No. 621,871. Patented Mar. 28, 1899.

M. TOLLE.

ASTATIC CENTRIFUGAL GOVERNOR.

(Application filed Aug. 23, 1897.)

(No Model.)

FIG. 1.

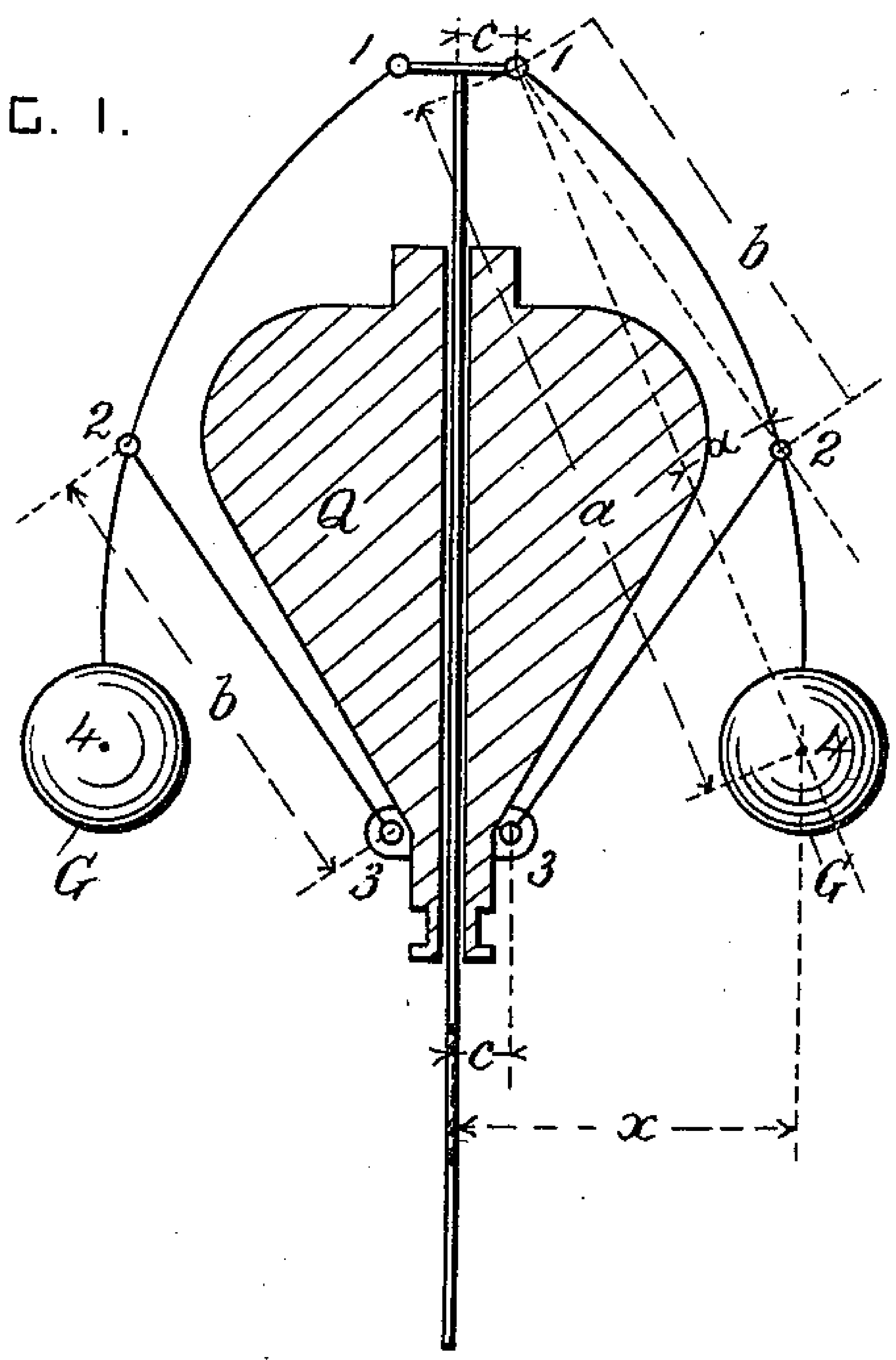


FIG. 2.

