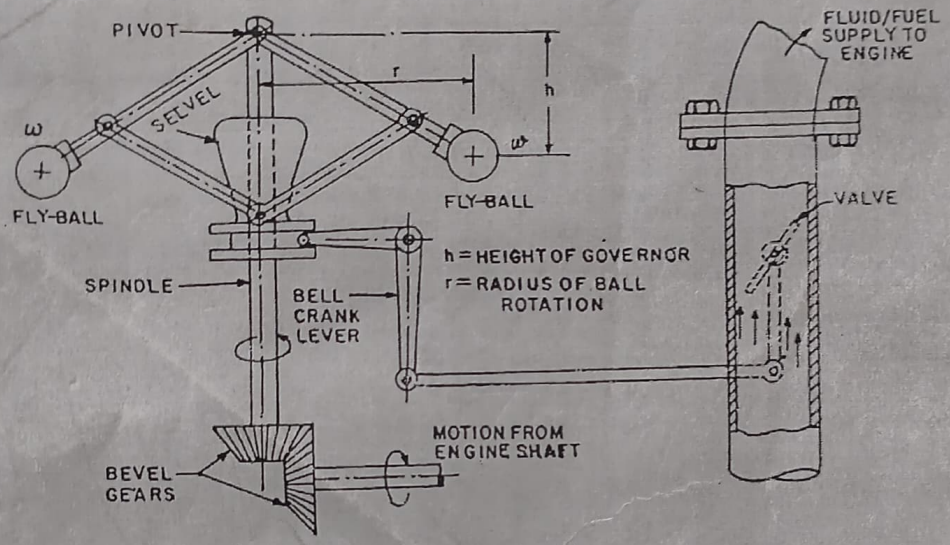
OBJECT : To study the different types of centrifugal governors. Find and compare Their sensitivity and draw the controlling force diagram using Universal Governor Apparatus.

APPARATUS: Universal Governor Apparatus.

THEORY :

FUNCTION OF GOVERNOR:

The function of a governor is to maintain the speed of an engine within prescribed limits for varying load conditions. Thus from no load on the engine to full rated load on the engine, the speed variation must be within prescribed limits. The governor will come into operation only when there is variation in the load on the engine. Thus in petrol engines, governor manipulated the throttle valve and in diesel engines, it manipulated the fuel pump.



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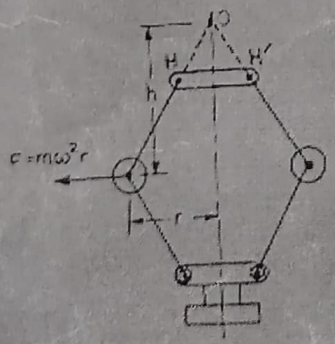
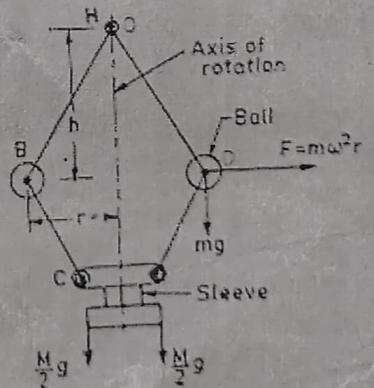




- **Height of Governor (h):** The vertical distance from the centre of the balls mass to the point of intersection of the arms or arms produced on the axis of the spindle is called the Height of the Governor denoted by 'h',

ISOCHRONISM:

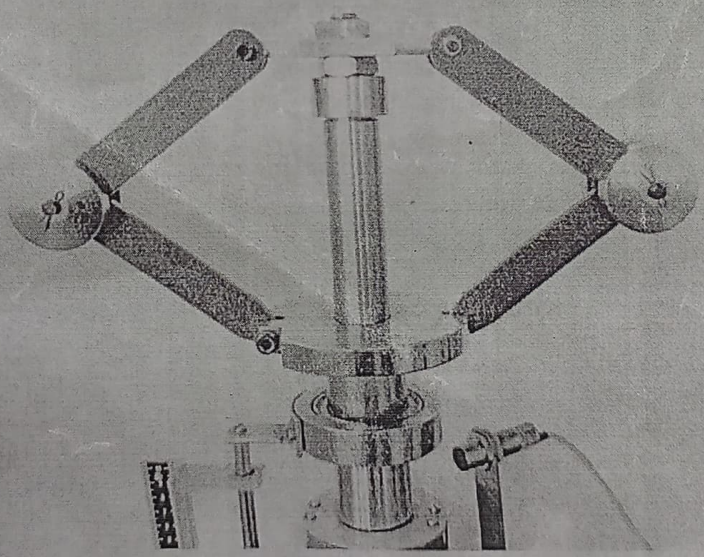
A governor is said to be isochronous if the equilibrium speed is constant for all radii of rotation of the balls within the working range or in other words a Governor with a range of speed zero. Isochronism is desirable when approximately one constant speed is desired to be kept for all loads.

