ON D'AURIA'S ENGINE GOVERNOR AND THE ACTION OF GOVERNORS IN GENERAL.

By the Inventor, L. D'AURIA,

Professor of Applied Mechanics, former Engineer of the Military Topographic Institution in Italy, etc.

In March, 1879, the writer of this note submitted to the Committee on Science and Arts of the Franklin Institute of the State of Pennsylvania an improved engine governor of his own invention, called "D'Auria's Engine Governor," which was examined on model and drawing, and found to be "very simple and compact, cheap in construction, comparatively small in dimensions, extremely sensitive, quick in action, nearly frictionless and isochronous." It was constructed upon the theory set forth by the inventor in the FRANKLIN INSTITUTE JOURNAL of March, 1879. After this examination the committee expressed the desire to make a practical test of the governor, and a 1-inch D'Auria's Engine Governor, furnished by the inventor, was attached on the engine of the Franklin Institute.

This governor, except the case when the engine was run without load, was found to act practically in accordance with the previous views of the committee. It commanded three different speeds to the engine, by means of three different sets of pulleys, and these speeds were 78, 62, 48 revolutions per minute when the engine was employed in running the dynamo-electric machine, and 76, 62, 48 revolutions per minute when the engine was running said machine together with an additional resistance procured by a brake lever. When the engine was run without load, the leakage of steam through the governor valve (which was a kind of oscillating slide valve, adjusted rather loosely to prevent friction) caused the engine to run at a greater speed than that due to the sensitiveness of the governor. Considering the engine was run at a very low speed, this inconvenience was of little importance, and even this source of objection has been successfully eliminated by the inventor, by using a balanced poppet valve as a substitute for the balanced slide valve. This improvement is shown, together with some little change of form of the governor itself, in Fig. 1, in which the balanced poppet valve (shown apart in Fig. 2)

is horizontally disposed within a valve chamber, *E*, made in the governor spindle, *K*, at the end of a cylindrical tube, *T*, which tube forms a practically tight steam joint with a steam box, *B*, provided with an induction passage, *I*.

The governor spindle, *K*, projects from the steam box, *B*, through a stuffing box, and receives rotary motion from the engine by means of gear, etc.

The steam box, *B*, is provided with a flange, and covers a larger steam chamber, *S*. An eduction passage, *D*, leads from the steam box to the engine, in which steam chamber the valve chamber, *E*, and its valve revolves.

The governor arm, which is formed by two equal side pieces, *AA*, riveted on each side of a ball, revolves also in the same steam chamber, *S*, being hung on both sides of the valve chamber, *E*.

The position of the point of suspension and that of the centre of gravity of the governor arm in reference to the axis of rotation, in order to obtain the closest approximation to isochronism, are determined after the theory set forth in the FRANKLIN INSTITUTE JOURNAL of March, 1879, page 130.

The connection between the governor arm and the throttle valve is made by a wire bent in form of U, as shown on the drawing, the sides of which are confined between the sides of the governor arm and the walls of the valve chamber, so that it cannot come out unless the governor arm be taken apart from the valve chamber to allow the wire to spring.

When the governor arm swings upwards by the centrifugal force acquired through the act of revolution, the valve is carried towards its seats.

The valve moves on three wing guides, which are constructed so as to permit it to oscillate with extremely small resistance; moreover, the valve does not enter the seats, but rests only upon the

Fig. 1.

Fig. 2.

edges, thus forming the limit of motion and controlling the range of the governor arm in swinging upwards. The contrary motion of both valve and governor arm is stopped by the contact between the cross-bar of the connecting wire with the valve chamber.

The steam from the boiler enters the induction passage, *I*, and flows through the openings, *P*, of tube *T*, to reach the valve chamber, *E*, after which, if the ports of the latter are opened, it will be delivered in the steam chamber, *S*, from which it will flow to the engine through the eduction passage, *D*.

As the weight of the throttle valve is very small, as compared with that of the governor arm, the frictional resistance is easily overcome by the least increase or diminution of centrifugal force of the governor arm, produced by any small variation of speed of the engine; and the governor being isochronous, the effect of such small variations of speed will be to entirely shut or open the valve chamber of the governor, and therefore to compel the engine speed to oscillate between very close limits.

Such a governor will not only control the speed of an engine to a definite number of revolutions per minute, but it is also able to control the irregularity of a single revolution of an engine, when it must be observed that during the period of expansion of steam the action of the governor is ineffective. If at such period of the stroke an increase of load takes place, it must be controlled by the momentum either of a flywheel or of parts of machines which derive their motion from the engine; and if the speed passes, in either direction, the limits due to the sensitiveness of the governor and its control of the valve during the period of expansion of steam for each stroke, such effect can only be attributed to a deficiency of such momentum.