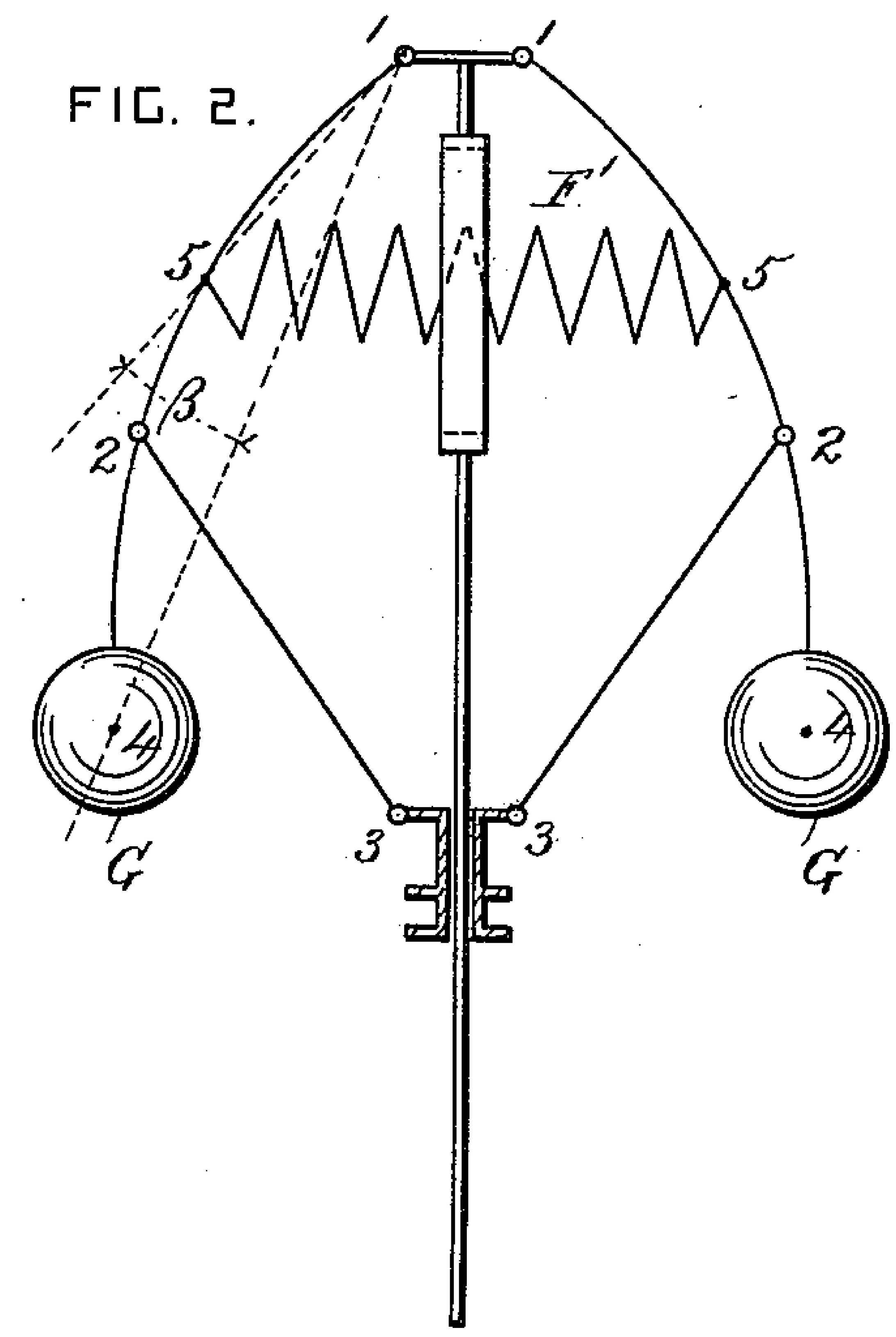


FIG. 4.

