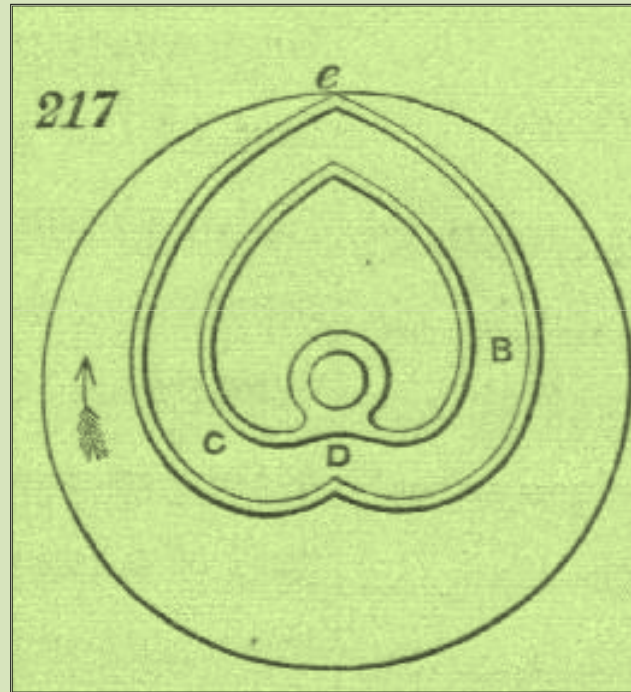


BALANCING OF MACHINERY



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Definition

Shaking Force:

A net unbalanced force acting on the frame of machine or mechanism (i.e., the resultant of the forces at all the connections between the machine and the frame).

Shaking Moment:

A net unbalanced moment acting on the frame of machine or mechanism (i.e., the resultant of the moments at all the connections between the machine and the frame).

Description

Since the shaking force and shaking moment are unbalanced effects, they will **cause the frame to vibrate**, with the magnitude of the vibration dependent on the amount of unbalance.

An important design objective is to **minimize machine unbalance**

Description

The process of designing or modifying machinery in order to reduce unbalance to an acceptable level is called **balancing**

Since unbalance is caused in the first place by the inertial forces associated with the mass of moving machine, the most common approach to balancing is to **redistribute the machine's mass**, accomplished by adding mass to, or removing mass from, various machine members.

However, other techniques, involving **springs** and **dampers** or **balancing mechanisms**, are also used.

