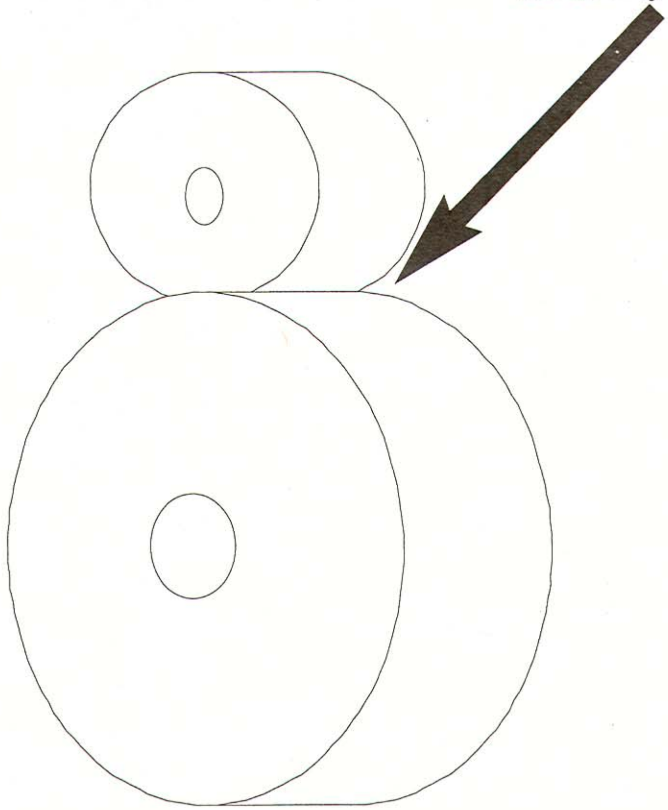
Fundamentals of Gearing

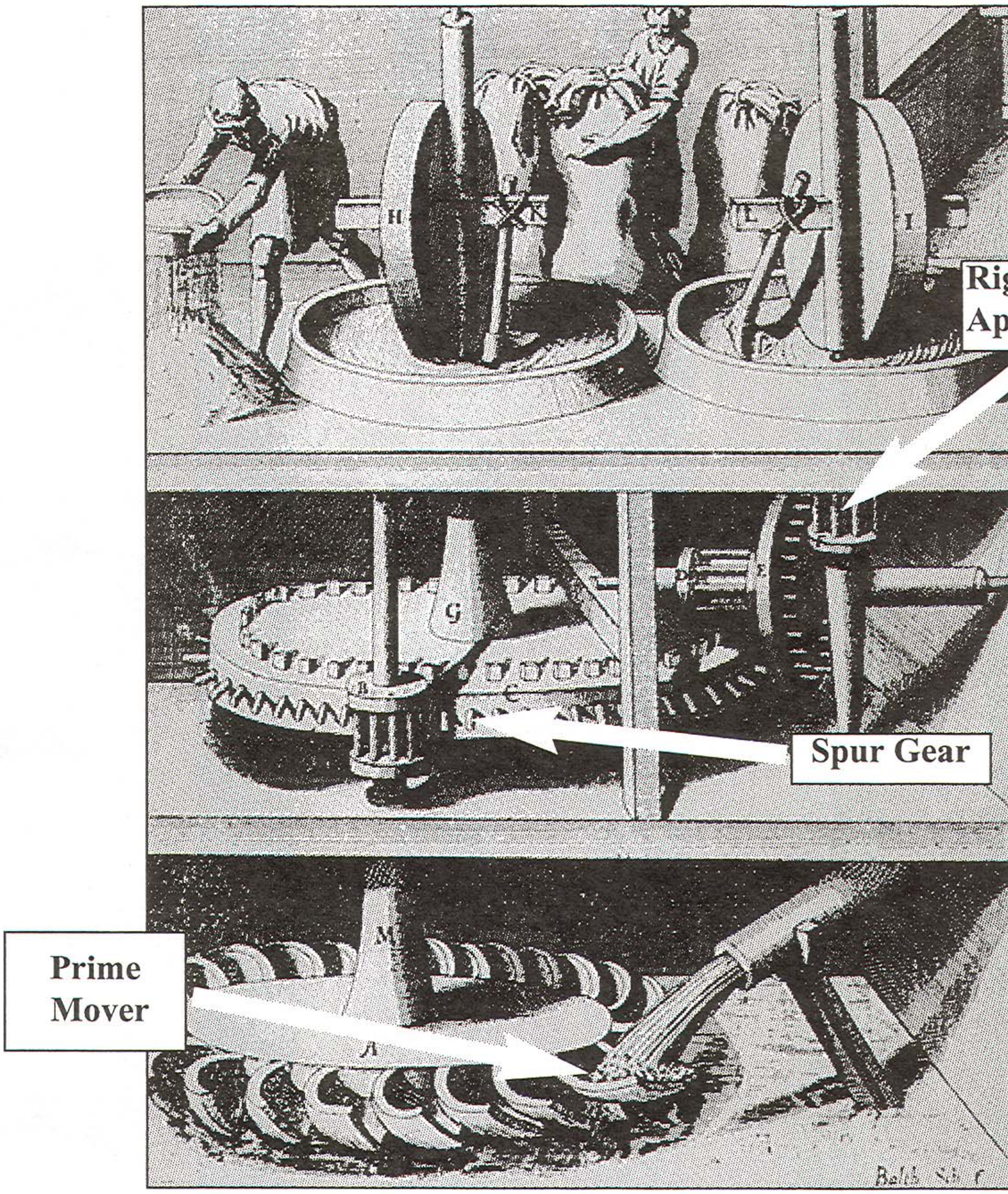
Transferring Load Via Friction



This works well up to the point that slippage starts to occur.....

Gotta Have Some Teeth

The Early Years



Modern gearing transmits:

Torque
Uniform Motion

An engineering/manufacturing marvel that is continuously marching towards perfection.

Transmitting Uniform Motion

Gearing transmits uniform motion between two rotating discs through the precise, lubricated meshing of gear teeth.

The art/science of gearing requires the proper application of geometry, mechanics and craftsmanship to product gearing which accomplishes the task while optimizing the trade off of performance and cost.