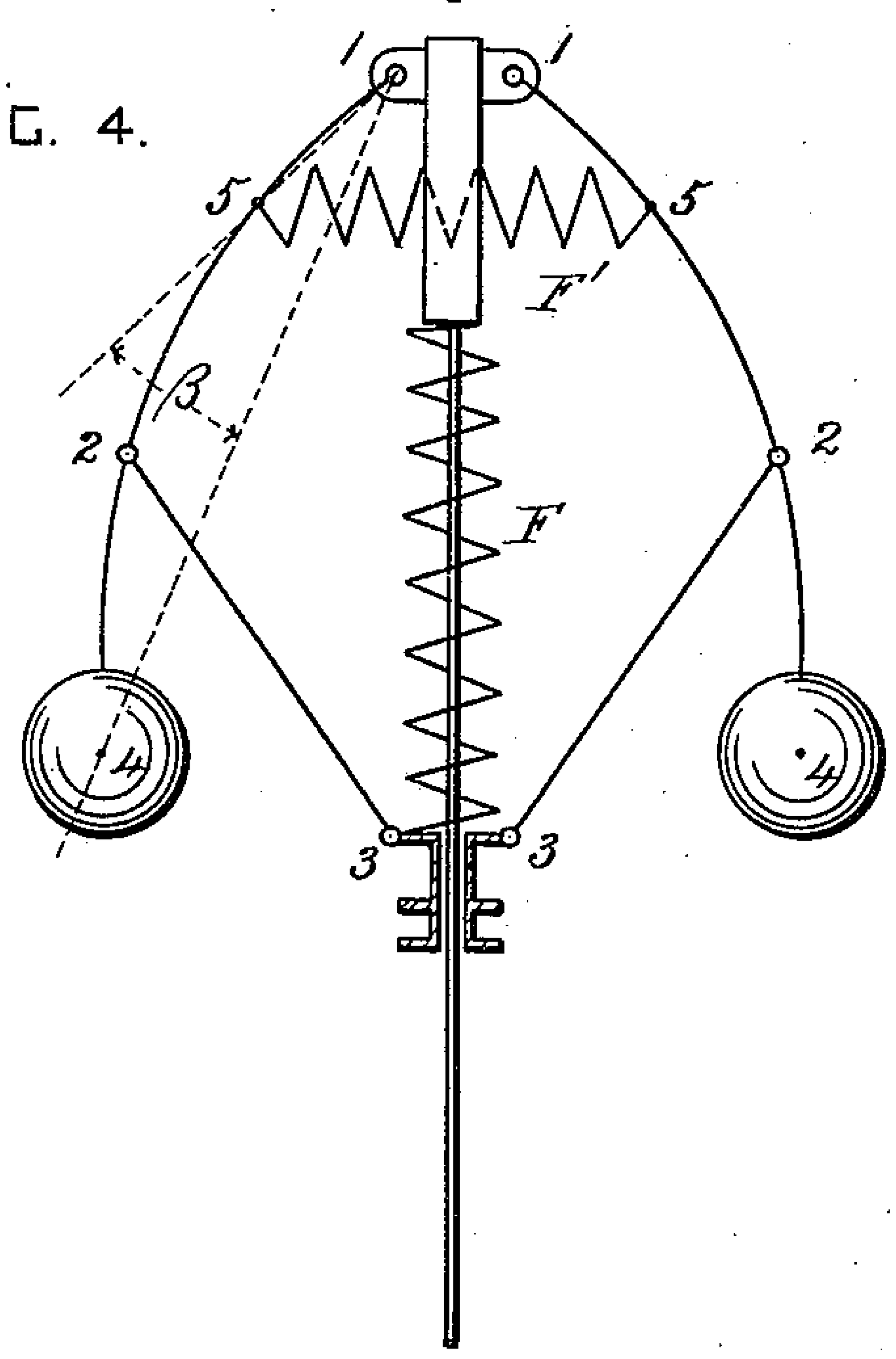