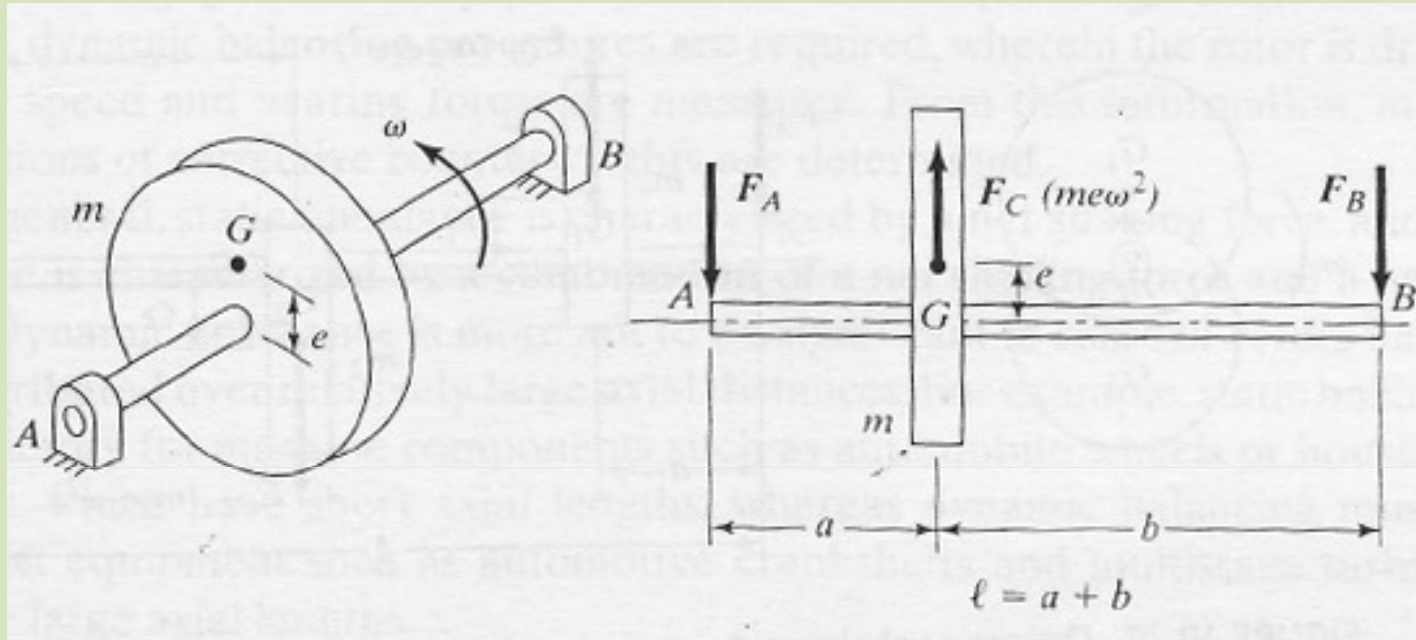
Balancing of Rigid Rotors

The type of unbalance due to a rotating mass is referred to as **rotating unbalance**

It occurs in such diverse applications:

- Turbine rotors
- Engine crankshafts
- Washing machine drums
- Window fans

Static unbalance caused by an eccentric mass on a rotating shaft



A rotor consisting of a disk of mass m attached to a rigid shaft with an assumed negligible mass. Constant angular velocity of ω . The center of mass, G , of the disk does not coincide with the bearing centerline AB , with the amount of this eccentricity represented by e . The rotor is acted upon by the centrifugal force $F_c = m.e.\omega^2$.

Static Balancing of Rigid Rotors

Summing forces and moments on the rotor, the **bearing reactions on the shaft**:

$$F_A = (b/l).me.\omega^2$$

$$F_B = (a/l).me.\omega^2$$

The net force on the frame:

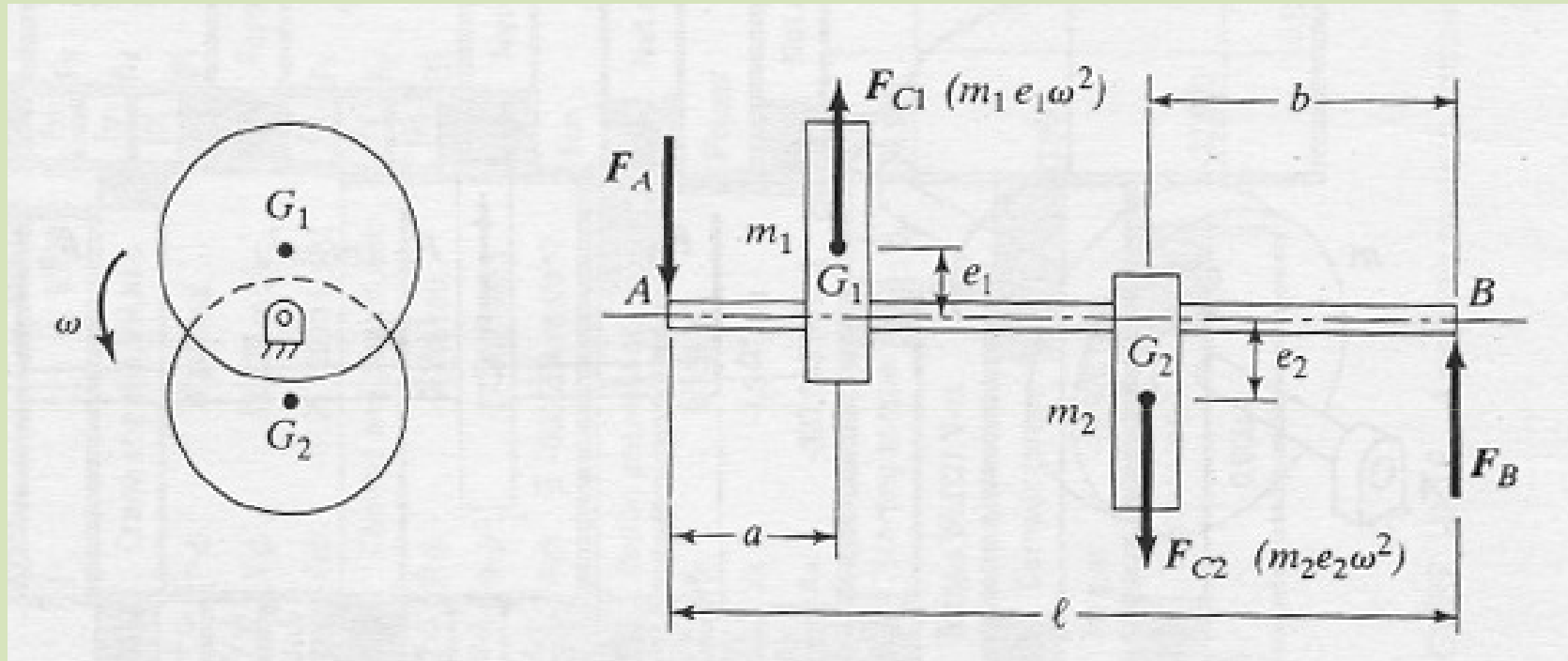
$$F_s = (a/l).me.\omega^2 + (b/l).me.\omega^2$$

$$= ((a+b)/l).me.\omega^2$$

$$= me.\omega^2$$

If the rotational speed is doubled, the shaking force is quadrupled

Dynamic unbalance due to eccentric masses at multiple axial locations on a rotating shaft



The rotor with two disks having masses m_1 and m_2 and eccentricities of e_1 and e_2 attached to a rigid shaft with an assumed negligible mass. Constant angular velocity of ω . Suppose that the centers of mass, G_1 and G_2 , of the disks are 180° apart.

Dynamics Balancing of Rigid Rotors

Summing forces and moments on the rotor, the **bearing reactions on the shaft**:

$$F_A = (\omega^2/l).[m_1.e_1.(l - a)-m_2.e_2.b].$$

$$F_B = (\omega^2/l).[m_2.e_2.(l - b)-m_1.e_1.a].$$

The magnitude of the shaking force:

$$F_s = | F_A - F_B | = \omega^2.[m_1.e_1 - m_2.e_2]$$

If , $m_1.e_1 = m_2.e_2$, then the shaking force is zero. However the individual bearing forces are nonzero, but opposite directions

$$F_A = F_B = (m_1.e_1.\omega^2/l).[l - (a+b)].$$

Balancing of Rigid Rotors

Any rotating unbalance that can be detected in a static test is referred to as **a static unbalance**. In general static unbalanced is characterized by a combination of a net shaking force and a net shaking moment.

Any unbalance that can be detected in a dynamic test in which the rotor is spinning is referred to as **a dynamic unbalance**. It is more apt to be significant in cases of rotors having their mass distributed over relatively large axial distances.

