Simple Gear Trains cont.

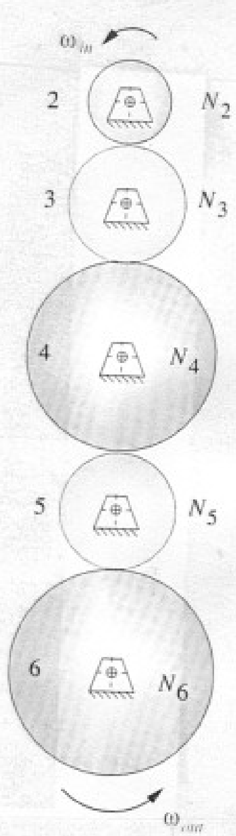


FIGURE 9-28
A simple gear train

Let's determine the angular velocity ratio m_v for the gear train as shown

$$m_v = \frac{\omega_{out}}{\omega_{in}} = \left(-\frac{N_2}{N_3}\right)\left(-\frac{N_3}{N_4}\right)\left(-\frac{N_4}{N_5}\right)\left(-\frac{N_5}{N_6}\right)$$

$$m_v = \frac{\omega_{out}}{\omega_{in}} = +\frac{N_2}{N_6}$$

$$\frac{\omega_{out}}{\omega_{in}} = \left(\frac{\text{Product of Driving Gears}}{\text{Product of Driven Gears}}\right)(-1)^{(\#\text{ of external mesh})}$$

$$\frac{\omega_{out}}{\omega_{in}} = \frac{N_2 N_3 N_4 N_5}{N_3 N_4 N_5 N_6}(-1)^4 = \frac{N_2}{N_6}$$

- The gears N_3, N_4, N_5 are called idlers. The idlers only affect the sign of the overall ratio. Having more than one idler does not make much sense.

Compound Gear Trains

To get a train ratio of greater than about 10:1, it is usually necessary to use a compound gear train. A compound gear train is one in which at least one shaft carries more than one gear.

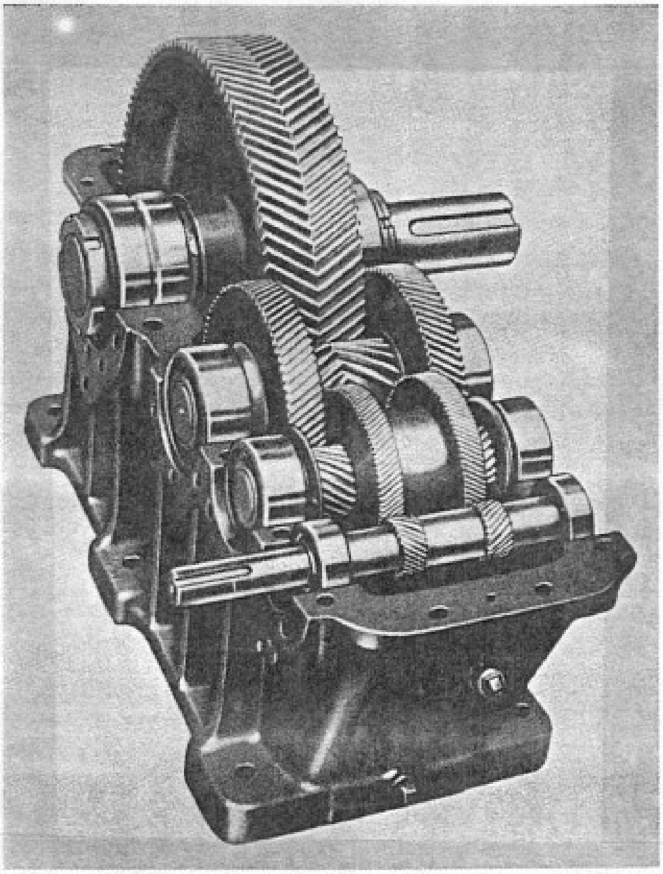


FIGURE 7.3 Triple-reduction speed reducer. (Courtesy of Jones Machinery, Division of Hewitt-Robins, Inc.)

- Why are there two sets of gears and
- which is the input?
- How many stages are there?

Consider the following gear train with gears 3 and 4 coupled together.

