



Gear Terminology



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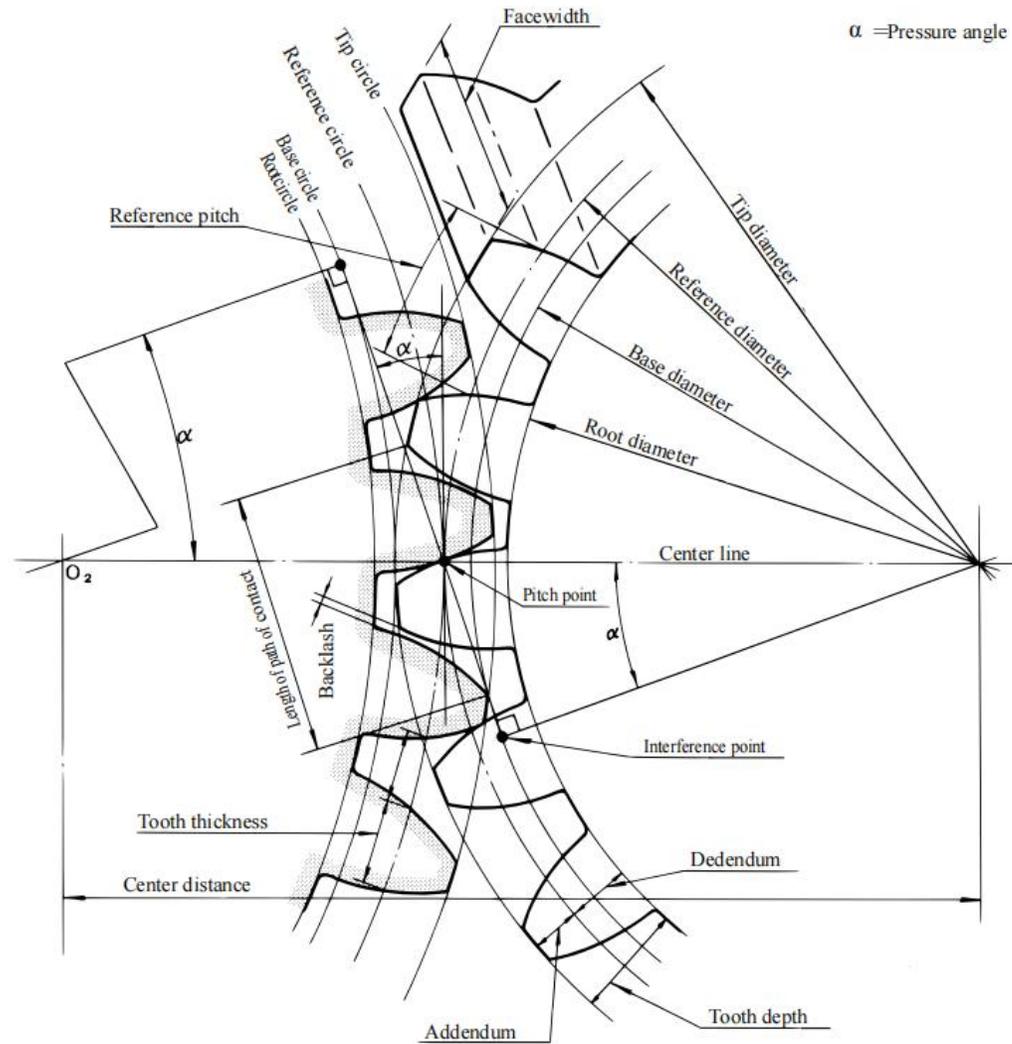
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Gear Terminology



The Module of a Gear

"Module" is the unit of size to indicate how big or small a gear is. It is the ratio of the reference diameter of the gear divided by the number of teeth.

$$\text{Thus: } m = \frac{d}{z} \quad \left(\text{Module} = \frac{\text{Reference diameter}}{\text{Number of teeth}} \right)$$

The mutual relation between the module and the reference diameter etc. is as follows:

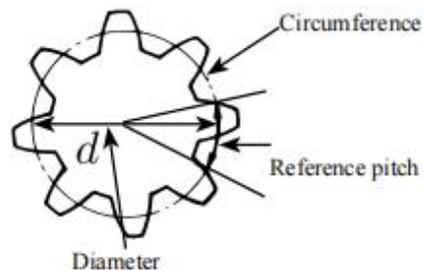
$$\text{Reference diameter } d = mz \quad \left(\text{Reference diameter} = \text{Module} \times \text{Number of teeth} \right)$$

$$\text{Number of teeth } z = \frac{d}{m} \quad \left(\text{Number of teeth} = \frac{\text{Reference diameter}}{\text{Module}} \right)$$

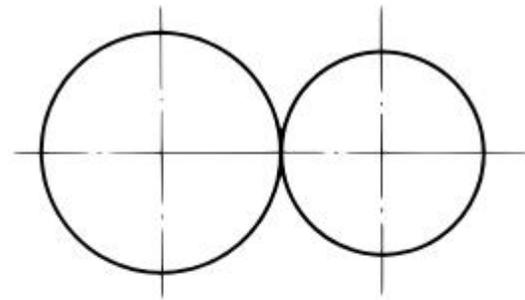
$$\text{Reference pitch } p = \pi m \quad \left(\text{Reference pitch} = \pi \times \text{Module} \right)$$

Then, what is the reference pitch?

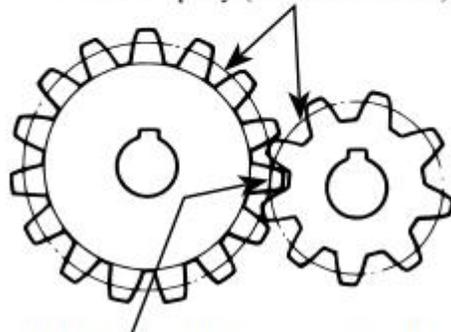
It is equal to the circumference divided by the number of teeth.



$$\text{Reference pitch} = \frac{\text{Circumference } (\pi d)}{\text{Number of teeth } (z)}$$



Friction pulley (Reference circle)



Both reference circles come in contact

what is the reference circle?

This is a friction pulley. As the surfaces are smooth, the rotation will not go properly when great force is applied. This problem will be solved if there are teeth on the periphery of the friction pulley. And this is the concept of gearing

[Summary]

- (1) The module describes the size of a gear.
- (2) A pair of gears can only mesh correctly if and when the base pitch is the same.

Involute Tooth Profile

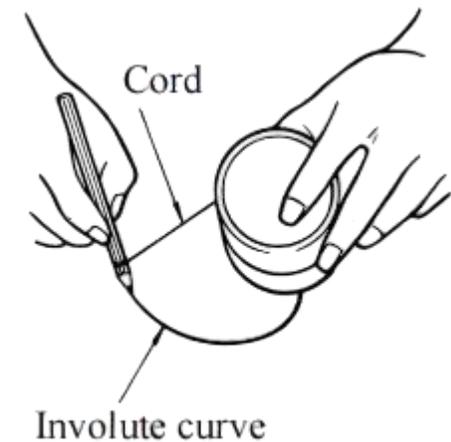
Is any tooth shape OK for gears? No. Random indentations (like a “dented pulley”) can cause slip, non-smooth rotation, vibration, and noise.

A good gear tooth profile must transmit power smoothly and reliably.

The involute tooth profile is the standard solution used in most gears.

The involute curve:

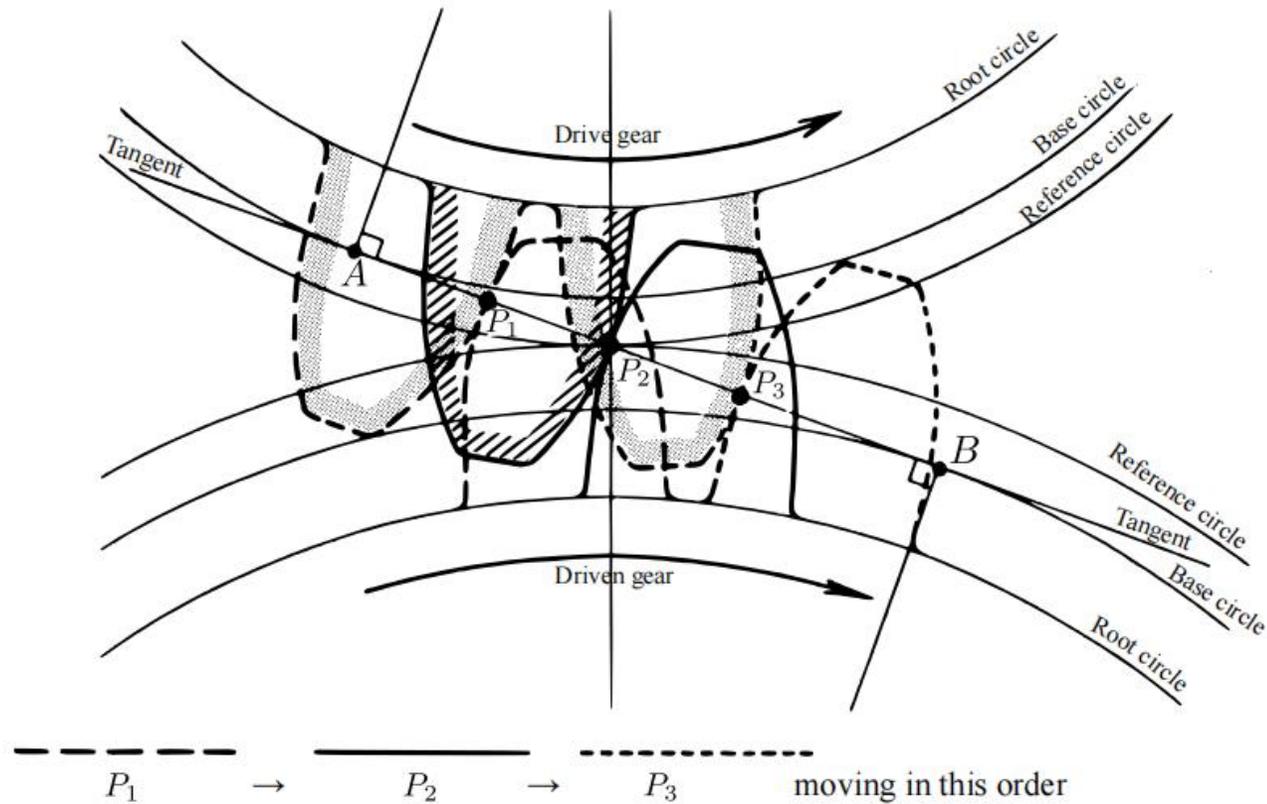
If a cord is wrapped around a cylinder, as shown in this figure, a point on the cord, as it is unwrapped from the cylinder, traces a curve called an involute. The circle from which the string is unwound is called the base circle.



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Involute Gear

This figure indicates how two involute teeth in mesh are moving to transmit rotary motion.



During meshing, the instantaneous contact point moves along the common tangent (often shown as $P1 \rightarrow P2 \rightarrow P3$).

This is similar to how a point on a belt travels around two discs—enabling smooth rotary motion transmission.

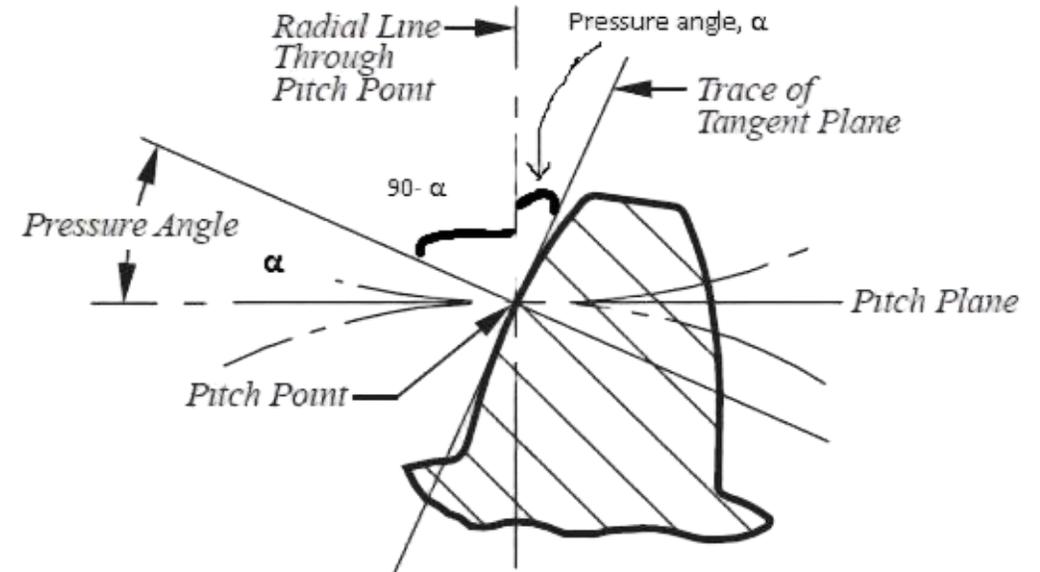
Features :

- Conjugate action is independent of center-distance changes (within a practical range)
- Lower manufacturing cost because the profile is relatively simple
- Most widely used tooth profile for gears

Pressure Angle

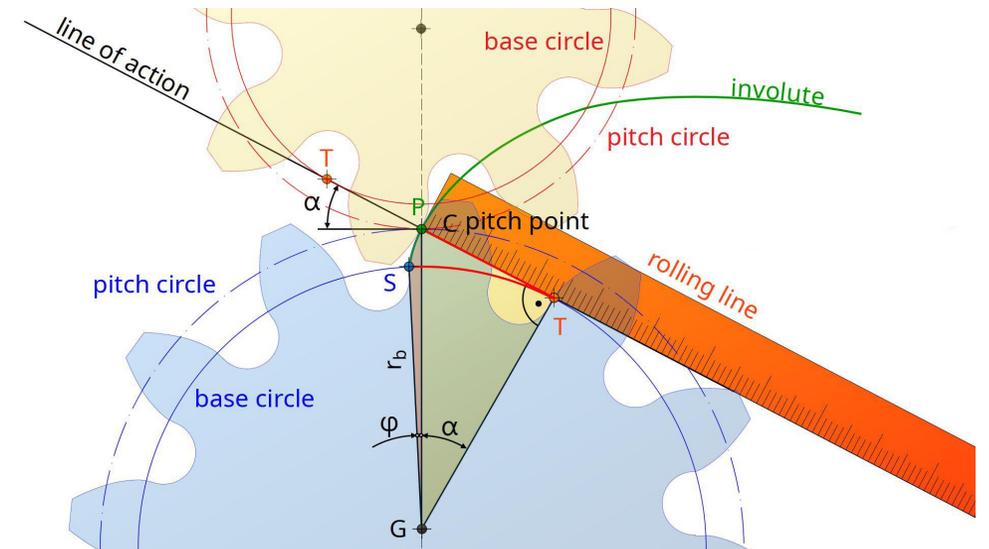
The pressure angle between the tooth profile and a radial line at its pitch point. In involute teeth it is often described as the angle between the line of action and the line tangent to the pitch circle.

Here $\alpha = \alpha'$. Therefore, α' also is the pressure angle.



