

Module 2 – GEARS

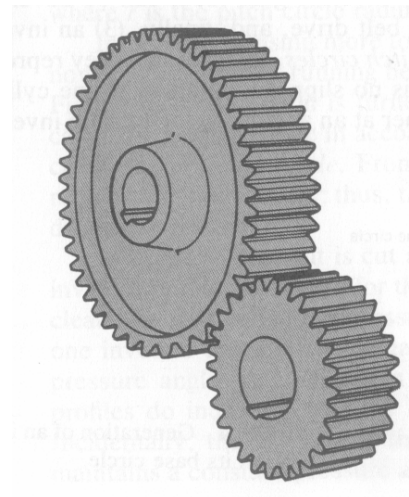
Lecture 1- Introduction

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6. Bevel Gear
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INTRODUCTION AND HISTORY OF GEARS

Gears are toothed members which transmit power or motion between two shafts, by meshing without any slip. Hence, gear drives are also called positive drives. In any pair of gears, the smaller one is called pinion and the larger one is called gear immaterial of which is driving the other.



When pinion is the driver, it results in step down drive in which the output speed decreases and the torque increases. On the other hand, when the gear is the driver, it results in step up drive in which the output speed increases and the torque decreases.

A typical example of step down drive is an automobile gearbox, in which the high speed low torque output of the engine is converted into low speed high torque output for driving the traction wheels.

Primitive gears shown in Fig. 2 were first used in door drive mechanism in temples and caves, and water lifting mechanisms 2600 B.C. in India and elsewhere.

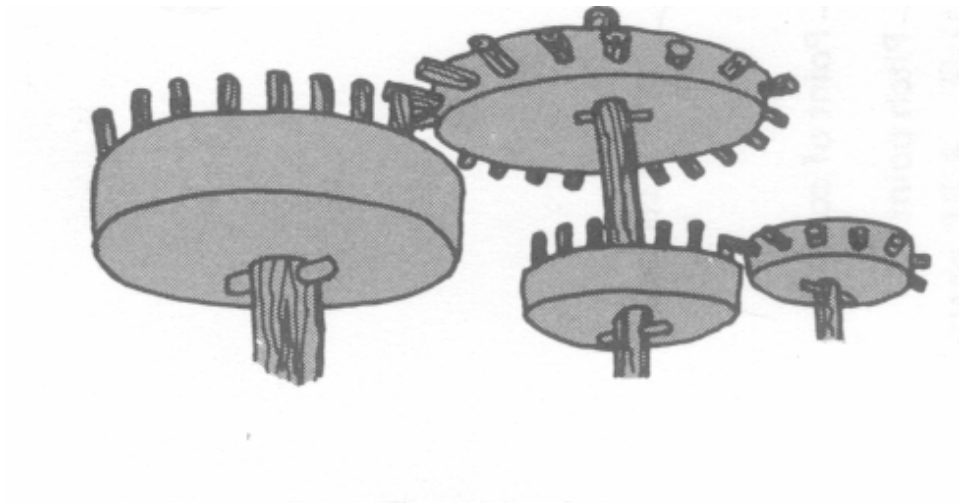
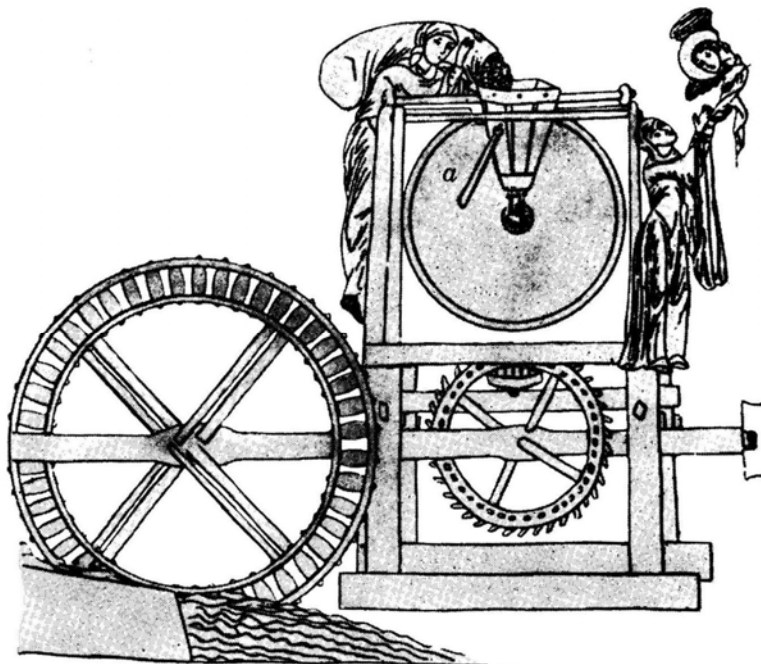


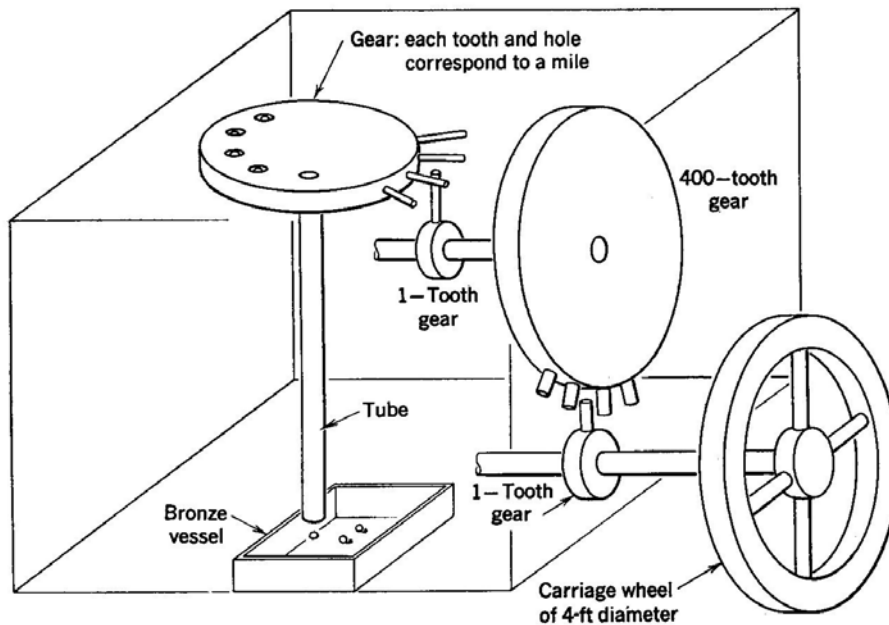
Fig.1

- Aristotle has described gears used during his times 400 B.C.
- Classical origin of worm gearing was made by Archimedes 287-212 B.C.

Water wheel and grain mill described by Vitruvius 40 B.C. had conversion of motion from horizontal to vertical shaft by gears.

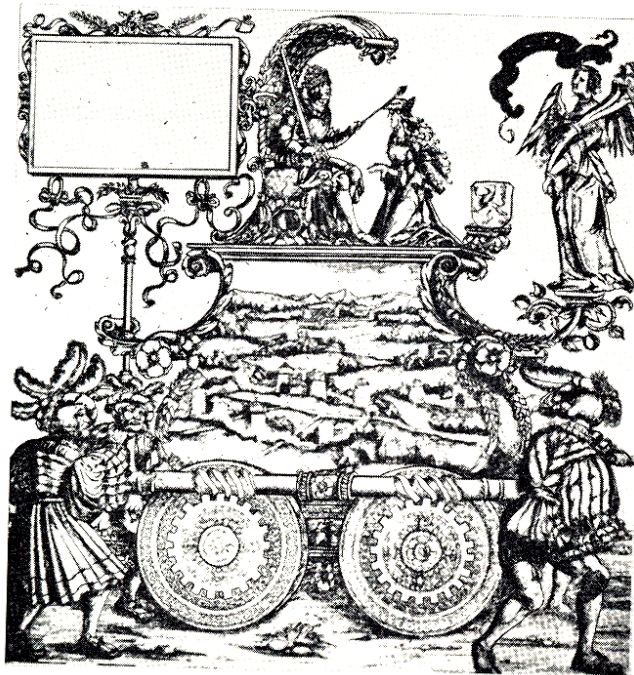


Schematic diagram of an odometer for a carriage described by Vitruvius 28 B.C.



