No. 664,392. Patented Dec. 25, 1900.

F. ELLICOTT.

CENTRIFUGAL GOVERNOR.

(Application filed Apr. 16, 1900.)

(No Model.) 2 Sheets—Sheet 1.

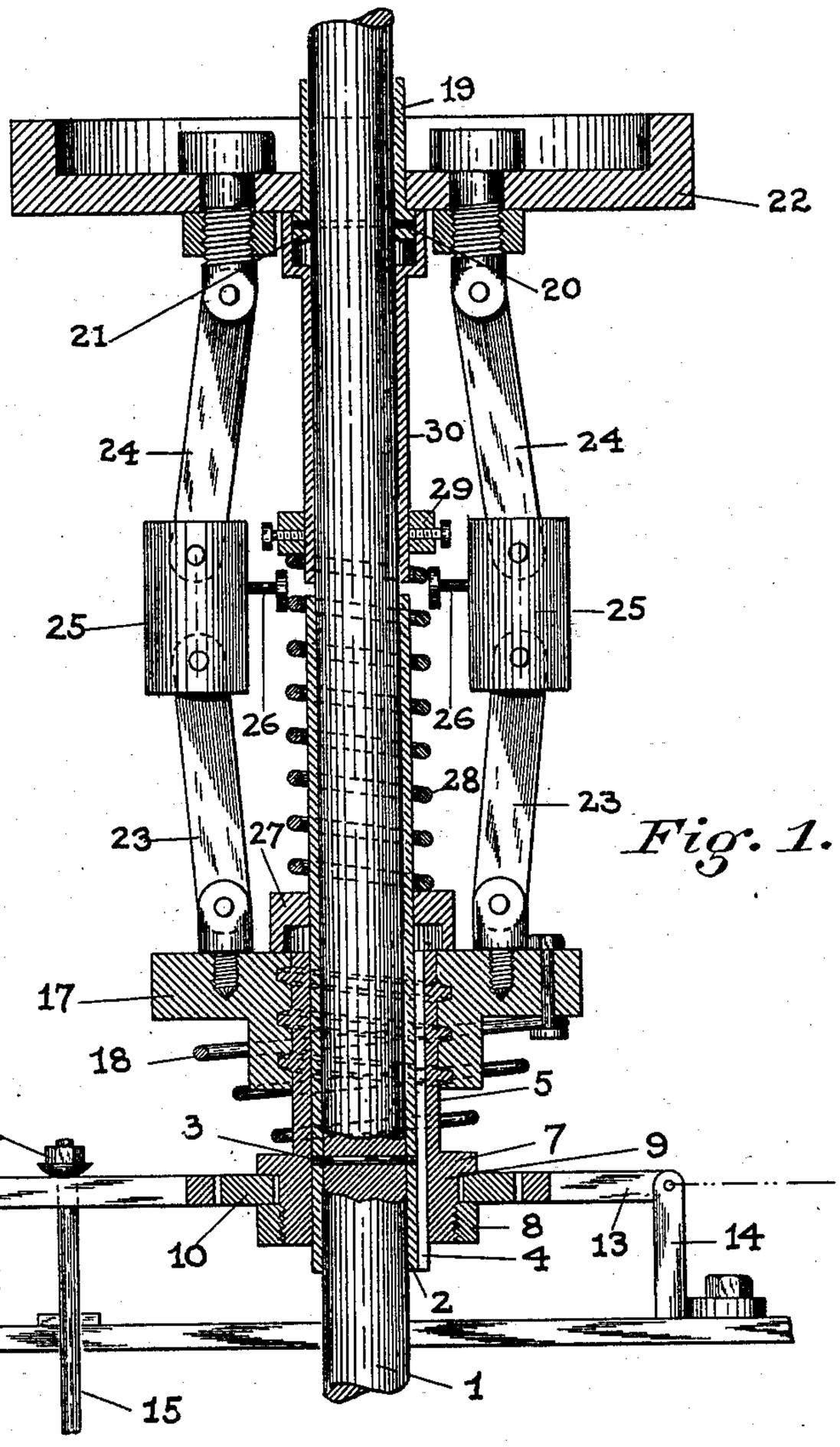

Fig. 1.