HUNTING OF GOVERNOR:

With the change of load, there is a change of mean speed and the centrifugal governors tend to oscillate around the desired new mean position. This is because the governor ball and the sleeve find a new position to restore the original speed as far as possible. But due to inertia, there is over-shooting of the desired position and thus they again move towards the desired position in the opposite direction with the same result. The process may be repeated and consequent oscillations may be set up. If the frequency of fluctuations in engine speed coincides with the natural frequency of oscillations of the governor, then, due to resonance the amplitude of oscillations becomes very high. Consequently the governor tends to intensify the speed variations instead of controlling it. Such situation is known as Hunting.

WATT GOVERNOR:

This is the simplest type of centrifugal governor and was used by watt on some of his early steam engines. Although this governor is now obsolete, it is of interest as it marked beginning of a class of governors which fall in the category "pendulum governors". The other governors of this category are Porter and Porell governors. **An important limitation of all these governors is that, as they depend heavily on force of gravity, the axis of spindle for these governors must be kept vertical. In the watt governor the movement of the sleeve is very less at high speed and thus is unsuitable for these speeds.**

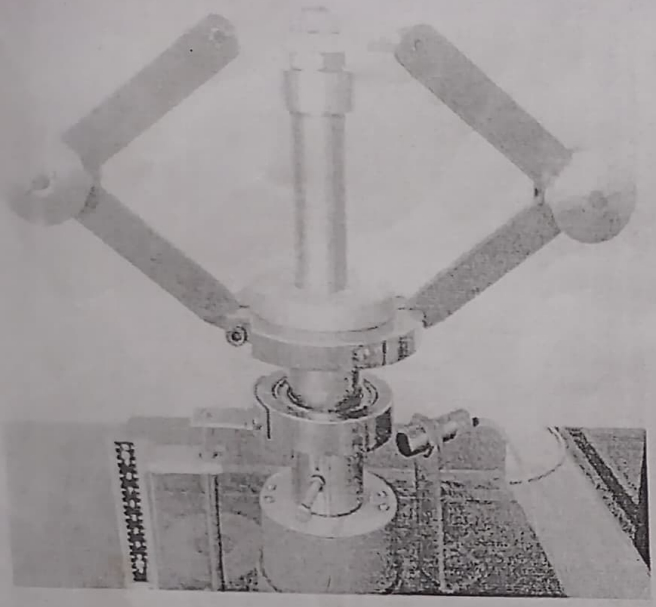


WATT GOVERNOR

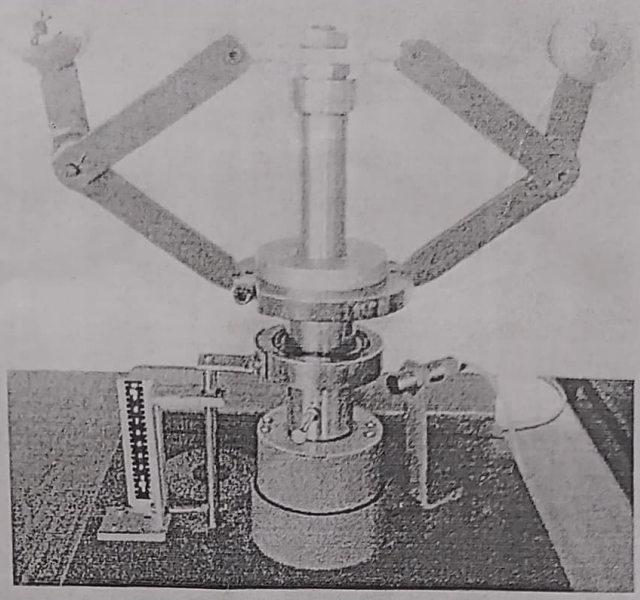
PORTER GOVERNOR:

A Porter Governor differs from a watt governor only in respect of a heavily weighted sleeve. Inward controlling force, required to ensure that balls move in circular path, is provided at the ball

centre by tensions T_1 and T_2 in the upper and lower arms respectively. As in watt governor, an increase in speed of rotation results in an increase in radius of rotation and a lift in the sleeve by corresponding amount. Conversely, a drop in equilibrium speed results in decreased radius of ball rotation and the sleeve is lowered by corresponding amount. In both the cases movement of sleeve is communicated through a bell-crank lever and a suitable mechanism to the valve controlling energy input to the engine.



PORTER GOVERNOR



PROELL GOVERNOR

PROELL GOVERNOR:

A Porter governor is known as a Proell governor if the two balls (masses) are fixed on the upward extension of the lower links which are in the form of bent links.

HARTNELL GOVERNOR:

It is a spring controlled governor, and a spring force is used either wholly or partly to effect controls in this governor. This features becomes interesting particularly when the governor shaft is either horizontal or is inclined to the vertical at some angle. **A spring force may be used with equal effectiveness for all the positions of governor-shaft axis. An additional plus point with a spring-controlled governors lies in that the initial compression in the spring can be adjusted to give any required equilibrium speed for a given ball radius.**

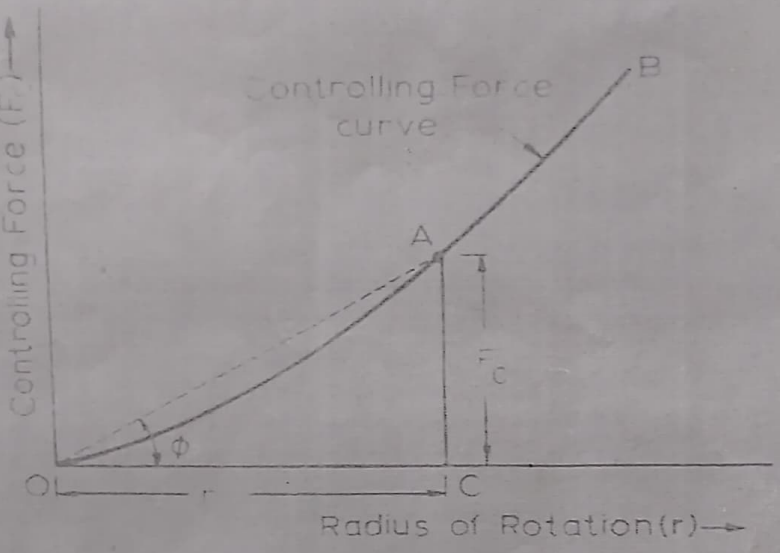
A Hartnell governor is represented diagrammatically in the fig. The sleeve "S" along with its attachment, slides on the rotating spindle of the governor, to which a frame-work, carrying the fulcrum pins of the bell-crank levers, are also attached. The frame is rigidly attached to the governor-spindle and therefore rotates with it at the same speed. Each bell-crank lever carries a ball at the end of its vertical arm and a roller at the end of its vertical arm and a roller at the end of horizontal arm. A helical compression spring, around governor spindle, provides equal downward force on the two rollers through the collar and sleeve. This downward force on rollers is the controlling force, required to ensure rotation of balls in a circular path. Lifting force on the rollers is due to the centrifugal force acting through the centers of governor balls.