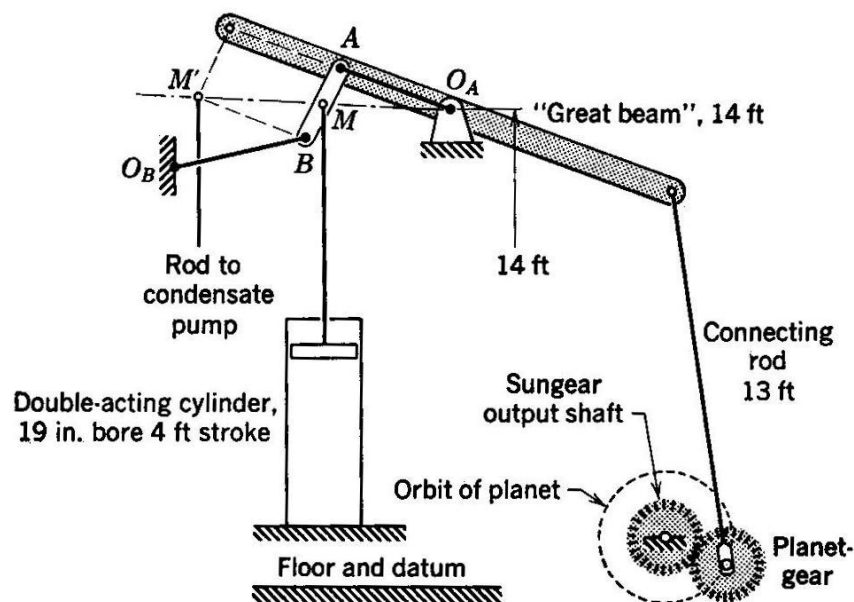
- Leonard da Vinci used multitudes of gears in various mechanisms developed by him 500 A.D.
- Greek and Roman literatures show extensive usage of gears for forward motion.
- Toothed gears used for the clocks of Cathedrals and other ecclesiastical buildings during the middle ages are still preserved in many places.
- Salisbury cathedral still possesses the oldest clock in England made in 1386.
- The Wells Cathedral clock made in 1392 is preserved in Science museum in South Kensington. Though the iron gears have worn out to some extent, they still keep good timings.

German artist Albrecht Durer's engravings show a vehicle designed for the Emperor Maximilian I during 15th century. That vehicle was driven by worm gears on all four wheels.



This clearly shows that he knew the concept of Gearing which helped him in sketching them accurately.

Schematic diagram of Watt's rotating Engine invented in 1784 is shown in the figure. It was the first engine to produce power directly on a shaft.

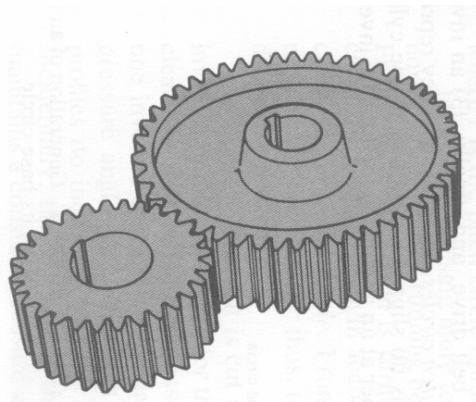


In 18th century, Industrial Revolution in England lead to usage of cycloidal gears for clocks, irrigation devices, water mills and powered machines.

Since then, the gear technology is advancing rapidly. It is most unlikely that gears are going to be replaced by any other component for their function in the near future.

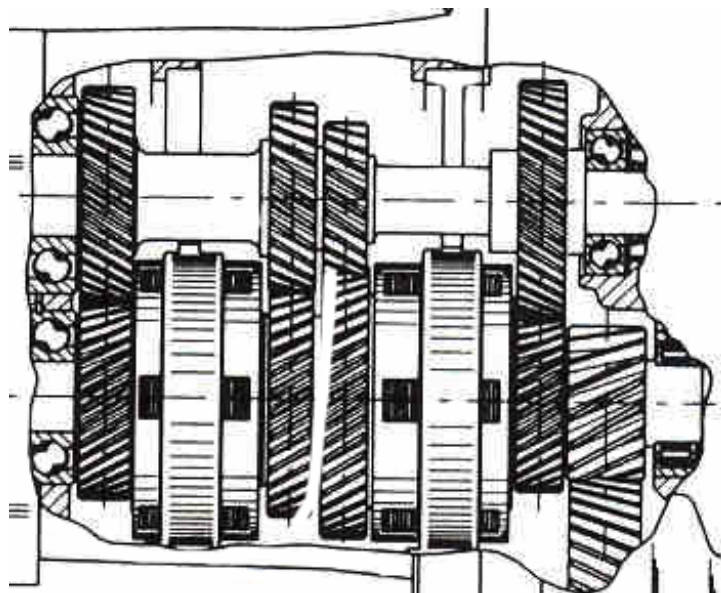
DEFINITION OF GEARS

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An example of a step up drive is the gearbox of a wind mill in which the low speed high torque of the wind mill blades is converted into high speed low torque for driving the generator at synchronous speed.

TYPES OF GEARS

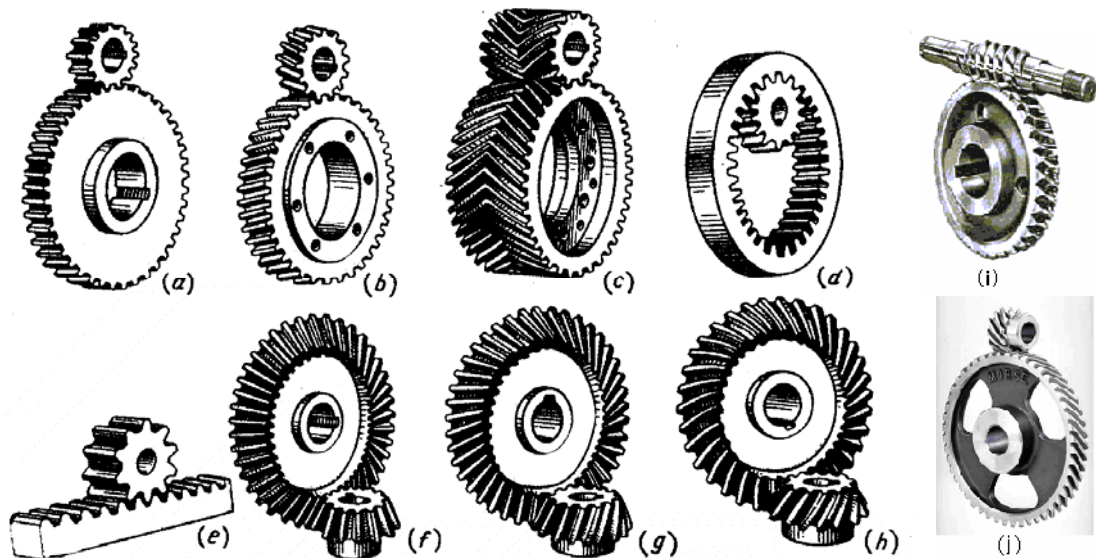
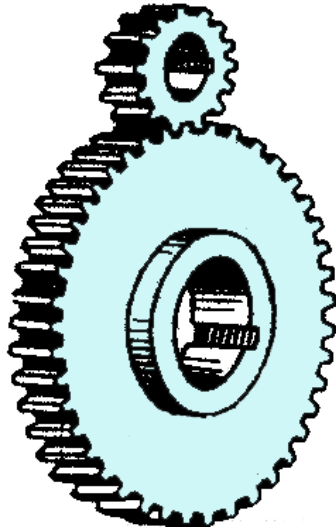


Fig. 1.2 (a) Spur gear, (b) helical gear, (c) Double helical gear or herringbone gear, (d) Internal gear, (e) Rack and pinion, (f) Straight bevel gear, (g) Spiral bevel gear, (h) Hypoid bevel gear, (i) worm gear and (j) Crossed helical or spiral gear.

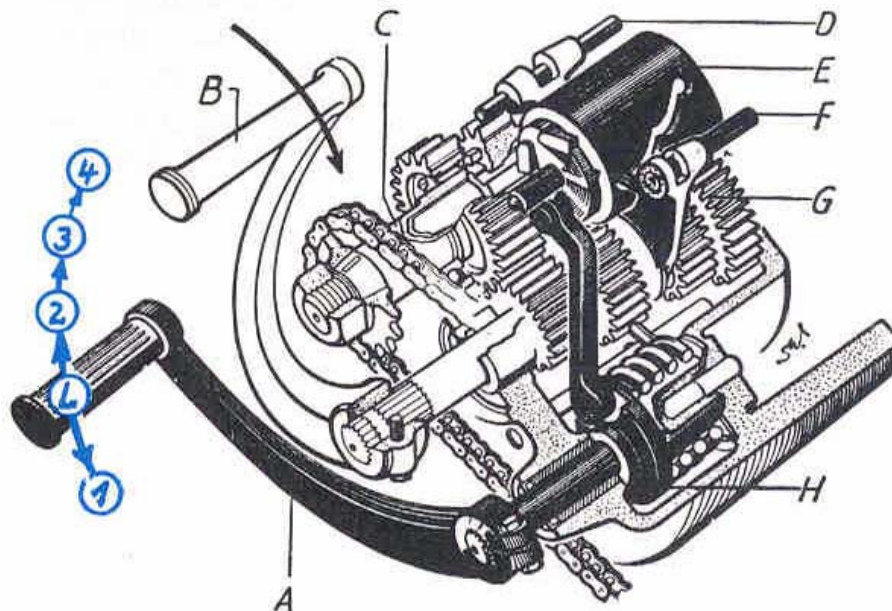
SPUR GEARS



- In spur gears teeth are parallel to the axis.
- Used for transmitting power between two parallel shafts.
- They are simple in construction, easy to manufacture and cost less.
- Spur gears have highest efficiency and excellent precision rating.
- They are used in high speed and high load applications.

