March 18, 1941. F. HENNIG ET AL 2,235,481

SPEED GOVERNOR

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Fig. 1.

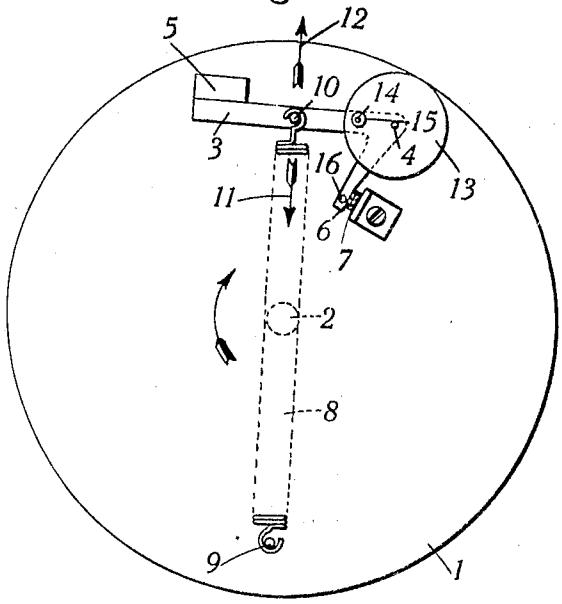


Fig. 2.

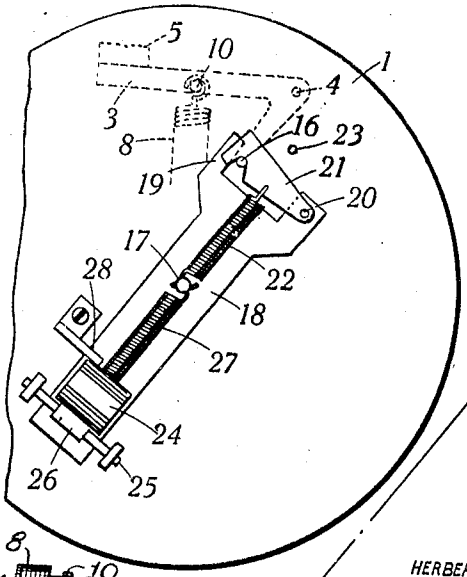
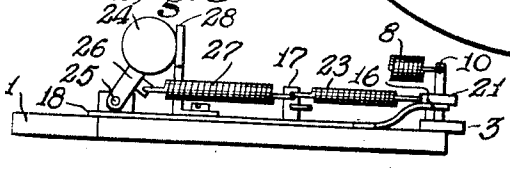


Fig. 3



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SPEED GOVERNOR

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6 Claims. (Cl. 200—80)

The present invention relates to rotary speed governors of the type which operate an electric contact in response to rotation above a predetermined speed by virtue of the centrifugal force exerted by a rotating mass; and particularly the present invention relates to such governors wherein the contacts to be controlled also rotate with the governors.

Known governors of this type have the disadvantage that the critical rotary speed at which the governor acts to operate its contact varies during the life of the governor as a result of the wearing away of the contact. Such wearing away causes the following three changes: (1) The normal position of the governor parts (assumed when the rotary speed is below the critical value so that the contact arms rest against the contact) is altered by the wearing away of the contact so that the corresponding normal length of the spring is decreased, thus resulting in a decreased initial tension of the spring; (2) the same alteration of the normal position of the governor parts also varies the displacement of the center of gravity of the centrifugal mass with respect to the center of rotation, thus correspondingly varying the initial centrifugal force which is exerted by the mass at the critical speed of rotation desired; (3) the mass of the centrifugal weight itself is varied by the dissipation of material from the movable contact, thus further varying the centrifugal force produced at the desired critical speed.

In accordance with the present invention the detrimental influences of the alterations above listed as (1) and (2) are avoided by designing the spring which opposes the centrifugal action of the mass so that at the desired critical speed the centrifugal force of the rotating mass is in balance with the force of the spring not only at one possible equilibrium position, but also in every position within the range of motion of the centrifugal weight which operates the contacts.

In previously known governors the restraining spring has generally been so designed that the rate of increase of spring force with respect to change in the radius of gyration of the mass (i. e. with respect to outward displacement of the mass away from the center of rotation) was considerably greater than the corresponding increase of centrifugal force of the rotating mass with respect to such change in the radius of gyration.