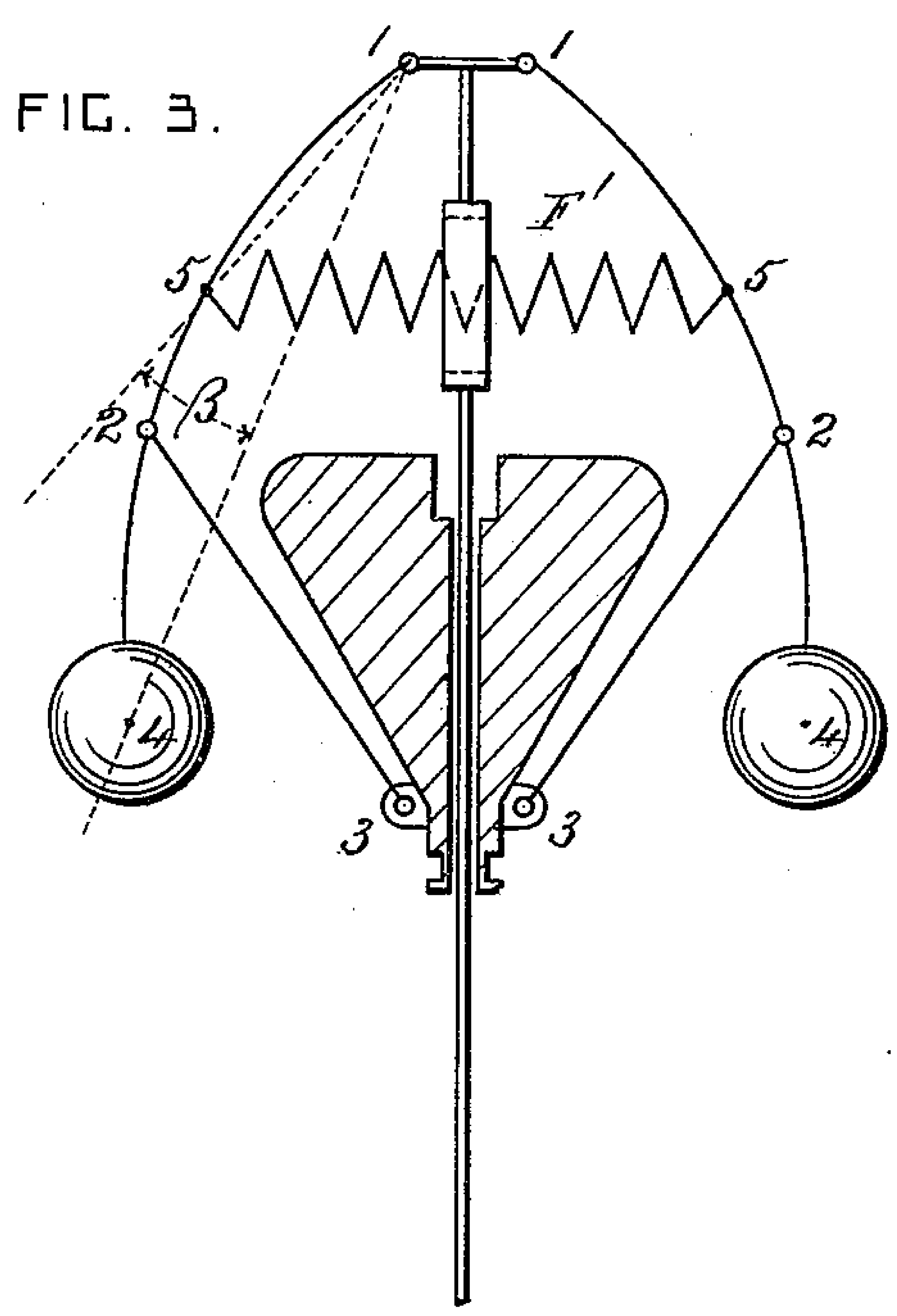