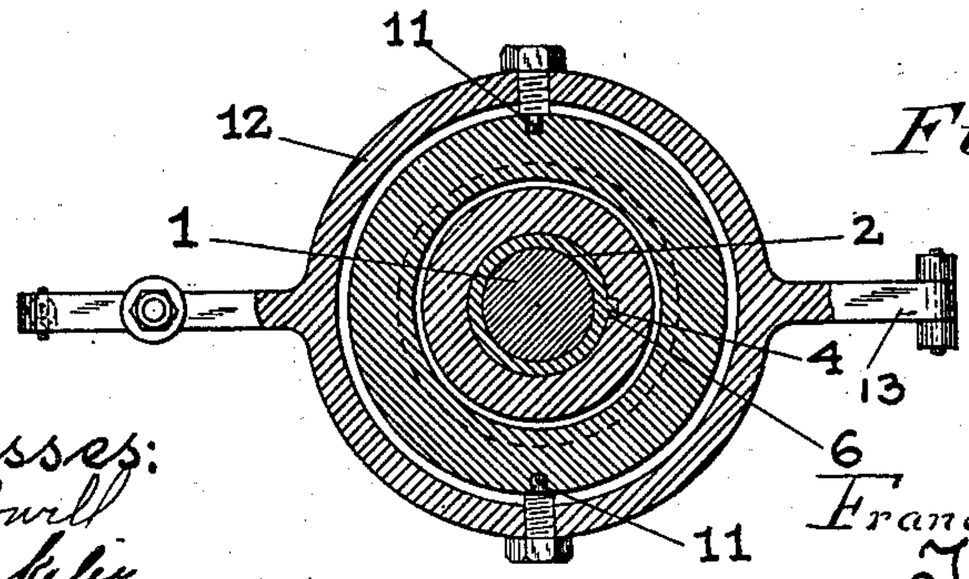

Fig. 2.

Witnesses:
W. N. Lurell
C. R. Bukley

Francis E. Ellicott
Inventor:
by Stewart & Stewart
Attorneys.

No. 664,392. Patented Dec. 25, 1900.

F. ELLICOTT.

CENTRIFUGAL GOVERNOR.

(Application filed Apr. 16, 1900.)

(No Model.) 2 Sheets—Sheet 2.

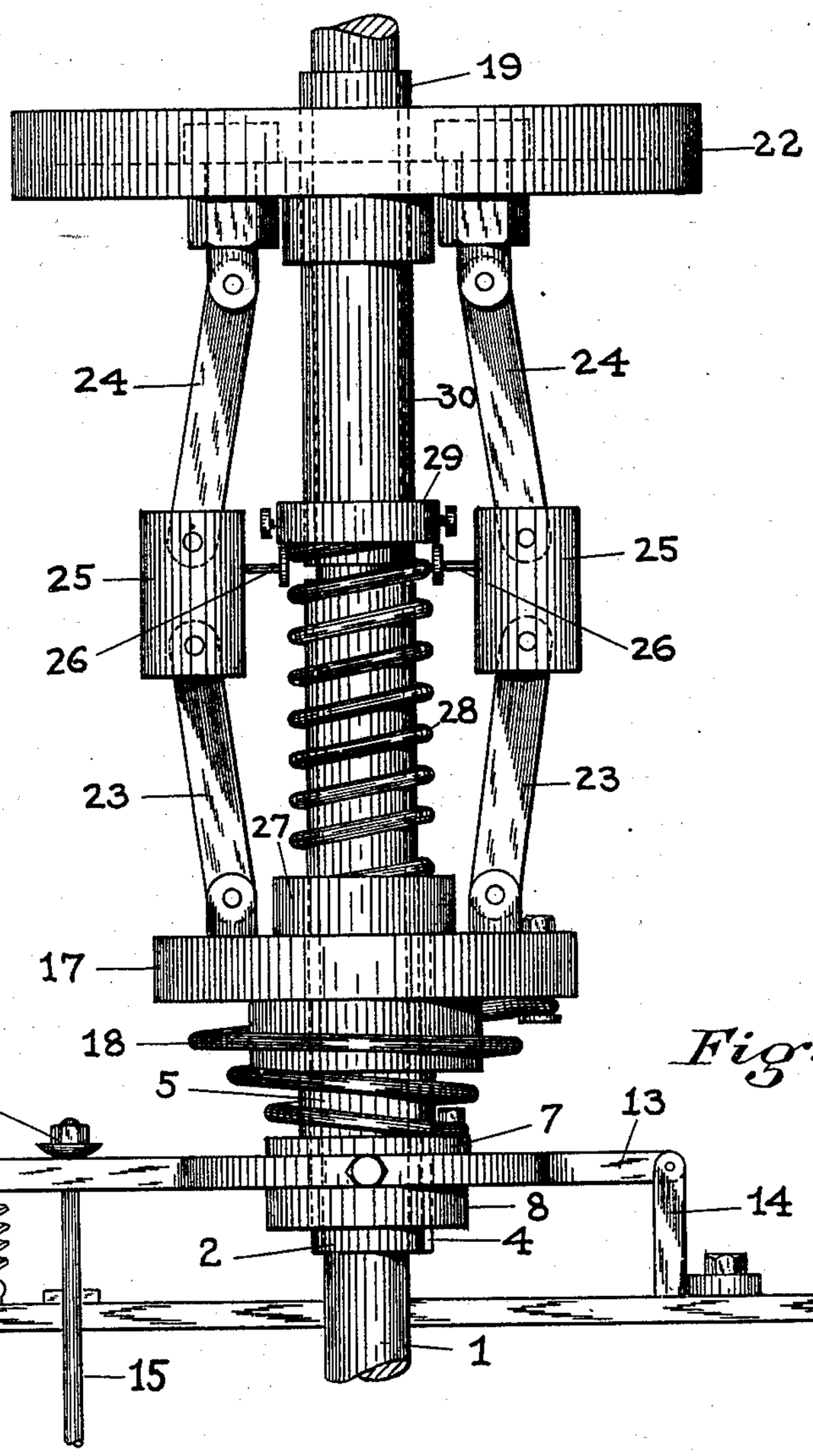

Fig. 3.

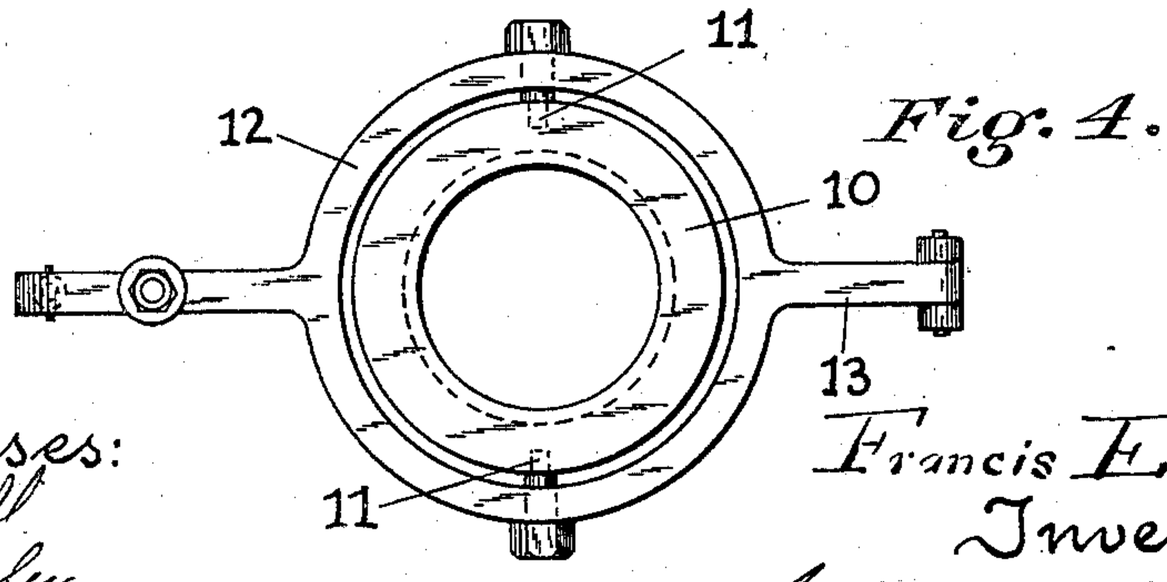

Fig. 4.

Witnesses:
O. P. Lovell
E. R. Berkeley

Francis Ellicott
Inventor:
By Munn & Munn
Attorneys

UNITED STATES PATENT OFFICE.

FRANCIS ELLICOTT, OF BALTIMORE COUNTY, MARYLAND.

CENTRIFUGAL GOVERNOR.

SPECIFICATION forming part of Letters Patent No. 664,392, dated December 25, 1900.

Application filed April 16, 1900. Serial No. 13,020. (No model.)

To all whom it may concern:

Be it known that I, FRANCIS ELLICOTT, a citizen of the United States of America, and a resident of Baltimore county, in the State of Maryland, (Ruxton P. O.,) have invented certain new and useful Improvements in Centrifugal Governors, of which the following is a specification.

My invention relates to a centrifugal speed-governor designed to govern a prime motor of any kind; and it consists of a combination of mechanical elements by which the governor is given great sensitiveness and caused to respond to changes of speed in the motor apparatus with great promptness, which enables it to alter the flow of motive power to the prime motor at the first instant at which a change in speed occurs. I have employed this centrifugal governor in connection with a governing apparatus of a turbine water-wheel successfully; but it is adaptable for use to govern any of the forms of prime motor, such as a steam or other fluid-engine, electric motor, or water-wheel.

The same numerals on all the figures indicate the same parts.

In the drawings, Figure 1 is a vertical section of certain parts of my governor, showing parts in full elevation. Fig. 2 is a horizontal section of the governor through its governing-lever on the line X X, Fig. 1. Fig. 3 is a full elevation of the governor. Fig. 4 is a plan of the governor-lever and its pivoted ring, by which it is connected to the governor.

Referring to Fig. 1, 1 is a driving-shaft.

2 is a sleeve secured on the driving-shaft by pin 3 and provided on one side with a feather 4. (Shown in Fig. 2.)

5 is a screw having a central aperture fitting upon the sleeve 2. It has a feather-way 6 in one side, which fits upon the feather 4 on the sleeve. The screw is therefore able to rise and fall on the sleeve while being turned by the shaft and the sleeve. On the lower end of the screw 5 is a projecting flange, below which is a thread, on which is screwed a ring 8, so as to form between the flange and the ring an annular groove 9. In this annular groove is a ring 10, which is pivoted at two opposite points 11 11 in the ring 12, which forms a part of the lever 13, one end of which is pivoted to a post 14 and the other end of which projects on the opposite side of the ring 12 and through which passes a stem 15, which is connected in any suitable manner with the controlling device of the prime motor. The stem is threaded above the lever and fitted with a nut to maintain its relation to the lever.

16 is a spring secured to the lever at one end and to a stationary part at the other, by which a desired tension is maintained upon the lever to counteract the upward pull of the governor. If the whole apparatus is erected vertically, the weight of the stem 15 and the parts which may be connected to it would be sufficient to counterbalance the pull of the governor. If it is horizontal or if the governor be located vertically and the stem horizontally and connected to the governor by a bell-crank lever or other device, the spring may be necessary.

17 is a nut threaded upon the screw 5 and secured to it by a coil-spring 18, one end of which is secured to the nut and the other end to the screw. The rotary motion of the shaft is thus communicated from the screw to the nut by means of the spring 18 and the screw will be screwed into the nut until the resistance of the spring overcomes the inertia of the nut and its connected parts, when the screw and the nut will move in unison. In the drawings in this case I have shown the spring 18 as a coil-spring, and this is a preferable form, because its tension can be adjusted with ease, and a coil-spring can be employed which will have the desired range of elasticity, thus permitting any desired number of revolutions of the screw in the nut before the limit of elasticity of the spring is reached or before the tension of the spring upon the nut and its connected parts has become sufficient to set them in motion in unison with the screw. It will be readily perceived, however, that a different form of spring might be employed which would have the same function in a greater or less degree.

19 is a sleeve secured to the shaft 1 by a pin 20. The sleeve 19 has upon its lower end an annular flange 21, upon which rests a fly-wheel 22, which is caused to revolve by its connection with the nut 17. The fly-wheel 22 is connected to the nut by means of two links 23 and 24 and the weight 25, which are

duplicated on two sides. The primary adjustment of the parts is such that the links 23 and 24 are maintained at an angle with one another, and this angle is determined by the set-screws 26 26. It will be perceived that the independent links and weights employed in the construction shown might be substituted by a pair of springs and weights made integral with one another, as is common practice in the construction of centrifugal governors.

27 is a chair surrounding the sleeve 2, hollowed out on the under side, and resting upon the nut 17 upon the chair rests a spiral spring 28, which surrounds the shaft 1 and the sleeve 2. The upper end of this spring is borne upon by a collar 29, secured to the sleeve 30, which surrounds the shaft 1. At its upper end the sleeve 30 has an annular extension which surrounds the annular flange 21 on the sleeve 19 and bears upon the under side of the fly-wheel 22.

