(No Model.)

J. S. BANCROFT & W. LEWIS

GOVERNOR FOR STEAM ENGINES.

No. 354,033. Patented Dec. 7, 1886.

Fig. 2.

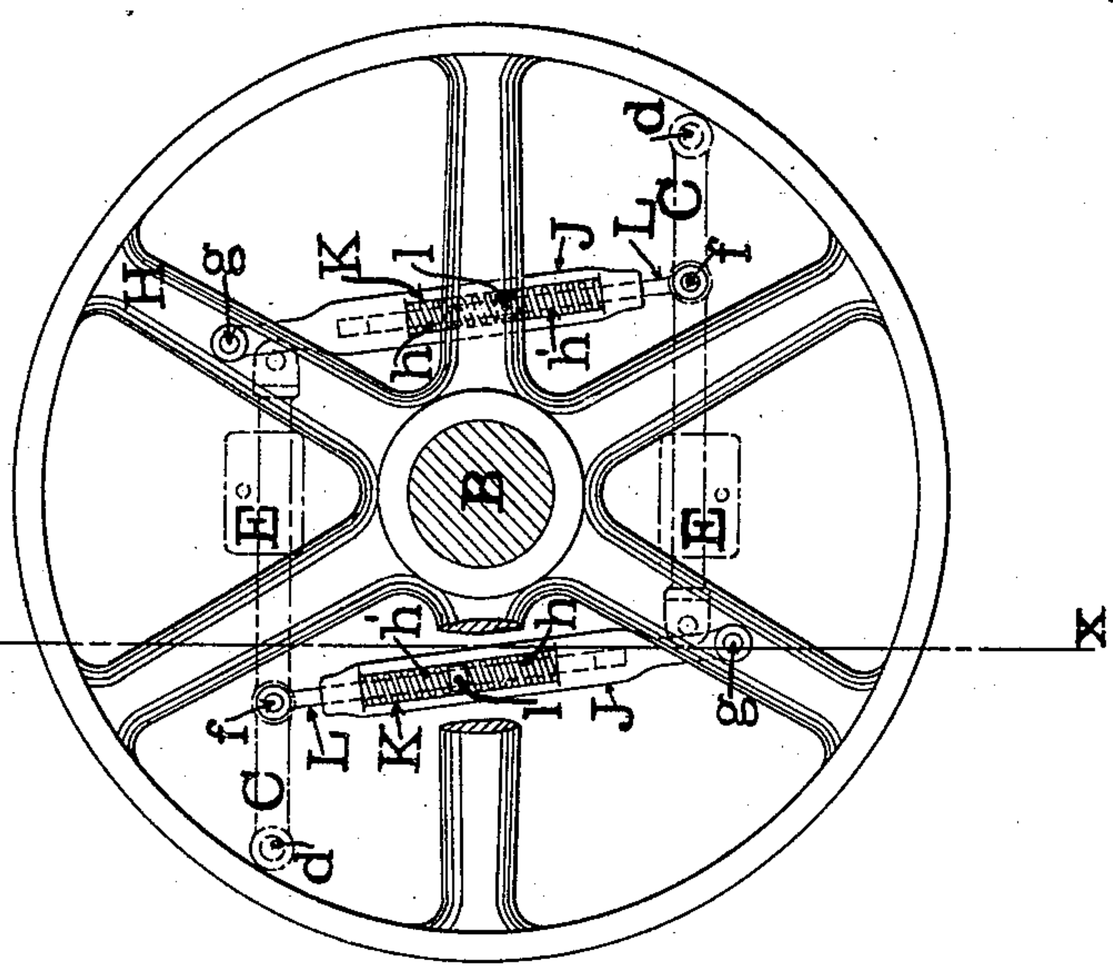


Fig. 3.