Modern Gear Technology

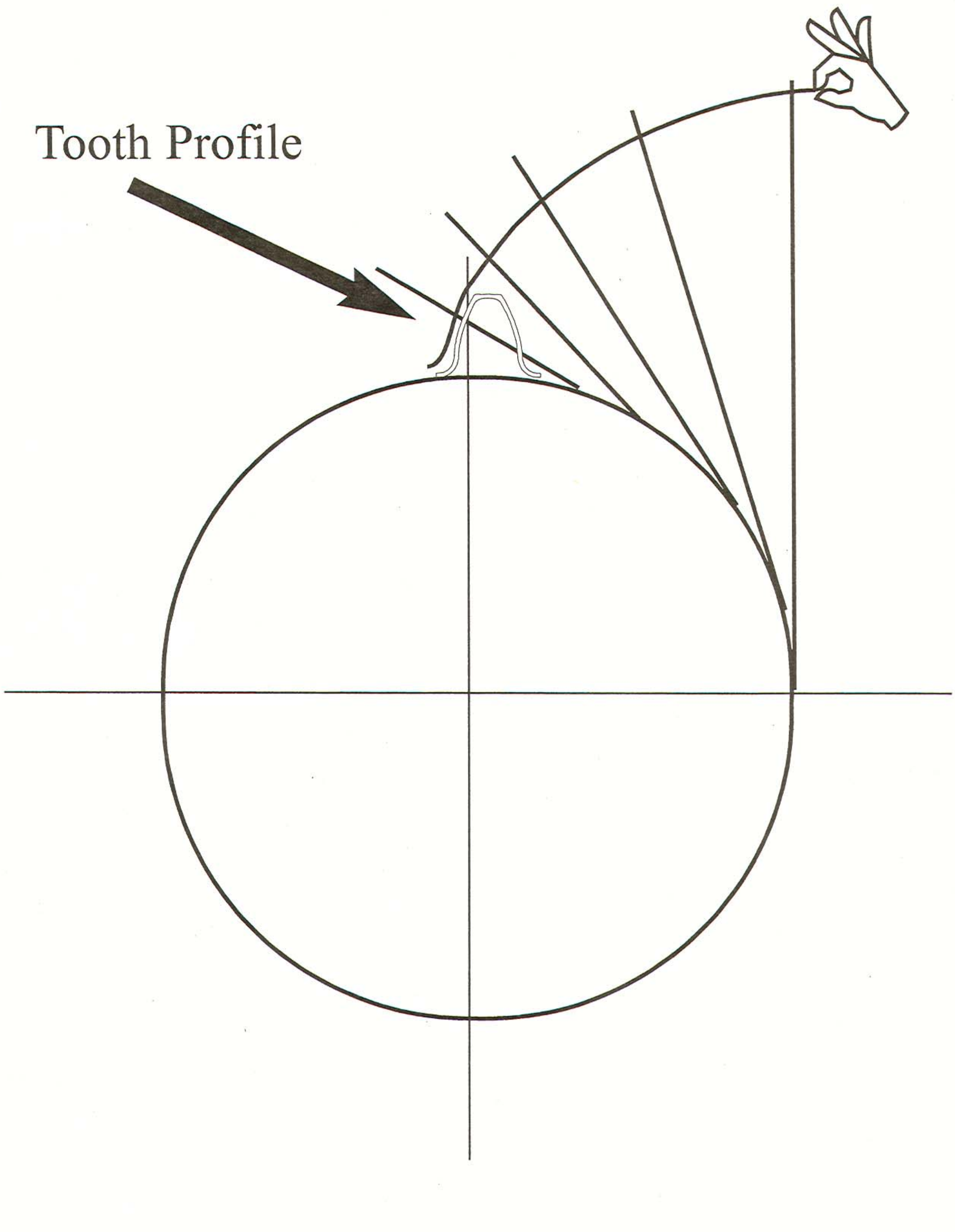
Provides for a reduction in speed and an increase in torque.

Provides for an increase in speed which is economically unobtainable using normal prime movers.

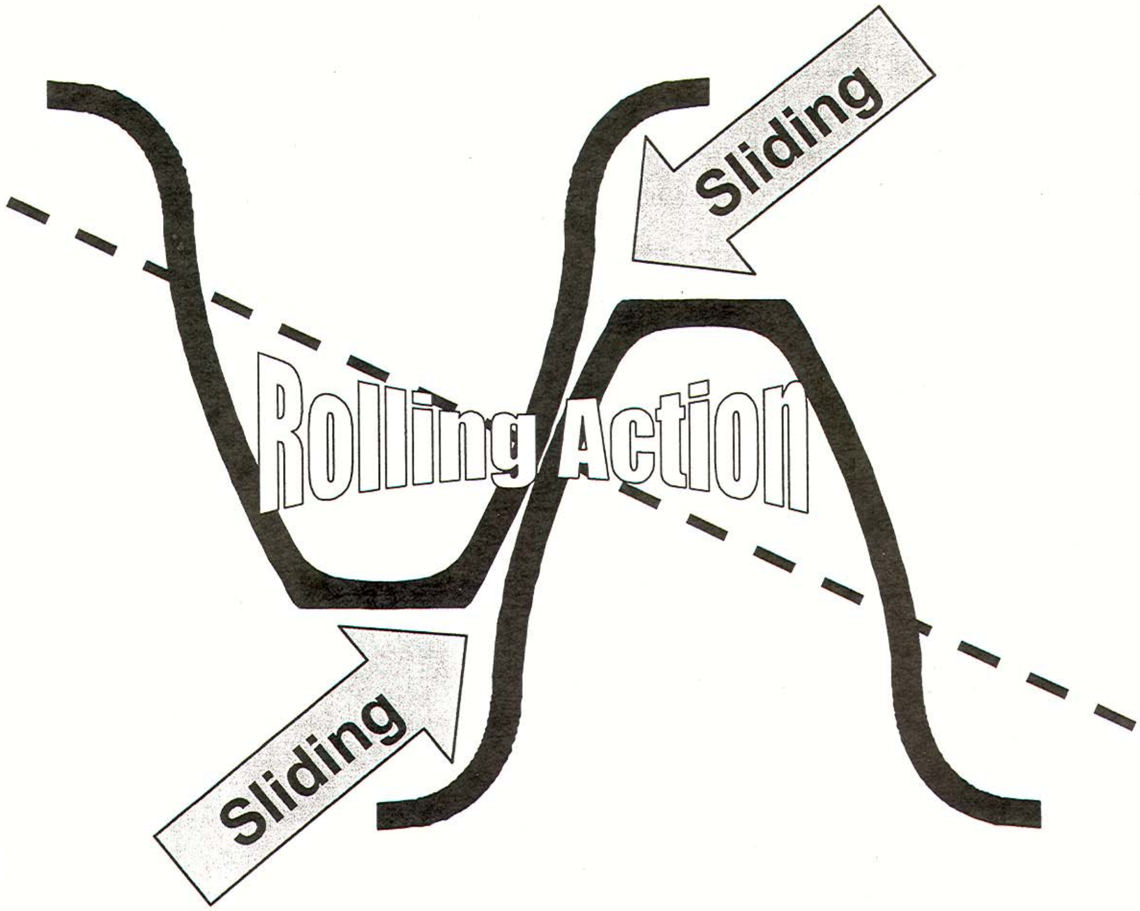
Nomenclature

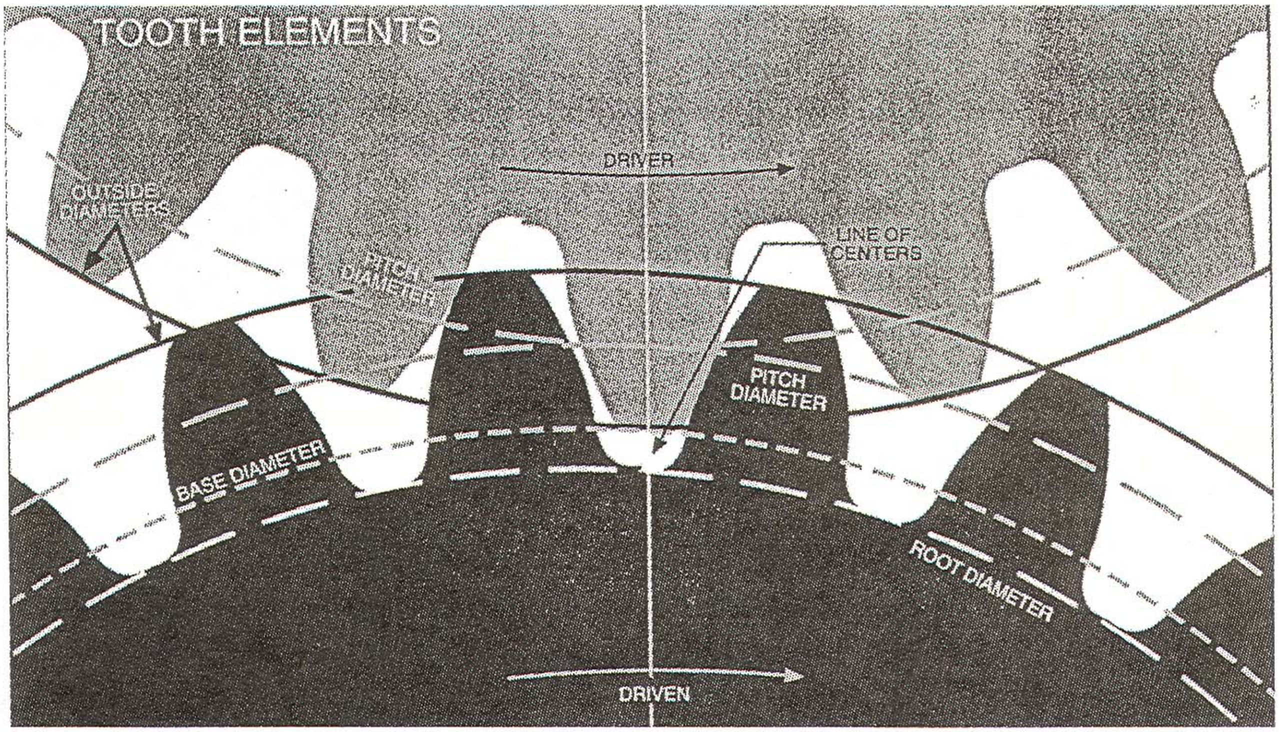
- Involute Curve
- Outside Diameter
- Root Diameter
- Pitch Diameter
- Addendum
- Dedendum
- Line of Action
- Line of Centers
- Pitch Point
- Backlash
- Diametral Pitch

Involute Curve



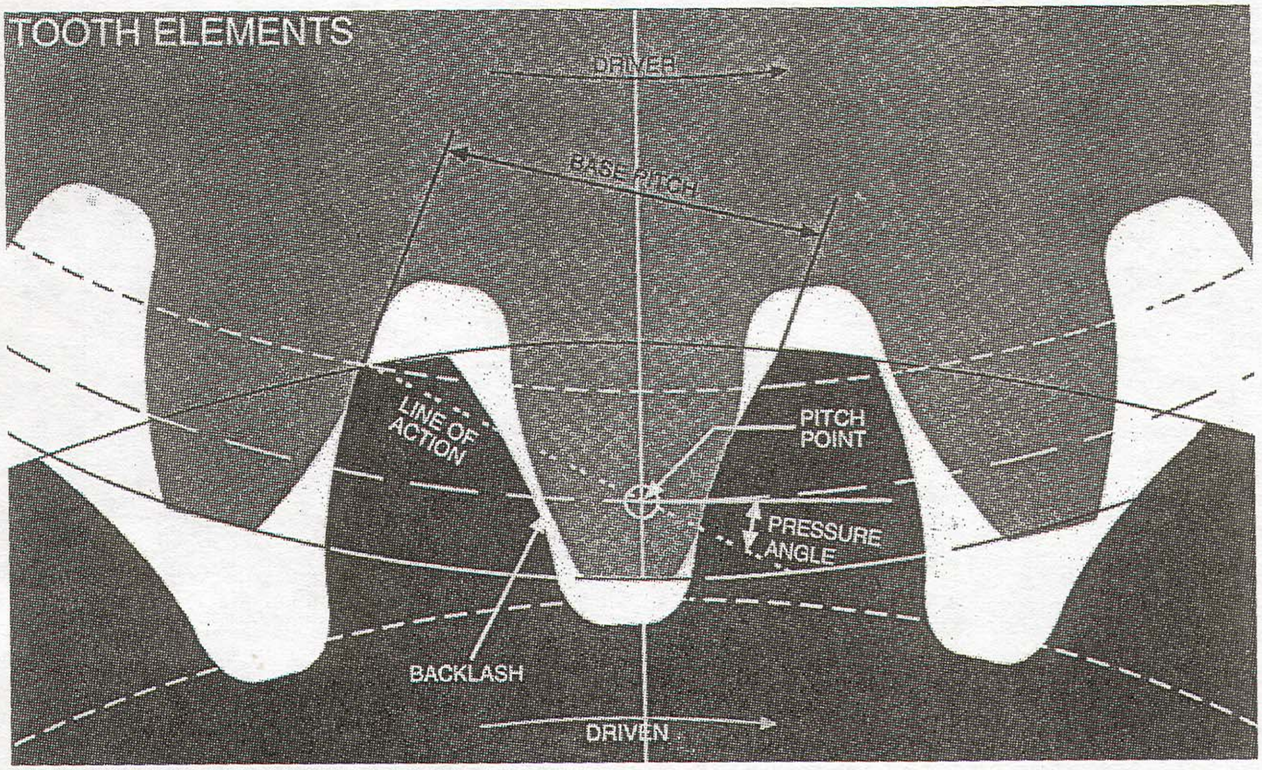
Involute Curves in Action



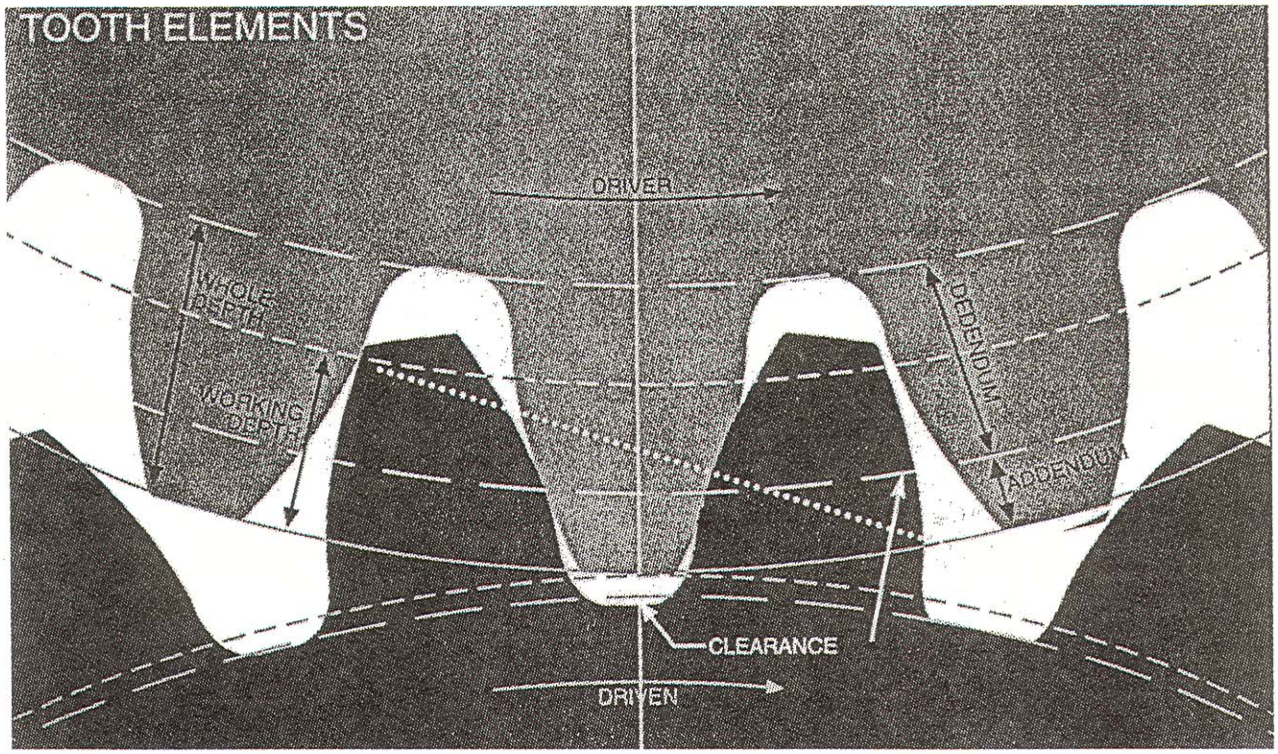


Definitions

Base Diameter	The diameter of the base circle on the circle from which the involute tooth profile is developed.
Pitch Diameter	The diameter of the pitch circle. In theory is is the imaginary circle that rolls without slippage with a pitch circle of a mating gear.
Outside Diameter	The diameter of the outside of the gear.
Root Diameter	The diameter of the root circle or the circle that is tangent to the bottoms of the tooth spaces
Line of Centers	The line which connects the centers of the pitch circles of two matng gears.



Pitch Point	The point of tangency of two pitch circles on the of centers.
Line of Action	The straight line passing through the pitch point and tangent to the base circles. It is actually the path of contact of mating involutes.
Base Pitch	The linear distance between adjacent involutes along a common normal such as the line of action, or the circular distance taken on the base circle.
Pressure Angle	The angle between the line of action and the line tangent to the pitch circle at the pitch point. Since an involute has no specific pressure angle until brought into intimate contact with another involute, the operating pressure angle is determined by the center distance at which a pair of gears operate. For uniformity and economies, standard pressure angles are established for standard gear tooth systems.
Backlash	The amount by which the width of a tooth space exceeds the thickness of the engaging tooth on the pitch circles.



Working Depth	The depth of engagement of two mating gears - in effect the sum of their addendums.
Face Width	The length of the teeth in an axial plane.
Whole Depth	The total depth of a tooth space, equal to the addendum plus the dedendum, or the working depth plus the clearance.
Addendum	The radial distance between the pitch circle and the outside diameter.
Dedendum	The radial distance between the pitch circle and the root circle.
Clearance	The amount by which the dedendum in a gear exceeds the addendum of its mating gear.

Diametral Pitch

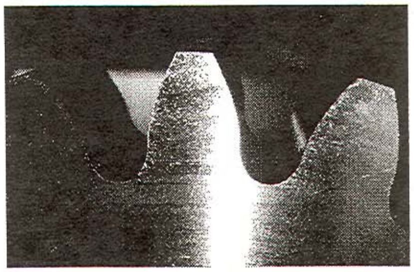
Ratio of number of teeth to the number of inches in the pitch diameter

Divide number of teeth by the pitch diameter to obtain the diametrical pitch or the number of teeth per inch for a given pitch diameter.

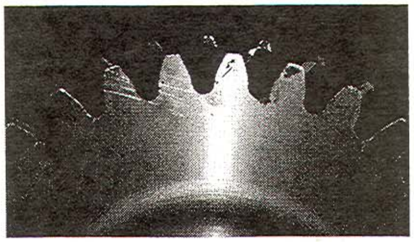
EXAMPLE: Spur Gear has 40 teeth and a pitch diameter of 10 inches

$$\text{Diametrical pitch} = \frac{40}{10} = 4$$

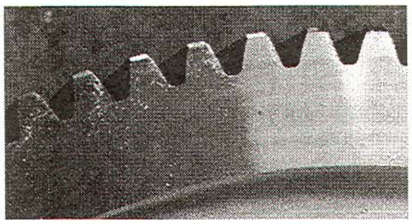
Diametral Pitch



1-1/4 D.P.



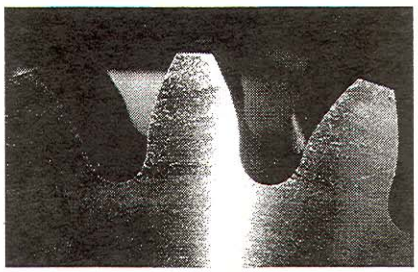
1-1/2 D.P.



3 D.P.

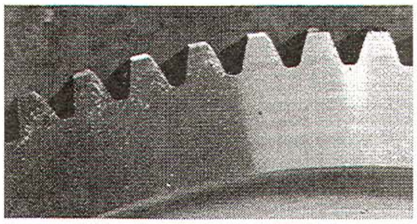
The smaller the number the coarser the pitch

Modular Pitch



Module 20

Module 16



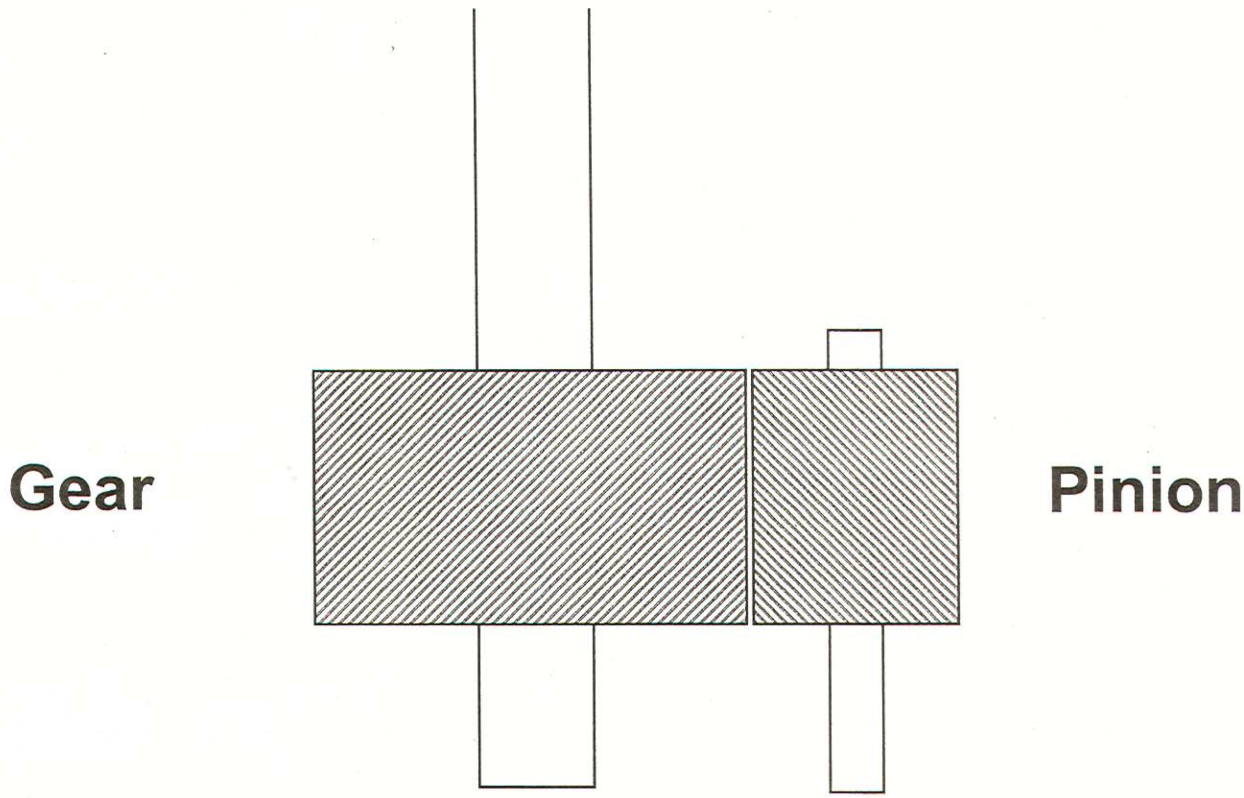
Module 8

The larger the number the coarser the pitch

Gear Box Components - Reducers

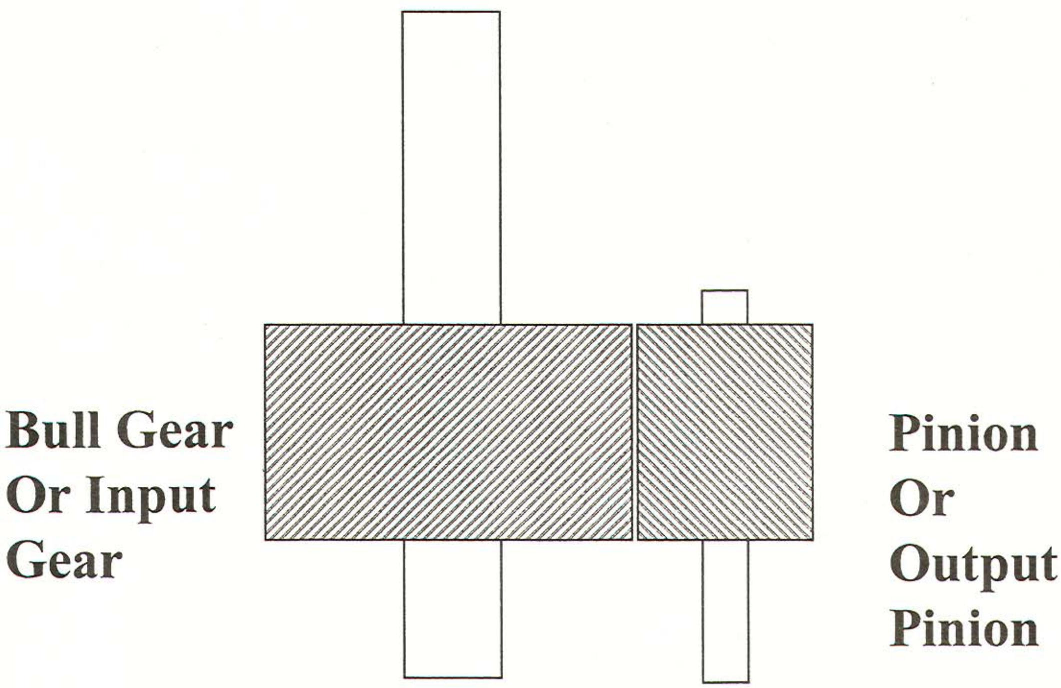
- Smaller Gear - Pinion
- Larger Gear - “Bull” Gear
- When there is more than a single stage reduction gear sets are called:
  - -High Speed or Input
  - -Low Speed or Output
  - -Intermediate
  - -Multiple intermediates are first intermediate, second intermdiate, and so on...

Single Reduction Gear Set



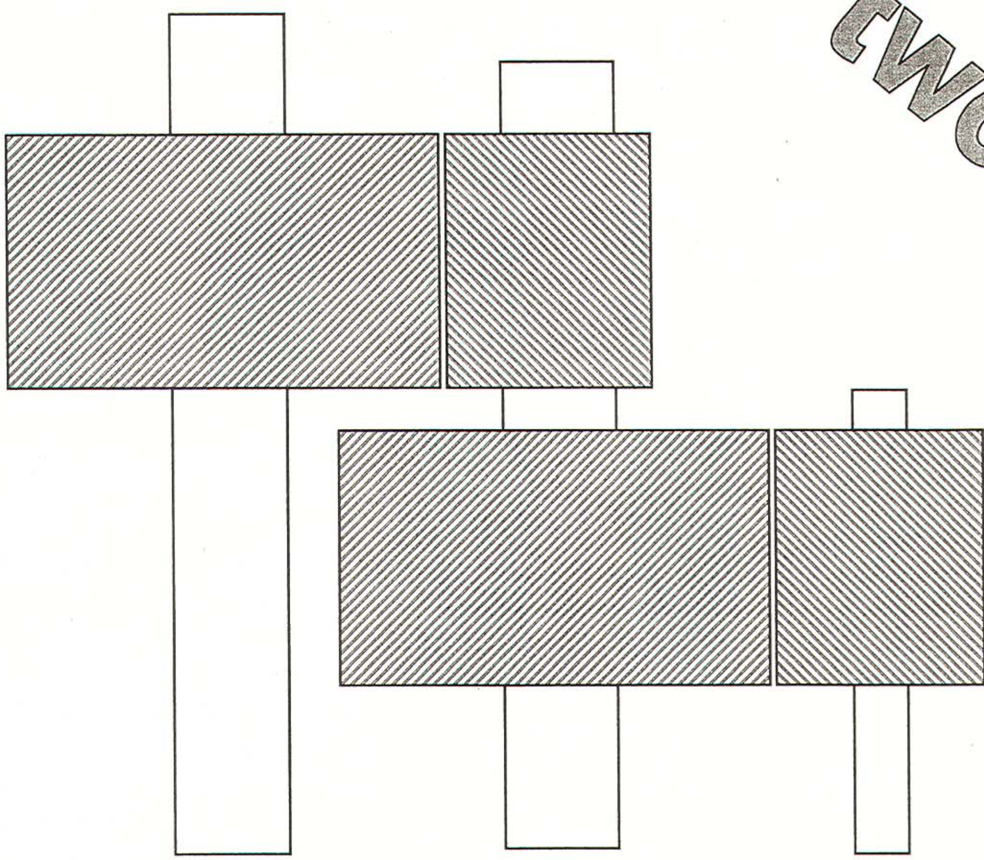
Gearbox Components

Single Stage Increaser

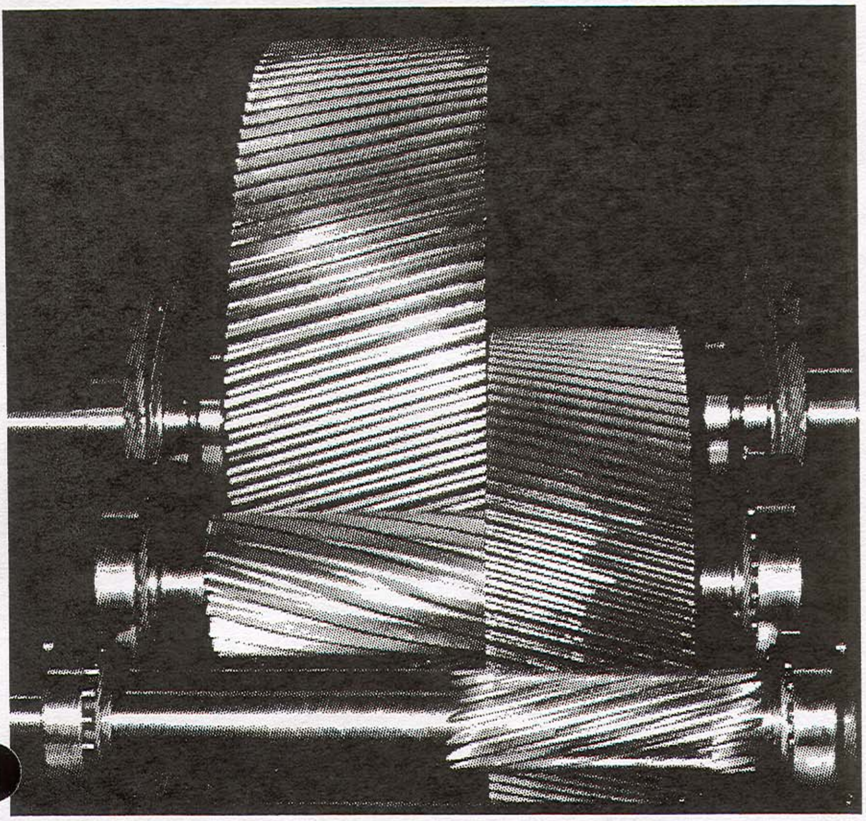


Multi-Stage Gear Assembly

"two stage

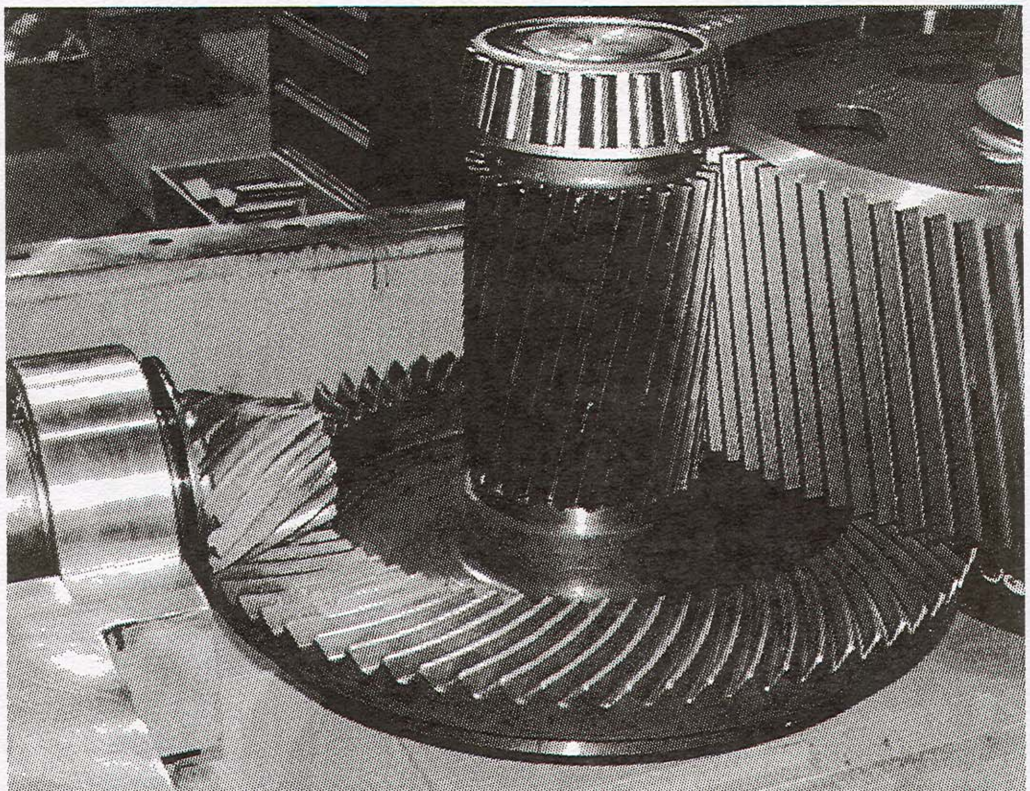


Double Reduction Gearbox

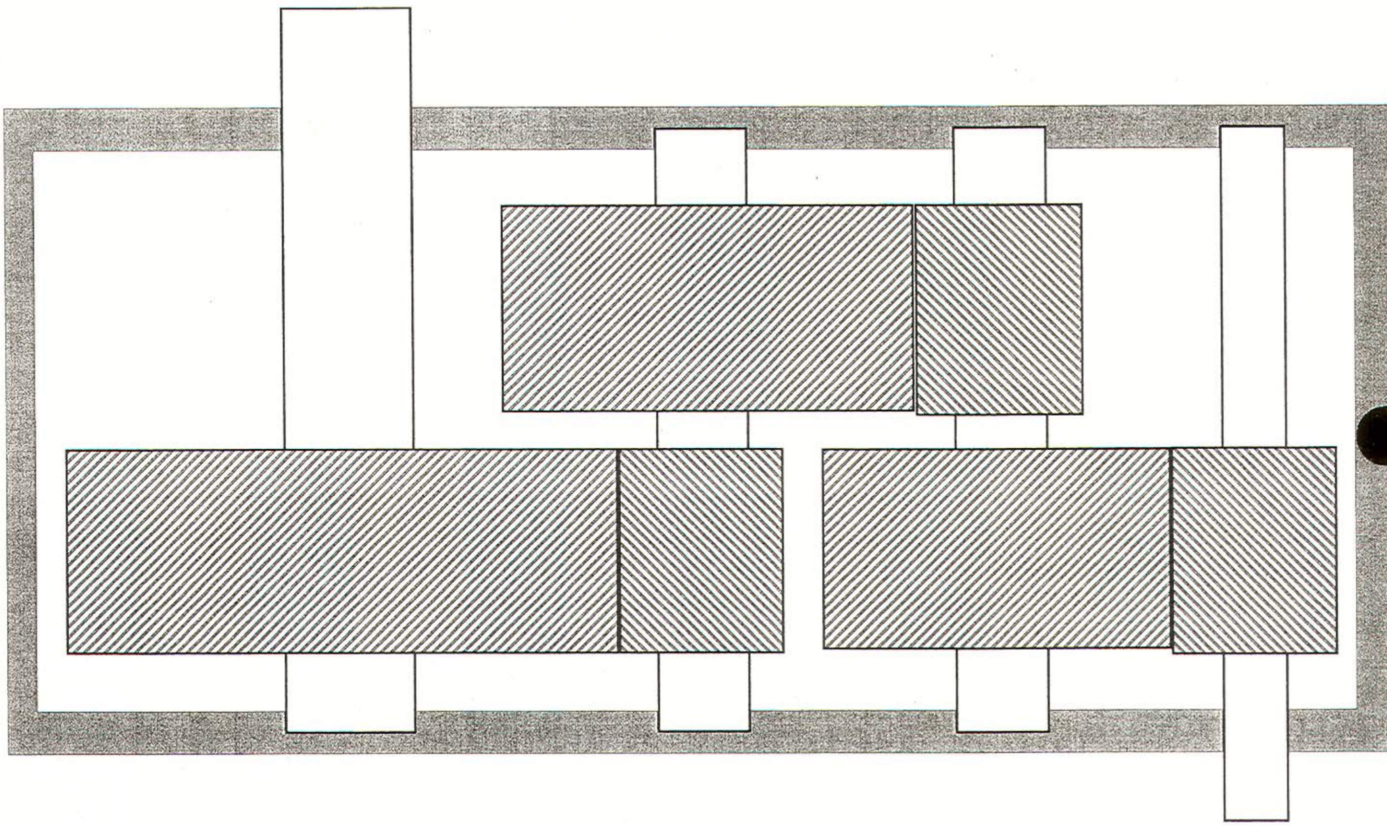


Parallel Shaft
Single Helical
Double Reduction

Right Angle
Spiral Bevel/
Single Helical
Double
Reduction