The operation of this device is as follows: When the driving-shaft turns, it turns the sleeve 2, which, through the feather 4, turns the screw 5. The screw 5 is screwed into the nut 17 until the tension of the spring 18 overcomes the inertia of the nut, the fly-wheel, and the governor-weights. The upward motion of the screw will raise the lever 13 a corresponding degree. As the weights 25 25 revolve, they will be extended by centrifugal force, the fly-wheel being supported by the flange 21, and the sleeve 19 cannot descend. Therefore as the governor-weights 25 25 are extended the whole structure connected with them—the nut, the screw, and the lever 13—will be drawn up together, compressing the spring 28. When the motor is running, it is the function of the governor to maintain the stem 15 at a position, depending upon the load, which will maintain the speed of the motor constant. When it is desired to stop the motor, the stem 15 must be actuated independently by hand or power and, as shown in the figures, drawn upward to a point where it will cut off the supply of motive power to the motor. In this position the nut 31 on the top of the stem 15 will be some distance above lever 13, and the lever 13 will be at its lowest position, due to the fact that the governor is at rest and the screw and lever at their lowest point. If now it is desired to start the motor, the stem 15 may be pushed down until its nut 31 contacts with the lever 13. This will of course open the power-admission device to the motor to its maximum capacity, and the motor will be immediately set in motion, and its speed will begin to accelerate and will soon attain a speed (if not controlled) greater than the speed desired. As the speed increases, however, the governor-weights 25 25 will begin to extend and will draw upward with them the nut, the screw, and the lever 13, and the stem 15 by the nut 31 until the governor-balls have attained a mean position of extension. If it is found that the speed permitted by the load is such as to carry the governor-weights beyond their mean position, it is necessary then to admit less motive power to the motor, and this is done by giving a requisite number of turns to the nut 31 until the governor-weights will maintain their mean position under a normal load and the power-admission device of the motor will be in a corresponding position to maintain a constant speed for a normal load at a mean position of the governor-weights. This relation once established is not altered while the devices are in operation. If now there be a reduction of load and an acceleration of speed, the motor will feel the reduction of load instantly and will jump forward in an acceleration of speed. The instant that the motor accelerates its speed the speed of the shaft 1 will be correspondingly accelerated and the motion of the shaft 1 will be communicated to the screw 5, which moves with it. The previous speed of the governor will have given a certain position and communicated a certain momentum to the fly-wheel and governor-weights, and at this speed these parts will have a certain inertia which will have to be overcome before their speed can be changed. If therefore the governing depended primarily upon the changing of the speed of the governor-weights and the fly-wheel, this could not be done quickly; but it does not depend upon this. The elastic connection consisting of the spring 18 between the screw 5 and the nut 17 permits the screw 5, when suddenly accelerated, instead of meeting with the resistance of the inertia of the other parts to meet only with the resistance of the coil-spring 18, which is sufficiently elastic to permit the screw 5 when suddenly accelerated to increase the tension of the spring 18 before the accelerated motion of the screw is communicated to the other moving parts of the governor. The increase of the tension of the spring 18 is the result of a tighter winding of the spring produced by a part of a revolution of the screw in excess of the revolution of the nut, and this excess of revolution of the screw beyond the revolution of the nut will cause the screw to be screwed into the nut a greater distance than normal. This entrance of the screw into the nut, the nut being for the instant stationary in a horizontal plane, will cause the screw to rise upon its sleeve 2 and carry with it the lever 13 and the stem 15, which will reduce the admission of motor power to the prime motor. In the course of a few seconds the added tension of the spring 18 will communicate to the nut 17 an added increment of power and will increase the speed of the parts connected to the nut and cause the governor-weights to extend and draw the nut upward. As this action occurs the nut will be unscrewed from around the screw, the spring will assume its normal tension again, and the parts will return to their former relation. The reduction of speed due to an increase of load will have an ex-

actly opposite effect. The increase of load will check the motion of the prime motor and the shaft 1 and the screw 5 instantly. This checking of motion will cause the speed of the screw to be less than the speed of the nut and the screw will be at once unscrewed a part of a revolution from the nut, permitted by the elasticity of the spring 18. This will cause a descent of the screw and a consequent descent of the lever 13 and of the stem 15, which will admit more motive power to the motor and begin at once to build up its speed to meet the added load before the heavier parts of the governor begin to feel the fluctuation of load due to their greater inertia. The reduction of the tension of the spring, due to its unwinding by the reduction of the speed of the screw, will cause the nut and its connected parts, the fly-wheel, and the governor-weights to drop from their speed to a lower speed until the spring has again assumed its normal tension and the parts are again readjusted. This construction gives to the governor a sensitiveness which is so great that a very minute fluctuation of the load is instantly taken care of and taken care of before the centrifugal device of the governor could take care of it.