The result is that in a governor of the known type the balance between spring force and centrifugal force at any given speed will only exist for one particular position of the centrifugal mass. For other possible positions of the centrifugal mass the spring force and centrifugal force will only be balanced if the speed is altered to a corresponding new value. Therefore, in such governors when the normal position of the parts is shifted by wearing away of the contacts, the resulting decrease of the normal or initial spring tension will be much greater than the corresponding decrease in normal or initial centrifugal force resulting from the same change of position of the parts. Therefore when the governor is in normal or initial position the spring force and centrifugal force will no longer be in balance with each other in the new position of the parts determined by the wearing away of the contacts with respect to the same predetermined critical speed for which the governor was originally designed, but rather the balance between the spring force and the centrifugal force will in the new position of the parts be reached at a lower rotary speed. Such governors, therefore, have the disadvantage that they require readjustment to the desired rotary speed at comparatively frequent intervals.

The above analysis of the prior art type of governors can be more clearly explained by the aid of a somewhat exaggerated arbitrary numerical example. Assume that in a prior art governor a centrifugal mass normally lies one inch from the center of rotation of the governor, being pulled inwardly by the governor spring and being determined in its position by the abutting of the contact which also serves as a front stop. Assume further that a conventional backstop is provided to limit the outward movement of the mass so that its extreme outward position is one and one-quarter inches from the center of rotation of the governor. If the governor is designed for operation at a given rotational speed, for example, 200 R. P. M., then the spring would conventionally be given an initial tension just sufficient to balance the outward centrifugal pull of the rotating mass when this mass was rotating at a speed of 200 R. P. M. in a circle of one inch radius. The stiffness of the spring (i. e. its rate of increase in force with extension in length) would, however, ordinarily be so chosen that when the governor mass was moved out to its backstop the tension exerted by the spring would be increased not twenty-five percent but a good deal more than twenty-five percent. Thus if the centrifugal weight were moved outward to its backstop position one and one-quarter inches from the center of rotation of the governor, the centrifugal force at 200 R. P. M. would be twenty-five percent

greater than the normal value of centrifugal force because of the twenty-five percent increase in the radius of gyration of this mass, but the increase in tension of the spring would be a great deal more than twenty-five percent so that under these conditions the inward force of the spring would be a great deal larger than the outward force of the mass and the weight would not be in balance but would tend to move inward. This would mean that in order to bring the spring force and centrifugal force into balance at the backstop position of the governor a considerably higher rotary speed would be necessary than the 200 R. P. M. rotary speed which was necessary for balance when the parts were in normal position.

In converse manner, if the contact point which serves as the front stop of such a governor should be burnt away so that in its normal position the centrifugal mass lay only seven-eighths of an inch from the center of rotation of the governor rather than one inch therefrom, the corresponding reduction of centrifugal force for the given desired speed of 200 R. P. M. would be nowhere near as great as the accompanying reduction in spring tension resulting from such corresponding inward displacement of the governor arm. Thus in its new position the centrifugal mass which would now have a radius of gyration of seven-eighths of an inch instead of one inch would have a reduction in centrifugal force of about one-eighth or twelve percent. The spring, however, whose rate of change of force with respect to a displacement of the governor arm is much greater, would be reduced in tension by a great deal more than twelve percent. Therefore, in this new position of the governor, which would result from a wearing away of the contact, the spring tension and the centrifugal force would no longer be in balance with one another at the desired rotational speed of 200 R. P. M. but would rather be in balance with one another at some new and lower speed.

It is thus clear that the conventional type of governor (in which the increase of spring tension for a given movement of the governor arm greatly exceeds the corresponding increase of centrifugal force resulting from the same given movement) inherently results in an alteration of the critical speed at which the governor will act, such alteration being caused by the wearing away of the contacts and the consequent change in the normal position of the governor arm.

In accordance with the present invention, however, the spring which opposes the centrifugal force is chosen in accordance with well known principles so that at the desired operating speed of the governor the force of the spring and the centrifugal force of the rotating mass will be in balance not only in one of the possible positions of the mass but rather universally in all possible positions within the range of outward movement of the mass. The result of this relationship between the spring and the centrifugally acting mass of the governor, is that the critical rotary speed at which the centrifugal force becomes just equal to the spring force so as to cause operation of the contacts remains constant even when the normal position of the parts is altered by the wearing away of the contact, so as to change the initial radius of gyration of the centrifugal weight and simultaneously change the initial tension of the spring.

Although it is preferred to dimension the spring with respect to the centrifugal governor arm so as to give an indeterminate balance or balance in any position within the range as above described, it may in some cases be impossible or impracticable by reason of constructional limitations, to dimension the spring exactly in accordance with such principles. In such cases the arm carrying the contact should be arranged to have the largest possible movement for a given movement of the governor arm because with such design the displacement of the normal position of the governor arm is minimized for a given amount of wearing away of the contact.

In accordance with a further feature of my invention, the detrimental influence caused by the alteration listed under (3) above, namely, the variation of the mass of the centrifugal member by dissipation of material from the movable contact point, is avoided by positioning the movable contact so that its centrifugal force is zero or at least produces no components in the direction of the spring force. The movable contact can, for example, be arranged in the plane determined by the main axis of rotation of the governor and the pivot of the governor arm. An alteration of the contact mass by the dissipation of material will therefore exercise no influence on the speed of rotation at which the governor operates.

It is further advantageous to dispose the spring so that its force acts either at the center of gravity of the governor arm or close to such center of gravity, since such an arrangement relieves the bearing of the governor arm of pressure during operation and thus avoids wear of this bearing.

When the spring is designed as above set forth, with respect to the centrifugally acting governor mass, this mass will be in a state of indeterminate balance whenever the governor is rotated at its critical speed, i. e. the mass will be capable of remaining in equilibrium in any possible position within its range of movement, and as a result of this indeterminateness of position it is possible that, under certain operating conditions when there is low rotational speed, small moments of inertia of the governor levers, or intermittent loading of the governed equipment, an irregular operation of the governor may be produced as a result of the considerable freedom of movement of the centrifugal weight.

The freedom of movement of the centrifugal weight can, in accordance with another feature of my invention, be decreased to a very small value by means of an inertia member mounted for free rotation and so associated with the centrifugal mass of the governor that the inertia member is moved together with the centrifugal mass when the movement of the latter exceeds a certain amount.

The use of a conventional fixed backstop for limiting the range of movement of the centrifugal mass has the disadvantage that as the contact is burned away the range of movement of the governor is increased and this in turn alters the rotary speed controlled by the governor. Such alteration of the controlled rotary speed can be compensated by modifying the design of the spring to give a relation differing from the indeterminate balance relation above described.

A further disadvantage of a fixed backstop is that as the freedom of movement of the governor arm increases with wearing away of the contact the irregularity of operation is increased even aside from any alteration in mean speed.

In accordance with my invention both the alteration of mean speed and the alteration of irregularity of operation which result from the use

of a fixed backstop are eliminated by a device which comes into operation every time the apparatus is stopped and which automatically adjusts the backstop so that the freedom of movement of the governor arm has a constant fixed value.

The structure of our invention may best be understood from the following description together with the drawing in which Fig. 1 is a plan view of the governor arrangement in accordance with an embodiment of the invention without the provision of the impact stop; Fig. 2 is a plan view of a novel backstop for use with a centrifugal governor in accordance with my invention the major part of the contact apparatus being removed for clearness; and Fig. 3 is an elevation of the novel stop mechanism viewed from the direction indicated by the line 3—3 of Fig. 2.

The centrifugal force contact governor of the present invention fundamentally consists of a support disc 1, which is fastened to shaft 2 which is to be regulated. The governor lever 3 is formed as a bell-crank pivoted at the pivot 4 and one arm thereof carries the centrifugal weight 5, the movable contact 6 being arranged on the other arm. The spring 8 is fastened at one end to the point 9 on the governor plate and at its other end to the point 10 of the contact lever 3, so as to oppose the centrifugal force of the contact lever. Arrows 11 and 12 indicate the direction of the spring force and the centrifugal force. The spring 8 is so chosen as to strength, that under the intended operating conditions the torque of the centrifugal force is equal to the torque of the spring force for every position of the governor lever 3. The governor accordingly operates in a state of indeterminant balance, that is, it is in balance regardless of its position so that even upon an alteration in the position of the governor lever 3 produced by wear in contacts 6 and 7 the condition of balance is maintained at the same operating speed. It is advantageous that spring 8 should be fastened to the centre of gravity of the governor lever 3. The contact 7 is fixed on to the plate 1 in such a position that when the contact closes the movable contact 6 lies in the plane defined by the axis 2 and the pivot 4 of the contact lever which is to be regulated. This arrangement ensures that an alteration in the mass of the governor lever by wear in the contact carried thereby cannot influence the operation, as the centrifugal force of the moved contact operates in line with the rotating pivot 4. The mass of the contact 6, therefore, has no effect upon the adjusting force actuating the governor lever 3. The inertia member which may under certain circumstances be necessary to limit the play is formed by a plate 13 which is loosely mounted on the governor lever pivot 4 and has a hole 15. The clutch pin 14 which is mounted on the governor lever 3 and has a smaller diameter than the hole 15, engages this hole. Thus a limited relative movement, determined by the diameter of the hole 15 and the pin 14, between lever 3 and mass 13 is permitted.

Fig. 2 illustrates an embodiment of the self-adjusting backstop of my invention. For purposes of clearness, the remaining components of the governor which are shown in Fig. 1 are only partly indicated here. The new added components should be considered as placed on a different plane so as not to interfere with the contact lever movement. The plate 18 is rotatably pivoted on pin 17, and with its lobe 19, forms the backstop, being arranged to engage the impact pin 16, which is mounted on the governor lever 3. The plate 18 has mounted on it the lever 21 which pivots on the axis 20 and has its V-shaped notch pressed against the impact pin 16 by spring 22. The V-shaped notch rotates plate 18 to a position determined by pin 16 and spring 22. In this way the same desired spacing between impact pin 16 and stop lug 19 is produced at all times. This is necessary in order to obtain a constant contact play. Upon rotation of the governor, the lever 21 is thrown outward by centrifugal force, against the action of spring 22, and lies against pin 23. In this way the impact pin 16 of the governor lever is released and can move as far as the impact stop 19. In order to fix the position of the plate 18 during operation, the centrifugal weight 24 is provided, which when pressed outwards by the centrifugal force, rotates around its pivot 25 fastened to the governor base plate 1. By means of the centrifugal weight 24, and more specifically by the camming action of the lower end of its lever 26, plate 18 is clamped on to the base plate 1. When the motor stands still, the centrifugal weight 24 is retracted by the spring 27 against the impact 28, and thereby the plate 18 is released again and may take a position determined by pin 16. The springs 22 and 27 and the mass of levers 21 and 24, are so proportioned that a locking of the impact stop 19 by the centrifugal weight 24 occurs at a low rate of rotation. The release of the impact pin 16 by the lever 21 occurs at a higher speed of rotation than is necessary to operate centrifugal weight 24, but before the operating speed is reached.

In Fig. 3 plate 18 is shown, together with spring 27 and the centrifugal weight 24 in side view, in order to make the operation of the centrifugal weight 24 clearer and to show the mode of locking.

What is claimed is:

1. A centrifugal force contact governor for performing a switching operation at a given critical speed comprising a rotatable member, a weight mounted on said member for movement over a working range of motion by centrifugal force, a spring operatively connected with said weight opposing said centrifugal force, said spring being so dimensioned with respect to the mass of said weight and the mechanical advantage of said operative connection that a balance between the centrifugal force and the spring force is established at said critical speed substantially independently of the position within said range of movement of said centrifugal weight, and a contact means controlled by movement of said centrifugal weight within said range of movement to perform a switching operation at said critical speed.

2. A centrifugal force contact governor in accordance with claim 1, further comprising an arm upon one end of which said weight is mounted pivoted to said rotatable member, said contact means being mounted on said arm on the end thereof, and an inertia member mounted on said pivot, and provided with stop means to limit the movement of said arm.

3. A centrifugal force contact governor in accordance with claim 1, further comprising stop means for limiting said range of movement of said weight, and adjusting means being operative upon cessation of rotation of said member for adjusting the position of said stop means relative to the at rest position of said weight.

4. A centrifugal force contact governor in accordance with claim 1, further comprising a lever

upon one end of which said weight is mounted pivoted to said rotatable member, said contacts being mounted on said arm on the other end thereof, the length of the end of said arm upon which said contacts are mounted relative to that upon which said weight is mounted being such that only a slight alteration of the position of said weight results upon wearing away of said contacts.

5. A centrifugal force contact governor in accordance with claim 1, further comprising a lever upon one end of which said weight is mounted pivoted to said rotatable member, said contacts being mounted on said arm on the other end thereof, said spring being connected to said lever at the center of gravity of said lever.

6. A centrifugal force contact governor for performing a switching operation at a given critical speed comprising a support member mounted for rotation about an axis of rotation, a lever pivoted on said member for rocking about a pivot axis, a weight fixed to said lever for movement over a working range of motion by centrifugal force, a spring operatively connected with said lever opposing said centrifugal force, said spring being so dimensioned with respect to the mass of said weight and the mechanical advantage of said operative connection that a balance between the centrifugal force and the spring force is established at said critical speed substantially independently of the position within said range of movement of said centrifugal weight, a contact carried by said rotatable member, and a further movable contact cooperating with said first contact and movable with respect thereto in response to rocking of said lever resulting from movement of said weight within said range of movement, said movable contact being positioned substantially in line with said two axes whereby the centrifugal force of said movable contact produces substantially no component of force tending to rock said lever.

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