

Note : When the balls rotate at uniform speed, controlling force is equal to the centrifugal force and they balance each other.

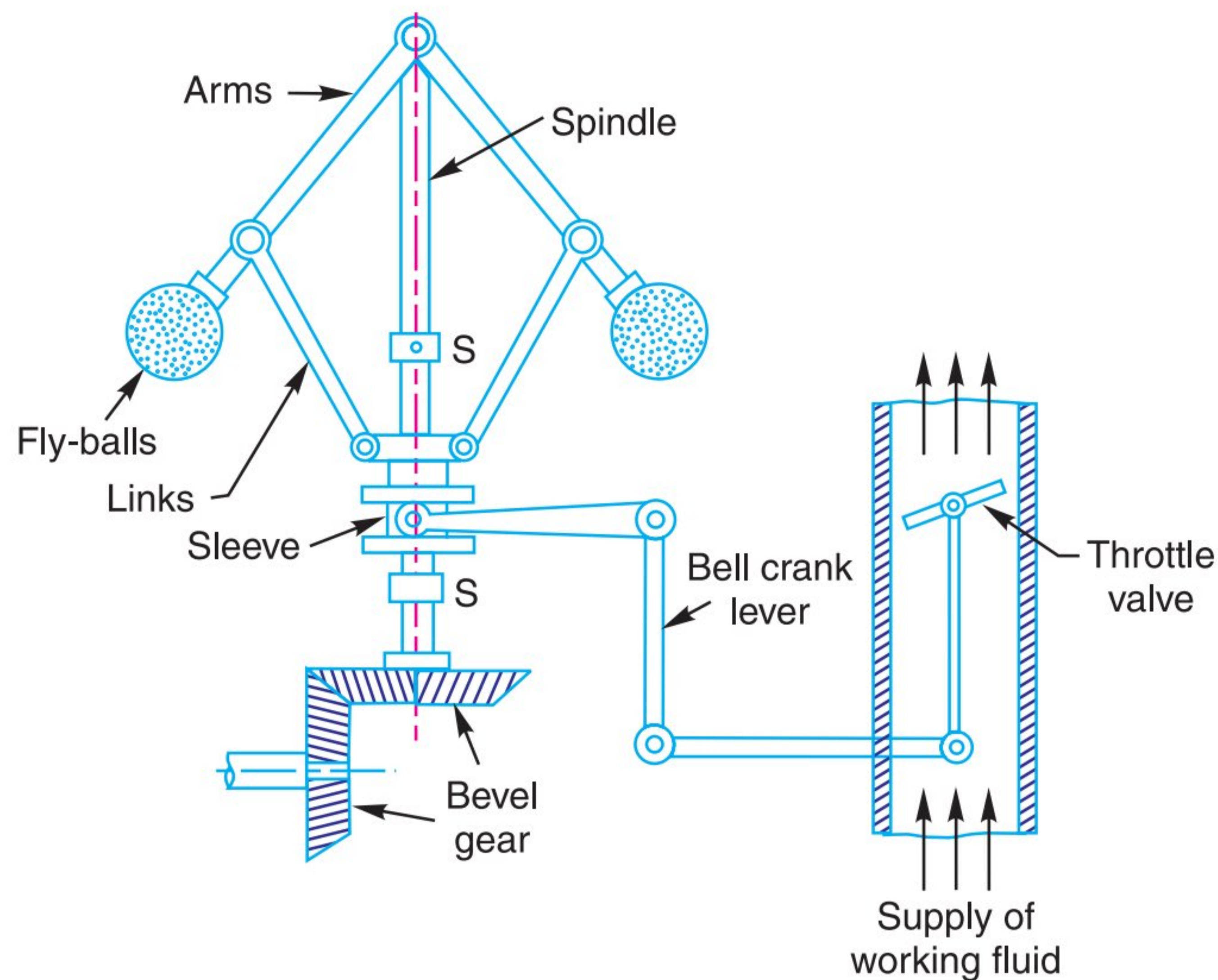


Fig. 18.1. Centrifugal governor.

