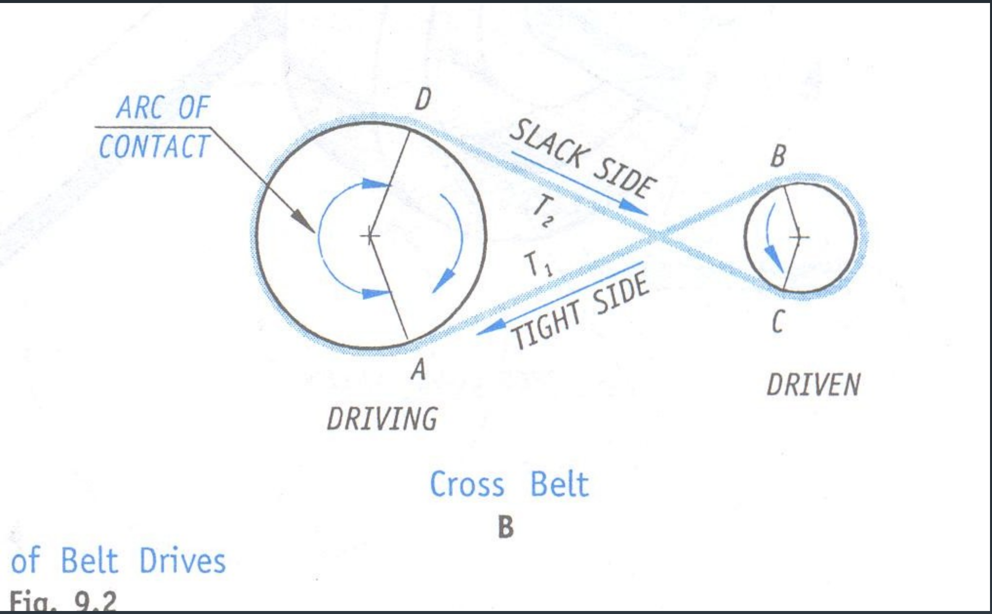
- Both driver and driven pulley rotate in both direction.
- Belt is passed over driver and driven.
- Driver pulley pulls the belt from one side and delivers to other side.
- Tension is more in lower side then upper side.



Cross belt drive

- Driven rotates in opposite direction to that of driver.
- At the point were the belt crosses it rubs against each other and there will be wear.
- To avoid this speed of belt should be less than

  15 m/s.



Comparison between Open belt drive and Close belt drive

Open Belt Drive	Closed Belt Drive
Both driver and the driven rotates in the same direction	Driver and driven rotates in opposite direction
When the shafts are horizontal, inclined it is effective to transmit the power	Even if the shafts are vertical it is effective to transmit the power
As there is no rubbing point, the life of the belt is more	Due to the rubbing point, the life of the belt reduces.
Require less length of the belt compared to crossed belt drive for same centre distance, pulley diameters.	Require more length of belt compared to open belt drive for the same centre distance, pulley diameters.

Definitions in belt drives

- **Velocity Ratio:**

Velocity ratio of belt drive is defined as the ratio between the speed of the driving pulley and the speed of the driven pulley.

Assuming there is no slip between the belt and the pulley rim, the linear speed at every point on the belt must be same. Hence

$$\prod d_1 n_1 = \prod d_2 n_2$$

Or

$$d_1 n_1 = d_2 n_2$$

$$n_1/n_2 = d2/d1$$

i.e., $\frac{\text{speed of driving}}{\text{speed of driven}} = \frac{\text{Diameter of driven}}{\text{Diameter of driver}}$

The ratio $\frac{n1}{n2} = \frac{d2}{d1}$ **is called as** velocity ratio **or** "transmission ratio" **of the belt drives**

When thickness (t) of belt is considered

$$\frac{n1}{n2} = \frac{d2 + t}{d1 + t}$$

Creep

The relative motion between the belt and the pulley surface due to contraction and expansion of belt is defined as “creep”.

Creep increases with load as it is caused by the elasticity of the belt.

It reduces the speed of the driven pulley which results in loss of power transmission.

