

E. E. WOODWARD.  
SPEED REGULATOR.  
APPLICATION FILED APR. 18, 1912.

1,106,434.

Patented Aug. 11, 1914.

2 SHEETS-SHEET 1.

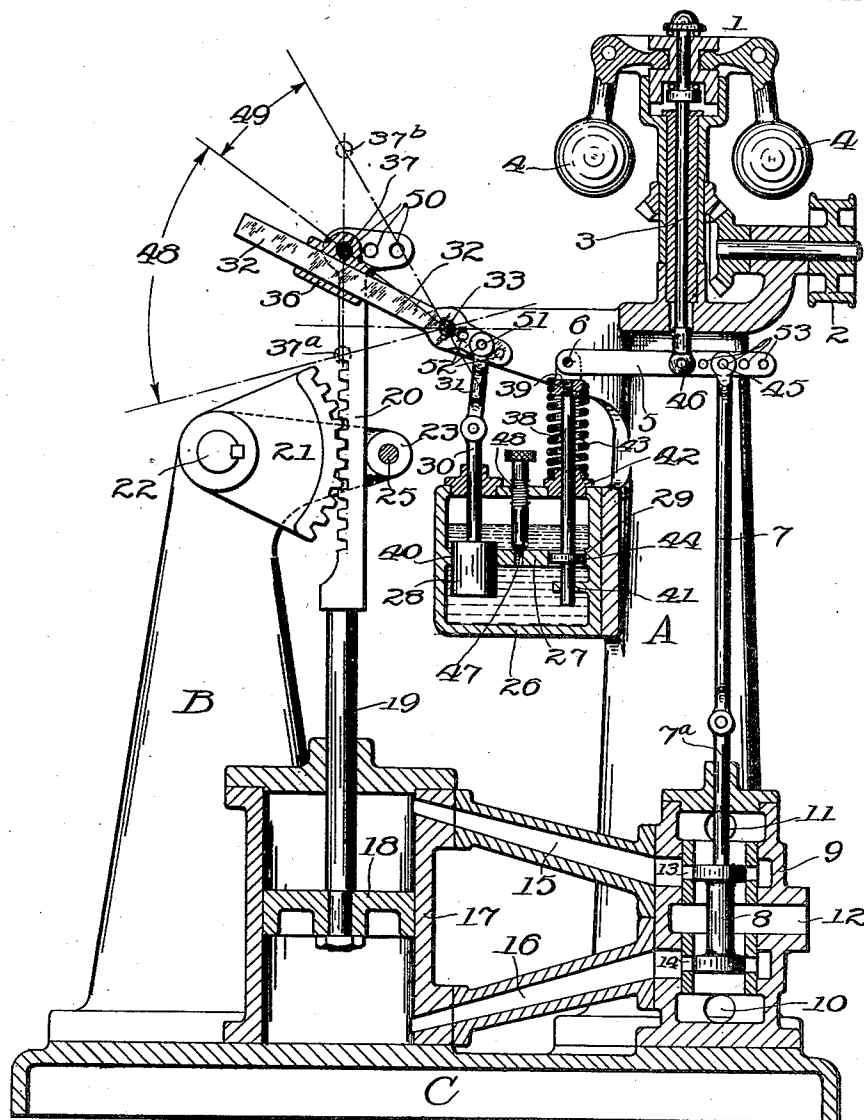


Fig. 1.

WITNESSES

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INVENTOR

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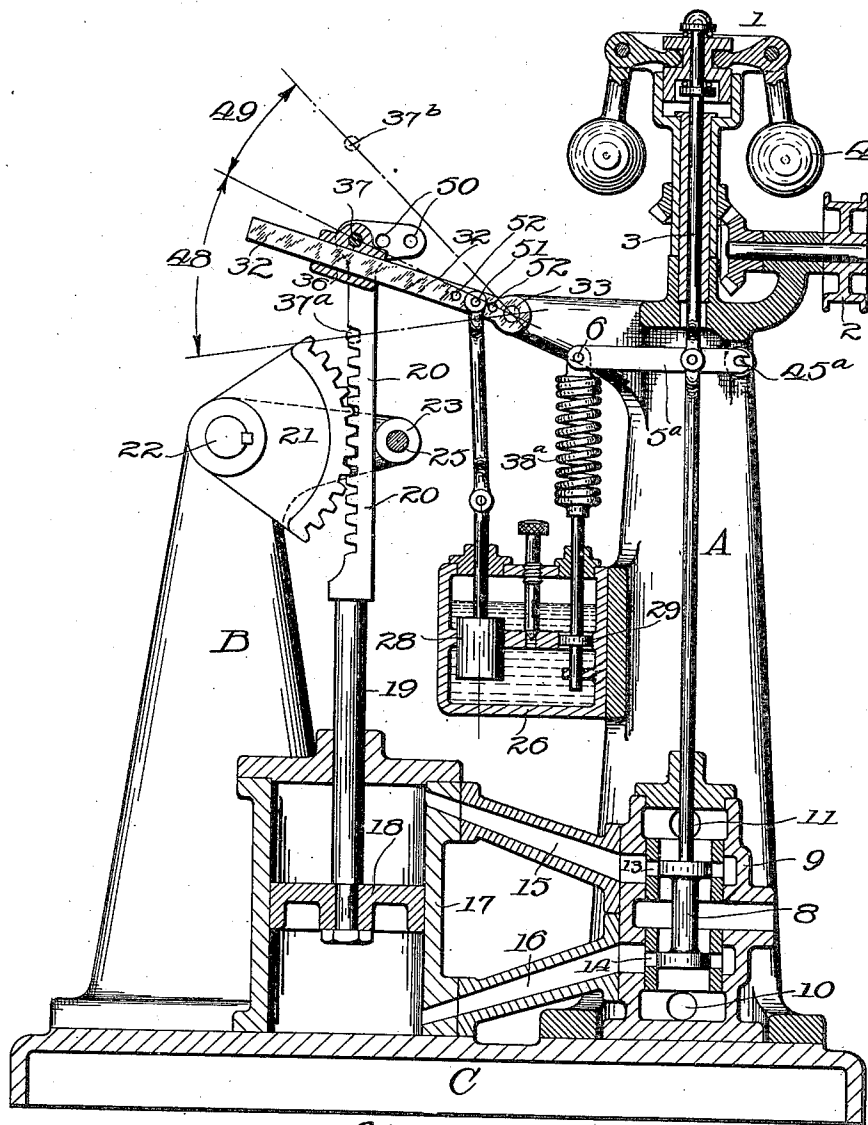


Fig. 2.

WITNESSES  
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# UNITED STATES PATENT OFFICE.

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## SPEED-REGULATOR.

1,106,434.

Specification of Letters Patent.

Patented Aug. 11, 1914.

Application filed April 18, 1912. Serial No. 691,646.

*To all whom it may concern:*

Be it known that I, ELMER E. WOODWARD, a citizen of the United States, residing at Rockford, in the county of Winnebago and State of Illinois, have invented certain new and useful Improvements in Speed-Regulators, of which the following is a specification.

This invention relates to improvements in that class of speed regulators in which a speed governor actuates power means, such as hydraulic cylinders or mechanical clutches, in order to operate the valve or gate which controls the speed of the engine, water wheel, or other prime mover. Such power means are necessarily set in motion, for instance, with centrifugal governors, whenever the centrifugal weights are caused, by a change of speed due to a change of load, to depart from their normal central position. It is obvious that such motion should be stopped when the valve of the prime mover has been opened or closed to that position which will cause the prime mover to run at its normal speed with the altered load.

It is a well recognized fact that when the weights of such speed governors are moved from their normal positions by variations in the speed, the tendency of the weights is to continue in their new positions after the valve of the prime mover reaches the proper position. This is due to the fact that the speed of the prime mover does not instantly respond to the changed position of the valve because a certain time is required to overcome the inertia of the moving parts of the prime mover and of the driven machinery. Hence there is a tendency for the centrifugal balls to remain at abnormal speed too long and thus for movement of the valve to be too great and to cause in the prime mover what is known as "racing" or "hunting."

It is one of the objects of this invention to produce a speed regulator including what may be called an anti-racing device so that the racing of the prime mover will be eliminated. In the regulation of a prime mover by means of a centrifugal governor it has been found that some two to four times as much compensation is required to prevent racing when the load is light as when the full power of the prime mover is in use. By the use of the word "compensation" herein, I refer to any movement simultaneous with

the movement of the gate which tends to check or limit the action of the governor which causes the movement of the gate. And by the use of the word "gate" I refer to the main operating valve of the prime mover. The amount of compensation required also varies with other conditions in the prime mover and the machinery driven. And a further object of this invention is to provide an anti-racing device so constructed as to compensate automatically for varying conditions in the load and adapted to be adjusted to meet other varying conditions in the prime mover and the driven machinery. It has also been found beneficial to limit the amount of compensation that may be attained, so that when there is a change of load approximating the full power of the prime mover the governor may not be checked until the gate is fully opened or closed, thus causing the speed to return more promptly to normal. And a further object of this invention is to provide means for so limiting the compensation in connection with said speed regulator.

In the accompanying drawings Figure 1 is a side elevation, partly in section, of a speed regulator embodying the features of my invention, and Fig. 2 is a similar view showing some modifications in the construction of the regulator.

In the form of a regulator I have used herein to illustrate my invention a centrifugal governor operates a valve, which allows fluid under pressure to act on a piston in a cylinder, and the piston rod in turn operates the gate which controls the supply of power to the prime mover. The regulator comprises a standard A and a standard B mounted upon a base C. Any suitable form of speed governor may be used. In this instance I have preferred the centrifugal governor 1, mounted on the standard A, operated in the ordinary manner by means of the pulley 2, and comprising the speed rod 3 which is adapted to move up or down as the fly balls 4 move in or out from their normal positions because of variations in the speed of the prime mover. The speed rod 3 acts upon a lever 5 which is pivoted at 6 to a part of the anti-racing device hereinafter to be described. The movement of the rod 3 by means of the lever 5 moves up or down the link 7 and the stem 7<sup>a</sup> of the valve 8. The valve 8 is inclosed in a fluid tight casing 9 within which are inlet

ports 10 and 11 which are adapted to receive fluid under pressure from any suitable source of supply. The casing also has a discharge or exhaust port 12 and ports 13 and 14. These latter ports are normally closed, but are opened as the valve 8 is moved upward or downward by the action of the governor. Passageways 15 and 16 connect the ports 13 and 14 with the upper and lower ends respectively of a cylinder 17. In this cylinder is a piston head 18 with a piston rod 19 which, in conjunction with the rack 20 attached thereto and the segment gear 21, serves to transmit motion from the piston head to the stem 22 which in turn actuates the gate of the prime mover. The rack 20 is permanently held in mesh with the segment 21 by means of the roller 23 pivoted to the standard B by the pivot 25.

The operation of this portion of the mechanism is as follows: When the speed of the prime mover is normal the balls of the speed governor maintain the speed rod 3 substantially in the center of its travel up and down. If the load driven by the prime mover is increased the prime mover will decrease the speed and the fly balls will move inward slightly raising the speed rod 3 and valve 8. The ports 13 and 14 will thus be opened more or less. Any exhaust fluid in the upper end of the cylinder 17 will be at liberty to pass through the passageway 15 and the port 13 out of the exhaust port 12. And fluid under pressure will enter port 10 and pass through port 14 and the passageway 16 into the lower end of the cylinder 17. The piston head 18 and the rack 20 will thus be forced upward, and the gate stem 22 will be operated so as to open the gate to the position required to maintain the desired speed with the altered load. The speed of the prime mover, however, will not instantly return to normal, and the opening of the gate would continue beyond the proper position if it were not for the anti-racing device. This device comprises a casing 26 adapted to contain a liquid and having a horizontal central partition 27. In this partition are formed openings constituting cylinders 40 and 44 to receive the plungers 28 and 29. The stem 30 of the plunger 28 is connected, by means of a link 31, to a lever 32 which is pivoted at 33 to an arm on the standard A. One arm of the lever passes freely through a slot in a sliding block 36 which is pivoted to the upper end of the rack bar 20 by a pivot 37.

It will be seen that whenever the piston 18 moves upwardly or downwardly the block 36 will be moved accordingly, and the lever 32 will force the plunger 28 downward or upward as the case may be. The plunger 29 is attached by means of the stem 38, to the head 39 which is pivoted at the point 6 to the floating lever 5. The plunger 28 is

of such a length that it is at all times within the cylinder 40; but the plunger 29 is preferably made so that it may in its movement be carried above or below the cylinder 44. Guides 41 and 42 serve to return the plunger 29 to its cylinder. A centering spring 43 is attached at its lower end to the guide 42 and at its upper end to the movable head 39. The spring 43 is wound partly open so that it may be either compressed or extended as the plunger 29 is moved downward or upward; and its length is so proportioned that it tends to hold the plunger 29 substantially in the center of the cylinder 44. The casing 26 is filled substantially full with some suitable liquid. In this instance I have preferred to use oil. As there is no tendency for the liquid to pass upward and out from the casing the stems 30 and 38 of the plunger need not be inclosed in stuffing boxes; so that the friction of the stems in the guides will be slight.

The operation of the anti-racing device is as follows: When the load driven by the prime mover is increased, and the fly balls moving inwardly cause the rack bar 20 to move upward and open further the gate, the rack bar 20 also forces upward the end of the lever 32 and thus forces downward the plunger 28. The effect of the plunger 28 is transmitted, by the fluid in the lower part of the casing 26, to the plunger 29, forcing it upward, and raising the pivot 6, and depressing the outer end of the lever 5, and hence the valve 8. This stops the movement of the piston 18 and prevents excess opening of the gate. The pivots 6 and 46 are thus elevated somewhat above their normal positions; but they gradually return to their normal positions as the fly balls return to their normal positions with the return to normal of the speed of the prime mover, and as the spring 43 moves the plunger 29 back to the center of the cylinder 44. A needle valve 47 allows the fluid to pass slowly between the two parts of the casing 26. This does not prevent the plunger 29 from being moved by the comparatively rapid movement of the plunger 28; but it retards the action of the spring 43 in restoring the plunger to its central position. In practice the needle valve 47 is adjusted, by means of the screw 48 on the stem of the valve, so that the plunger 29 is returned to the central position in substantially the same time as is required for the prime mover to return to normal speed after the gate has been correctly adjusted for any change of load.

The action of the governor shown in Fig. 2 is similar to that of Fig. 1 herein described; but the operation of the anti-racing device shown in Fig. 2 is slightly different. Thus the upward movement of the rack bar 20 raises instead of lowers the plunger 28,

and allows the air pressure acting on the oil in the casing 26 to force the plunger 29 downward, thus extending the spring 38<sup>a</sup>. As the pivot 45<sup>a</sup> is rigidly attached to the standard A, the tension of the spring, acting through the lever 5<sup>a</sup>, tends to cause the fly balls to resume their normal positions and to close the valve 8, and thus stop movement of the piston 18 when the gate has reached the correct position. As the speed of the prime mover returns to normal the tension of the spring 38<sup>a</sup> is gradually dissipated by the return of the plunger 29 to its central position.

As hereinbefore mentioned, it has been found that from two to four times as much compensation is required in order to prevent racing when the load is light as when nearly the full power of the prime mover is in use. I have provided for proper compensation with varying loads by the use of the lever 32, the sliding block 36 and the pivot 37 adjustably attached to the rack bar 20. In the drawings pivot 37 is shown in the position it occupies when the gate of the prime mover is one-half open. In this position of the parts the lever 32 is inclined with reference to the horizontal. The dotted circle 37<sup>a</sup> shows the position of the pivot when the gate is closed, and the dotted circle 37<sup>b</sup> shows the position of the pivot when the gate is entirely open. The arc 48 shows the angular movement of the lever 32 as it passes from the closed to the half-open position of the gate. This movement will be seen to be much greater than that indicated by arc 49, which shows the angular movement of the lever as the gate passes from its one-half movement to its entire open position. It will thus be seen that the proportionate movement of the plunger 28 and hence of the compensating effect due to the movement of the plunger will be much greater with light loads which are carried when the valve is nearly closed than with heavy loads which are carried when the valve is nearly open.

In order to more closely adapt the compensation to the particular needs of the case due to variations in the average load carried, or other causes, I have provided means whereby this differential rate of movement of the lever may be increased or decreased. These means comprise the pivot openings 50 in the upper end of the rack bar 20. By placing the pivot 37 so that it is closer to the pivot 33 the difference in the angular movement of the lever in the two cases above mentioned will be increased.

As the amount of compensation required to prevent racing varies with other conditions in the prime mover and the machinery driven, I have provided also an adjustment of the pivot 51 comprising a plurality of pivot openings 52 in the end of the lever 32.

In this way the total proportionate distance that the plunger 28 travels during the stroke of the piston 18 may be varied, and hence the compensating effect may be varied accordingly. By these means the change of speed caused by a change of load may be caused to produce a prompt change of the gate that will result in a change of power almost exactly equal to the change in load. In practice it is also found beneficial to limit the compensation to a portion only of the movement of the balls, so that when there is a change of load approximating the full power of the prime mover the governor may not be checked until the gate is fully opened or closed, thus causing the speed to return more promptly to normal. My invention provides simple and improved means of accomplishing this result. When the plunger 28 has forced the plunger 29 to the end of its cylinder 44 the fluid passes by the plunger 29 without causing further movement of the plunger so that no further compensation results. By varying the length of the plunger 29 and its cylinder to meet any particular needs the travel of the plunger can be limited to any desired extent.

Further adjustment for limiting the compensation may be attained by changing the position of the pivot 45. Varying the distance between the pivots 45 and 46 varies accordingly both the rate and the total amount of the compensation, which is often desirable. If changes are frequently made from substantially full load or substantially no load, or conversely, a slight amount of compensation only is desirable, as material excess motion of the valve is not possible. On the other hand, if the changes are large but are not substantially full-load changes, a large amount of compensation is desirable because the change in speed of the prime mover due to the load will be correspondingly large, and without a large amount of compensation, there will be an undesirable excess opening of the gate. To allow for such adjustment I have provided herein a plurality of pivot openings 53 in the outer end of the lever 5 so that the distance between pivots 45 and 46 may be varied to suit the special needs.

I have not described herein the action of the governor, and the anti-racing device when the load is decreasing. In that case the movement of all of the parts is in a direction opposite to that which follows an increase in the load, and the result is a partial closing of the gate.

Although I have described the structure herein shown with some particularity, it is to be understood that this is merely for the purpose of illustrating my invention, and that modifications in the structure may be made by those skilled in the art without departing from the scope of the invention.

I claim as my invention:

1. A speed regulator comprising means for controlling the speed of a prime mover, means for compensating for the time required for the speed of said prime mover to respond to a change of the gate thereof, means for automatically adapting said compensating means to varying loads on said prime mover, and means for limiting said compensation and said adaptation to a portion of the full movement of said speed-controlling means.

2. A speed regulator comprising means for controlling the speed of a prime mover, means for compensating for the time required for the speed to respond to a change of the gate of said prime mover, means for automatically adapting said compensating means to varying loads on said prime mover, and means for limiting said compensation to a portion of the full movement of said speed-controlling means.

3. A speed regulator comprising means, including fluid pressure mechanism, for controlling the speed of a prime mover, means for compensating for excess effect of said speed-controlling means, means for differentially compensating for varying loads on said prime mover, and means for limiting said differential compensation to a portion of the full movement of said speed-controlling means.

4. A speed regulator comprising means, including fluid pressure mechanism, for controlling the speed of a prime mover, means for compensating for excess effect of said speed-controlling means, and means for differentially compensating for varying loads on said prime mover, said latter means comprising a pivoted lever operatively connecting said compensating means and said mechanism.

5. A speed regulator comprising means, including fluid pressure mechanism, for controlling the speed of a prime mover, means for compensating for excess effect of said speed-controlling means, and means for differentially compensating for varying loads on said prime mover, said latter means comprising a pivoted lever, said lever being operatively connected to said compensating means, a sliding block, one arm of said lever passing through said block, said fluid pressure mechanism adapted to impart to said block rectilinear reciprocatory movement.

6. A speed regulator comprising speed-controlling means actuated by a prime mover, fluid pressure mechanism actuated by said means and adapted to control the operating valve of said prime mover, and means for differentially compensating for the effect of excess motion of said speed-controlling means according to the load on said prime mover, said compensating means comprising a fluid reservoir, two plungers

in said reservoir, one of said plungers limiting the movement of said speed-controlling means and being operated by the other plunger, the said other plunger being connected to said fluid pressure mechanism by means of a lever, and means for changing the length of both arms of said lever.

7. A speed regulator comprising means for controlling the speed of the prime mover, means for compensating for the time required for the speed to respond to a change of the gate of said prime mover, means for automatically adapting said compensating means to varying loads on said prime mover, and means for limiting said compensation and said adaptation to a portion of the full movement of said speed-controlling means, said limiting means comprising a fluid reservoir, a plunger in said reservoir, means for moving said plunger according to the movement of said speed-controlling means, and a second plunger in said reservoir operated by said first mentioned plunger during a portion only of the stroke of said first mentioned plunger.

8. A speed regulator comprising speed-controlling means actuated by a prime mover, fluid pressure mechanism actuated by said speed-controlling means and adapted to control the operating valve of said prime mover, means for differentially compensating for the time required for the speed of the prime mover to respond to a change of the valve according to the load on the prime mover, and means for limiting said compensation to a portion of the full movement of said speed-controlling means.

9. A speed regulator comprising speed-controlling means actuated by a prime mover, fluid pressure mechanism actuated by said speed-controlling means and adapted to control the operating valve of said prime mover, means for differentially compensating for the time required for the speed of the prime mover to respond to a change of the valve according to the load on said prime mover, and means for limiting said compensation to a portion of the full movement of said speed-controlling means, said compensating means comprising a fluid reservoir, a plunger in said reservoir, means for moving said plunger according to the movement of said speed-controlling means, a second plunger in said reservoir operated by said first mentioned plunger during a portion only of the stroke of said first mentioned plunger.

10. A speed regulator for controlling the speed of a prime mover comprising fluid pressure mechanism, said mechanism comprising a valve operated by said prime mover, a cylinder, a piston in said cylinder, a piston rod attached to said piston, a fluid reservoir, a plunger in said reservoir, a lever operatively connecting said plunger with

said piston rod, the connection between said lever and said rod comprising a slide block pivoted to said rod, said block having a slot therethrough, and one arm of said lever passing through said block, said piston adapted to impart rectilinear reciprocatory movement to said block.

11. A speed regulator comprising a governor adapted to be actuated by a prime mover and to control the speed of said prime mover, and means for varying the effect of said governor according to the load on said prime mover, comprising a sliding block having rectilinear movement, and a lever reciprocated by said block.

12. A speed regulator comprising a governor adapted to be actuated by a prime mover, and to control the speed of said prime mover, means for compensating for excess effect of said governor, and means for limiting said compensation to a portion of the full movement of said governor.

13. A speed regulator for a prime-mover, consisting of a speed governor driven by the prime-mover, power means controlled by the speed governor for operating the gate of the prime-mover, compensating means for limiting the movement of the gate, and means for dissipating the compensating effect, said means consisting of a single spring arranged to be compressed or extended by said compensating means.

14. A speed regulator, consisting of a speed governor, a cylinder, a piston and a liquid in said cylinder, means including a

resilient member operatively connecting said piston to said governor, and means operating synchronously with the gate of the prime-mover operatively connected with said piston.

15. A speed regulator, consisting of a speed governor, a cylinder, a piston and a liquid in said cylinder, said piston being operatively connected to the speed governor in part by means operating synchronously with the gate of the prime-mover, and a second piston in said cylinder operatively connected by a spring with said governor.

16. A speed regulator comprising a speed governor, a lever, said governor being adapted to be operatively connected with the gate of a prime-mover by means including said lever, a cylinder, a piston and a liquid in said cylinder, said piston being operatively connected to the speed governor in part by means operating synchronously with the gate of the prime-mover, a second piston in said cylinder, a piston rod having one end fixed to said second piston, a coil spring having one end fixed to the other end of said rod, the other end of said spring being fixed to said lever.

In witness whereof I have hereunto affixed my signature in the presence of two witnesses.

ELMER E. WOODWARD.

Witnesses:

ROBERT J. KELLY,  
GEORGE SORESENSEN.