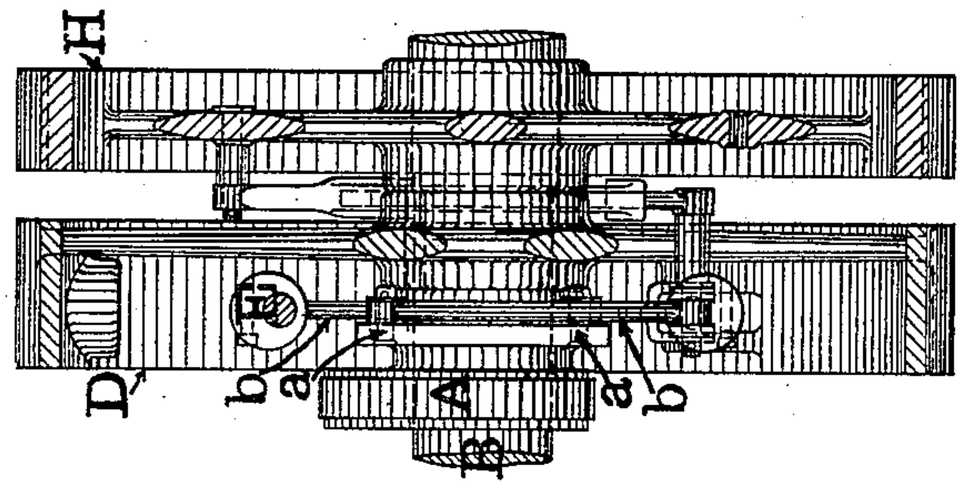
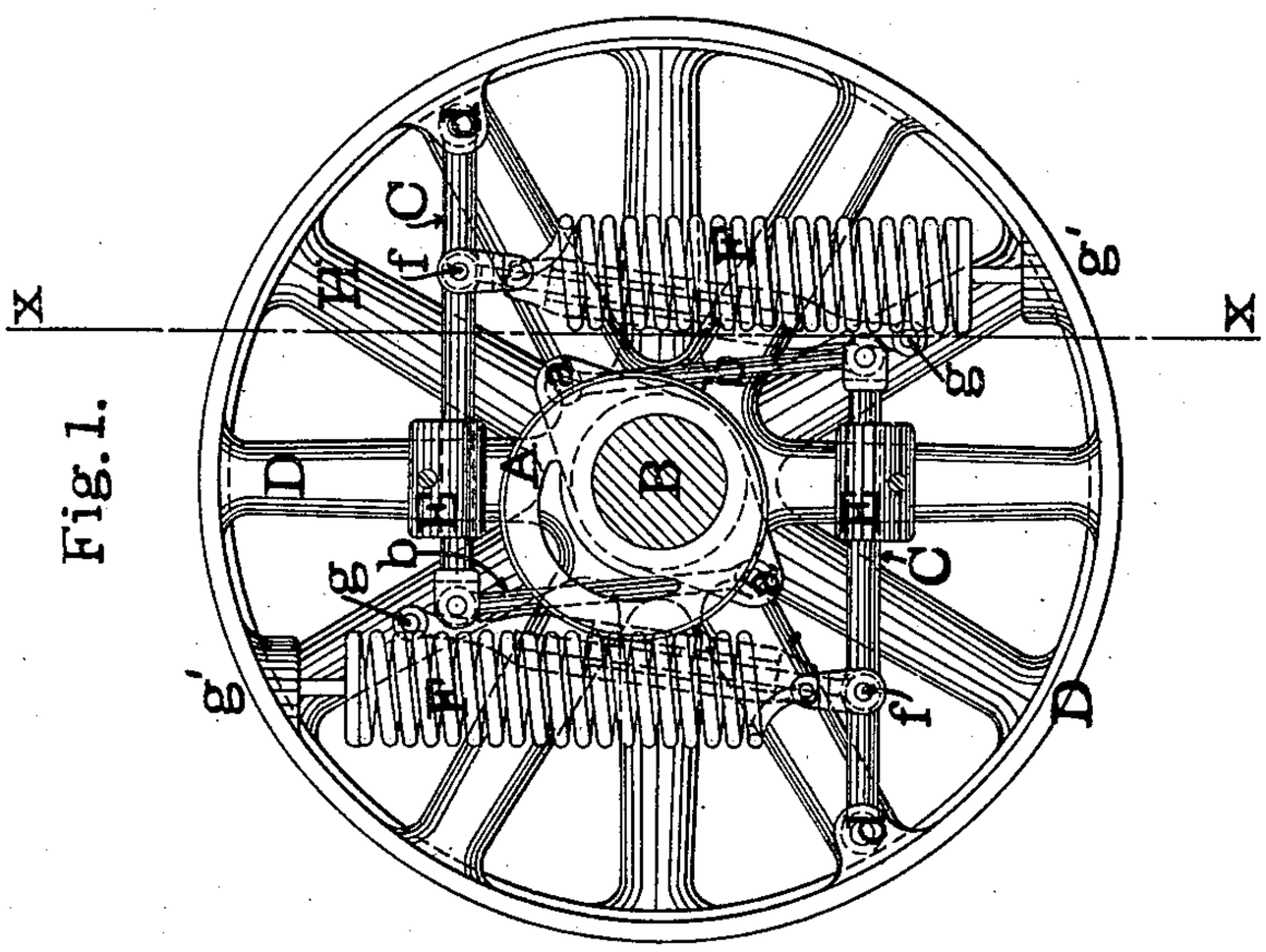


Fig. 1.



WITNESSES.

H. W. Teller

David L. Lukins

INVENTORS.

J. Sellers Bancroft

Wilfred Lewis

UNITED STATES PATENT OFFICE.

J. SELLERS BANCROFT AND WILFRED LEWIS, OF PHILADELPHIA, PA., ASSIGNORS TO WILLIAM SELLERS & COMPANY, (INCORPORATED,) OF SAME PLACE.

GOVERNOR FOR STEAM-ENGINES.

SPECIFICATION forming part of Letters Patent No. 354,033, dated December 7, 1886.

Application filed May 13, 1886. Serial No. 202,104. (No model.)

To all whom it may concern:

Be it known that we, JOHN SELLERS BANCROFT and WILFRED LEWIS, of the city and county of Philadelphia and State of Pennsylvania, have jointly invented certain new and useful Improvements in Governors for Steam-Engines, of which the following is a specification.

Our invention relates to that class of governors in which the angular variation of an eccentric about its shaft or the variation of its throw regulates the admission of steam to the engine by means of a suitable valve, the variation of the eccentric being effected by the movements of a weight to and from its center of gyration, while the centrifugal motion of this weight is resisted by a spring which tends to draw the weight toward the axis of its supporting-shaft. This type of governor is for the purposes of this specification called a "centrifugal governor." If the increasing centrifugal force of the weight due to its motion out from the center were exactly balanced by the increased strain on the centripetal spring, the governor would be in equilibrium in any position of the weight at the normal number of revolutions per minute; but it would also be in a very unstable condition, and the least disturbance resulting from any variation in speed, load, or friction of the valve would set up oscillations of the governor-weight, which would swing rapidly back and forth through its whole range. This is the condition technically known as "hunting." To remedy this well-known defect, governors of this class have hitherto been so adjusted that the centripetal force of the system would increase relatively to the centrifugal force as the weight increased its radius from the axis about which it rotated, with a corresponding relative increase in the centrifugal force as the weight approached the axis of rotation, and by this means the tendency of the oscillations to increase in amplitude can in a measure be checked. When thus adjusted, however, the governor will no longer be in equilibrium in all parts of its range, and consequently this form of governor will then have the defects of the old Watts governor—namely, that the engine must make a greater number of revolutions per minute when light than when loaded, which in many cases would be detrimental to the work produced. Brakes have also been applied to the moving parts of this class of governor for the purpose of checking these vibrations, with the effect of increasing the variation in speed necessary to change the position of the governor in order to regulate the steam-admission for any change of load, so that this device has been very unsatisfactory. The device known as a "dash-pot" has also been used to check these vibrations; but if made so as to offer sufficient resistance to check the ordinary oscillations under a practically-constant load, it would be impossible for the governor to respond promptly to the change required for a large variation in load, as for electric-lighting or wood-working machinery. As the eccentric must be moved forward to cut off earlier when its position is varied by rotation on its shaft, it follows that it must always be moved in the opposite direction to the variation in speed of the engine which it has to correct, and hence the inertia of the eccentric itself when thus adjusted delays the operation of shifting its position until the variation of the centrifugal force of the governor caused by the change of speed of the engine is sufficiently great to overcome this inertia.

It is the object of our present invention to provide means whereby this class of governor may be adjusted to any required degree of isochronism, and at the same time rendered more stable and also more sensitive and certain in action; and to these ends our invention consists in providing a centrifugal governor with an inertia-weight so connected to a moving part of the governor that when the engine varies in its rate of revolution the inertia of the weight will tend to move the governor and eccentric in the proper direction to re-establish the normal speed of the engine; and it further consists in connecting this weight to a moving part of the governor system through an elastic connection.

In the accompanying drawings, which form part of this specification, Figure 1 represents an elevation of an arrangement of our present invention as applied to one form of centrifugal governor. Fig. 2 is a rear elevation of the same, showing the elastic connection more

clearly; and Fig. 3 is a section on the line *x x* of Figs. 1 and 2.

A represents an eccentric journaled on the shaft B, which may be the crank-shaft of the engine or a shaft driven from it, as preferred. The eccentric A is provided with two arms, *a a*, to which are attached, preferably by ball-joints, to prevent cramping, the two connecting-rods *b b*, jointed to the ends of the pivoted weighted levers C C, journaled at *d d* in the governor-case D, which is secured firmly in the proper position to the shaft B. Weights E E are secured to the levers C C, so as to bring the centers of gravity of the levers in such position that they will move as nearly as possible on a radial line from the center of the shaft.

Attached to the levers C C at *f f* are the springs F F, which by their action balance the centrifugal force of the levers C C, the opposite ends of these springs being coupled by adjusting-screws to the governor-case D at the points *g' g'*. The location of the points *f f* on the levers C C and the adjustment and proportion of the springs F F must be such as to balance the centrifugal effect of the weighted levers C C at the desired number of revolutions per minute. If this adjustment is exact, the centrifugal and centripetal forces of the governor will be exactly balanced in all positions of the levers C C, and the engine would theoretically run at the same speed for any variation of load within the range of adjustment of the eccentric, which is moved forward so as to cut off earlier as the weighted levers move outward from the center. In practice, however, a governor so delicately adjusted would be unable to hold the engine at any speed, for the least disturbance sufficient to overcome the friction of the joints would start an oscillation of the governor which would change the speed of the engine, and the swing back of the governor to compensate for this change would carry the weighted levers through their full range, and this action would continue until the steam was shut off. As the work of the eccentric is reciprocating, there is always a slight motion on the joints, and consequently little or no friction of rest to resist any disturbance, so that it has hitherto been impossible to adjust such a governor so as to be isochronous in all positions.

The springs F F have hitherto always been adjusted so that their centripetal effect on the levers C C would increase much faster than the centrifugal force of the weighted levers due to the increased distance of their centers of gravity from the center of gyration, and this of necessity required the engine to run faster in order to hold the governor at the point required for early cut-off, and in fact heretofore all forms of this governor required that the engine should change its speed to hold the governor at any changed point of cut-off. To obviate this defect we attach to the governor system an inertia wheel or weight, hereinafter described, whereby the centripetal and centrifugal forces may be exactly balanced in all positions, and at the same time the liability to hunt may be eliminated.

H represents an inertia weight or wheel, loosely fitted so as to turn freely on the shaft B, and connected with the weighted levers C C by means of the elastic connections J J, which in this case are connected to the levers C C by projecting pins or studs from the points *f f*, and are coupled with the inertia-wheel H at the points *g g*.

It will be observed that the motion of the levers C C will move the eccentric A and inertia-wheel H in opposite directions, as the connections *b* and J are on opposite sides of the shaft B. The fly-wheel H has, owing to its greater size and mass, much more inertia than the eccentric A, and hence on any change of speed of rotation of the engine from the normal one the inertia-weight H will, by reason of its greater inertia, tend to move the eccentric in the proper direction to regulate the steam-admission, and hence the governor will be assisted instead of retarded in making the necessary compensation.

The elastic connection J is arranged so that two springs are placed to balance each other either in compression or extension, as may be preferred, so that they oppose a gradually-increasing resistance to any force tending to lengthen or shorten the connection J, which in this case is formed of a case coupled to the inertia-wheel H at *g*, and provided with a recess, K, in which are placed two spiral springs, *h h'*. A rod, L, pivoted at *f*, takes a bearing in the case passing through the spiral springs *h h'*, and has secured to it the collar *l* between the two springs *h* and *h'*. In this way motion of the pivots *g* and *f* toward or from each other will compress the springs *h* or *h'*, respectively, and hence the connection J will tend to return to its original length by moving the governor or the inertia-wheel H. This elastic connection J between the governor system and the inertia-wheel is necessary to permit prompt action on the part of the governor, for although the tendency of the inertia of the wheel is in the same direction, its action is slower, and on any change of speed of the engine the governor system moves first, compressing one set of the springs in the elastic connections, which action tends to check the governor and keep it from moving too far. If we consider the inertia-wheel as clamped to the shaft, then the springs in the elastic connection would evidently resist the motion of the weighted levers C C in either direction, and would thus have precisely the same effect to check hunting as the system heretofore in use in this class of governors—namely, that of so proportioning the springs F F to the weighted levers C C that the centripetal force of the springs would increase relatively to the weights as the weights moved out from the center, and vice versa as they moved in. With the inertia-wheel clamped to place, the governor evidently could not be made isochronous. When free to

move, however, as it is slower in its motion than the governor, it forms a movable abutment for the elastic connection, and hence always checks any tendency to hunt on the part of the governor, while its own inertia, aided by pressure received by the decided action of the governor, will cause it to take the new position required by any change of load on the engine, when the springs *h h'* again come into equilibrium and restrain the governor, as before.

The inertia-wheel H and centrifugal governor, by means of the elastic connection, act as checks upon each other and mutually prevent any variation of speed. In the drawings the levers and springs are shown in pairs, so as to diminish the friction of movement and balance the rotating mass, and if preferred the inertia-weight H may be placed in the form of a weighted lever pivoted near the shaft, taking care to couple it to the eccentric or weighted lever in such manner that its inertia will tend to move the eccentric in the same direction as the governor tends to. For any change of speed of the engine it is not necessary that the governor should rotate the eccentric, as shown, as it may move it across the shaft so as to change the valve travel and the point of cut-off.

Having now described our invention, what we claim as new, and desire to secure by Letters Patent, is—

1. In combination with a centrifugal governor, an inertia-weight, so connected with the governor system that its inertia will tend to move that system in the proper direction to re-establish the normal speed of the engine whenever any change of the work has caused a variation from that speed, substantially as and for the purposes set forth.

2. A centrifugal governor system, an inertia-weight, and an elastic connection between the governor system and the inertia-weight, the combination being and operating substantially as and for the purpose set forth.

J. SELLERS BANCROFT.
WILFRED LEWIS.

Witnesses:
H. W. SELLERS,
DAVID L. LUKINS.