APPLICATION OF SPUR GEARS

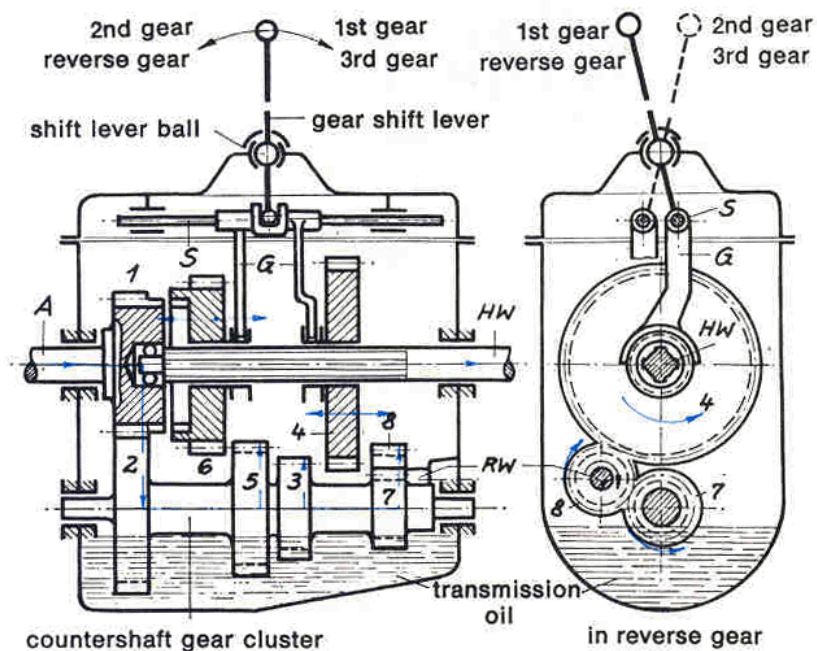
Gear Box of a motor cycle



12. Foot pedal gear control by shift cam assembly

- A gear shift pedal
- B kick starter
- C main-and clutch-shaft
- D and F shift forks
- E shift cam
- G start-and counter-shaft
- H cam shaft with linkage for shift cam

Sliding mesh gear box of an automobile



countershaft gear cluster
sliding gear type transmission
with 3 forward speeds

A input shaft

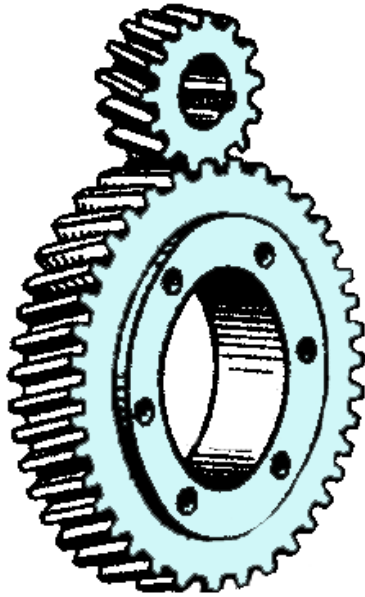
HW main shaft

RW reverse shaft

G shift forks

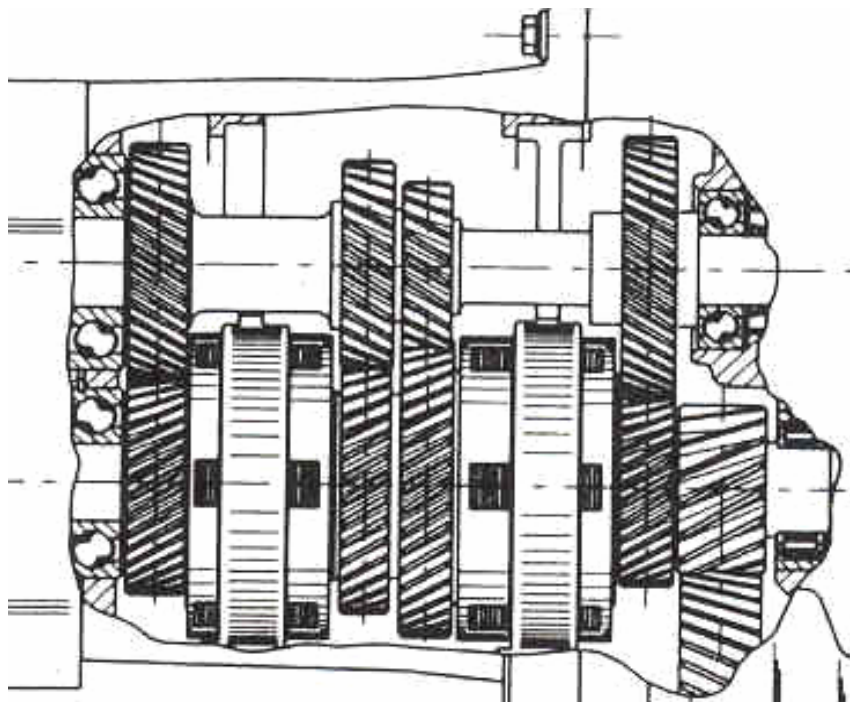
S shift rod

HELICAL GEARS



- Helical gears are used for transmitting power between two parallel shafts.
- They have teeth inclined to the axis.
- Hence, for the same width, their teeth are longer than spur gears and have higher load carrying capacity.
- Their contact ratio is higher than spur gears and they operate smoother and quieter than spur gears. Their precision rating is good.

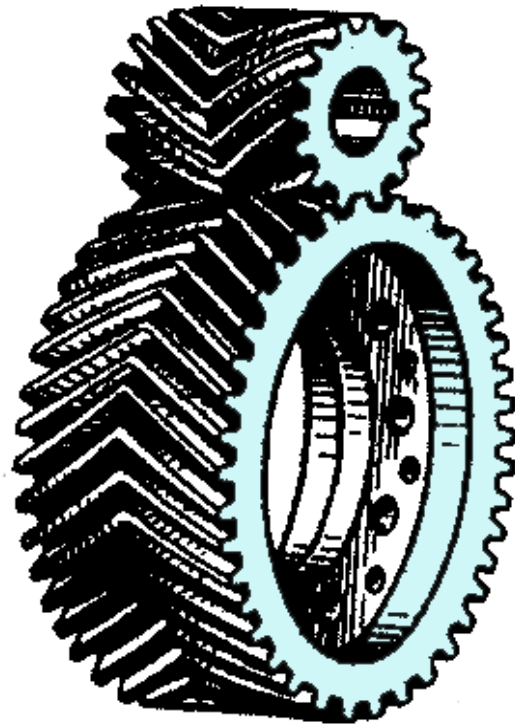
These gears find wide applications in constant mesh gearboxes of automobiles.



HELICAL GEARS - DISADVANTAGES

- Because of the helix angle axial loading is imposed on the shaft. Hence, the shaft support bearings have to be designed to take the axial load.
- Cutting of these gears is costlier than spur gears.
- The longer surface of contact reduces the efficiency of a helical gear relative to a spur gear.

DOUBLE HELICAL OR HERRINGBONE GEARS



- Double helical or Herring-bone gears used for transmitting power between two parallel shafts.
- They have opposing helical teeth which nullify two axial thrusts.

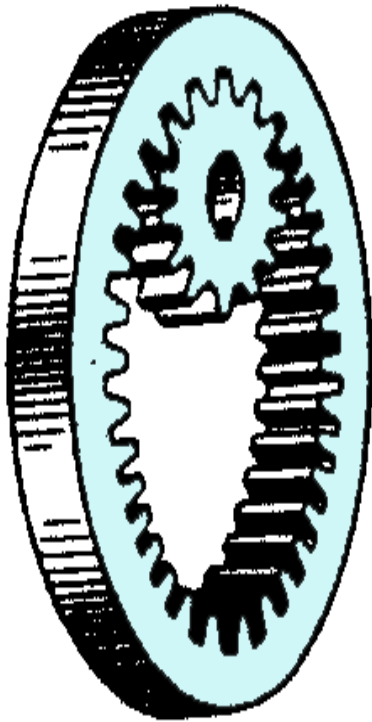
Though their load capacity is very high, manufacturing difficulty makes them costlier than single helical gear.

APPLICATION OF DOUBLE HELICAL GEARS OR HERRINGBONE GEARS

- These gears find wide applications in cement mills and crushers.