FIG. 3.



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ASTATIC CENTRIFUGAL GOVERNOR.

SPECIFICATION forming part of Letters Patent No. 621,871, dated March 28, 1899.

Application filed August 23, 1897. Serial No. 649,275. (No model.)

To all whom it may concern:

Be it known that I, MAX TOLLE, a subject of the King of Prussia and Emperor of Germany, residing at Cologne-on-the-Rhine, Prussia, Germany, have invented certain new and useful Improvements in Astatic Centrifugal Governors Adjustable for any Number of Revolutions; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

This invention relates to speed-governors; and it consists in the novel construction and combination of the parts hereinafter fully described and claimed.

In the drawings, Figures 1, 2, 3, and 4 are diagrams showing side views of different forms of the governor.

The centrifugal force of revolving masses is balanced in centrifugal governors either only by the weight G of the masses or also by the weight Q of a sleeve or by a spring F. Let us call C_g the portion of centrifugal force balanced by the balls G G, C_f the portion balanced by F, and C_q that balanced by Q. For the efficient working of the governor not only must the whole centrifugal force C change with the increase of the distance x of the balls from the spindle in such a manner as to bring about the astatic state or as nearly an astatic state as possible, but the separate parts C_g, C_q, and C_f must increase in a certain definite manner with the increase of the distance x of the balls from the spindle. The law according to which C_q changes is the most important. It is easy to understand that the best arrangement is that in which the governor would become astatic if there were only Q, and that of constant value. The astatic state with regard to Q—that is to say, equilibrium between Q and C_q for all positions of the sleeve for the same angular velocity w—takes place when $C_q = M w^2 x$ (M being the corresponding part of the revolving masses) is determined from Q by the mechanism in such manner that C_q increase in direct proportion to the distance x or $C_q = x$ const., for in this case we have $M w^2 x = x$ const., or $w^2 = \frac{\text{const.}}{M}$ will remain constant. The constructions of governors hitherto known do not possess this property. Some of them are, generally speaking, perfectly astatic, but in such way that G produces—as, for instance, in governors of Proell, Kley, Steinle, and Hartung—an unstable equilibrium, while Q causes a strongly static state, the actions of both balancing each other. If the weight Q on the sleeve is altered in such case for the purpose of altering the number of revolutions, the whole character of the governor is thereby changed, its astatic quality disappears, and the governor becomes strongly static or unstable and therefore useless; but such an alteration of the load on the sleeve takes place even without intention, as the resistance of the connecting parts acts as a load during the ascent of the sleeve and as a balance-weight during its descent. If, on the contrary, the character determined only by Q is an astatic one, (and of course the general character also,) then the alteration of Q does not cause any alteration of the general astatic state. To obtain this result is the object of the governor shown in Fig. 1. The lines 1 2, connecting the two pivots 1 and 2, deviate in an outward direction from the straight line 1 4, connecting the center 4 of the ball and the fixed point of rotation 1, and form with said line 1 4 an angle α. This angle depends on the dimensions of the governor and is calculated as follows: Let us call the average angle (or one within the limits of use) of deviation of the balls φ, the corresponding distance of the rotating mass from the spindle x, the distance of the pin 1 from the spindle c, the same for the pin 3. Let the arm $1-2$ be equal to the arm $2-3=b$, and the arm $1-4=a$, then we have the following equation:

$$\text{Tg. } \alpha = \frac{c}{a \cos.^3 \varphi} + \text{tg.}^3 \varphi.$$

This equation is deduced in the following manner: Referring to the drawings,

$$x = c + a \sin. \varphi.$$

It further follows from the equation of the moments of forces for point 1:

$$C_q\, a \cos.\varphi = Q\, 2\, b \sin.(\varphi + \alpha)$$

or

$$C_q = Q\frac{2\, b \sin.(\varphi+\alpha)}{a \cos.\varphi} = Q\frac{2\, b}{a}(\cos.\alpha\, \mathrm{tg}.\varphi + \sin.\alpha)$$

$$d\, C_q = Q\frac{2\, b}{a}\cos.\alpha\frac{d\,\varphi}{\cos.^2\varphi};\ d\, x = a \cos.\varphi\, d\,\varphi.$$

The conditions for an astatic point therefore are as follows:

$$\frac{d\, C_q}{d\, x} = \frac{C_q}{x} = \frac{Q\frac{2\, b}{a}\cdot\frac{\cos.\alpha}{\cos.^2\varphi}\cdot d\,\varphi}{a \cos.\varphi\,.\, d\,\varphi} = \frac{Q\frac{2\, b}{a}(\cos.\alpha\, \mathrm{tg}.\varphi + \sin.\varphi)}{c + a \sin.\varphi}$$

or

$$\mathrm{Cos}.\alpha\,(c + a \sin.\varphi) = a \cos.^3\varphi\,(\cos.\alpha\, \mathrm{tg}.\varphi + \sin.\alpha)$$

$$\frac{c}{a} + \sin.\varphi = \cos.^3\varphi\, \mathrm{tg}.\varphi + \cos.^3\varphi\, \mathrm{tg}.\alpha.$$

$$\mathrm{Tg}.\alpha = \frac{\frac{c}{a} + \sin.\varphi - \sin.\varphi\cos.^2\varphi}{\cos.^3\varphi} = \frac{\frac{c}{a} + \sin.^3\varphi}{\cos.^3\varphi}.$$

