R. Defrees,

Steam Governor.

No. 97,056. Patented Nov. 23, 1869.

Fig. 3.

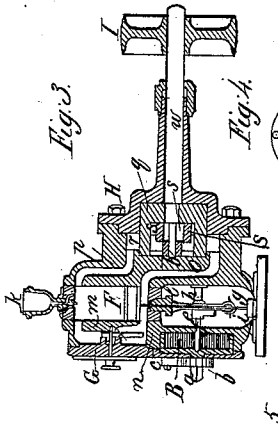


Fig. 4.

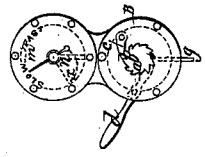


Fig. 5.

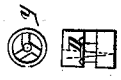


Fig. 2.

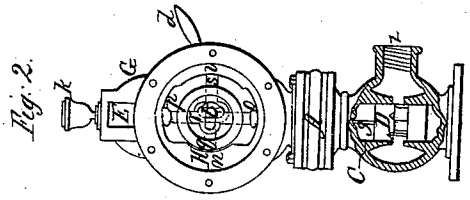
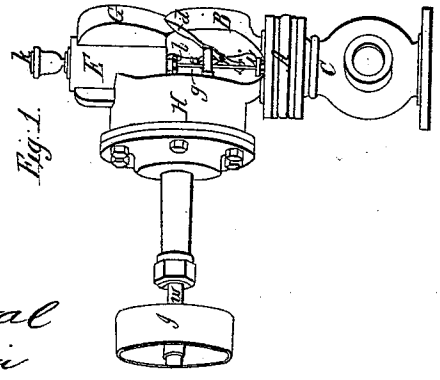


Fig. 1.



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ROLLIN DEFREES, OF NEWARK, NEW JERSEY; ASSIGNS TO JOHN D. DEFREES, ANTHONY DEFREES, AND THOMAS PERCIVAL, THREE-FOURTHS OF HIS RIGHT.

Letters Patent No. 97,056, *dated November* 23, 1869; *antedated November* 19, 1869.

IMPROVEMENT IN STEAM-ENGINE GOVERNORS.

The Schedule referred to in these Letters Patent and making part of the same.

To all whom it may concern:

Be it known that I, ROLLIN DEFREES, of the city of Newark, in the county of Essex, and State of New Jersey, have invented a new and useful Improvement in Steam-Engine Governors; and I do hereby declare that the following is a full, clear, and exact description of the same, reference being had to the accompanying drawing, hereto attached, and forming part of these specifications, and to the letters of reference marked thereon.

My invention relates to that class of regulators known as "liquid-governors," and consists in the employment, as a means of regulating the speed of the steam-engine, of a stream of oil, or other liquid, flowing through an adjustable narrow aperture, the several mechanical appliances requisite to maintain a constant flow of the liquid, and to connect and transmit its influence to the valve which controls the admission of steam to the engine, and also in the construction and operation of the valve itself.

Before proceeding to a particular description of my invention, it may not be improper to take a general view of the work which a steam-governor is required to perform, and how that work has hitherto been done, in order the better to appreciate the defects which my improvement is designed to obviate, and the advantages it is intended to secure.

The steam-engine governor is a machine designed to maintain, in the engine to which it is applied, a uniform speed under varying conditions of load and pressures of steam. It consists primarily of two parts, the valve, which controls the admission of steam to the engine, and the apparatus whereby any tendency of the engine to vary its speed is made automatically to open or close the valve, as the increase or dimunition of the engine's load may require.

Of the valve, nothing more is required than that it should be so constructed as to give an opening as large as the area of the steam-ports of the engine, and offer as little resistance as possible to the passage of the steam when open, should move very easily, have the pressure of the steam upon it so balanced as not to affect its motion, and be capable of closing gradually, so that its position may determine the amount of steam admitted, whether much or little.

There is a great variety of governor-valves in use, many of which fulfil all these requirements quite perfectly, yet I believe the one I propose is more simple and reliable than any in use. But in the apparatus which works the valve, equal perfection has not hitherto been attained. This part of the governor always involves the employment of two forces, one of which should be constant, or capable of producing a uniform motion, the other variable with the speed of the engine.

