Gear Trains

It is desired to transfer motion from one shaft to another. This is most easily done by using rolling cylinders or a belt drive.

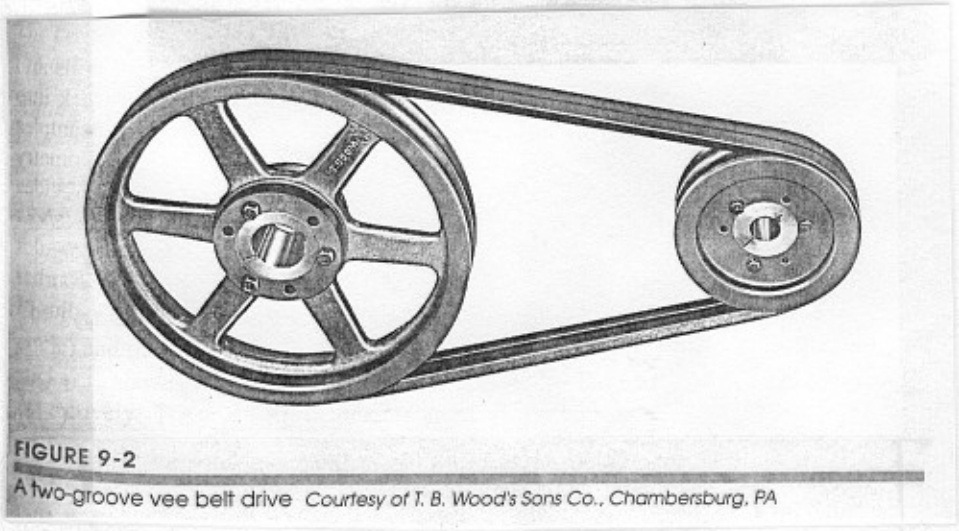
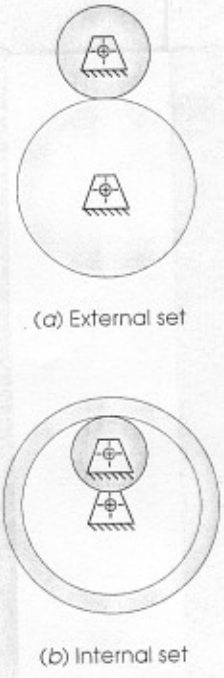


FIGURE 9-2
A two-groove vee belt drive *Courtesy of T. B. Wood's Sons Co., Chambersburg, PA*



(a) External set

(b) Internal set

FIGURE 9-1
Rolling cylinders

Belts and rolling cylinders work well in some applications but what if the rotation between the input and output shaft was important?

Figure 12-1 Timing® belt drive (Licensed TM). Drives of this type are designed to transmit fractional horsepower up to 600 hp or more. Belt speeds range up to 16,000 ft/min. [Courtesy Dodge Manufacturing Division, Reliance Electric Co.]

OK, so we could use a timing belt. But what if the transmission of torque is important?

In order to have high torque transmitted from one shaft to the next, we need to use a gear train. An exception to this is the continuously variable transmission.

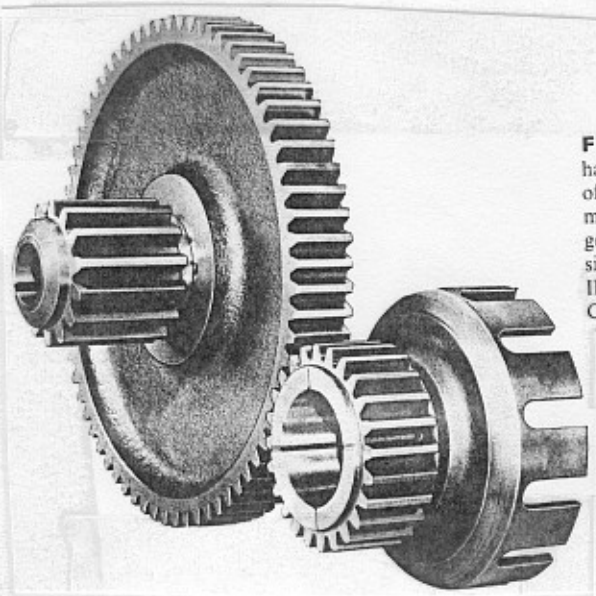


Figure 10-1 The spur gears shown have their teeth cut parallel to the axis of the shaft on which the gears are mounted. The smaller of the two meshing gears is called the pinion; the larger is simply designated as the gear. [Courtesy Illinois Gear Division, Wallace Murray Corporation.]