Three Stage Gearbox



Calculating Gear Ratios

$$\frac{\text{Teeth on the Bull Gear}}{\text{Teeth on the Pinion}} = \text{Gear Ratio}$$

If a Bull Gear has 100 Teeth
and the Pinion has 20 Teeth

The Ratio is expressed as 5.0:1

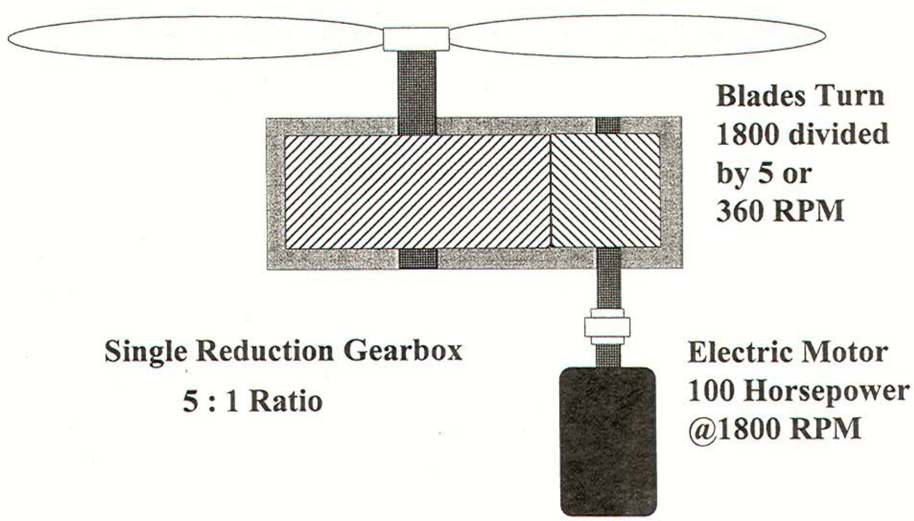
Calculating Gear Speeds

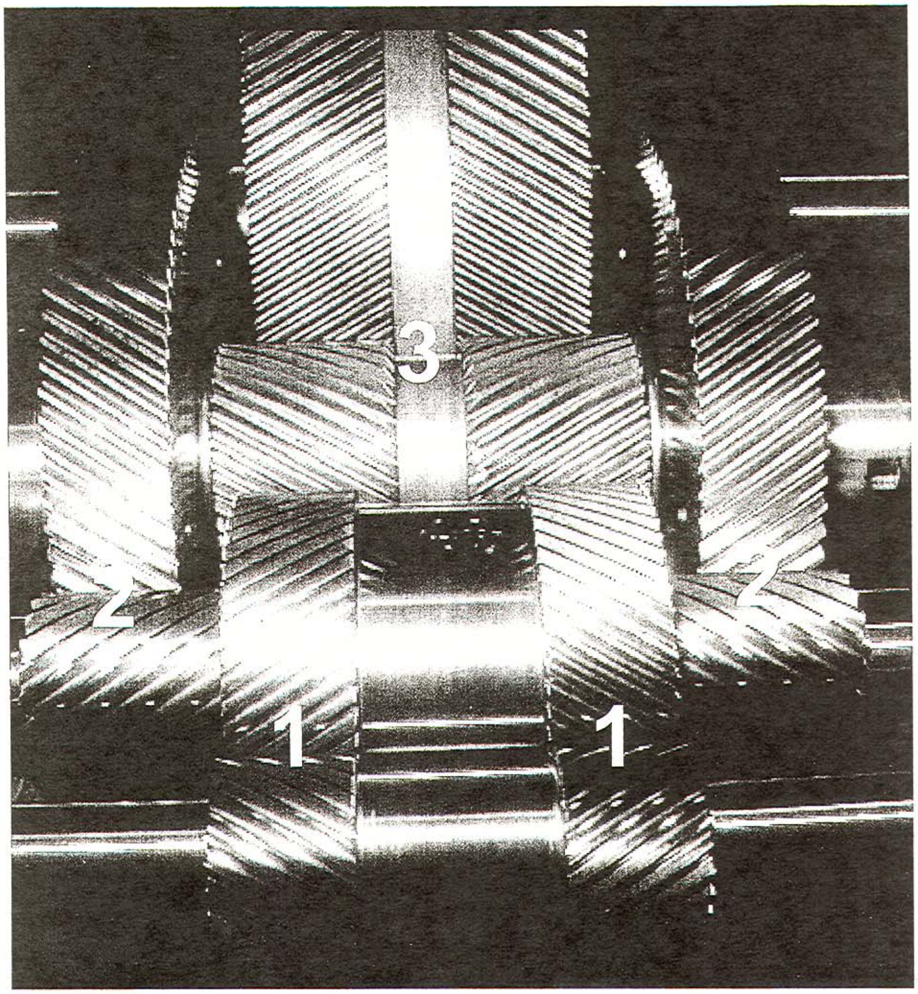
$$\frac{\text{Pinion Speed}}{\text{Ratio}} = \text{Bull Gear Speed}$$