A great momentum in an engine is always beneficial to the action of the governor, its operation being to lengthen the time in which a change of speed takes place; but it does not in any way affect the sensitiveness of the governor. In other words, it may reduce the acceleration and retardation of speed, but it will not prevent the engine from reaching the extreme limit of its speed due to the sensitiveness of the governor.

It can be asserted that an isochronous governor, when practically frictionless, has a complete control of a steam engine. On the other hand, with a governor subjected to a considerable friction, a better

control is obtained when the isochronous properties are avoided. These propositions can be demonstrated as follows :

Imagine two governors, both subjected to friction, one isochronous and the other non-isochronous. Suppose the first, if frictionless, to have its steam passage opened or shut indifferently, running always at 100 revolutions per minute; and the second, also, if frictionless, to have its steam passage full opened, running at 98 revolutions per minute; and quite shut, running at 102 revolutions per minute. Moreover, suppose both governors require 5 per cent. more speed to overcome their friction while the valve is moved in the direction to shut the steam passage, and 5 per cent. less speed while same valve is moved in the direction to open it. Suppose, further, that the engine is running with its steam passage full open, with a gradually accelerating velocity of rotation. As soon as the speed of the isochronous governor reaches 105 revolutions per minute the steam passage will be suddenly closed by the governor valve; the speed of the engine will be now retarded, with more or less rapidity of retardation as affected by the momentum of the flywheel or moving parts, until 100 revolutions per minute is reached. At this rate of speed the governor, by our supposition, does not offer to move the valve in the direction of opening, but the operation of retardation must progress, by absorption of force from the momentum of the moving parts, until the speed falls to 95 revolutions per minute, when the valve will be full opened by the governor with the same suddenness of action. With such a governor the engine speed will be established at velocities oscillating between 95 and 105 revolutions per minute. Then if a change of load brings the engine speed to one of these limits, the governor will undoubtedly change the speed to the other limit. A graphical representation of this is given in Fig. 3, in which the distance between *AB* and *CD* represents the stroke of the governor valve. *AB* corresponds to the position of the governor valve when it shuts the steam passage, and *CD* corresponds to the position of this valve when it opens the steam passage entirely. *EF* and *GH* represent the limits of the engine speed in revolutions per minute. Between *AB* and *CD* is the line representing the action of the governor valve, and between *EF* and *GH* is the line representing the speed of the engine, with variations which correspond graphically to the action of the governor valve.

Between *A* and *C* are marked, in revolutions per minute, the positions of equilibrium of the governor while the valve moves to shut

the steam passage, and between *B* and *D* are marked, in the same manner, the positions of equilibrium of the governor while the valve moves to open the steam passage.

Examining now the non-isochronous governor, with a similar supposition of open steam passage and with the speed accelerating above 102 revolutions per minute, the valve will begin to close the steam passage, and it will gradually be reduced by the valve while the speed passes from 102 to 107 revolutions per minute. When the latter speed is reached, the steam passage will be quite shut, and it will not begin to open until the speed falls to 97 revolutions per minute, because the valve would keep the steam passage closed with the governor, if frictionless, running at 102 revolutions per minute; therefore,

to overcome the friction while the valve moves in the direction to open the valve chamber, according to our supposition, the speed must fall to 97 revolutions per minute. While the speed passes from 97 to 93 revolutions per minute the steam passage will be opened gradually.

With such a governor the engine speed *can* oscillate between 93 and

107 revolutions per minute; but if a change of load brings the engine speed to one of these limits, then the valve will gradually open or shut the passage of steam; and it may be asserted that before the passage shall be either opened or shut, the engine will have been regulated in speed, and the uniformity of speed may be maintained with a *partly* open steam passage until another change of load may disturb it. This makes a non-isochronous governor preferable to an isochronous one, when both are subjected to frictional resistance to be overcome by the governor itself.

A graphical representation of the action of the supposed non-isochronous governor at various rates of speeds for the engine is given in Fig. 4, with the same letters of reference as in Fig. 3, referring to the similar things.

A graphical representation of the action of an isochronous and frictionless governor, and that of the engine speed, is given in Fig. 5, also with the same letters of reference as in Fig. 3, referring to similar things. In this last representation the engine speed is shown by a straight line—a condition which follows, because an isochronous and frictionless governor commands an engine to run with uniform speed.

Supernumerary Rainbows.—When a rainbow is very brilliant, secondary or supplementary bows are often seen near the centre of the arch. Kaemtz, Langwith and other observers have supposed that the reduplication is never visible near the extremities of the bow. Montigny saw, in August last, two ordinary bows with four supernumerary arches near the ground, which extended to about a third the height of the inner bow. There were two distinct layers of rain-clouds, and the supplementary bows seemed to be formed in the lower layer.—*Bull. de l'Acad. de Belg.* C.