← Spur Gears

The teeth are cut parallel to the axis of the shaft on which the gears are mounted. The smaller of the two gears in the mesh is called the pinion. The larger is called the gear.

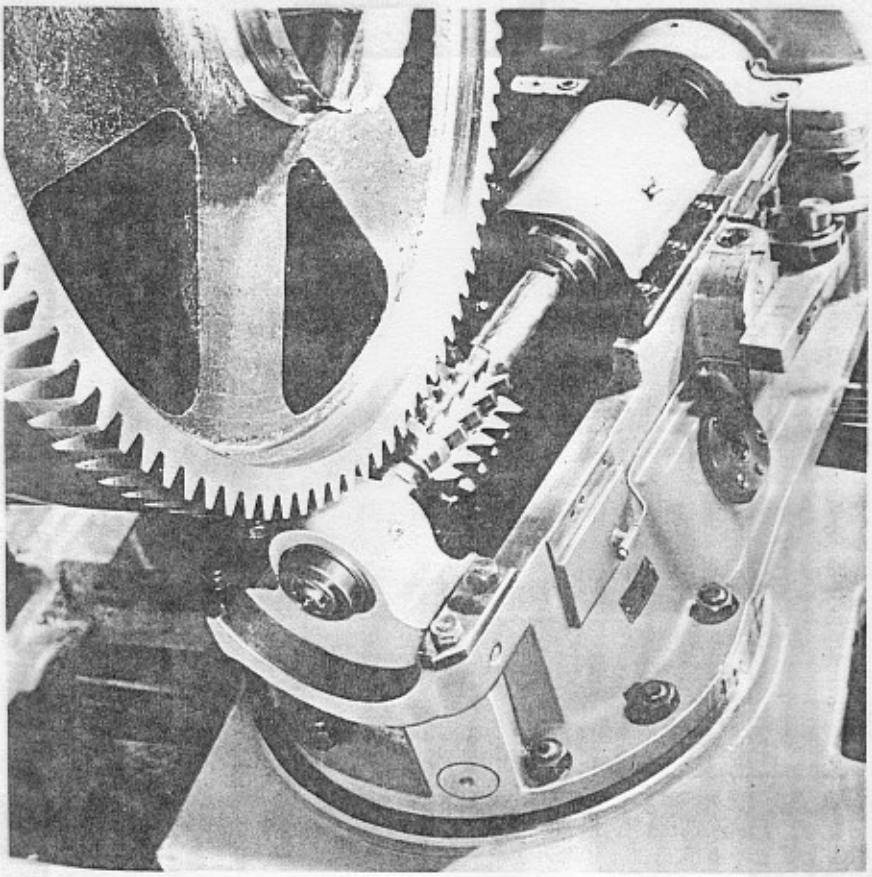


Figure 10-13 The hobbing process, when used to cut gears, is very fast for coarse pitches, better for higher hardnesses, and has the advantages of a generated gear. The hobbing process is usually used to manufacture spur gears which must operate smoothly at higher speeds. [Courtesy Horseburgh-Scott.]

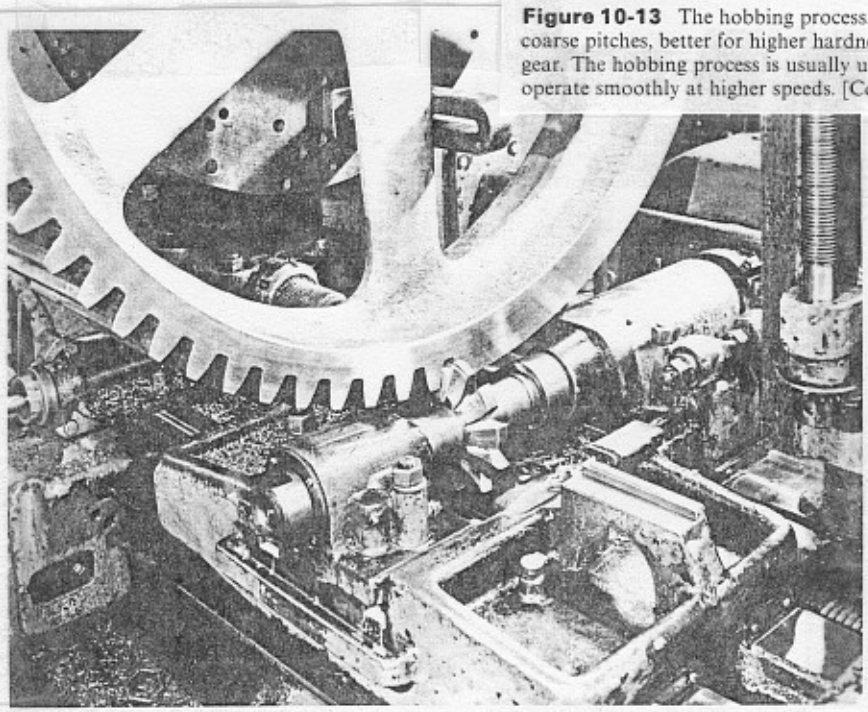
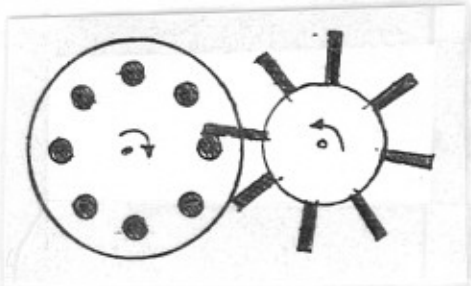
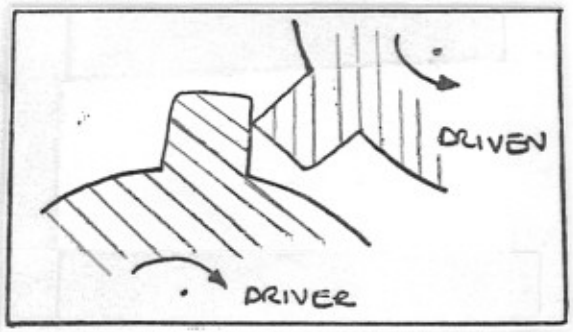


Figure 10-10 The formed disc cutter shown is usually used to manufacture gears for rough, heavy duty, slow speed applications. The process, which cuts teeth one at a time, is quite economical. [Courtesy Horseburgh-Scott.]

When one or more gears are coupled together, they are referred to as a gear set.

Fundamental Law of Gearing: The angular velocity ratio between the gears of a gearset remains constant throughout the mesh.





What is wrong with these gears?

Answer: They don't give a constant velocity ratio, the backlash is poor and there is rubbing

To solve these problems we can design the gear teeth to be shaped such that the gear tooth surface is always parallel to another surface, always in contact, and have no sliding between teeth. Such a curve is called an "involute."

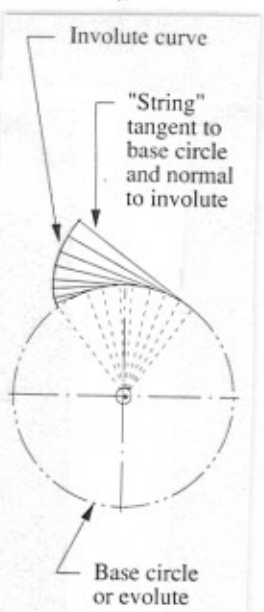


FIGURE 9-5
Development of the involute of a circle

- A gearset is typically designed to increase (or decrease) angular velocity or torque

$$\text{Angular velocity Ratio} = \frac{\omega_{out}}{\omega_{in}} = \pm \frac{r_{in}}{r_{out}}$$

$$\text{Torque Ratio} = \frac{\omega_{in}}{\omega_{out}} = \pm \frac{r_{out}}{r_{in}}$$

- In the figure below, note the pressure angle is formed by the velocity at the pitch point and the line of action