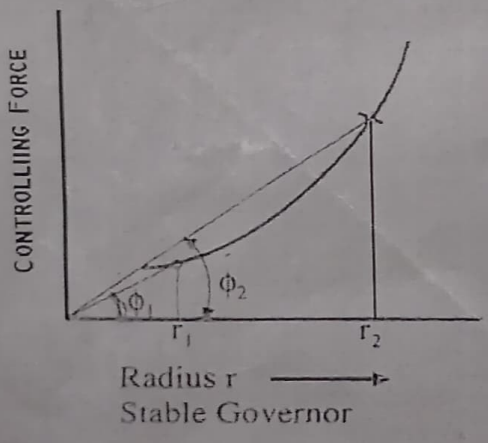
Controlling Force:

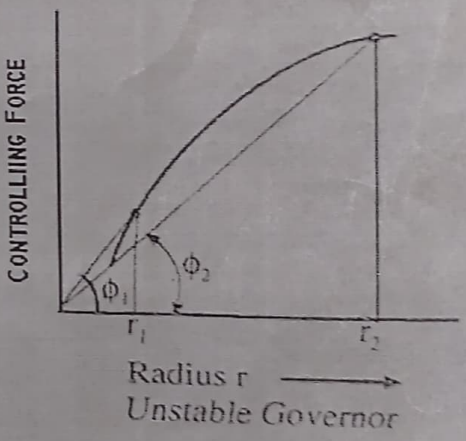
When the speed of rotation is uniform, the balls of a governor are subjected to outward centrifugal force, which will tend to move those outwards. But the outward movement of the balls is resisted by an equal and opposite force acting radially inwards. This inward force is known as controlling force. Hence controlling force is equal to centrifugal force but acting in the opposite direction. It is denoted by F_c.

So,

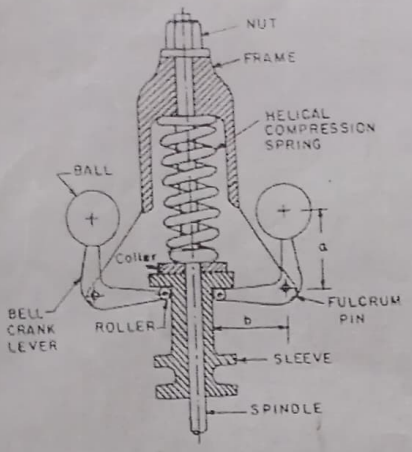
Controlling force, $F_c = m.\omega^2 . r$

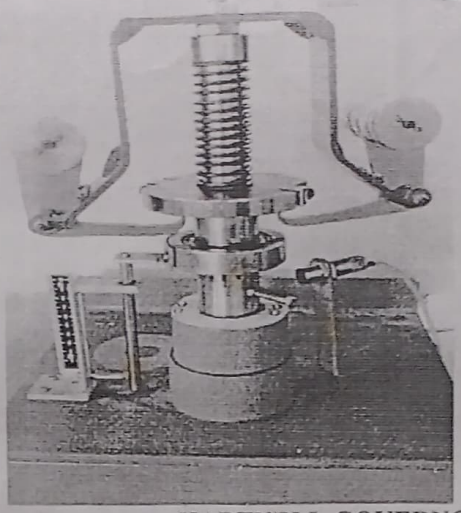






For a Stable Governor as '**r**' increases, ω increases, $F/r = m\ \omega^2$ increases and therefore φ increases. Thus for Stability with increases in '***r***', φ should also increase.





HARTNELL GOVERNOR

Procedure:

1. Fix the governor according to the diagram on universal governor apparatus.
2. Firmly tight all the lock nuts, key and screws.
3. Switch on the power.
4. Now slowly increase the speed by increasing voltage from the regulator.
5. Now note down the equilibrium speed (N_1) for some lift of the sleeve.
6. Now again increase the speed till the sleeve lift to 50 mm and note down the second equilibrium speed(N_2)
7. Now switch off the power and remove the first governor and fix the second governor according to the diagram.
8. Repeat the steps from 3 to 6 and note down the reading.
9. Now fill the observation table and compare the sensitivities of the governors.
10. Measure the radius of rotation for different speed and draw controlling force diagram.

Observation Table:

Governor	Lift (cm)	Speed(N) rpm	Radius of Roation (r)	Mass of ball (m)	Sensitivity	Controlling Force(F)
WATT						
PORTER						
PROELL						
HARTNELL						

Result:

Precautions:

1. Switch off the power while assembling the apparatus.
2. Firmly tight all the locknuts, screws and keys of the assembly.
3. Speed should be increased slowly.
4. Keep distance from the Governors while in running.
5. Observe the equilibrium speed accurately.

Discussion: