bottom of the cylinder, at the ends, and take their motion from a separate wrist-plate which oscillates on the same pin with the plate A.@@1

175. Fig. 103 shows a compact form of trip-gear by Dr Proëll.

A rocking-lever *ab* is made to oscillate on a fixed pin through its centre by a connexion to the crosshead of the engine. When the end *a* rises, the

bell-crank lever *c* engages the lever *d,* and when *a* is de­pressed the lever *d* is forced down and the valve *e* is opened to ad­mit steam to one end of the cylin­der. As *a* con­tinues moving down a point is reached at which the edge of *c* slips past the edge of *d,* and the valve is then forced to its seat by a spring in the dash-pot *f*.

This disengage­ment occurs early or late ac­cording to the position of the fulcrum piece *g,* on which the heel of the bell- crank *c* rests dur­ing the opening of the valve.

The position of

*g* is determined by the governor. A similar action, occurring at the other end of the rocking-bar *ab,* gives steam to the other end of the cylinder. In one form of Proëll’s gear both ends of *ab* act on the same steam-valve, which is then a separate expansion-valve fixed on the back of a chest in which an ordinary slide-valve works.

176. In the ordinary form of centrifugal governor the position of the throttle-valve, or the expansion-link, or the Corliss trigger de­pends on the configuration of the governor, and is definite for each position of the balls. In disengagement governors, of which the governor A shown on the right-hand side in fig. 104 is an example, any reduction of speed below

a certain value sets the regu­lating mechanism in motion, and the adjustment continues until the speed has been re­stored. Similarly a rise of speed above a certain value sets the regulating mechan­ism in motion in the other direction. If the spindle *a* (fig. 104) is connected to the regulator so as to give more steam if it turns one way and less if it turns the other, the speed at which the engine will run in equilibrium must lie between narrow limits, since at any speed high enough to keep *b* in gear with *a* the supply of steam will go on being reduced, and at any speed low enough to bring c into gear with *a* the supply will go on being increased. This mode of governing, besides being sensibly isochronous, has the advantage that the power of the governor is not limited by the controlling force on the balls, since the governor acts by deflecting a portion of the power that is being developed by the engine to the work of moving the regulator. It is rarely applied to steam-engines, probably because its action is too

slow. This defect has been ingeniously remedied in the supple­mentary governor of Mr W. Knowles, who has combined a dis­engagement governor with one of the ordinary type in the manner shown in fig. 104.@@2 Here the spindle *a,* driven by the supple­mentary or disengagement governor A, acts by lengthening the rod *d* which connects the ordinary governor B with the regulator. It does this by turning a coupling nut *e* which unites two parts of *d,* on which right- and left-handed screws are cut. Any sudden

fluctuation in speed is immediately responded to by the ordinary governor. Any more or less permanent change of load or of steam- pressure gives the supplementary governor time to act. It goes on adjusting the supply until the normal speed is restored, thereby converting the control of the ordinary governor, which is stable, and therefore not isochronous, into a control which is isochronous as regards all fluctuations of long period. The power of the com­bination is limited to that of the common governor B.

177. Other governors which deserve to be classed as disengage­ment governors are those in which the displacement of the governor affects the regulator, not directly by a mechanical con­nexion, but by admitting steam or other fluid into what may be called a relay cylinder, whose piston acts on the regulator. In order that a governor of this class should work without hunting, the piston and valve of the relay cylinder should be connected by what is termed differential gear, the effect of which is that for each displacement of the valve by the governor the piston moves through a distance proportional to the displacement of the valve. An example of differential gear is shown in fig. 105. Suppose that the rod *a* is connected with the governor

so that it is raised by an acceleration of the

engine’s speed. The rod *c* whieh leads from

the relay piston *b* to the regulator serves as a

fulcrum, and the valve-rod *d* is consequently

raised. This admits steam to the upper side

of the piston and depresses the piston,

which pulls down *d* with it, since the end

of *a* now serves as a fulcrum. Thus by

the downward movement of the piston the

valve is again restored to its middle posi­

tion and the action of the regulator then

ceases until a new change of speed occurs.

A somewhat similar differential contriv­

ance is used in steam-steering engines to

make the position of the rudder follow,

step by step, every movement of the hand-

wheel ;@@3 also, in the steam reversing gear

which is applied to large marine engines, to make the position of the drag-link follow that of the hand-lever ; and also in certain electrical governors.@@4 The effect of adding a differential gear such as this to a relay governor or other disengagement governor is to convert it from the isochronous to the stable type.

178. Another group of governors is best exemplified by the “differential” governor of the late Sir W. Siemens@@5 (fig. 106). A spindle *a* driven by the engine drives a piece

*b* (whose rotation is resisted by a friction

brake) through the dynamometer coupling

*c*, consisting of a nest of bevel-wheels and

a loaded lever *d.* So long as the speed re­

mains constant the rate at which work is

done on the brake is constant and the lever

*d* is steady. If the speed accelerates, more

power has to be communicated to *b,* partly

to overcome the inertia and partly to meet

the increased resistance of the brake, and the

lever *d* is displaced. The lever *d* works the

throttle-valve or other regulator, either directly or by a steam relay. The governor is isochronous when the force employed to hold *d* in position does not vary ; if the force increases when *d* is displaced, the governor is stable. A governor of this class may properly be called a dynamometric governor, since it regulates by endeavour­ing to keep constant the rate at which energy is transmitted to the piece *b.* In one form of Siemens’s governor the friction-brake is replaced by a sort of centrifugal pump, consisting of a para­boloidal cup, open at the top and bottom, whose rotation causes a fluid to rise in it and escape over the rim when the speed is sufficiently great. Any increase in the cup’s speed augments largely the power required to turn it, and consequently affects the position of the piece which corresponds to *d.@@*6 Siemens’s governor is not itself used to any important extent, but the principle it em­bodies finds application in a number of other forms,

179. The “velometer” or marine-engine regulator of Messrs Durham and Churchill@@7 is a governor of the same type. In it the rotation of a piece corresponding to *b* is resisted by means of a fan revolving in a case containing a fluid, and the coupling piece which is the mechanical equivalent of *d* in fig. 106 acts on the throttle- valve, not directly but through a steam relay. In Silver’s marine governor@@8 the only friction-brake that is provided to resist the rotation of the piece which corresponds to *b* is a set of air-vanes. The inertia is, however, very great, and any acceleration of the engine’s speed consequently displaces the dynamometer coupling,

@@@1 Numerous forms of Corliss gears are illustrated in W. H. Uhland’s work on Corliss engines, translated by A. Tolhausen (London, 1879). A more recent form of gear by Mr Inglis is described in *Engineering,* vol. xl. p. 251.

@@@2 *Proc. Inst. Mech. Eng.,* 1884.

@@@3 See a paper by Mr J. MacFarlane Gray, *Proc. Inst. Mech. Eng.,* 1867.

@@@4 Williams, *Min. Proc. Inst. C.E.,* vol. lxxxi. p. 166.

@@@5 *Proc. Inst. Mech. Eng.,* 1853.

@@@6 *Proc. Inst. Mech. Eng.,* 1866 ; or *Phil. Trans.,* 1866.

@@@7 *Proc. Inst. Mech. Eng.,* 1879.

@@@8 *Brit. Ass. Rep.,* 1859, p. 123.