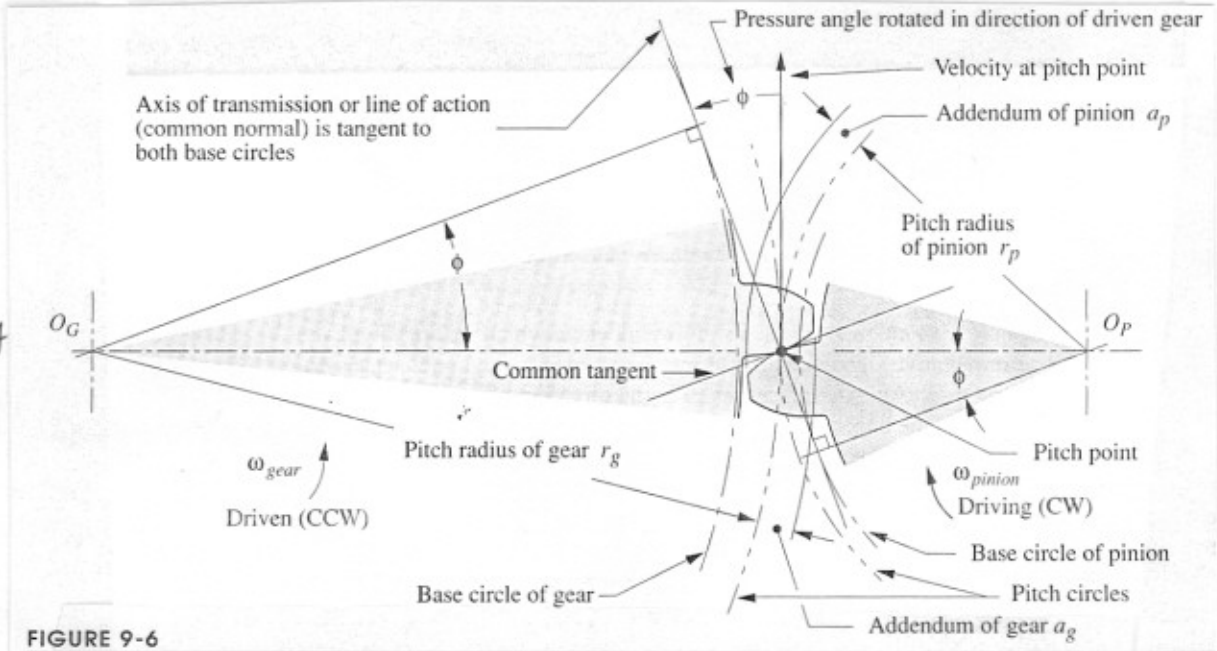


FIGURE 9-6
Contact geometry and pressure angle of involute gear teeth

ϕ is usually 20° or 25°

- If we look at the line of action of the teeth while they are at two different locations, you can notice that the line of action (axis of transmission) always passes through the pitch point.

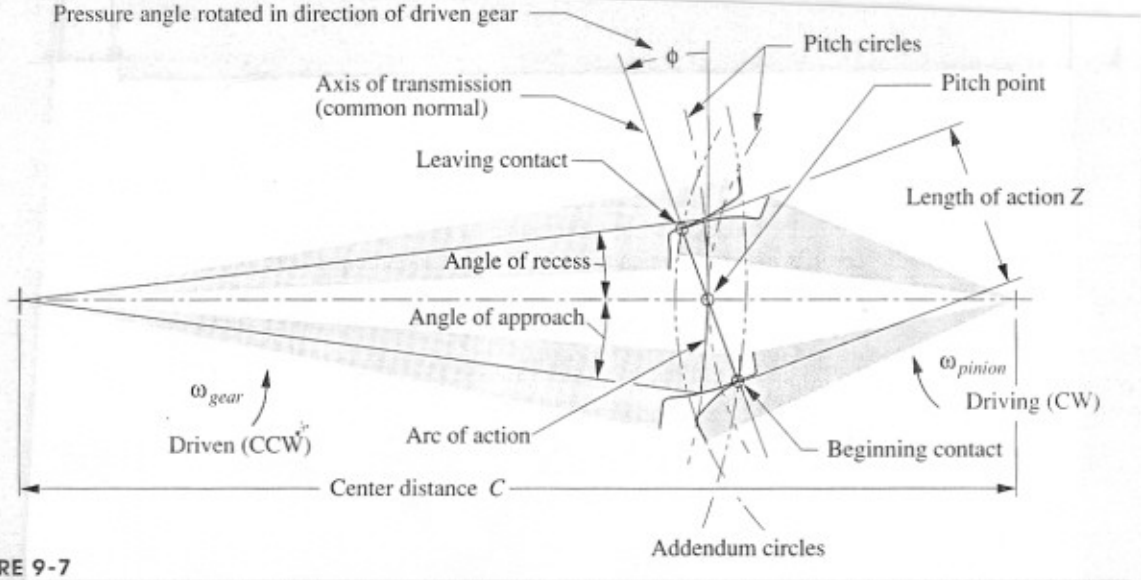


FIGURE 9-7
Pitch point, pitch circles, pressure angle, length of action, arc of action, and angles of approach and recess during the meshing of a gear and pinion

Fundamental Law of Gearing: The common normal of the tooth profiles, at all contact points within the mesh, must always through a fixed point on the line of centers, called the pitch point.

