Jan. 1, 1946. H. R. RICARDO 2,392,265

CENTRIFUGAL GOVERNOR

Filed Feb. 23, 1943 2 Sheets-Sheet 1

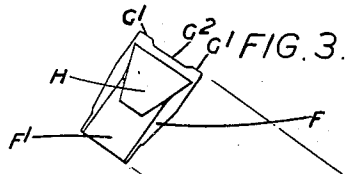


FIG. 3.

FIG. 1.

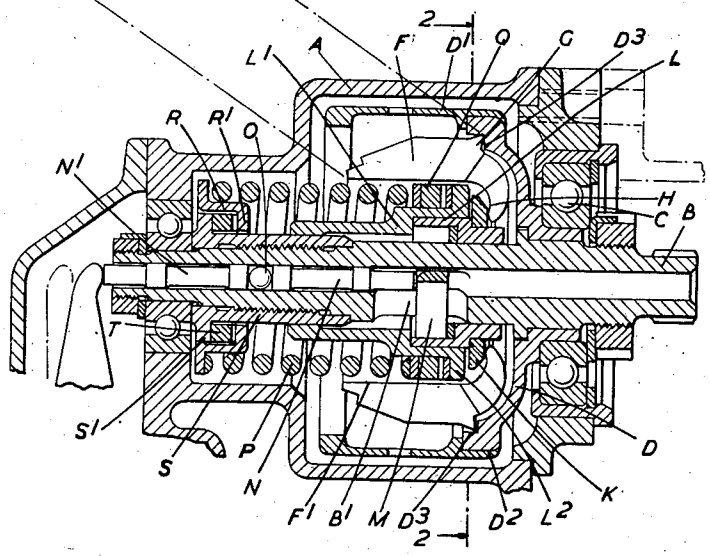
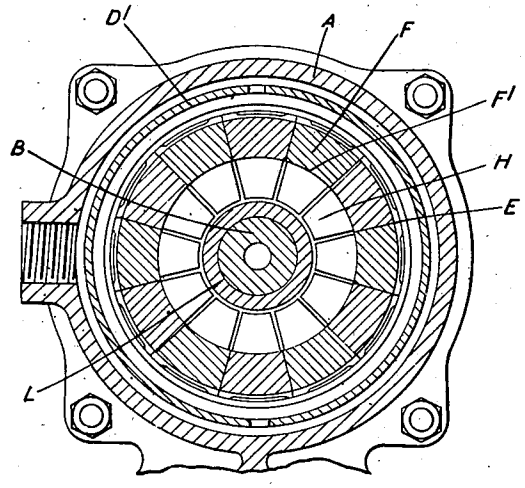


FIG 2



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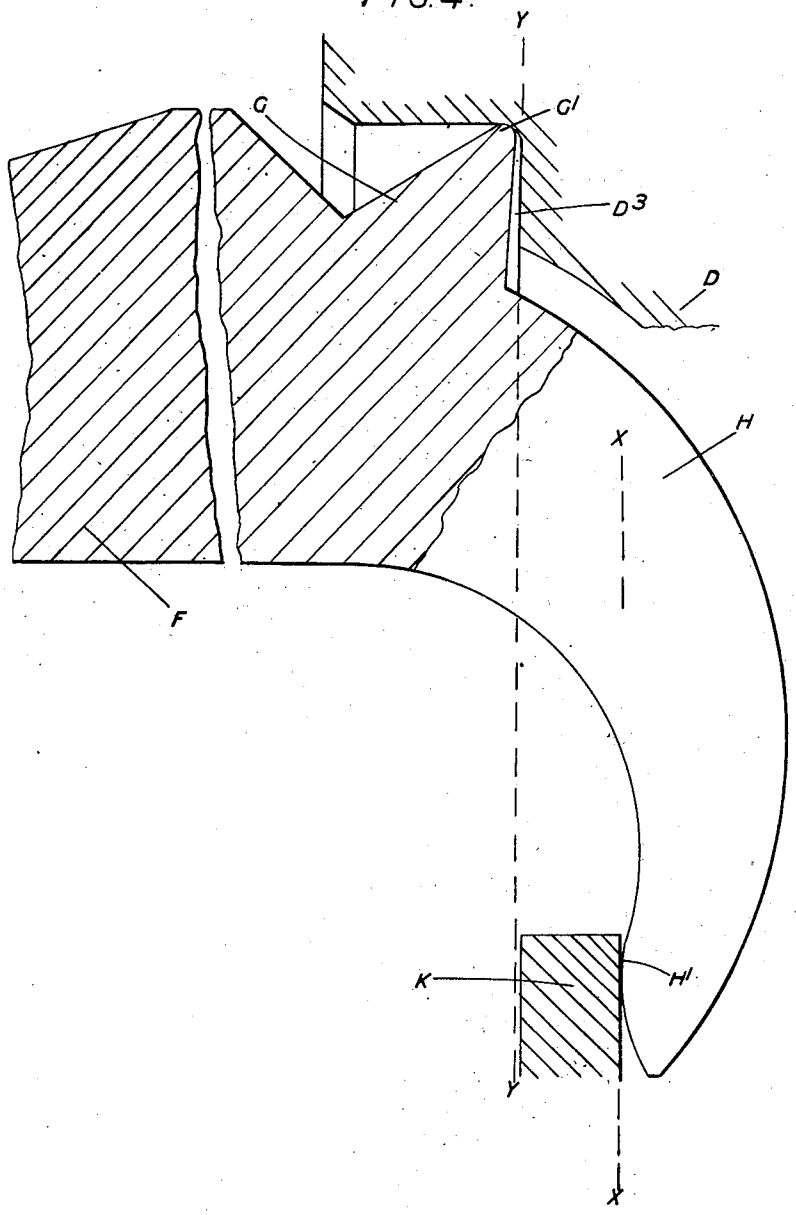
Attorneys