Balancing of Rigid Rotors

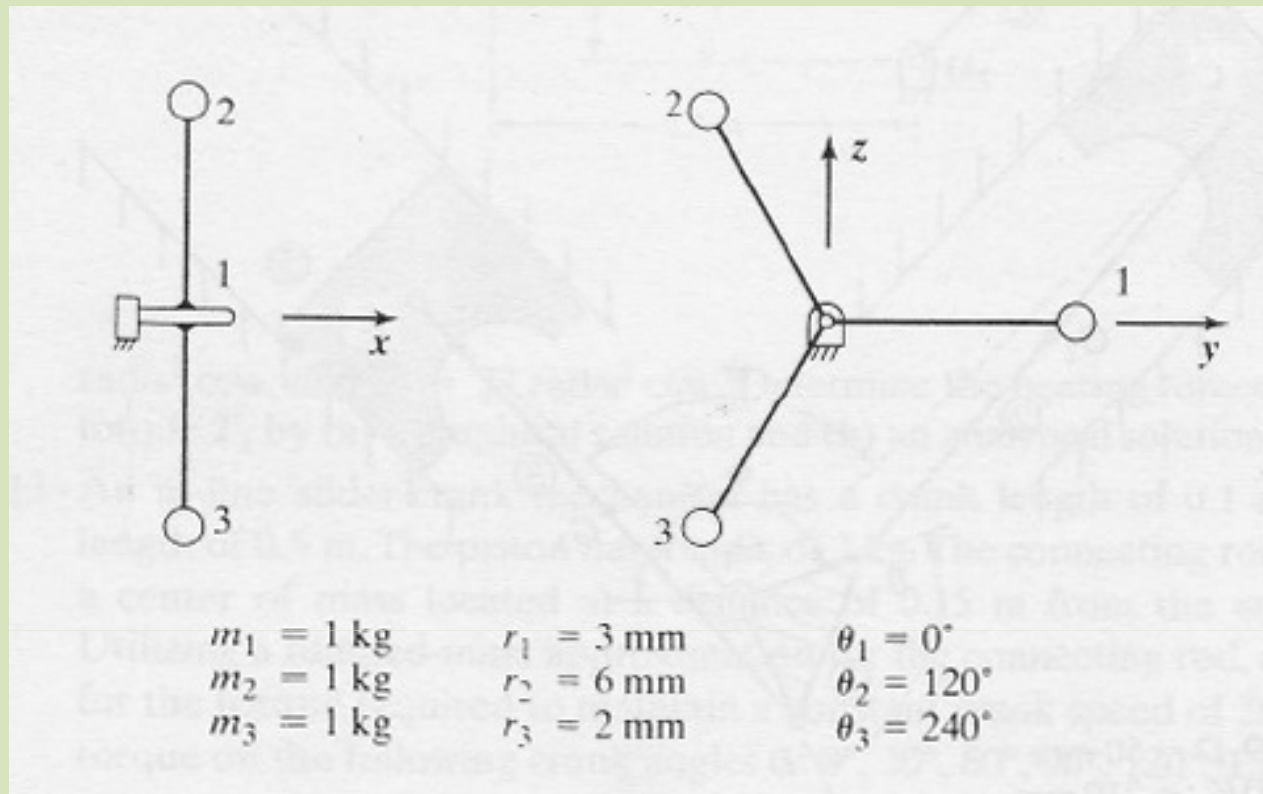
Static balancing may be satisfactory for machine components such as automobile wheels or household fans, which have short axial lengths.

Dynamics balancing must be performed on equipment such as automotive crankshafts and multistage turbine rotors that have large axial lengths.

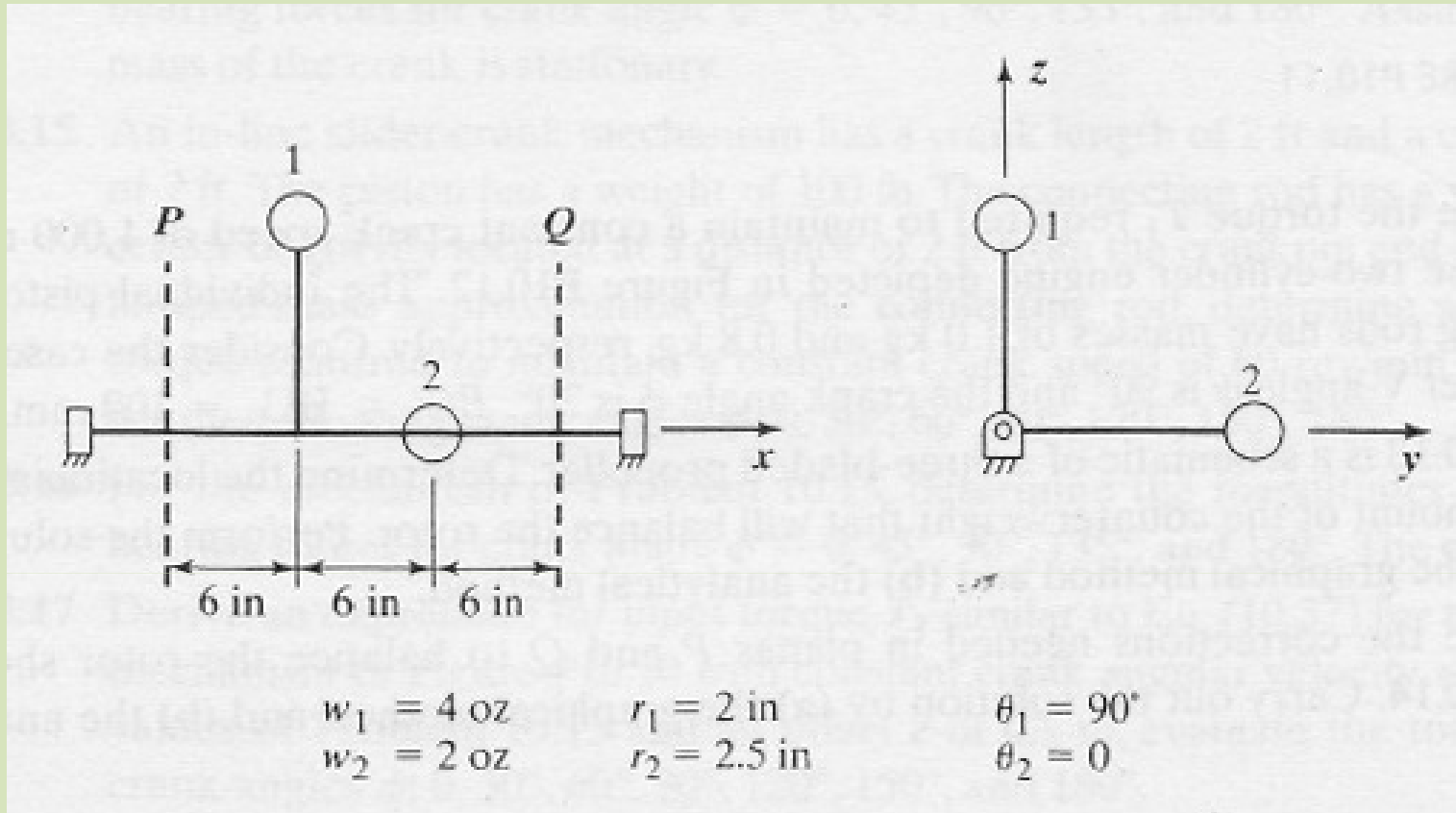
Balancing of Rigid Rotors

General balancing procedures for sizing and positioning corrective masses on rotors are based on the following criteria:

1. For static balance, the shaking force must be zero
2. For dynamic balance, the shaking force and the shaking moment must both be zero



The above figure is a schematic of a three –bladed propeller. Determine the location and correction amount of the counterweight that will balance the rotor. Perform the solution by using the analytical method.



Determine the corrections needed in planes P and Q to balance the rotor shown in the above figure. Carry out the solution by the analytical method.

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