The valve should be suspended between these two forces, so that when the variable force preponderates, the valve shall close, and admit less steam, and when it becomes weaker than the constant force, the valve should open.

The constant force is the measure of the engine's speed, and upon its uniformity, and the quickness and delicacy with which the variable force acts, depends the perfection of the governor.

In all the governors in common use, the constant force is derived either from the gravitation of weights or the elasticity of springs; but the weights used are generally attached to arms or levers, moving in vertical arcs, the force exerted varying with the leverage, from a maximum, when the arms are horizontal, to a minimum as they approach the perpendicular, and the springs are usually either coiled-wire springs or flat springs, having a very limited range of motion, and varying greatly in tension throughout their traverse.

It is readily seen, that in governers so constructed, there is no actual constant force to which the speed of the engine may be regulated, and hence it is not strange that they should fail perfectly to answer their purpose.

The variable force, in governors hitherto in use, is derived from the centrifugality of balls or weights, swung round a circle by the motion of the engine, or from the resistance of fluids, as of the air to the revolution of a fan, or of oil, or other liquid, to the action of a propeller. But where balls are employed, in order to exert sufficient force to move the valve, the balls must have considerable weight, and their inertia prevents prompt changes of motion and quickness of valve-action; hence ball-governors operate best only when applied to slow-moving engines.

The centrifugal force, moreover, does not vary in uniform ratio with the speed; hence, the necessity of the employment of a "graduating-valve," to counteract this defect. And this, too, is but a partial correction, for the "graduating-valve" will not act the same under different pressures of steam.

The force developed by the resistance of fluids is quite feeble, and requires great delicacy of motion of the valve, while any unusual friction of the moving parts, or top great tightness of the packing of the valve-rod, is likely to prevent its motion, and interfere seriously with the action of the governor.

Other governors, of different construction from those mentioned, have likewise been proposed, wherein a uniform motion was sought to be obtained by means of clock-work, or from the inertia and momentum of revolving wheels; but these involve other defects, which have prevented them from coming into general use.

But all these various governors have one common defect, in that the valve is always connected directly with some moving part, which receives its motion

from the engine, and consequently the position of the valve depends upon the speed of the engine, and not, as it should, upon the quantity of steam which the engine requires to carry its load and maintain a uniform speed.

It is obvious, that in a ball-governor, the position of the valve depends upon the divergence of the balls, and the divergence of the balls depends upon the speed of the engine; consequently it is plain, that in order to keep the valve wide open when under a heavy load, the engine must run slower, and to keep the valve close when without a load, it must run faster than when moderately loaded.

In general, the speed of the engine will be found vibrating between these two extremes.

Governors of different construction behave similarly, from like causes, and variations of the pressure of the steam produce the same effects as variations in the load.

The only remedy is to make the position of the valve independent of the speed of the engine.

A perfect governor must be not only an absolute regulator of the speed of the engine, keeping its motion always uniform under varying conditions of load and pressure, acting so promptly and delicately as instantly to check any disposition of the engine to change its speed, and so strongly withal as to be practically unaffected by friction or sticking of the valve, but it should also be capable of instant adjustment, without stopping the engine, to run at any desired rate, governing equally well at all speeds, and in the event of any accident, whereby it is prevented from acting, such as the breaking or running off of the belt which drives it, it should stop the engine, thereby preventing destruction of machinery, and danger to life, by the engine's "running away."

The object of my invention is to supply a governor completely meeting all these requirements, yet simple in construction, cheap, durable, and unlikely to get out of order.

I will now proceed with a particular description of the construction and operation of my governor, referring to the accompanying drawing, wherein—

Figure 1 represents a perspective view of the governor and valve;

Figure 2, a front elevation, with portions removed to show the construction;

Figure 3, a vertical section;

Figure 4, a portion as seen from the rear; and

Figure 5, the valve detached from its chamber.

The governor is shown as mounted on the top of the valve-chamber, which is supposed to be supported by the steam-pipe.

A disk, of wood or other non-conducting material, A, intervenes to prevent the transmission of heat from the steam to the working parts of the governor; but the governor will act equally well in all positions, whether vertically above, below, horizontal with the valve, or detached therefrom, the connection being made with rods, as in some other governors. This feature, together with the absence of loose or swinging parts, which would be affected by the motion of a vessel, renders it particularly adapted for a marine governor.

The essential parts of my governor, aside from the valve, are a spring, which supplies the constant force, and a current of oil or other liquid, whose pressure furnishes the variable force, depending upon the speed of the engine.

There is also a pump, for producing the current, driven by the engine through the medium of a belt, a narrow passage, through which the current must pass, where its quantity may be controlled by means of an adjustable valve, for the purpose of regulating the governor to produce any required speed of the engine; and suitable means of transmitting the pressure of the current and force of the spring to the governor-valve, so that the valve may be suspended between those two forces, and moved by their difference, when any occurs, so as to admit more or less steam, as may be required to restore the equilibrium. These are compactly arranged within the compass of a small casting, and are constructed and arranged in the simplest manner.

The spring, whose place is at B, figs. 1, 3, and 4, is a flat spiral steel spring, like a clock-spring, having a range of elasticity of eight or ten turns, but of this range, only about one-sixth of a turn is used, the variation of tension through so small a portion of the traverse of the spring being too little to have any perceptible effect, small beyond calculation. The force is, therefore, practically constant.

The means by which the spring is wound up to the required tension is the squared end of a gudgeon, *a*, figs. 3 and 4, on the spring-case, to which the outer spire of the spring is fastened. *b* and *c* are the ratchet and pawl, which keep it wound.

The inner end of the spring is attached to a shaft, *f*, bearing on its extremity a crank, *e*, by means of which the force is transmitted, through the long-handled lever *d*, to the valve-rod *g*. This lever *d*, in connection with the crank *e* and slotted stud *h*, forms a parallel motion, whereby the valve-rod *g* is moved up and down in a right line, without any side thrust to bind or spring it.

The use of the handle is to raise the valve from off its seat when starting the engine.

The opposite ends of the valve-rod *g* pass through the stuffing-boxes *i* and *l* into the valve-chamber C and oil-reservoir E. This reservoir is a cylinder, in which freely moves the piston F, attached to the end of the valve-rod, which enters it. This is the means by which the pressure of the liquid, acting on the piston, moves the valve.

At the upper and lower ends of the cylinder, on one side, are ports, with passages *m* and *n*, leading through the regulating-valve G, and on the other, passages *o* and *p*, leading through the pump H. This pump is a rotary one, of very simple construction. It consists of a suitable outside casing, in which revolves a short hollow cylinder or drum, *q*, which is traversed at right angles by two pieces, *r* and *s*, whose ends form the four vanes or pistons of the pump.

In the centre of each of these pieces is a link or slotted hole, which works over a pin, *t*, set in the casing eccentrically with the drum *q*. The effect of this pin is to cause the ends of the pieces *r* and *s* to project out of the drum on one side, and be drawn into it on the other, as they and the drum revolve.

The top and bottom the drum making close joints with the top and bottom of the casing, and the sides of the casing, at *u* and *v*, being curved to suit the sweep of the vanes through one-fourth a revolution, it will readily be seen, that when the drum revolves, the liquid filling the machine will be drawn in through one of the passages *o* or *p*, carried by the vanes to and discharged through the other.

The pump will work equally well in either direction, the course of the current only being reversed when the motion is reversed.

As the governor is drawn, the pump should revolve toward the left, carrying the current from *o* to *p*, thus drawing the liquid from beneath, and forcing it in above the piston F. But should it be more convenient to have the pump turn to the right, all that is necessary is to reverse the spring B, so that its force will still be exerted in the opposite direction to the pressure of the current, when the governor will perform its functions equally well.

Into the drum *q* is inserted a shaft, *w*, which, passing through the sleeved cover and stuffing-box of the pump-casing, bears, on its outer extremity, a pulley,

I, through which motion is communicated to the pump by means of a belt from another pulley on the engine-shaft.

The liquid, carried by the action of the pump from below above the piston F, finds its way back again through the passages *m* and *n* and the regulating-valve G.

This valve consists of a shallow circular casing, in which is movable, by means of a shaft passing through its centre, a slide or gate, *x*, figs. 3 and 4, made of a flat, thin piece of metal, one edge of which is cut to the shape of one-half evolution of an arithmetical spiral, whose pitch is equal to twice the diameter of the valve-casing, and the other edge corresponds to a radius of the same circle. This gate, according to its position, covers more or less of the elongated narrow part of the passage *n*, and affords a ready means of regulating the quantity of liquid which passes through; for the flow of a liquid through an aperture is uniform under constant pressure, and the quantity passed varies directly as the area of the opening, other things being equal.

The shaft of the gate *x* bears, on its outer extremity, a pointer, by means of which the gate is set, and its position determined, and the cover of the casing bears the words "slow" and "fast," which show the direction in which the pointer is to be moved to produce the desired change in the speed of the engine.

On the top of the oil-chamber of the governor is placed a brass oil-cup, *k*, both for ornament, and for the convenience of supplying the chamber with oil when it needs replenishing, which will be not oftener than once a month if there be no leakage.

The governor-valve resembles, in the external appearance of its casing C, many of the valves now in use, but differs in internal construction, and is quite simple and effective.

The valve-casing is a cast-iron hollow sphere, of suitable size, terminated on opposite sides by hollow flanged necks, which are prolonged inward toward the centre of the sphere, where they nearly meet, leaving between them, all around, only a space equal in breadth to one-fourth the diameter of the steam-pipe. These necks are bored and reamed right through to a straight, smooth calibre, somewhat larger (the thickness of the sides of the valve) than the steam-pipe. It is in this channel that the valve is fitted and works, the space between the in-projecting necks forming the steam-port of the valve-seat.

At right angles to these necks is another neck, *z*, for the insertion of the steam-pipe.

The two flanges are turned up, and upon one of them the other parts of the governor rest, the non-conducting insulator A intervening, and by means of the other flange, the governor is bolted to its place on the engine.

The valve D, figs. 2 and 5, consists of two thin, flat rings, or short hollow cylinders of brass, supported one above the other, at a distance equal to the breadth of the steam-port of the valve-casing, by means of a wedge-shaped tri-lobed core, *y*. The diameter of these rings is such that they fit snugly, yet slide easily through the channel formed by the necks of the casing, and their breadth such as to enable them to cover the steam-port entirely.

It will be seen, that when placed within the casing, the space between these rings forms another steam-port, corresponding to that of the casing.

When the valve occupies a central position, the passage through is wide open, but when moved in either direction therefrom, the rings overlap, and diminish the opening of the port in the casing, until, when it has moved a distance equal to the breadth of the port, or one-fourth the diameter of the steam-pipe, the opening will be entirely closed.

The tendency of the spring B is to close the valve upon one side; that of the pressure of the liquid, upon the other.

When the engine is running steadily, these forces will be *in equilibrio*, holding the valve at just such point, between wide open and shut, as will admit steam enough to preserve the rate of speed and the equilibrium.

Should the engine, from any cause, receive an impulse or check, tending to alter its speed, the equilibrium will be disturbed, one force will overcome the other, the valve will be moved, diminishing or increasing the admission of steam, as may be required to preserve the speed and restore the equilibrium. But should either of these forces cease to act, from the breaking of the spring, or the parting or running off of the belt which drives the pump, or the stoppage of the pump from any cause, the other force, unresisted, will close the valve and stop the engine.

It will be seen that this valve is perfectly balanced by the steam-pressure, and that it gives a wide, unobstructed opening with but slight movement.

The drawing represents the lower edge of the upper ring of the valve as cut into by some small notches. This was done to prevent a too sudden closing of the valve when the engine was running light, or without any load, but they are not deemed essential.

Let us now go back and examine more particularly the action of the other parts of the governor.

We will suppose that the engine is making one hundred revolutions per minute, and that the size of the pulleys is such that the governor runs twice as fast, (it matters not what be their relative speed,) that the pump passes three cubic inches of liquid per revolution, and that the regulating-valve G is so adjusted that the port *n* will pass just six hundred cubic inches per minute, under the pressure allowed by the tension of the spring B, acting through the piston F.

Now it is evident, that if from any cause the engine should tend to increase its speed, the pump will be driven faster, and will carry up more oil from below the piston above it than can run back through the valve G. The force of the spring will be overbalanced, the piston depressed, the valve closed down, less steam admitted, and the tendency of the engine to run too fast corrected.

Should the engine tend to move too slowly, the opposite takes place—more oil escaping from above the piston, forced upward by the spring, than the pump carries up to take its place, the piston rises, the valve is opened, more steam admitted, and the error corrected, as before.

It is apparent that as long as the regulating-valve G will pass but just six hundred cubic inches per minute, the engine can obtain just steam enough to make one hundred revolutions per minute, no more and no less. If the valve G be altered so as to pass but three hundred cubic inches, the engine can make but fifty revolutions. If it pass twelve hundred cubic inches, the engine will make two hundred revolutions.

We will now suppose that a difference of one and a half cubic inch in the quantity of liquid above and below the piston is sufficient to carry the valve throughout its full traverse, from wide open to shut, and that the engine, running at one hundred revolutions per minute, is inclined, from some cause, to alter its speed to the amount of one per cent., an alteration too small to be perceived in running machinery, and which would not, from friction of parts, be likely to affect the best ball-governor; yet this increase of speed would cause the pump to gain on the regulating-valve (discharging six hundred cubic inches) at the rate of six cubic inches per minute, which, should it continue, would cut the steam off entirely in fifteen seconds, the valve being wide open at the commencement, or would close the valve one per cent., and correct the tendency to run too fast in three-twentieths of a second. In

other words, a governor proportioned as we have supposed, would correct any variation of the speed of the engine before it had continued longer than half a stroke. If the valve were but partially open when the variation commenced, the correction would be accomplished proportionally quicker.

From this it appears that this governor will regulate with great delicacy. That it will also act with great power, is apparent, from the consideration that the action which closes the valve is exactly that of the hydraulic jack, and that which opens the valve is the force of the spring B, which may be made of any required strength.

It is also seen that the position of the governor-valve D is entirely independent of the speed of the engine.

The point at which equilibrium takes place between the two forces which move it, will depend altogether upon the amount of load on the engine, the pressure of the steam in the steam-pipe, and the amount of valve-opening required to keep the engine up to or down to the speed at which it is set to run. If anything disturbs this equilibrium, the valve will go up or down until it finds the spot at which equilibrium is again restored, when the speed of the engine will be just the same as when the valve stood at the former point; for the stream of oil passing through the valve G, being under the uniform pressure of a constant force, (the spring,) will not be either hurried or hindered, nor can the pump carry more oil, or less, than the valve conveys, without the steam-valve at once changing, and bringing it back to the proper speed.

I do not claim, as my invention, the construction of a governor, whereby it may be adjusted to drive the engine at different speeds, or to stop the engine in case of accident, for I am aware that all this has been done before; but

I claim as my invention, and desire to secure Letters Patent, for—

1. The combination and arrangement of the spring B with the reservoir E and pump H, whereby the force of the spring shall be uniform, substantially as herein set forth.

2. The combination of the reservoir E, piston F, spring B, pump H, and shaft M, whereby the speed of the engine-governor, through the pressure of a current of oil, or other liquid, driven in a continuous circuit, by means of the pump, will be regulated, in the manner substantially as shown and described.

3. The combination and arrangement of the devices whereby to suspend the governor-valve between the two forces, without any solid connection between it and any part which receives its motion directly from the engine, so that its position may depend, not upon the speed of the engine, but upon the amount of valve-opening required to maintain the engine at a uniform speed, as herein set forth.

4. The construction and arrangement of the devices for varying the speed of the engine at will, with the adjustable valve in the oil-passages, whereby to regulate the quantity of liquid circulating in a given time through the governor, substantially as shown and described.

5. The construction and arrangement of the rotary pump, with reference to the devices immediately arranged therewith, as shown and described.

6. The construction and arrangement of the governor's steam-valve D, substantially as described.

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Witnesses:

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