of the governor from the position which gives no steam-supply to the position which gives full steam-supply , and the governor is said to be sensitive if this range is a small fraction of *n*.

To find the configuration which the governor will assume at any particular speed, or the speed corresponding to a particular configura­tion, it is only necessary to determine the whole controlling force F per ball acting along the radius towards the axis for various values of *r*. Let a curve *ab* (fig. 44) be drawn showing the relation of F to *r*. At any assigned value of *r* set up an ordinate QC = 4π2n2rM. Join OC. The point *c,* in which OC cuts the curve, determines the value of *r* at which the balls will revolve at the assigned speed *n*. Or, if that is given, and the value of *n* is to be found, the line O*c* produced will determine C, and then n2 = QC/4π*r*M. The sensibility of the governor is determined by taking points *a* and *b* corresponding to full steam and no steam respectively, and drawing lines through them to determine the corresponding values of QA and QB. When the frictional resistance *f* is known, an additional pair of curves drawn above and below *ab,* with ordinates F + *f* and F *f* respect­ively, serve to show the additional variations in speed which are caused by friction. The governor is stable throughout its whole range when the curve *ab* has a steeper gradient than any line drawn from O to meet it.

79. *Isochronism.—*If, when the balls are displaced, the controlling force F changes proportionally to the radius *r*, the speed is constant. In other words, the equilibrium of the governor is then neutral; it can revolve in equilibrium at one, and only at one, speed. At this speed it assumes, indifferently, any one of its possible configurations.

The slightest variation of speed drives it to the extremity of its range; hence its sensibility is indefinitely great. Such a governor is called *isochronous.* Where springs furnish the controlling force, an approach to isochronism can be secured by adjusting the initial tension of the springs, and this forms a convenient means of regulating the sensibility.

But in practice no governor can be absolutely isochronous. It is indispensable to leave a small margin of stability for the sake of preventing violent change in the supply of steam, especially when there is much frictional résistance to be overcome by the governor, or where the influence of the governor takes much time to be felt by the engine. An over-sensitive governor is liable to fall into a state of oscillation called *hunting.* When an alteration of speed begins to be felt, however readily the governor alters its form, the engine’s response is more or less delayed. If the governor acts by closing a throttle-valve, the engine has still a capacious valve-chest on which to draw for steam. If it acts by changing the cut-off, its opportunity is passed if the cut-off has already occurred, and the control only begins with the next stroke.

When the demand for power suddenly falls, the speed rises so much as to force the governor into a position of over-control, such that the supply of steam is no longer adequate to meet even the reduced demand tor power. Then the speed slackens, and the same kind of excessive regulation is repeated in the opposite direction. A state of forced oscillation is consequently set up. The effect is aggravated by the momentum which the governor balls acquire in being displaced. Hunting is to be avoided by giving the governor a fair degree of stability, by reducing as far as possible the static frictional resistances, and by introducing a *viscous* resistance to the displacement of the governor, which prevents the displace­ment from occurring too suddenly, without affecting the ultimate position of equilibrium. For this purpose many governors are furnished with a *dash-pot,* which is a hydraulic or pneumatic brake, consisting of a piston connected to the governor, working loosely in a cylinder which is filled with oil or with air.

80. *Regulation by the Governor of the Steam-Supply: Throttle- Valve.—*The throttle-valve, as introduced by Watt, was originally a disk turning on a transverse axis across the centre of the steam- pipe. It is now usually a double-beat valve or a piston-valve. When regulation is effected by varying the cut-off, and an expansion­valve of the slide-valve type is used, the governor generally acts by changing the travel of the valve. In other forms of automatic expansion-gear the lap of the valve is altered ; in others the governor acts by shifting the expansion-valve eccentric round on its shaft, and so changing its angular advance.

81. *Trip-Gear.—*In large stationary engines the most usual plan of automatically regulating the expansion is to employ some form of trip-gear, the earliest type of which was introduced in 1849 by G. H. Corliss (1817-1888), of Providence, U.S.A. In the Corliss system the valves which admit steam are distinct from the exhaust-valves. T he latter are opened and closed by a reciprocating piece which takes its motion from an eccentric. The former are opened by a reciprocating piece, but are closed by springing back when released by a trip or trigger-action. The trip occurs earlier or later in the piston’s stroke according to the position of the governor. The. admission-valve is opened by the reciprocating piece with equal rapidity whether the cut-off is going to be early or late. It remains wide open during the admission and then, when the trip-action comes into play, it closes suddenly. The indicator diagram of a Corliss engine consequently has a nearly horizontal admission-line and a sharply defined cut-off. Generally the valves of Corliss engines are cylindrical plates turning in hollow cylindrical seats which extend across the width of the cylinder. Often, however, the admission-valves in trip-gear engines are of the disk or double-beat type, and spring into their seats when