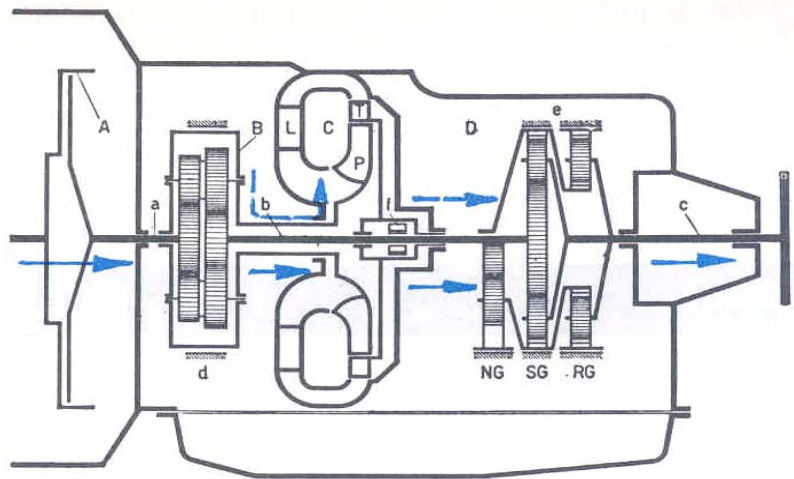
INTERNAL GEARS



- Internal gears are used for transmitting power between two parallel shafts.
- In these gears, annular wheels are having teeth on the inner periphery.

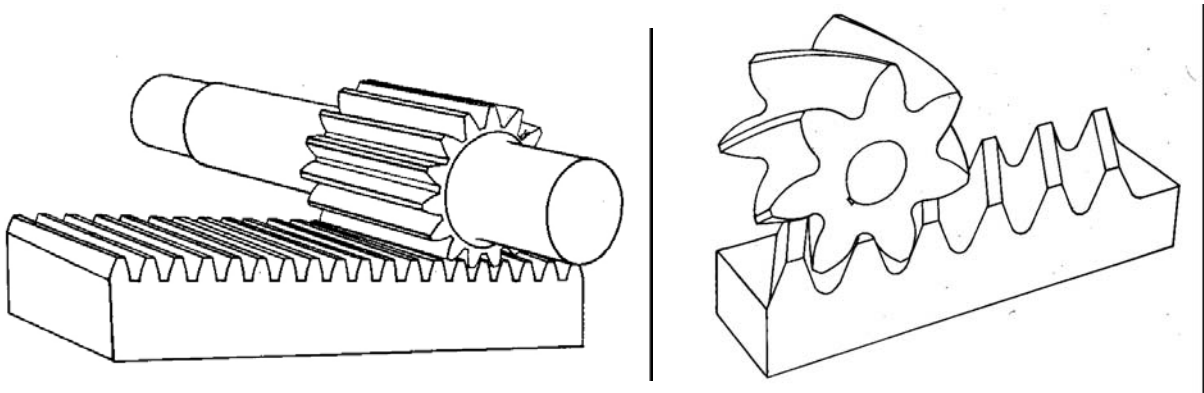
APPLICATION OF INTERNAL GEARS

- Applications of internal gears can be seen in planetary gear drives of automatic transmissions of automobiles, reduction gearboxes of cement mills, step-up drives of wind mills.

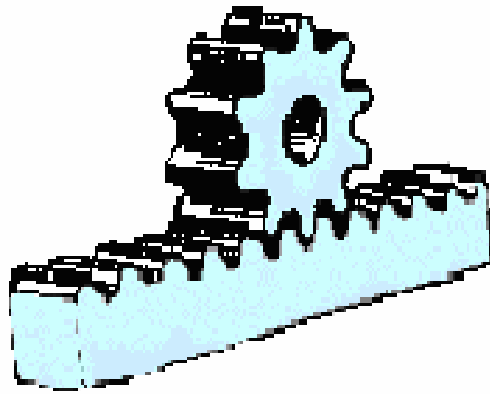


RACK AND PINION

- Rack is a segment of a gear of infinite diameter.
- The tooth can be spur or helical.

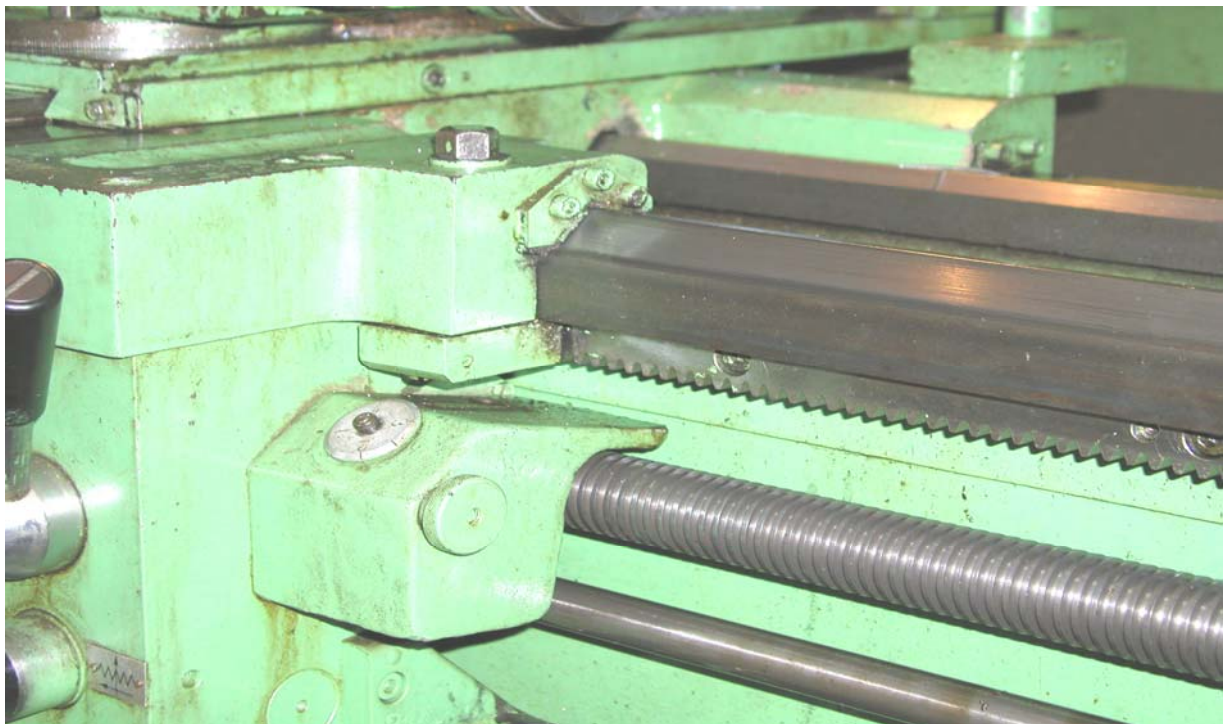


- This type of gearing is used for converting rotary motion into translatory motion or visa versa.



APPLICATION OF RACK AND PINION

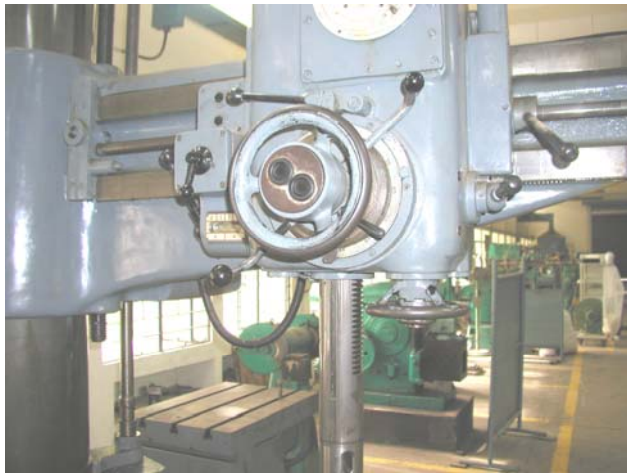
Lathe carriage: Drive mechanism



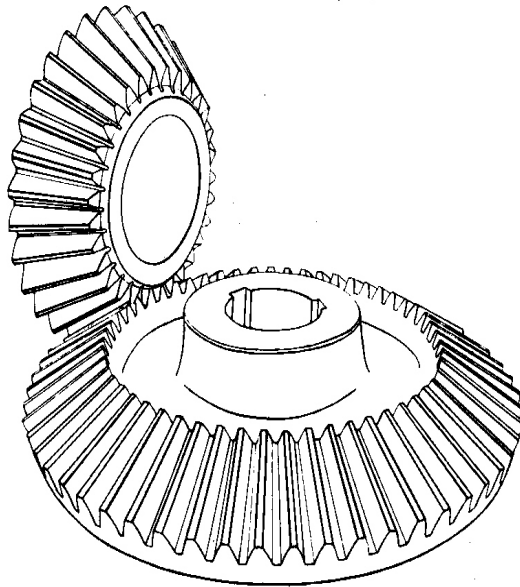
Lathe carriage drive



Radial drilling machine spindle drive



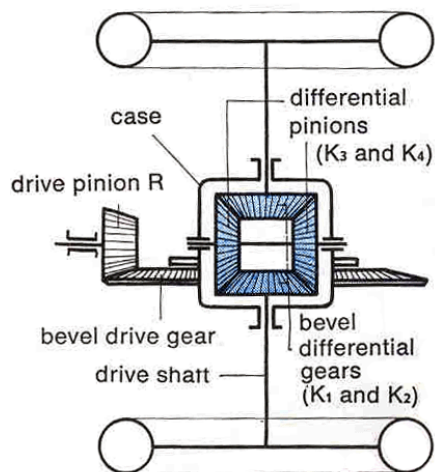
STRAIGHT BEVEL GEARS



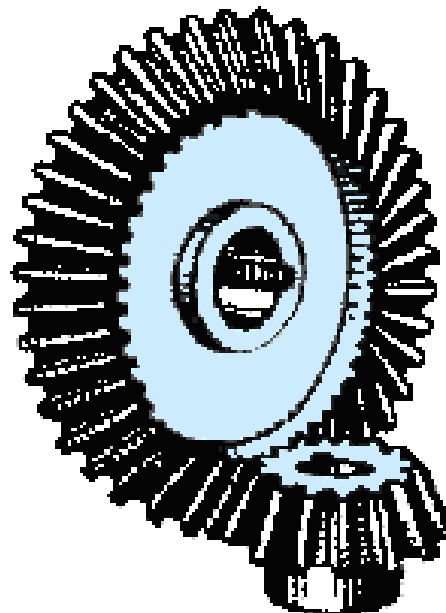
- Straight bevel gears are used for transmitting power between intersecting shafts
- They are suitable for 1:1 and higher velocity ratios.
- They can be used for right-angle or any angular drive.

APPLICATION OF STRAIGHT BEVEL GEARS

Automobile differential drive

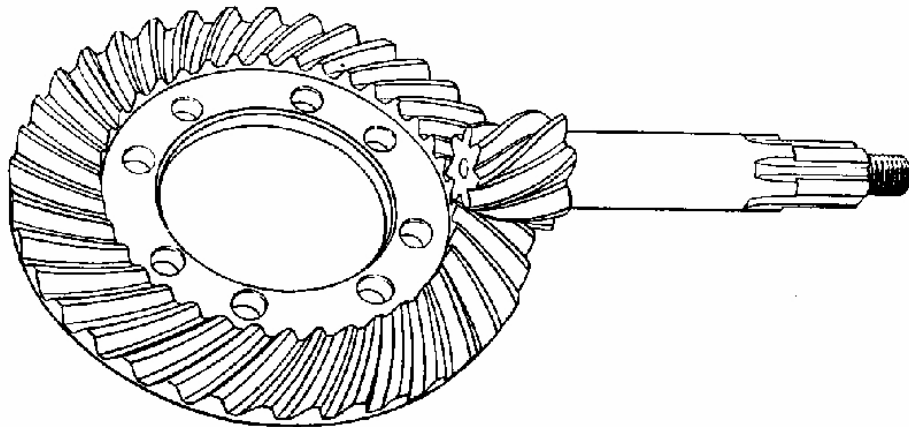


Final drive with differential



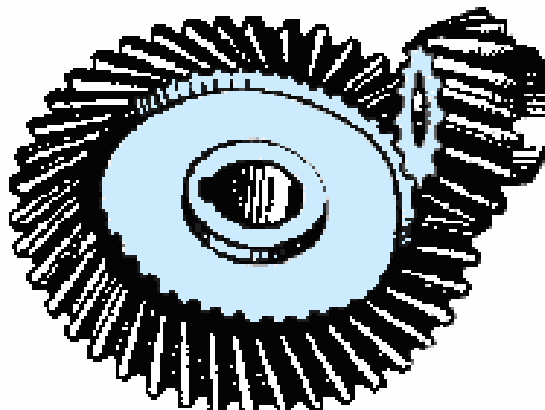
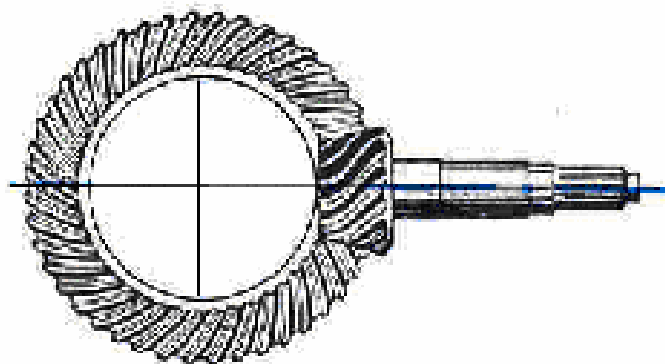
SPIRAL BEVEL GEARS

- Spiral bevel gears are also used for transmitting power between intersecting shafts.
- They operate smoother than straight bevel gears and have higher load capacity.



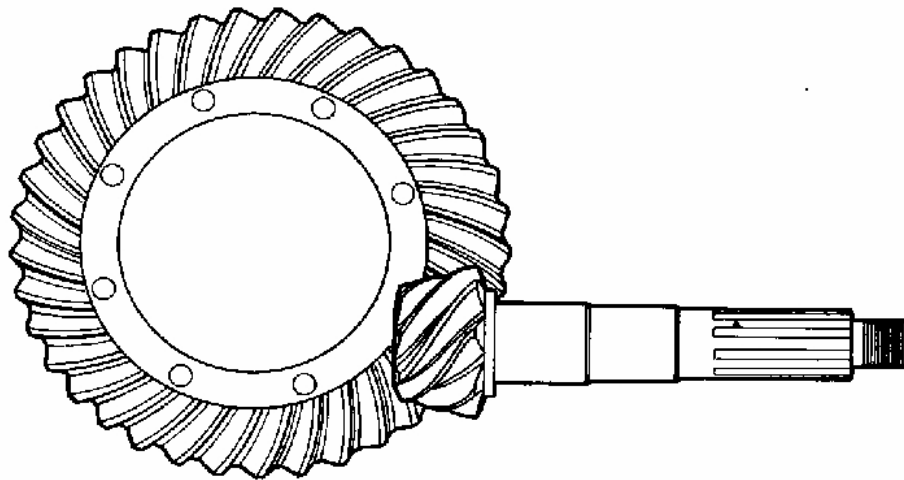
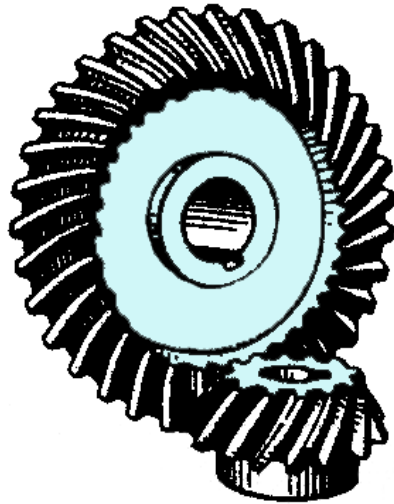
APPLICATION OF SPIRAL GEARS

- **Automobile differential drive**



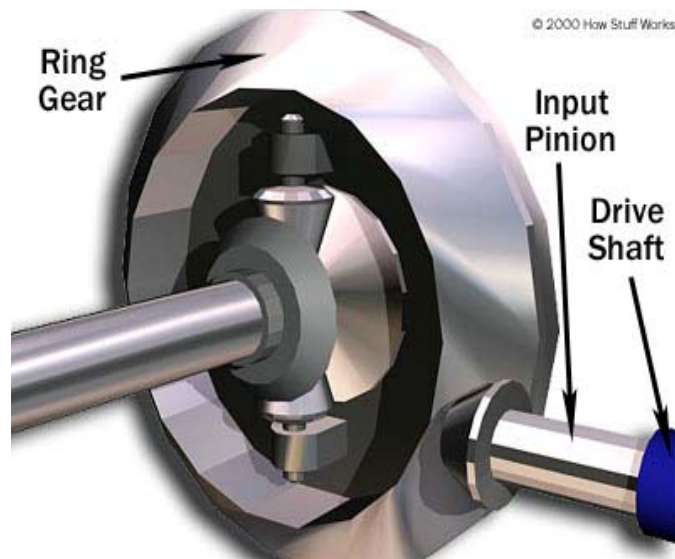
HYPOIDAL BEVEL GEARS

- These gears are also used for right angle drive in which the axes do not intersect. This permits lowering of the pinion axis and avoiding hump inside the automobile otherwise needed for the drive line power transmission.

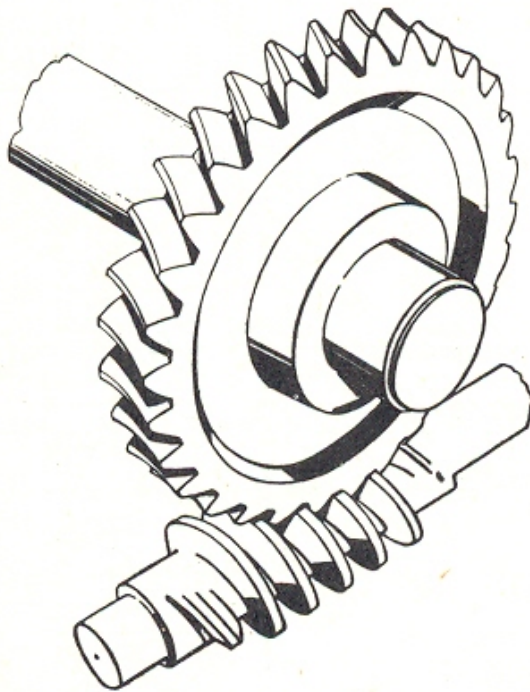


APPLICATION OF HYPOIDAL BEVEL GEARS

These gears are widely used in current day automobile drive line power transmission.



WORM GEARS



- They are used in right-angle or skew shaft drives.
- The presence of sliding action in the system even though results in quieter operation, it gives rise to considerable frictional heat.



- Hence, they need good lubrication for heat dissipation and for improving the efficiency.
- High reductions are possible which results in compact drive.

APPLICATION OF WORM GEARS

Worm gears are used widely in material handling and transportation machinery, machine tools, automobiles etc.

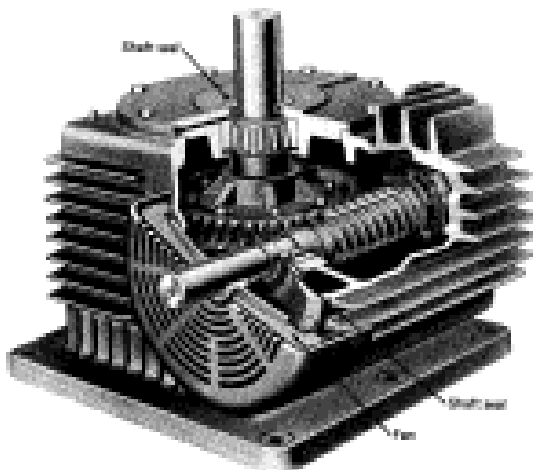


Figure 16.26 Worm gear speed reducer with fan and fins to increase heat transfer. (Courtesy Cleveland Gear Company.)

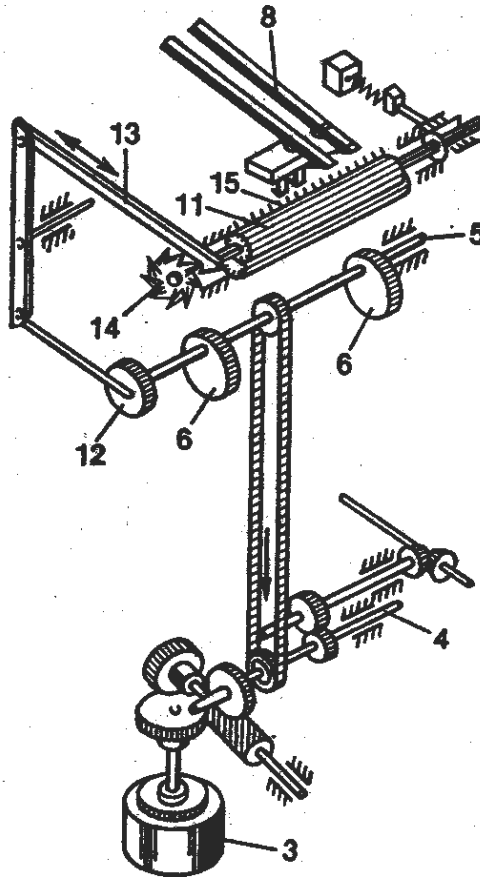
CROSSED HELICAL GEAR OR SPIRAL GEARS



- They have high helix angle and transmit power between two non-intersecting non-parallel shafts.
- They have point contact which reduces their load carrying capacity.
- Hence, they are used for light load applications only.

APPLICATION OF CROSSED HELICAL OR SPIRAL GEARS

They are used for light load and low speed application such as textile machine shown in the figure, sewing machines, instruments, distributor and speedometer in automobiles.

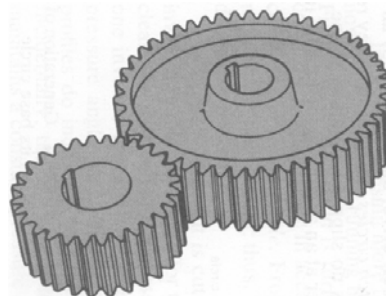


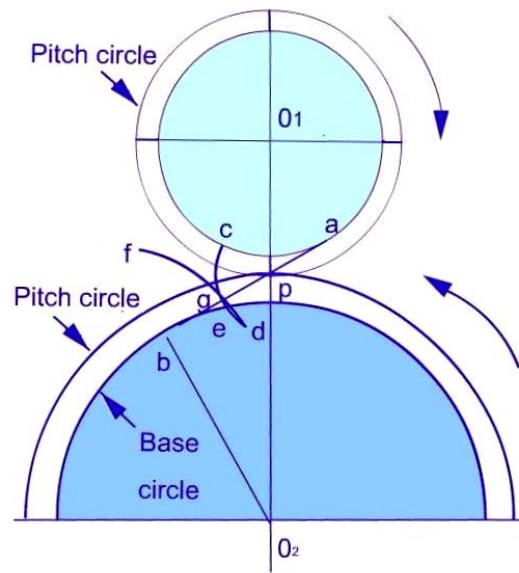
LAW OF GEARING

The fundamental law of gearing states that the angular velocity ratio between the gears of a gear set must remain constant throughout the mesh.

$$\frac{\omega_1}{\omega_2} = \frac{d_2}{d_1}$$

$$\frac{n_1}{n_2} = \frac{d_2}{d_1} = \frac{Z_2}{Z_1}$$

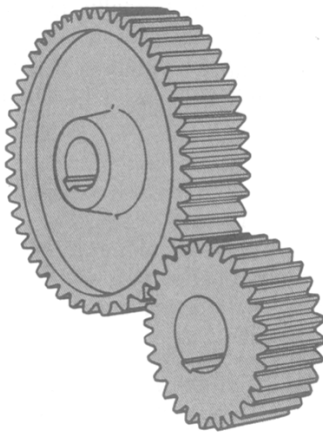




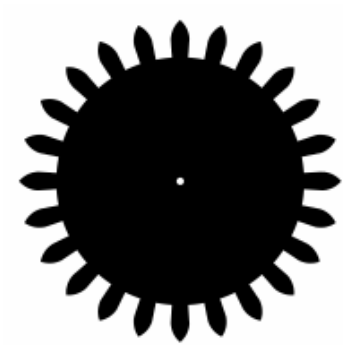
In order to maintain constant angular velocity ratio between two meshing gears, the common normal of the tooth profiles, at all contact points within mesh, must always pass through a fixed point on the line of centers, called pitch point.

PROFILES SATISFYING LAW OF GEARS

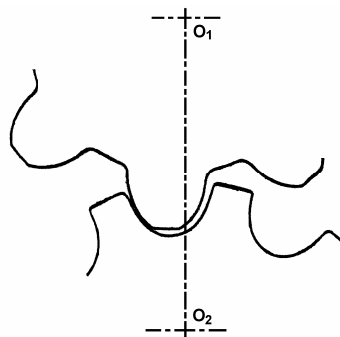
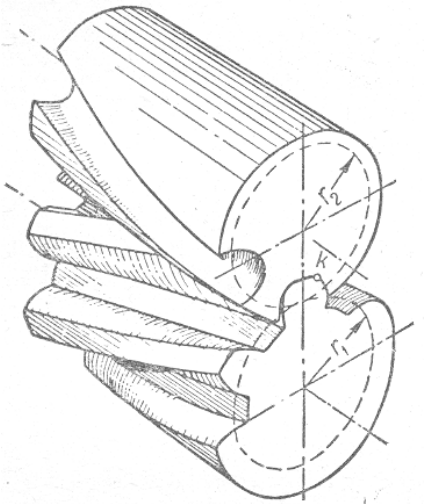
Involute



Cycloidal



Circular Arc



INVOLUTE GEAR TOOTH PROFILE

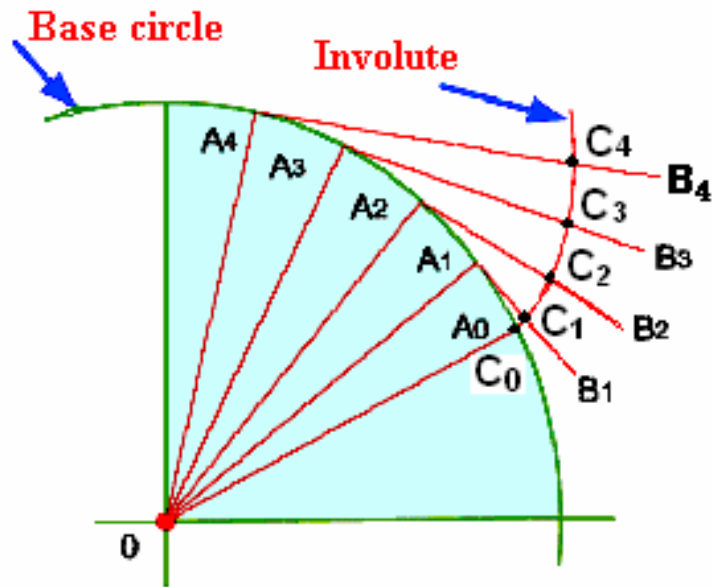


Figure showing the generation of involute profile on one side.