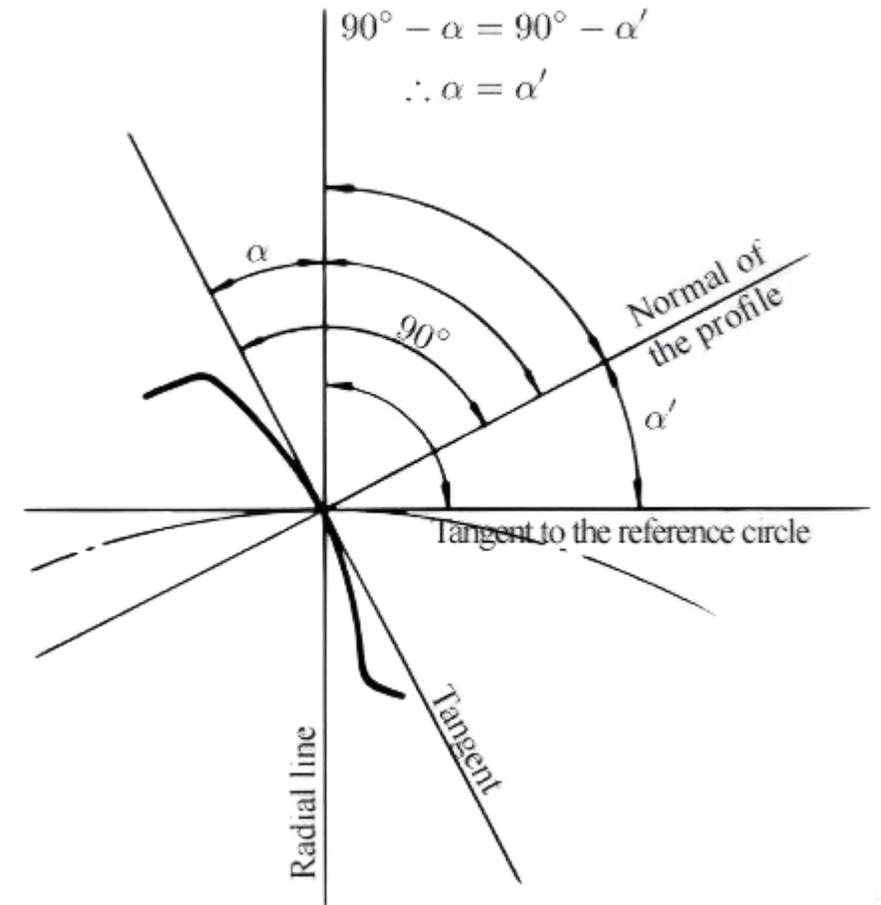
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- Is the pressure angle “just a drawing parameter”?
No. It defines how force is transmitted between meshing gears.
- Definition (in involute gears): the angle between the line of action and the tangent to the pitch circle (at the pitch point).
- At the pitch point, the driving gear pushes the driven gear along the common normal / line of action (matches the figure concept).
- Typical pressure angles: 14.5° / 20° / 25° (20° is most commonly used in many standard systems).



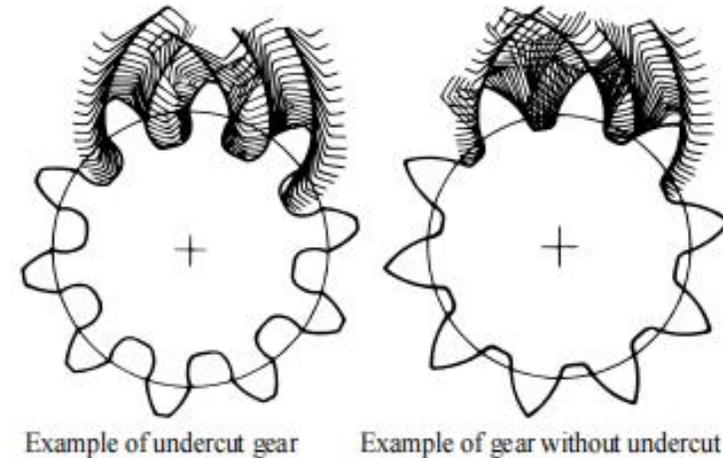
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- Load distribution: smaller angles (e.g., 14.5°) can run smoother, but may reduce load capacity. Larger angles (e.g., 25°) can carry higher loads, but may introduce more friction and noise.
- Tooth strength & durability: higher pressure angles generally increase tooth strength, helpful for heavy-duty use (e.g., tractors, trucks).
- Efficiency & noise: lower pressure angles are typically quieter and more efficient, while angle optimization matters in high-precision systems (e.g., EV drivetrains).



Profile Shifted Gears

- Is a standard tooth profile always OK, even with a small tooth count? Not always.
- When the number of teeth is small, the generating tool may remove part of the tooth root, creating undercut.
- Undercut can reduce root thickness, weaken the tooth, and worsen meshing stability.
- Profile shift (tooth profile correction) introduces a controlled modification to the generated tooth form to prevent or reduce undercut.
- Beyond undercut prevention, profile shift can also help tune the center distance and meshing conditions.