18.4. Terms Used in Governors

The following terms used in governors are important from the subject point of view ;

1. Height of a governor. It is the vertical distance from the centre of the ball to a point where the axes of the arms (or arms produced) intersect on the spindle axis. It is usually denoted by h .

2. Equilibrium speed. It is the speed at which the governor balls, arms etc., are in complete equilibrium and the sleeve does not tend to move upwards or downwards.

3. Mean equilibrium speed. It is the speed at the mean position of the balls or the sleeve.

4. Maximum and minimum equilibrium speeds. The speeds at the maximum and minimum radius of rotation of the balls, without tending to move either way are known as maximum and minimum equilibrium speeds respectively.

Note : There can be many equilibrium speeds between the mean and the maximum and the mean and the minimum equilibrium speeds.

5. Sleeve lift. It is the vertical distance which the sleeve travels due to change in equilibrium speed.



Centrifugal governor

18.5. Watt Governor

The simplest form of a centrifugal governor is a Watt governor, as shown in Fig. 18.2. It is basically a conical pendulum with links attached to a sleeve of negligible mass. The arms of the governor may be connected to the spindle in the following three ways :

1. The pivot P , may be on the spindle axis as shown in Fig. 18.2 (a).
2. The pivot P , may be offset from the spindle axis and the arms when produced intersect at O , as shown in Fig. 18.2 (b).
3. The pivot P , may be offset, but the arms cross the axis at O , as shown in Fig. 18.2 (c).

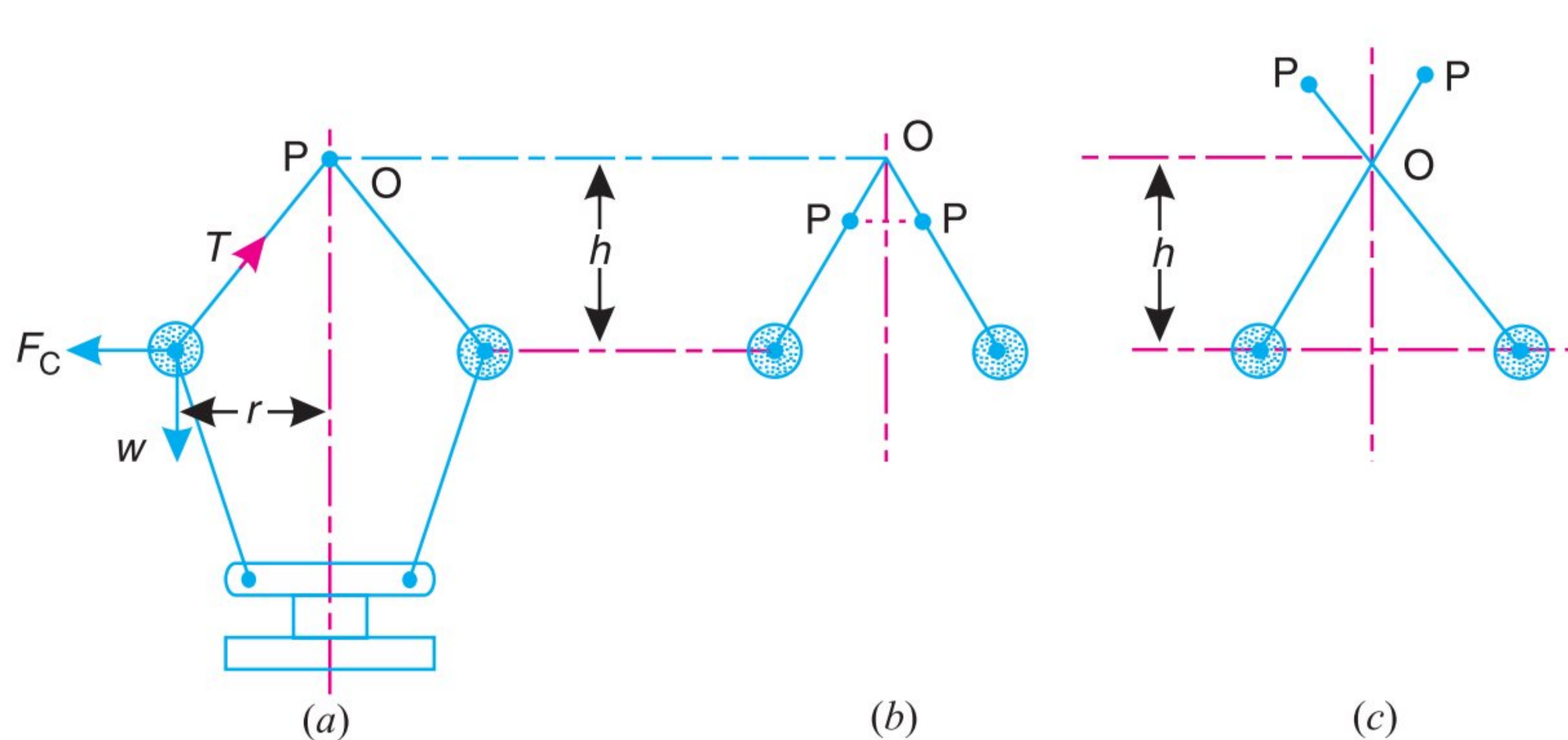


Fig. 18.2. Watt governor.

Let

- m = Mass of the ball in kg,
 w = Weight of the ball in newtons = $m.g$,
 T = Tension in the arm in newtons,
 ω = Angular velocity of the arm and ball about the spindle axis in rad/s,
 r = Radius of the path of rotation of the ball *i.e.* horizontal distance from the centre of the ball to the spindle axis in metres,
 F_C = Centrifugal force acting on the ball in newtons = $m.\omega^2.r$, and
 h = Height of the governor in metres.

It is assumed that the weight of the arms, links and the sleeve are negligible as compared to the weight of the balls. Now, the ball is in equilibrium under the action of

1. the centrifugal force (F_C) acting on the ball, 2. the tension (T) in the arm, and 3. the weight (w) of the ball.

Taking moments about point O , we have

$$F_C \times h = w \times r = m.g.r$$

or $m.\omega^2.r.h = m.g.r$ or $h = g / \omega^2$... (i)

When g is expressed in m/s^2 and ω in rad/s, then h is in metres. If N is the speed in r.p.m., then

$$\omega = 2\pi N/60$$

$$\therefore h = \frac{9.81}{(2\pi N/60)^2} = \frac{895}{N^2} \text{ metres} \quad \dots (\because g = 9.81 \text{ m/s}^2) \dots \text{(ii)}$$

Note : We see from the above expression that the height of a governor h , is inversely proportional to N^2 . Therefore at high speeds, the value of h is small. At such speeds, the change in the value of h corresponding to a small change in speed is insufficient to enable a governor of this type to operate the mechanism to give the necessary change in the fuel supply. This governor may only work satisfactorily at relatively low speeds *i.e.* from 60 to 80 r.p.m.

Example 18.1. Calculate the vertical height of a Watt governor when it rotates at 60 r.p.m. Also find the change in vertical height when its speed increases to 61 r.p.m.

Solution. Given : $N_1 = 60$ r.p.m. ; $N_2 = 61$ r.p.m.

Initial height

We know that initial height,

$$h_1 = \frac{895}{(N_1)^2} = \frac{895}{(60)^2} = 0.248 \text{ m}$$

Change in vertical height

We know that final height,

$$h_2 = \frac{895}{(N_2)^2} = \frac{895}{(61)^2} = 0.24 \text{ m}$$

∴ Change in vertical height

$$= h_1 - h_2 = 0.248 - 0.24 = 0.008 \text{ m} = 8 \text{ mm Ans.}$$

18.6. Porter Governor

The Porter governor is a modification of a Watt's governor, with central load attached to the sleeve as shown in Fig. 18.3 (a). The load moves up and down the central spindle. This additional downward force increases the speed of revolution required to enable the balls to rise to any pre-determined level.

Consider the forces acting on one-half of the governor as shown in Fig. 18.3 (b).

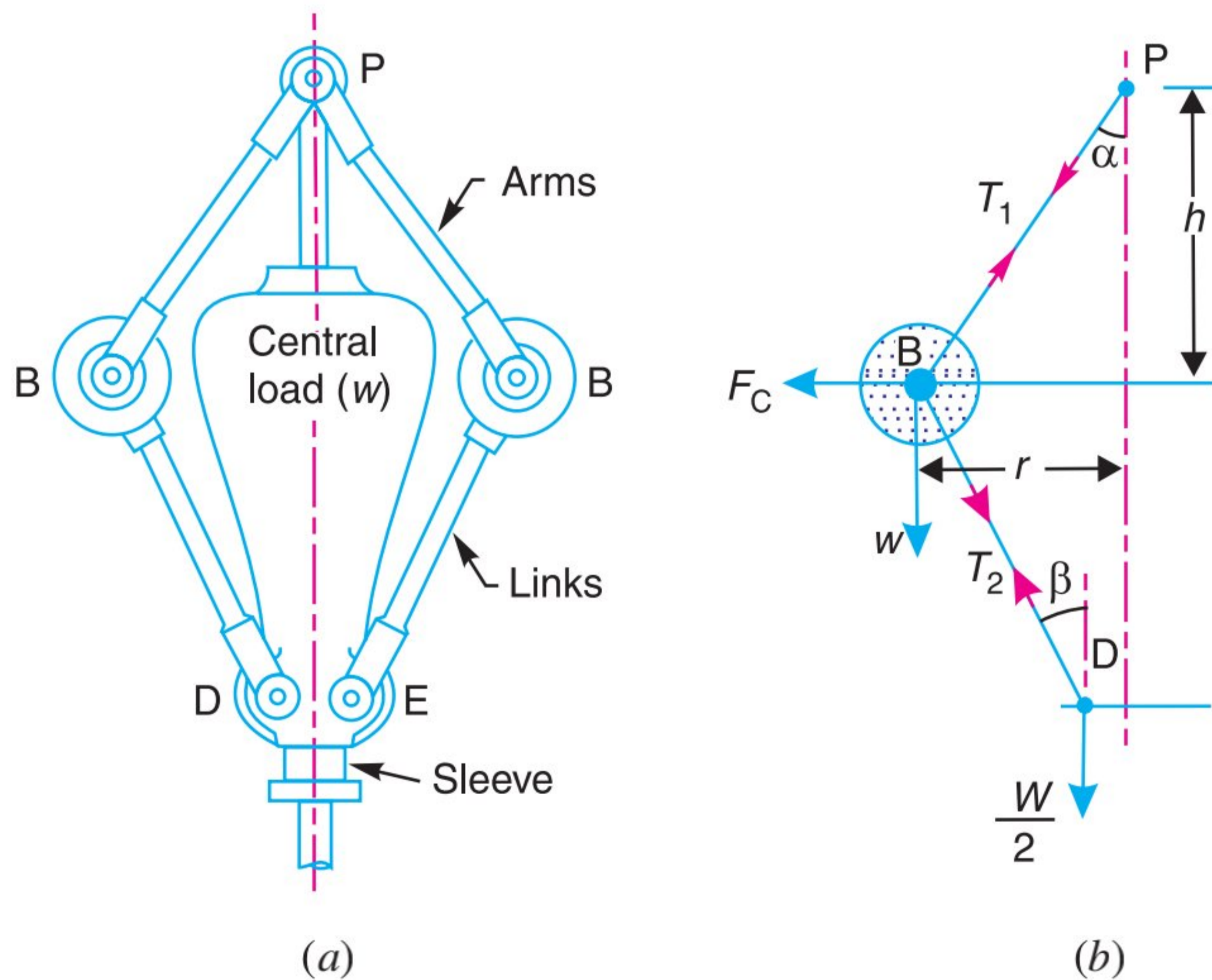


Fig. 18.3. Porter governor.

Let

m = Mass of each ball in kg,

w = Weight of each ball in newtons = $m.g$,

M = Mass of the central load in kg,

W = Weight of the central load in newtons = $M.g$,

r = Radius of rotation in metres,