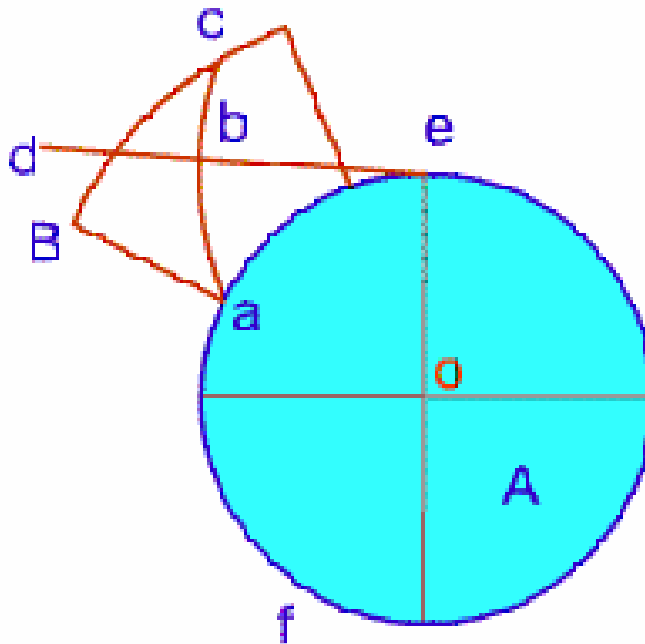


Figure showing the generation of involute profile on other side.

INVOLUTE GEAR TOOTH PROFILE

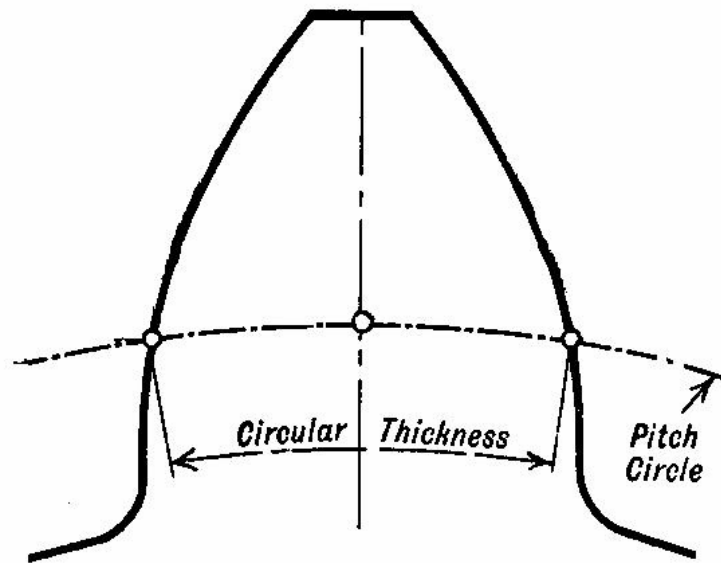
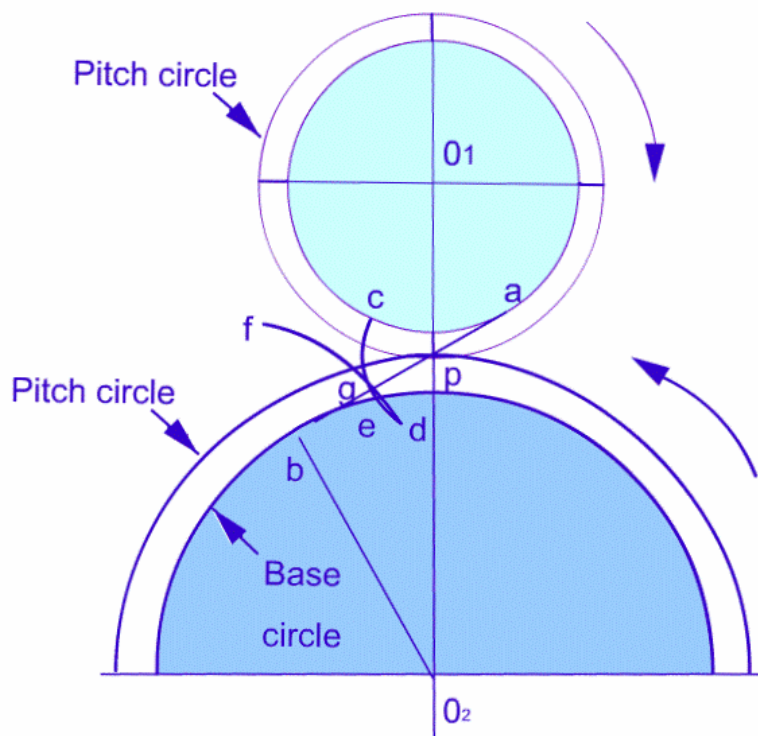


Figure showing involute gear tooth profile appearance after generation.