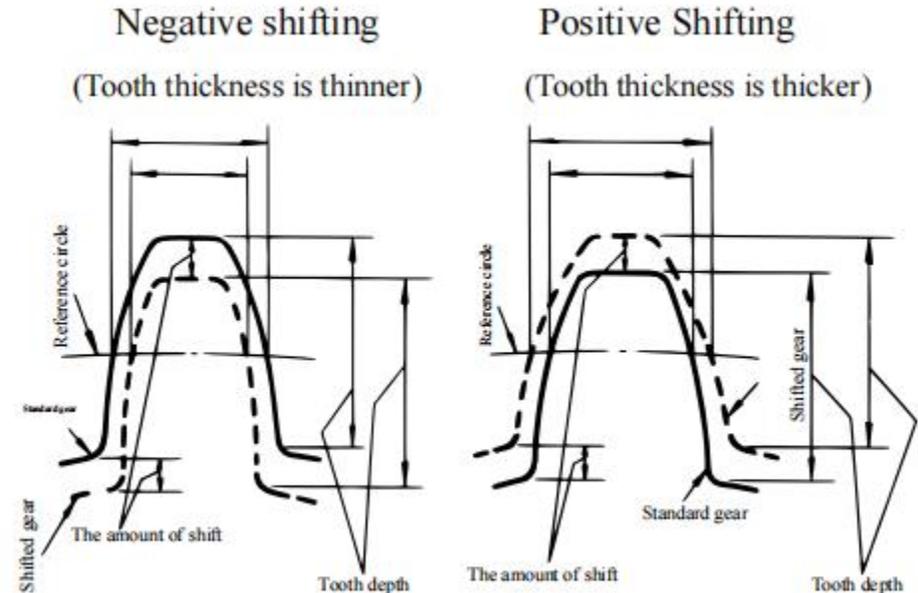
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Is positive shift simply “making the tooth deeper”?No.

Profile shifting mainly changes tooth thickness distribution; the tooth depth does not necessarily change (as shown in the figure).

- Positive shifting (+): tooth thickness becomes thicker (especially beneficial for the pinion), helping improve root robustness and undercut resistance.
- Negative shifting (-): tooth thickness becomes thinner, often used as a counter-balance in a gear pair.

A common design approach is pinion positive shift + gear negative shift. When the absolute shift values are equal, it can satisfy certain constraints (e.g., maintaining the intended center distance in a paired design).



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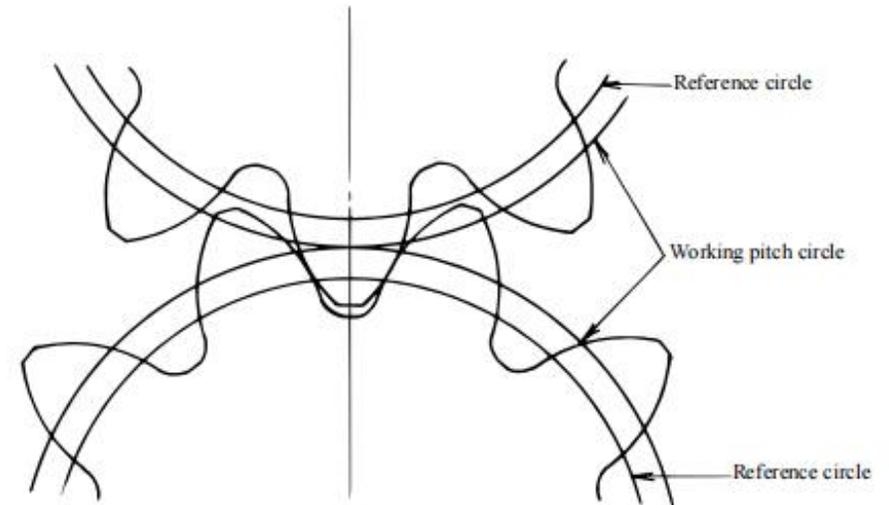
In standard spur gears, the reference circles roll together during meshing.

In profile shifted gears, the working pitch circles contact and roll instead—this changes the meshing geometry.

The pressure angle at the working pitch circle is the working pressure angle, which can differ from the reference pressure angle.

Key benefits:

- 1.Prevents undercutting when the tooth count is small
- 2.Helps adjust center distance when packaging constraints exist
- 3.Balances strength between pinion and gear by shifting—typically strengthening the pinion while compensating on the gear



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