Therefore

$$\mathrm{Tg}.\alpha = \frac{c}{a\cos.^3\varphi} + \mathrm{tg}.^3\varphi.$$

When a rhombic suspension is deviated from, α must be correspondingly corrected. I propose, in combination with this property, to use the new manner of loading by a spring illustrated in Fig. 2. The spring arrangements used hitherto—for instance, those in German Patents Nos. 35,880, 71,040, and 64,755—with the axial arrangement of the spring, all suffer from the great drawback of having too great friction and being therefore not sufficiently sensitive. The reason of this is that the spring-pressure-balancing centrifugal force has to be transmitted through several rods. The construction shown in Fig. 2 enables this drawback to be avoided, horizontal centrifugal force being balanced by horizontal spring-tension, all pressure of pivots being thus avoided. Only the difference of the spring-tension minus centrifugal force is transmitted at the fixed pin. At the first glance the arrangement of H. Hartung, protected by the German Patent No. 75,790, seems to fulfil this purpose much better, for in his arrangement centrifugal force is taken up directly, so that there is hardly any pressure on the pins, which only have to carry the weight of the revolving masses, while in the arrangement according to Fig. 2 the point of attachment 5 of the spring is removed from the center 4 of the revolving balls, so that the line 1 5 deviates in an outward direction from the line 1 4 and forms with the latter on angle β. This arrangement for the first time enables the astatic state to be obtained with a spring arranged at right angles to the spindle. In the arrangements of springs such as that of Hartung's the tension of the spring increases in proportion with the distance of the revolving mass from the spindle. As for the astatic state the centrifugal force increases in proportion to the distance of the revolving mass from the spindle—that is to say, the end of the spring must lie in the spindle for the spring-tension O. The other end lies also there. Consequently the spring when not in tension would have to have the length O, which is impossible; but if the spring when not in tension has a length 2^c tension changes in proportion to the distance of the revolving balls from an axis drawn at a distance e from the spindle parallel to the latter, the force of the spring increases quicker than would correspond to the astatic state—that is to say, the governor becomes so strongly static as to become useless. In the construction according to Fig. 2 the force of the spring and centrifugal force are not equal, but their moments with respect to the point of rotation 1 must be equal. As the leverage (measured in the normal direction) of the spring-tension decreases quicker than the centrifugal force, then, vice versa, the increase of the latter must be slower than that of the spring-tension, whereby instead of being strongly static an astatic governor is produced if the angle β is made sufficiently great. The greater therefore the length of the spring F_1 when not in tension the greater the angle β must be made. The specific value of β for each separate case will be determined from the dimensions of the spring according to well-known rules of calculation. Were β made still greater, then the governor would become unstable. I intend to utilize this latter quality as well.

At first, without altering the general character of the construction shown in Fig. 2, a weight may be added to it. Thus it becomes possible to adjust the governor when desired for a new number of revolutions, Fig. 3. The alteration of the weight of the sleeve Q is, however, still inconvenient. It would be easier to add a constant force as a load for the sleeve by bringing a spring into a state of tension. Such a spring F (indicated in Fig. 4) caused the governor at first to be strongly static, owing to the tension of the spring increasing with the ascent of the sleeve, (for the governor was in this case astatic only with the constant weight of the sleeve.) To eliminate this static character a second spring F_1, Fig. 4, may be used, which when the angle β becomes sufficiently great can render the governor unstable, as mentioned before.

The pin 5 and 2 may of course be caused to coincide by suitably selecting the dimensions of the springs. The construction shown in Figs. 2 and 4 can be also arranged upside down or with a horizontal spindle without thereby affecting the main characteristics.

Having thus fully described my invention, I claim as new and desire to secure by Letters Patent—

An astatic speed-governor proportioned according to the formula

$$\text{Tg. } \alpha = \frac{c}{a \cos.^3 \varphi} + \text{tg.}^3 \varphi$$

whereby the central load such as the weight Q may be changed without rendering the governor static, substantially as set forth.

In testimony whereof I have affixed my signature in presence of two witnesses.

MAX TOLLE.

Witnesses:

JUNO PASSOYFAR,

CARL MEYER.