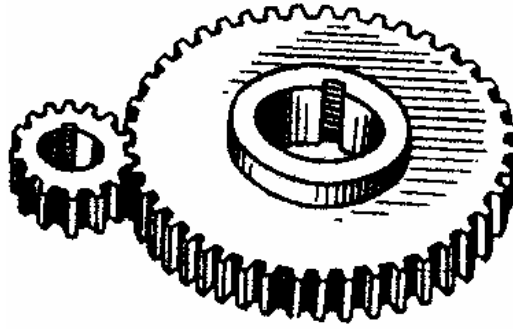


Gear meshing

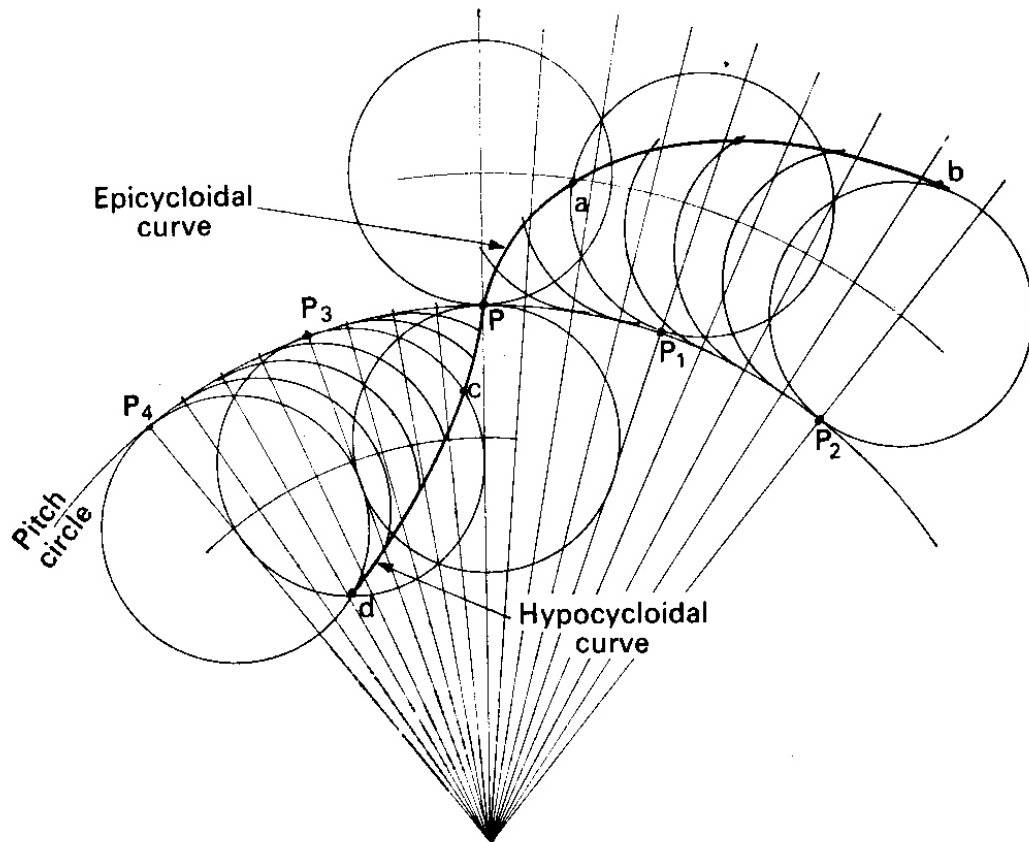
INVOLUTE GEARS

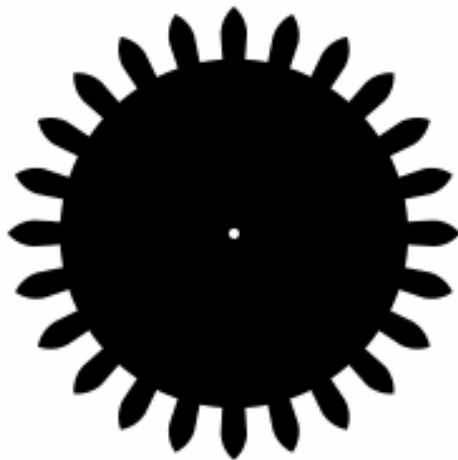
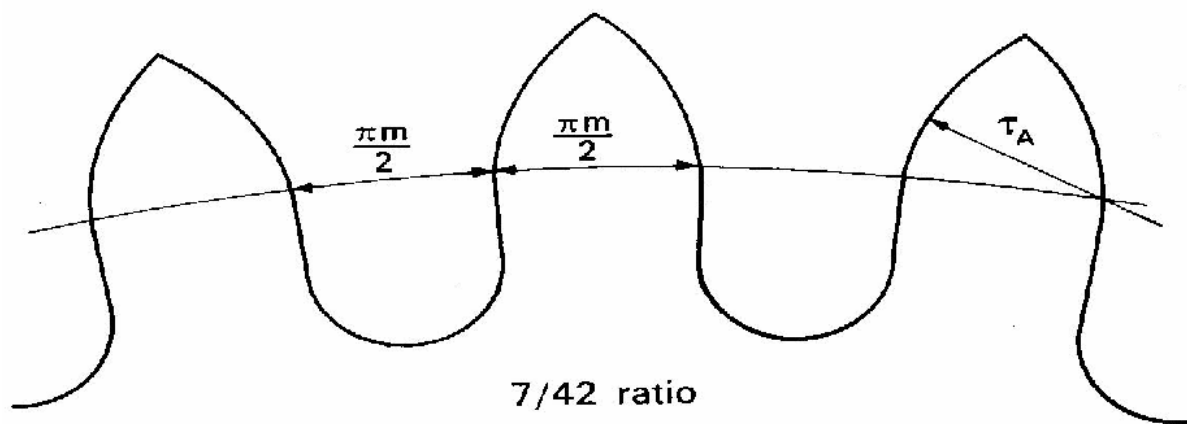
ADVANTAGES:

1. Variation in centre distance does not affect the velocity ratio.
2. Pressure angle remains constant throughout the engagements which results in smooth running.
3. Straight teeth of basic rack for involute admits simple tools. Hence, manufacturing becomes simple and cheap.



CYCLOIDAL GEAR TOOTH PROFILE





Clock gear tooth profile

CYCLOIDAL GEARS ADVANTAGES:

- Cycloidal gears do not have interference.
- Cycloidal tooth is generally stronger than an involute tooth owing to spreading flanks in contrast to the radial flanks of an involute tooth.
- Because of the spreading flanks, they have high strength and compact drives are achievable.
- Cycloidal teeth have longer life since the contact is mostly rolling which results in low wear.

CYCLOIDAL GEARS DISADVANTAGES:

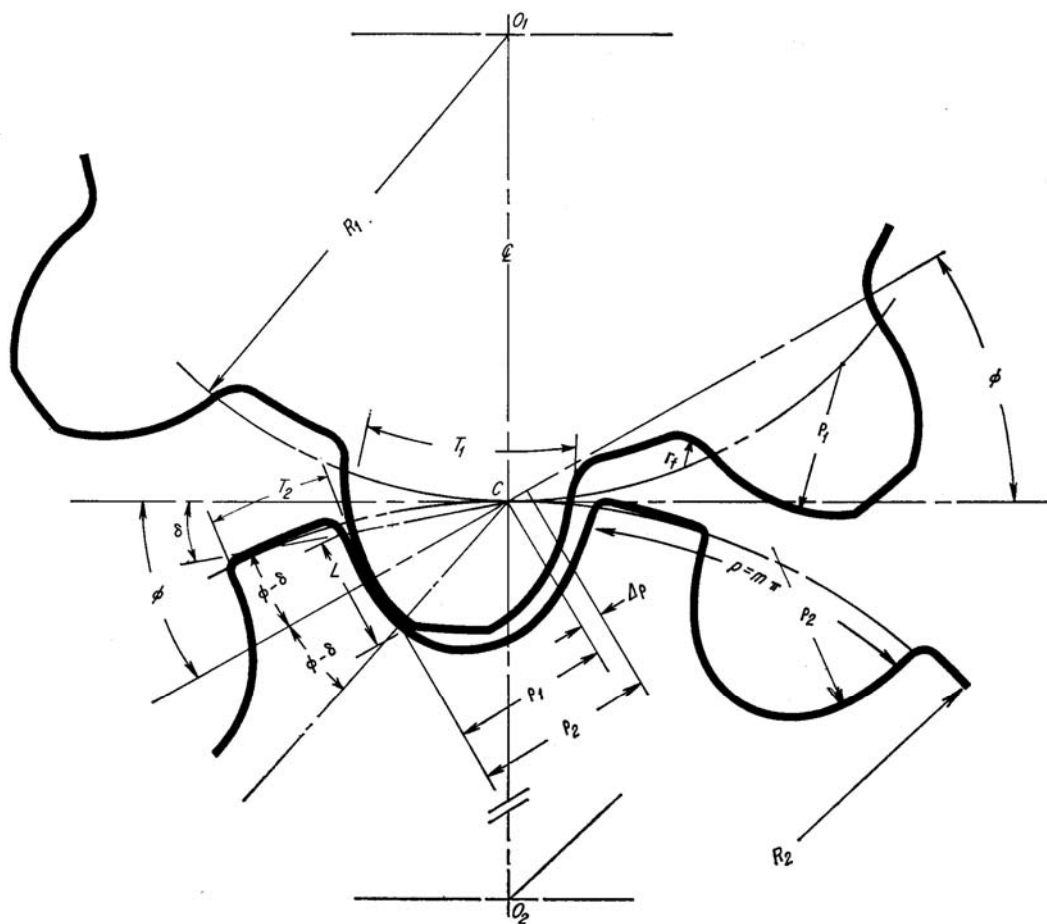
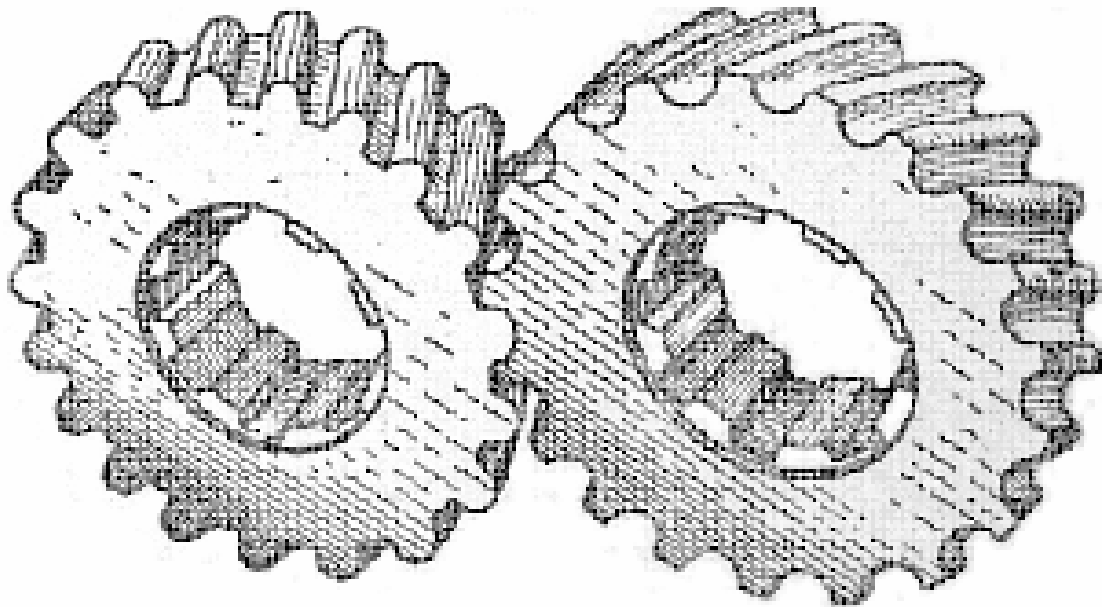
- For a pair of Cycloidal gears, there is only one theoretically correct center distance for which a constant angular-velocity ratio is possible.
- The hob of Cycloidal gear has curved teeth unlike involute rack teeth. Hence hob manufacture is difficult and costly.
- Cycloidal gear will cost more.

APPLICATION OF CYCLOIDAL GEARS



1. Cycloidal gears are extensively used in watches, clocks, and instruments where interference and strength are prime considerations.
2. Cast bull gears of paper mill machinery.
3. Crusher drives in sugar mills.

WILDHABER or NOVIKOV OR CIRCULAR ARC TOOTH PROFILE



ADVANTAGES

- A convex surface is always in contact with another concave surface.
- The beam strength is much higher for the pinion than for the gear when the gear is much larger than the pinion.
- The contacting teeth have rolling action and hence wear is less.
- The convex profile of the pinion teeth and the radii close to the same value within the practical limits, result in maximum possible wear strength for the gear pair.

DISADVANTAGES

- The circular-arc profiles are not conjugate and consequently, in a plane each tooth can make contact at only one point in each revolution.
- The circular-arc gears are very sensitive to variations in center distances and are hence best suited for slow-speed operation.
- For the circular-arc gears in a plane, the contact ratio is zero. Hence, the circular-arc teeth cannot be used on spur gears but must be used on helical gears, where the contact ratio for the gear can be made greater than 1.0 by providing overlap ratio.

APPLICATION OF WILDHABER or NOVKOV or CIRCULAR ARC GEARS

Slow speed Gear boxes