$$\frac{1800\text{RPM}}{5.0 : 1} = \text{Bull Gear Speed}$$

$$\text{Bull Gear Speed} = \frac{1800\text{RPM}}{5.0 : 1} = 360\text{RPM}$$

Cooling Tower Gearbox Application





Calculating Multi-stage Ratios

Given a 3 stage gearbox
with each stage having a 5:1 ratio
What is the ratio of the Gearbox?
5 x 5 x 5 = 125:1
Now if the input speed is 1800 RPM
What is the output speed?
1800/125 = 14.4 RPM

Calculating Torque

$$\text{Torque} = \frac{\text{HP X 63025}}{\text{RPM}}$$

$$\text{Torque} = \frac{\text{100 HP X 63025}}{\text{14.40 RPM}}$$

Torque = 437,674 in/lb

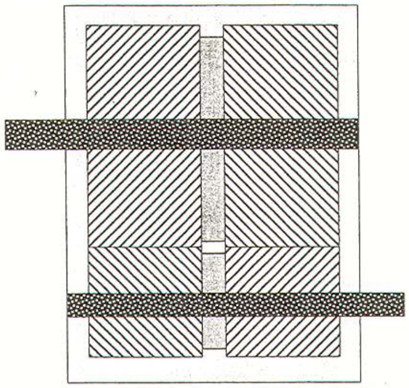
Torque is inversely related to speed

A gear reducer that decreases speed creates a proportional increase in torque.
Decreasing Speed by a factor of 5
Increases Torque by a factor of 5

Reduce Speed, Increase Torque

Speed Decrease = Torque Increase
125:1 Ratio
Speed Decrease X 125
Torque Increase X 125

Increaser Applications



Input Gear
100 Teeth

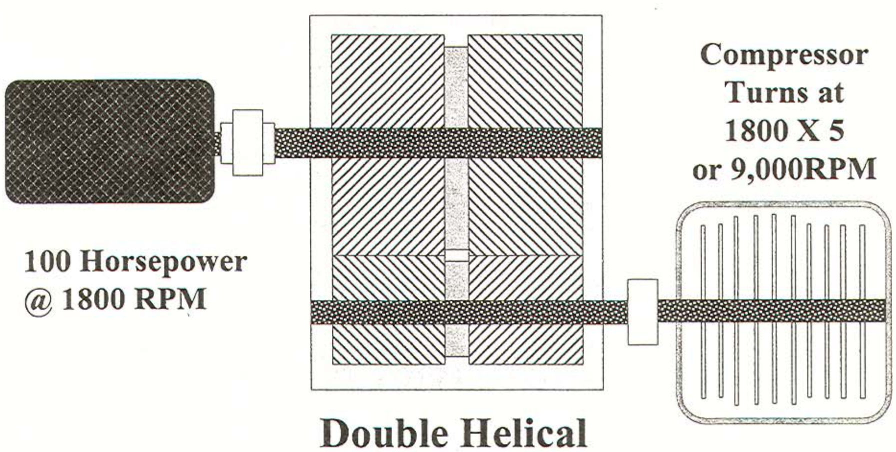
Output Pinion
20 Teeth

The Ratio Becomes 1:5

Double Helical because of shaft speed and thrust!

Speed Increaser Output
Ratio X Input RPM = Speed Increaser Output
1:5 Ratio With 1800 RPM Input
5 X 1800 = 9,000 RPM

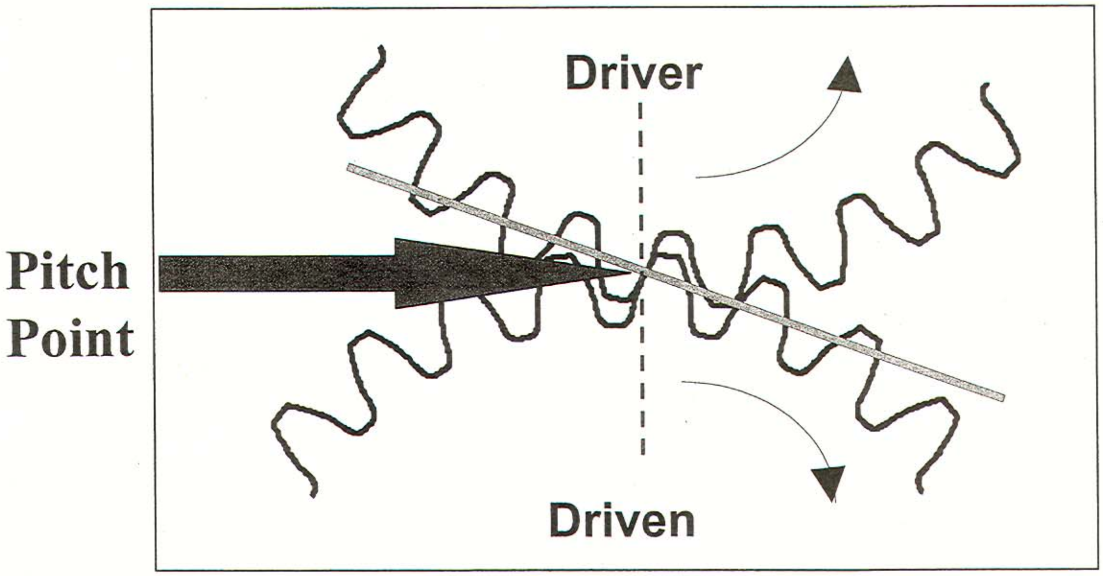
Increaser Applications



Double Helical
1:5 Ratio

Speed

Pitch Line Velocity



Low Speed Applications

Typically Less than 2000 RPM or

Less that 5000 FPM Pitch line Velocity

High Speed Applications

Typically Higher that 2000 RPM, or

Above 5000 FPM Pitch Line Velocity

Gear Designers Care About

How Much Power is Required?

How Fast Must it Turn?

What is Peculiar About the Application?