- Another important property of involute gears is that the center distance errors do not affect the velocity ratio. The velocity ratio of involute gears is fixed by the ratio of base circle diameters. The pressure angle will change and the pitch point will shift but the line of action will still be tangent to both base circles.

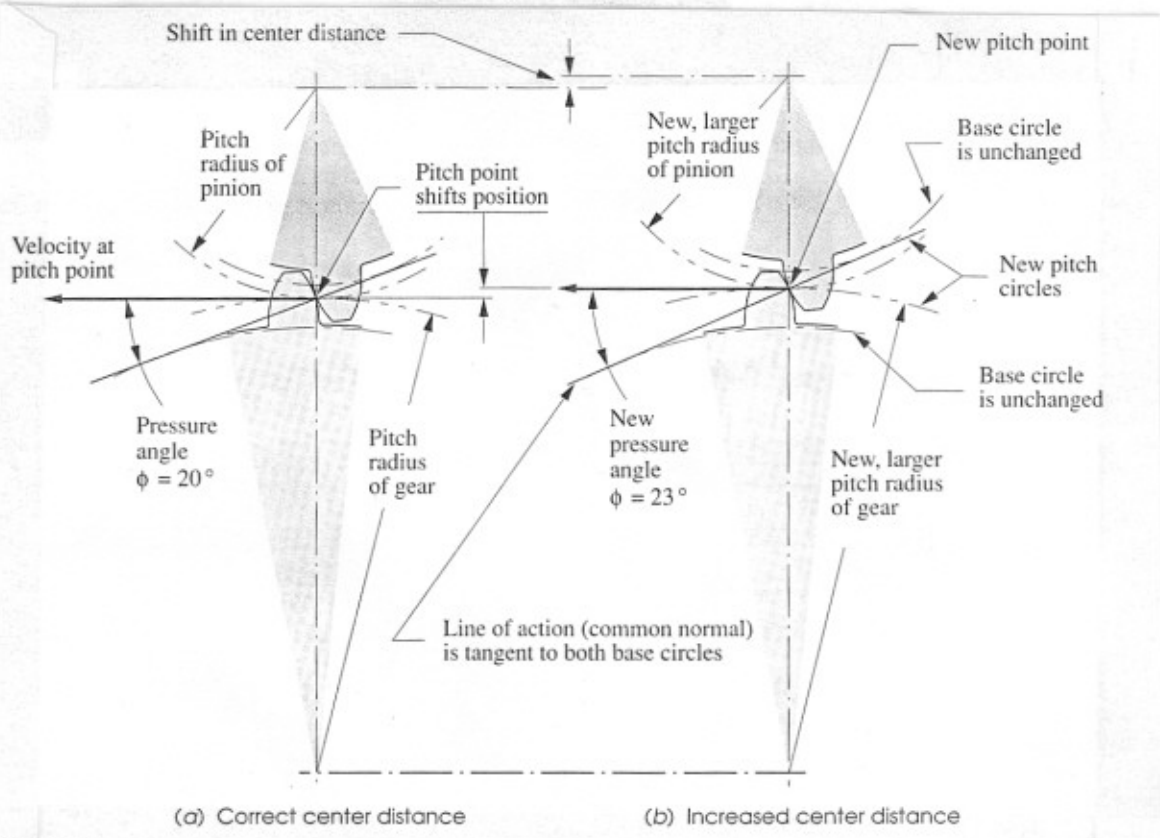


FIGURE 9-8
Changing center distance of involute gears changes the pressure angle and pitch diameters

- Increasing the center distance between gears will also increase the backlash (The clearance between the mating teeth measured at the pitch circle). Backlash is not an issue if the gearset is run with a non reversing torque.
- Antibacklash gears are two gears back to back on the same shaft that are rotated slightly in opposite direction and then fixed to take up the backlash.