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FIG. 4.



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UNITED STATES PATENT OFFICE

2,392,265

CENTRIFUGAL GOVERNOR

Harry Ralph Ricardo, London, England

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In Great Britain September 17, 1941

2 Claims. (Cl. 264—15)

This invention relates to centrifugal governors of the spring-loaded type adapted for use at high speeds and has for its object to provide a construction and method of manufacture which will ensure that the geometrical relation between the centre of gravity, the fulcrum point and the point of application of the spring load shall be identical in all the centrifugal weights comprised in a single governor so that complete dynamic balance may exist in all attitudes of the governor. A further object is to produce a governor which for a given overall diameter shall have a maximum of active centrifugal weight.

According to this invention the weights of the governor are constituted by a series of similar segments formed by making radial cuts through a body which has been shaped by turning. In the method employed for making these weights a body is turned with a substantially cylindrical part and an inturned end and the whole of this body is divided into equal segments by radial cuts each of these segments constituting a weight and all these segments being used in the one governor and being equally and simultaneously operative on a single spring-loaded part of the governor. The fulcrum about which each weight turns is a knife edge formed by a part of an annular rib projecting on the exterior of the turned body which is cut into the segments which make the individual weights. When the governor is at rest the weights are nested all round the governor spindle as an annulus each separate weight being a segment of the turned body and the fulcrum of each weight being an external projection forming a knife edge which bears on an annular surface on a rotating part of the governor all the weights being equally and simultaneously operative on one and the same spring-loaded part. In the construction there is combined with a cup-shaped member mounted on and rotatable with the governor spindle, a part acted on by a spring against the pressure of which this part can be moved relatively to the spindle, and a series of similar weights constituted by all the segments into which an annular turned body has been divided by spaced radial cuts, every weight having a knife-edge fulcrum about which it turns on a common annular surface formed within the cup-shaped member, while a part of every segmental weight bears against and as it moves acts on an annular surface on the spring-loaded member. Since the weights merely bear and move on the two surfaces with which they are in contact, namely on the one hand the annular ledge on which the knife edges rest and turn and on the other hand the spring-loaded surface, it will be apparent that there is no positive connection or circumferential abutment between the driving spindle and the weights. Thus the drive is transmitted frictionally through these contacts which are made respectively at the fulcrum and the toe of each weight and the weights are consequently free to move circumferentially with respect to the driving spindle when rapid changes occur in the driving speed.

The accompanying drawings illustrate by way of example a construction according to this invention. In these drawings,

Figure 1 is a longitudinal sectional elevation of the improved centrifugal governor.

Figure 2 is a transverse section on the line 2—2 in Figure 1 looking in the direction of the arrows.

Figure 3 is a projected view of one of the weights as looked at from a point on the axis of the governor situated towards the right-hand side of Figure 1.

Figure 4 shows in elevation and on a much enlarged scale one of the weights and in section the annular ledge on which rests and turns the fulcrum of the weight.

Within a stationary casing A the governor spindle B is mounted in bearings C and is driven in such a manner as may be convenient by the engine or other mechanism which is to be controlled by the governor. On the spindle B, which is hollow, is fixed a cup-shaped member which may be described as having two parts of which one D is a cupped end portion, the inner part of which is connected to the spindle, and a cylindrical portion D^1 suitably attached at D^2 to the margin of the cupped part. This whole cup-shaped member D, D^1 rotates within and clear of the outer casing and encloses the weights. By making this cup-shaped member in two parts it is possible for the end portion D to be made of a material capable of being hardened after machining. Within this part D and near its periphery there is turned a shoulder or ledge D^3 on which rest the knife edges of the fulcra of all the weights. These weights are made by radial cuts E (see Figure 2) through an annular body which has been shaped by turning so that it has a part F which is substantially cylindrical within as at F^1, has a convenient formation externally with a single projecting rib G, and at one end has an inturned part H. Each individual weight, which has the appearance of a longitudinal section through one side of the whole turned body, has

somewhat the shape of the letter J, as can be seen in Figures 1 and 4, but with a projection, formed by the annular external rib G on the turned body, constituting a knife edge fulcrum G^1 situated at about the commencement of the curve of the J, while the straight part of that letter constitutes the operative weighted portion F and the toe, which is at the end of the curved part H, is adapted to act on the spring-loaded part of the governor. It is important that as each weight swings about its fulcrum the toe of the part H shall tend to roll rather than slide on the face of the spring-loaded hardened washer K. To attain this it is necessary to suitably determine the relative positions of the planes, normal to the axis of the governor, in which lie respectively the fulcra of all the weights and the points of contact between the toes of the weights and the washer K. The arrangement in the example illustrated is such that at or about the mid-point of the outward swinging movement of the weights from their inmost or static position the plane in which lie the toe contacts will approximately coincide with the plane in which lie the fulcra G^1 of the weights.

The hardened washer K on which bear the toes of the parts H of the weights, is carried by a two-part sleeve adapted to slide on the governor spindle B. One portion L of this sleeve fits within the other part L^1 and in the spindle is a slot B^1 which extends diametrically across and through it so as to allow a key M to pass across the axis of the spindle B and slide within the latter. The ends of this key M are engaged by the two concentric parts L, L^1 of the sliding sleeve. Within the hollow governor spindle B lies a rod the one end of which rests against this key M. Conveniently this rod is built up of two coaxial portions N, N^1 which are separated by a ball, the arrangement serving to prevent the rod from binding owing to possible distortions of the hollow governor spindle. The arrangement is such that as the two-part sleeve L, L^1 is caused to slide on the spindle B by the centrifugal action of the weights F the key M which passes through the spindle will cause the rod N, N^1 within it to slide similarly.

A coiled spring P is supported at one end on an enlargement at the end of which is a flange L^2 formed on the one outer part L^1 of the sliding sleeve, and between the last coil of the spring and this flange is a gimbal or rocking washer Q which provides a universal bearing for the end of the spring. At its other end the spring P is engaged by a collar R which is loosely carried on a sleeve S screwed on to the governor spindle B this sleeve having an external flange S^1 between which and an inturned flange R^1 of the collar R is a gimbal or rocking washer T. The initial compression of the spring is given by screwing the sleeve S on to the governor spindle B.

It will be seen that when the spindle B is rotated beyond a certain speed the centrifugal force acting on the ring of weights F will cause every one of them to pivot about its knife-edge fulcrum G^1 thus causing the inwardly directed parts H of the weights to impart sliding movement along the spindle to the sleeve L, L^1 on which acts the spring P. As this sleeve L, L^1 is thus moved its moves correspondingly the rod N, N^1 within the spindle B and the end of this rod which projects beyond the end of the spindle imparts movement to the control mechanism of the engine or machine with which the governor is associated. When the speed of rotation reaches a certain value the weights F turn about their knife-edges G^1 until they rest against the inside of the cylindrical portion D^1 of the cup-shaped member which thus prevents any further movement of the weights in an outward direction. It will be understood that when the governor is at rest the spring P tilts all the weights inwards and causes the centre of gravity of the weights to approach the axis of the governor until the sides of the nested weights come into contact with one another.

By employing the method of manufacturing these weights in accordance with the present invention all the weights of a particular governor will be identical. In this method of manufacture there is first formed by turning operations a hollow cylindrical body with an inturned end portion. This body is so shaped in the process of turning that a section through it in a plane containing its axis of symmetry will be identical with the contour of each and all of the finished governor weights. The body is then divided into equal segments by two successive milling operations under the control of a dividing headstock. In one method of carrying out these milling operations the turned partly cylindrical body is held on a suitably formed stump carried by the dividing headstock and the body is divided into segments by means of the thin milling cutter. The extent of the cuts in this operation is limited to dividing the cylindrical part of the body into segments leaving the inturned end portion untouched. Next a clamping ring is placed over the divided portion of the body and the inturned part is divided at the same indexing positions as before, but using a thicker milling cutter. The effect of the second milling operation is to complete the division of the body into segments and by the use of a thicker cutter the width of the inturned portions of the segments is caused to be less than that of the portions of the segments formed from the cylindrical part of the body. These narrower portions form the projecting arms H of which the toes bear on the washer K and through it on the part L, L^1 on which acts the governor spring P. It is to be noted that the turned body is formed with a somewhat larger diameter than the actual diameter of the annulus formed by the segments when nested together, since when the body is divided into these segments owing to the material removed by the radial milling cuts, the segments approach the governor axis when their side faces are in contact.

As each segment is cut from the body it has on what may be called its back a portion G of the projecting rib which is provided by the turning operations on the body. At first this rib extends all across the width of a segment, but by a milling operation the centre portion of this rib is removed as at G^2 (see Figure 3) so as to leave two projecting parts G^1 adjacent to the side edges of the segment these parts forming a pair of knife-edges on which the weight can turn. These projecting parts G^1 are then hardened as also are the rounded ends of the inwardly projecting parts or toes H of the weights. The annular ledge D^3 on which the knife-edges rest is also hardened. The cutting away of the intermediate portion of the rib on the back of each segment may be carried out while the body is in the milling machine under the control of the indexing head and before the division of the body into segments. If there should happen to be slight discrepancies in the amount of material between

each pair of knife-edges G these discrepancies will have very little effect on the position of the centre of gravity of the weight.

In Figure 4 there is shown on a much enlarged scale one of the weights so that there may be seen clearly its detail formation and the relative positioning of its parts. In the first place it may be noted that the fulcrum G^1 constituted by the apex of the rib G is rounded and rests in the angle D^4 of the ledge or shoulder D^3 formed in the part D. This part D^4 is given a curvature the radius of which is larger than the radius of curvature of the fulcrum G^1. This ensures free rolling of the fulcrum on the part on which it rests. With respect to the position of the toe H^1 of the part H in relation to the fulcrum, Figure 4 shows the weight in its inmost and static position and in this position the plane X—X, which is normal to the axis of the governor and contains the point of contact between the toe H^1 and the spring-loaded washer K, lies appreciably to one side of the plane Y—Y, also normal to the governor axis, in which lies the fulcrum G^1. The distance between these planes X—X and Y—Y is such that at or about the mid-point of the range of movement of the weight F the plane X—X will substantially coincide with the plane Y—Y. This ensures a reduction in the amount of sliding between the toe H^1 and the face of the hardened washer K in the middle part of the distance through which the weight can move, and it is preferably arranged that this shall be the condition existent at the normal speed at which the governor is used.

As the weights only rest within the restraining cup-shaped member D and have no positive connection with it and there is no circumferential abutment against which the weights can bear, it will be apparent that the drive is transmitted by the frictional load on the fulcra G^1 and on the toes H^1. Under all normal accelerations and decelerations this friction is sufficient to avoid any slipping of the weights relatively to the parts which are positively driven, but if the governor is subjected to violent or rapid speed changes, as for instance if the engine is passing through a period of torsional vibration, then the weights can slip round in the cup member D. In this way the driving shaft of the governor and any accompanying gearing will be relieved of heavy inertia loading. If the governor is fitted to an engine having a pronounced cyclic speed variation, the weights may creep round possibly first one way and then the other in the cup member D, and if this action takes place it will tend to have a beneficial effect in distributing wear on the ledge D^3 on which the fulcra rest.

It will be apparent that by employing this method for the production of the weights it is possible to ensure that they will all be identical not only as regards mass, but also as to the geometrical relation of the centre of gravity, the fulcrum point, and the point of application of the spring force. As a consequence of this complete identity between the weights a governor constructed as above described may be run at high speeds with complete freedom from vibration. Further, owing to the nature of the weight construction a large amount of active mass can be provided for the governor in a given space.

The detail shape of the weights, that is to say the initial shape given in the turning process to the body from which the weights are formed may vary.

What I claim as my invention and desire to secure by Letters Patent is:

1. A weight assembly for use in centrifugal governors, said assembly including an annular support member having an internal surface formed as a surface of revolution, and a plurality of weights assembled within said support member in equi-spaced relation about the axis of said surface, each of said weights being formed to provide a fulcrum, bearing on said surface, on which the weight may independently rock in a plane containing the axis of said surface, the adjoining faces of said weights being formed as plane surfaces defining a plurality of planes radial to the said axis, whereby said weights may partake of circumferential movement with respect to said support member on the occurrence of rapid speed changes, said faces engaging to limit relative circumferential movement of said weights.

2. A weight assembly for use in centrifugal governors, said assembly including an annular support member having a surface formed as a surface of revolution, and a plurality of weights assembled with said support member in equi-spaced relation about the axis of said surface, each of said weights being formed to provide a fulcrum, bearing on said surface, on which the weight may independently rock in a plane containing the axis of said surface, the adjoining faces of said weights being formed as plane surfaces defining a plurality of planes radial to the said axis, whereby relative circumferential movement of said weights and said support is only frictionally resisted, said faces engaging to limit relative circumferential movement of said weights.

HARRY RALPH RICARDO.