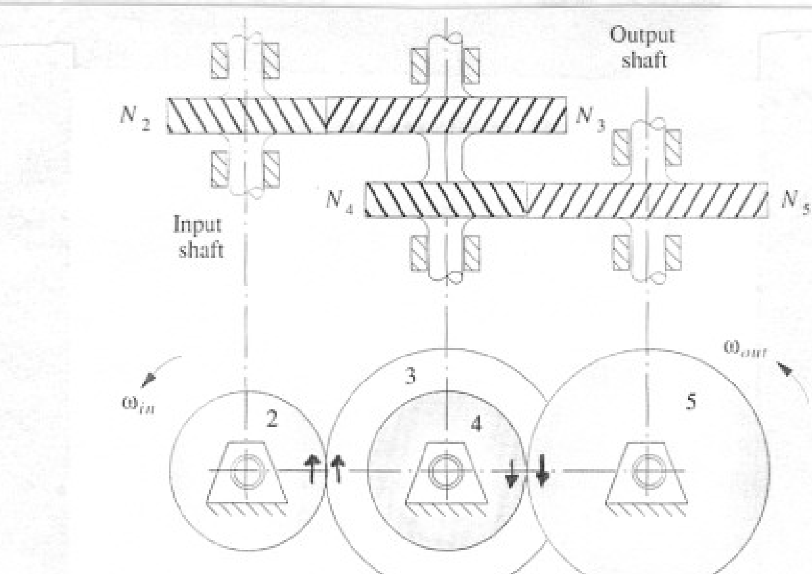


FIGURE 9-29
A compound gear train.

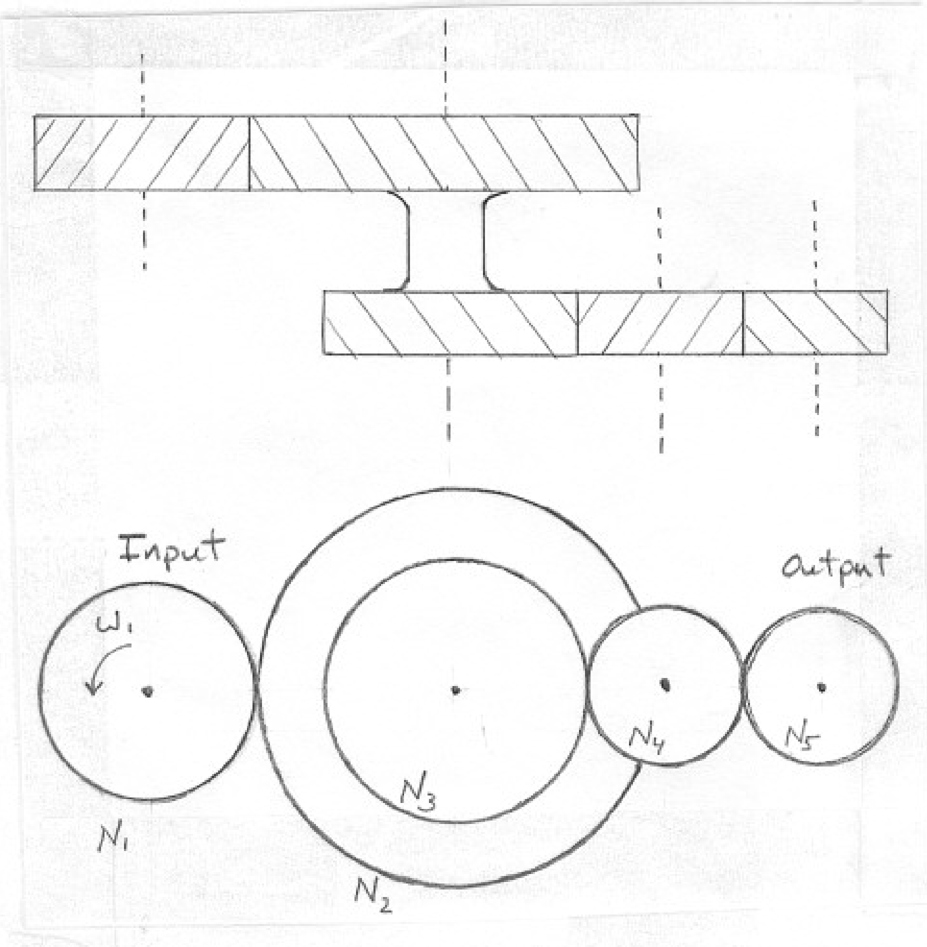
$$\frac{\omega_{out}}{\omega_{in}} = (-1)^2 \frac{N_2 N_4}{N_3 N_5}$$

$$\frac{\omega_{out}}{\omega_{in}} = + \frac{N_2 N_4}{N_3 N_5}$$

$$m_v = \frac{\omega_{out}}{\omega_{in}} = (-1)^{(\#\text{ of external mesh})} \left\{ \frac{\text{product of the Driver gear teeth}}{\text{product of the Driven gear teeth}} \right\}$$

Example

Consider the following gear train. If the input speed is 100 rpm, what is the rotation rate of gear 5 in Hertz?



$N_1 = 20$

$N_2 = 80$

$N_3 = 30$

$N_4 = 25$

$N_5 = 25$

Example

Design a compound train that will provide a train ratio of 180 : 1

① First let's determine the number of stages we'll need

For a gear ratio < 10 use 1 stage

< 100 use 2 stages

< 1000 use 3 stages

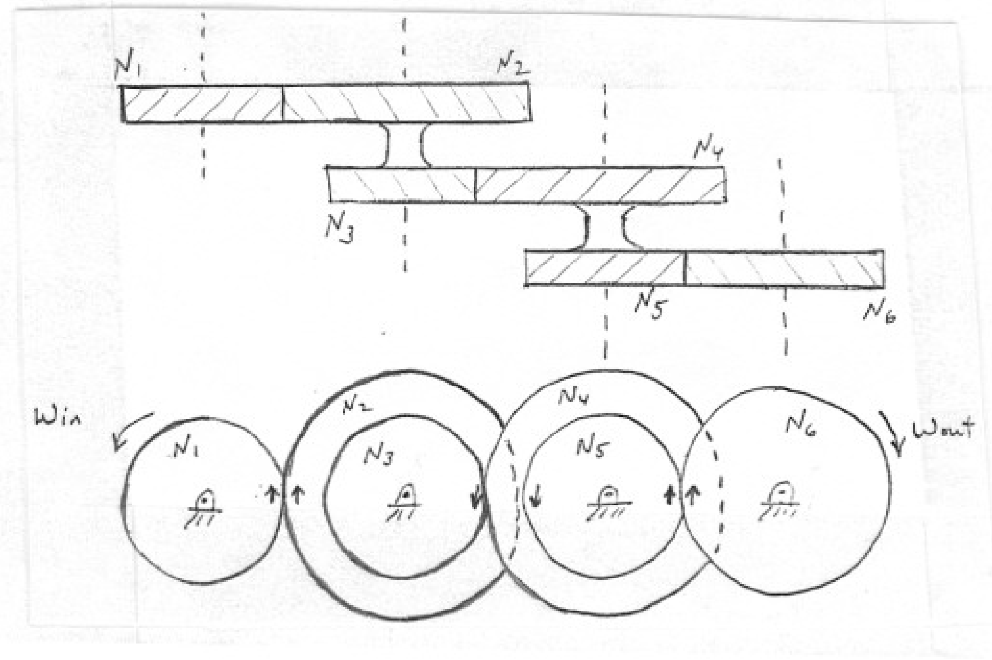
In order to keep each stage less than 10:1 we need 3 stages

② Each stage should have about the same gear ratio for a good design. Since there are 3 stages we can take the cube root of 180 → $\sqrt[3]{180} = 5.646$

Gear Ratio	×	Pinion Teeth	=	Gear Teeth
5.646		12		67.75
5.646		13		73.4
5.646		14		79.05
5.646		15		84.69

See Table 9-4b for the minimum # of teeth

Since 79.05 is closest to an integer we can try that.



So choose

79 : 14 for each stage

$$\frac{\omega_{in}}{\omega_{out}} = \frac{\omega_1}{\omega_6} = (-1)^{\#\text{ of mesh}} \left\{ \frac{N_{Driven}}{N_{Drivers}} \right\} = (-1)^3 \left\{ \frac{N_2 N_4 N_6}{N_1 N_3 N_5} \right\}$$

$$\frac{\omega_1}{\omega_6} = -\left(\frac{79}{14}\right)\left(\frac{79}{14}\right)\left(\frac{79}{14}\right) = -179.68$$ $\therefore$ The gear ratio is 179.68 : 1 → Is this good enough? Yes, for non-timing applications. No, for exact timing applications. Let's redesign for an exact gear ratio of 180:1

(3) Let's start with an integer value using the previous gear ratio choose 6 → $\frac{180}{6} = 30$ → since 30 is evenly divisible by 6 let's divide again → $\frac{30}{6} = 5$. Now that we have defined our gear ratios for each stage 6:1, 6:1, 5:1

Let's choose a pinion with 14 teeth

Drivers → $N_1 = N_3 = N_5 = 14$

Driven → $N_2 = 6(14) = 84$

$N_4 = 6(14) = 84$

$N_6 = 5(14) = 70$

$$\frac{\omega_{in}}{\omega_{out}} = -\left(\frac{84}{14}\right)\left(\frac{84}{14}\right)\left(\frac{70}{14}\right) = -180$$

- Of course we now would have to find the appropriate gears in a catalog that have the correct number of teeth for a given diametral pitch