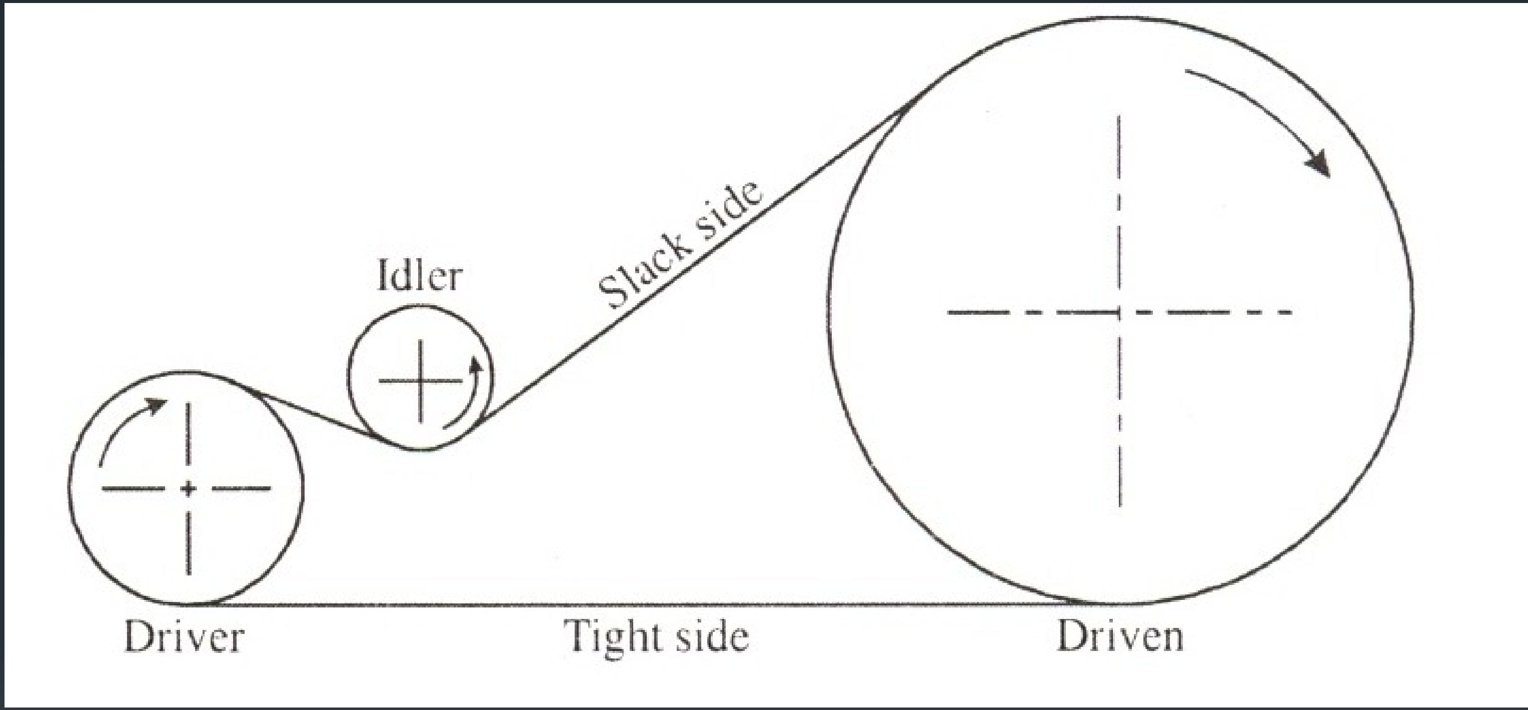
Slip

Relative motion between pulley and the belt passing over it is defined as "slip".

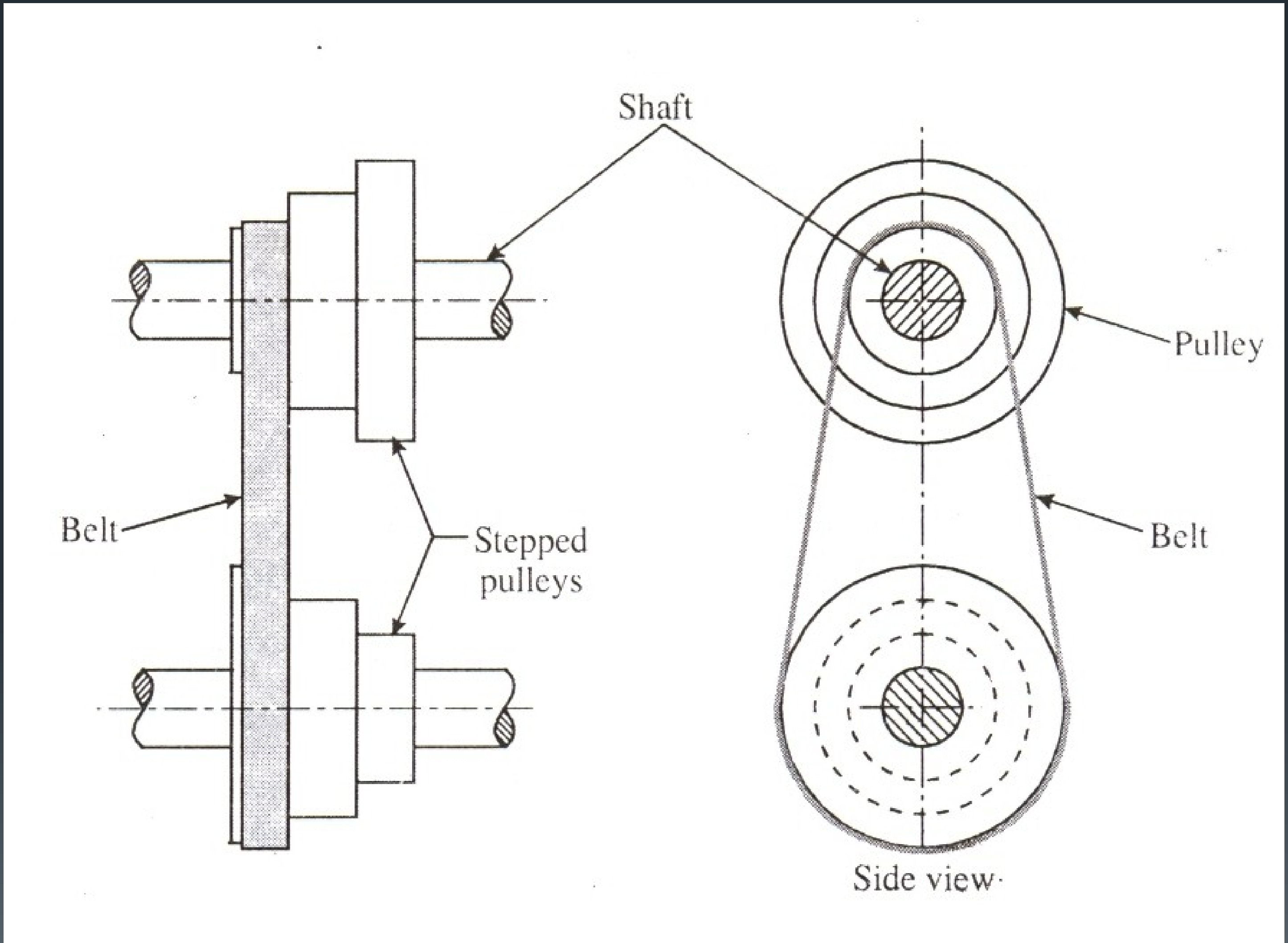
Velocity ratio (when slip is considered) $= \dfrac{n1}{n2} = \dfrac{d2}{d1} = \left\{ \dfrac{100}{100-S} \right\}$

Where S= % slip

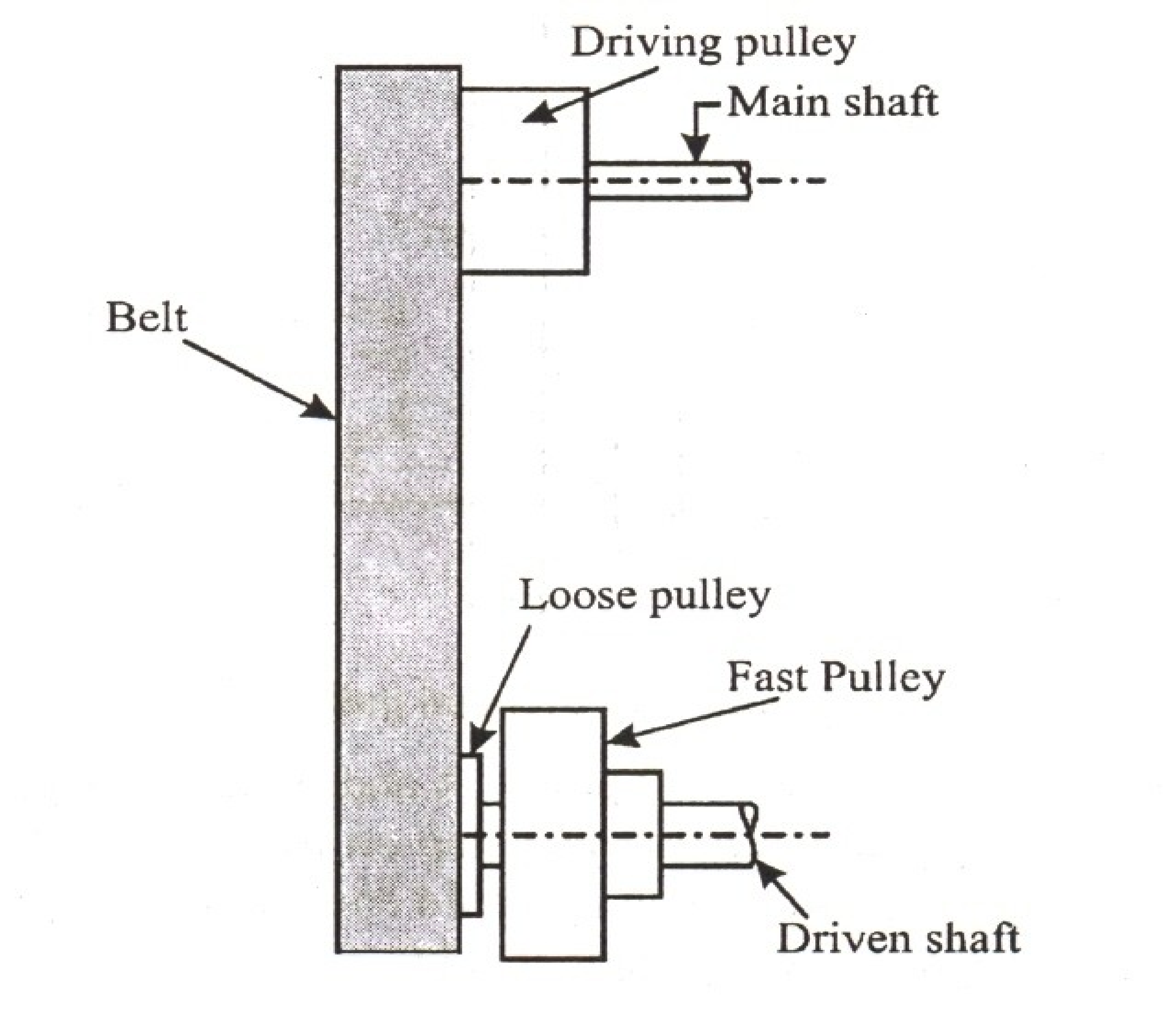
Idler pulley



Stepped Pulley



Fast and loose pulley



Advantages of flat belt drives

- Running and maintenance cost is low.
- Possibility to transmit power over a moderately long distance.
- Efficient at high speeds.

Disadvantages

- **Not preferred for short centre distance.**
- **Belt joints reduces the life of the belt.**
- **Loss of power due to slip and creep.**

Gear Trains

- **When two or more gears are made to mesh with each other to transmit power from one shaft to other. Such an arrangement is called <u>gear train</u>.**

- **Simple gear train (SGT)**

- **Compound gear train (CGT)**

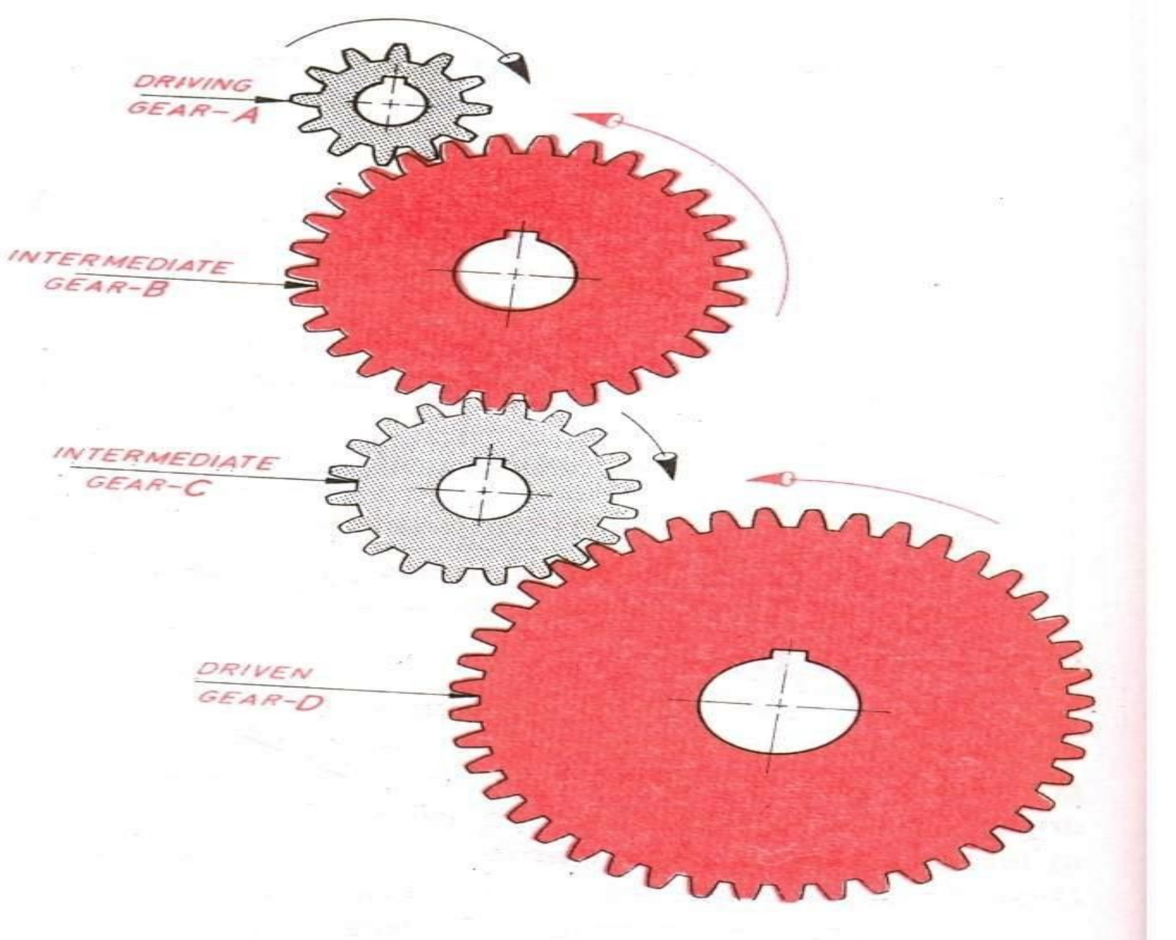
Simple gear train

- **Arrangement of gears in series is known as <u>simple gear train</u>.**

- **Intermediate gears are provided between the driver and driven.**

The function of the idler gears is

1. To cover the space between the driver and driven gears and to
2. Obtain the desired direction of driven



Simple Gear Train

The velocity ratio of the gear train showr is obtained by multiplying

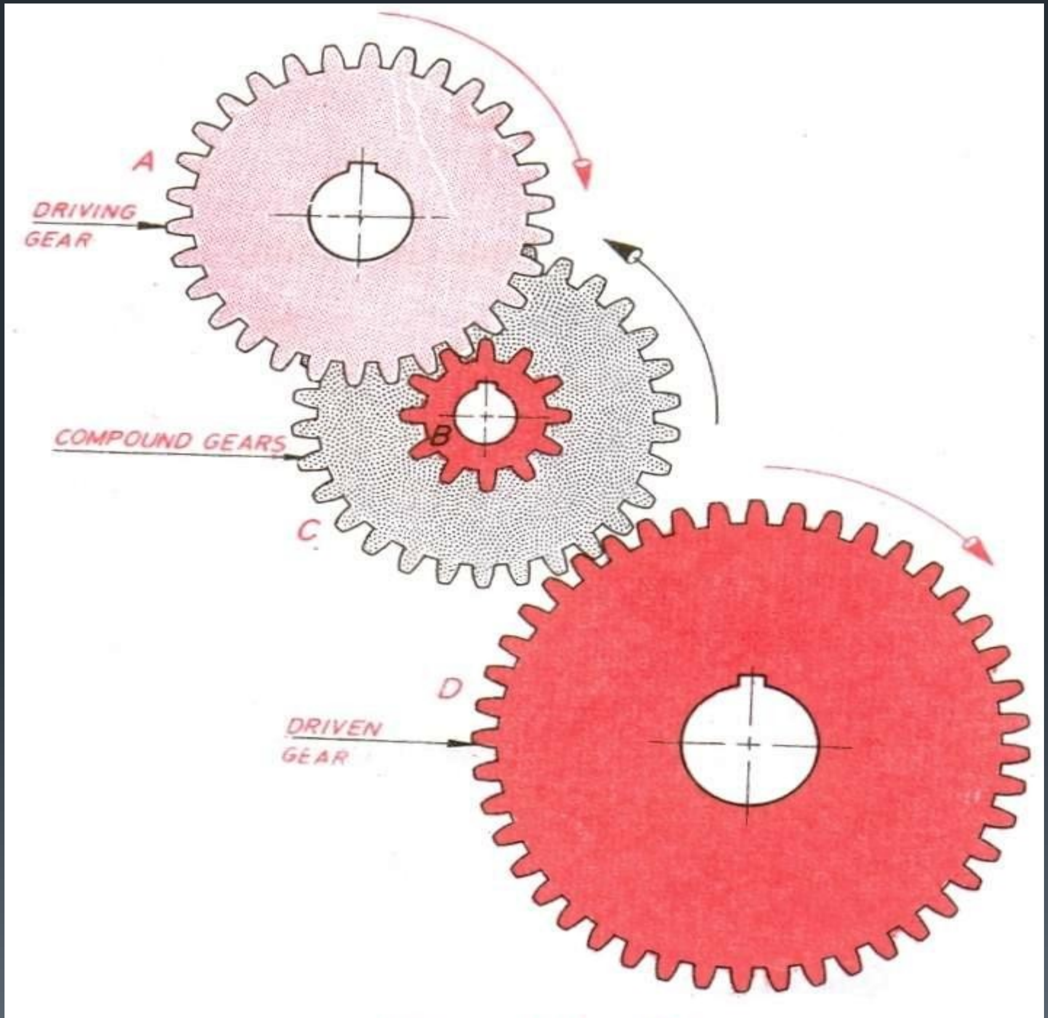
$$\text{Velocity ratio} = \frac{n_2 \times n_3 \times n_4}{n_1 \times n_2 \times n_3} = \frac{T_1 \times T_2 \times T_3}{T_2 \times T_3 \times T_4}$$

$$\text{Velocity ratio} = \frac{n_4}{n_1} = \frac{T_1}{T_4}$$

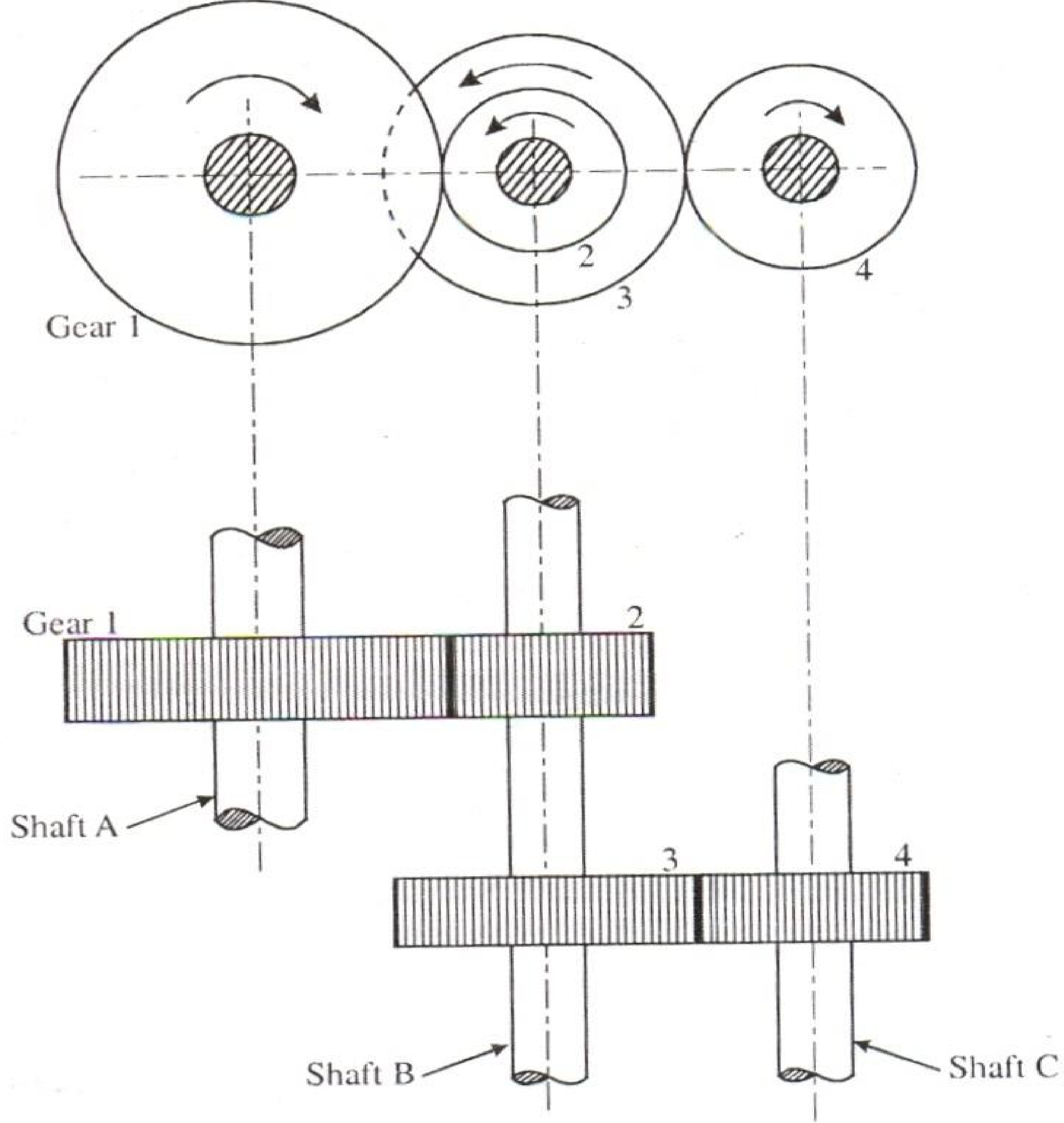
$$\Rightarrow \text{Velocity ratio} = \frac{\text{speed of last gear (driven)}}{\text{speed of first gear (driver)}} = \frac{\text{number of teeth on first gear (driver)}}{\text{number of teeth on last gear (driven)}}$$

Compound gear train

- When two or more gears are compounded, then the gear train is known as compound gear train.



Compound Gear Train



Compound gear train

Gear 1 drives gear 2

$$\therefore \text{velocity ratio} = \frac{n_2}{n_1} = \frac{T_1}{T_2}$$

Similarly, gear 3 drives gear 4

$$\therefore \text{velocity ratio } \frac{n_4}{n_3} = \frac{T_3}{T_4}$$

The velocity ratio of the gear train is obtained by multiplyin (1) and (2).

$$\text{Velocity ratio} = \frac{n_2 \times n_4}{n_1 \times n_3} = \frac{T_1 \times T_3}{T_2 \times T_4}$$

$n_2 = n_3$ since gear 2 and gear 3 are keyed to the same spindle.

$$\therefore \text{velocity ratio} = \frac{n_4}{n_1} = \frac{T_1 \times T_3}{T_2 \times T_4}$$

$\therefore$ velocity ratio

$$= \frac{\text{speed of last gear (driven)}}{\text{speed of first gear (driver)}} = \frac{\text{product of number of teeth on driver}}{\text{product of number of teeth on driven}}$$