The fly-wheel, which is made quite heavy, gives to the governor apparatus a steadiness of motion which prevents overgoverning, and the sensitiveness of the spring 18, which connects the screw and the nut, will permit slight fluctuations of load to be so quickly compensated for by the increase or reduction of motive power admitted to the motor as to maintain the speed constant. My governor is so sensitive that with plants in which the fluctuations of load are slight it will maintain them at a constant speed by constant regulation. If the governor be used, however, upon plants where the fluctuations of load are very great, the extreme sensitiveness of the device may cause an overgovernment or seesawing of the device. To prevent this, I provide a check upon the sensitive government. It will be noticed that the top of the screw 5 is twice the depth of the recess in the under side of the chair 27. If, therefore, a very constant change of load occurs sufficient to cause the screw or the nut to change their positions an amount equal to anything more than a half-revolution of the screw, the screw would protrude into the recess in the chair 27 and strike against the inside of the chair and lift the chair up against the tension of the spring 28. The spring 28 thus brought into bearing upon the screw would augment the tension of the spring 18 upon the screw and offer an additional increment of resistance to it, which would probably be sufficient to check overgovernment in most cases. If the constant acceleration of the motor be still too great, it can be taken care of by the added resistance of the spring 28, and if the spring 28 be so much compressed as to overcome the weight of the fly-wheel, which rests upon the flange 21 of the sleeve 19, the whole structure, including the fly-wheel, the governor-weights, the nut, and the screw, will be lifted up by the sleeve 30, which appears on the under side of the fly-wheel. This will release the fly-wheel 22 from the support of the flange 21, and the governor-weights will be forced still farther out by the operation of the spring 28, by the weight of the fly-wheel, and the governor-weights, and the lever 13 will be drawn up still farther, and with it the stem 15, until the device admitting power to the motor will be almost if not wholly closed. It will be perceived, therefore, that there are three means provided for checking the upward motion of the screw and bringing the lever 13 back to a position where it will so control the stem 15 as to cause the stem to admit a proper quantity of power to the motor to maintain a constant speed.

The fly-wheel in my governor is made heavy and supported so as to relieve the governor-balls of any of its weight, and it is balanced as perfectly as possible, so that it may be driven at any desired speed, preferably a very high speed, and will maintain a true-running balance. In an ordinary ball-governor the wear of the parts will soon throw the governor out of balance, and hence in great measure prohibit high speed. It will be perceived that the higher the speed of a heavy fly-wheel (within certain limits) the steadier its motion and the greater its momentum. It is this steady motion and momentum which I utilize for the purpose of maintaining a uniformity of speed.

With a governing device so sensitive as mine, in which the motor-controller which admits power to the motor is directly connected to the screw and is moved by the first change of speed of the motor, a device of small momentum would quickly respond to the change of speed of the driving-shaft and would fall too low in speed, and a wide seesawing would result. With my apparatus, however, the speed and momentum of the fly-wheel maintain the position of the governor-weights, notwithstanding the increased or decreased tension of the spring which connects the nut and the screw, and it is only after a comparatively long period that the increased tension of the spring is able to materially accelerate the speed of the fly-wheel and its connected parts or the reduced tension allow that speed to drop. In this interval of time the sudden increase of power admitted to the motor or the sudden reduction of power admitted to the motor will cause it to respond to the load and return to a speed closely approximating normal before the centrifugal governor has changed its position, so that when the centrifugal governor comes to take up the actual government the variation of the motor from normal is very slight. The flexibility of the quick-acting portion of the governor is so great that a change in the power admitted to the motor is accomplished with the least pos-

sible resistance and in the first instant of time, with the result that the controller is generally overthrown by the screw by any sudden change of load and then drawn back again by the sudden influence of the added or lessened power upon the motor, and by the time it gets back to a point approximating normal the fly-wheel and its connected parts take up the governing and steadies the motion at a normal speed.

In this application I have described the combination of a screw, nut, centrifugal weights, and fly-wheel; but it will be perceived that I may omit the fly-wheel and employ only an ordinary centrifugal governor with my screw and nut and get good results; but the best results are obtained by using all of the elements combined.

It will be perceived that the relation of the nut and screw in my governor may be reversed without altering the invention. In this application I have shown and described the direct connection of the screw to the driving-shaft and of the nut to the centrifugal governor; but it would of course be an equivalent construction to reverse this relation and connect the nut to the driving-shaft and the screw to the centrifugal governor and the operation would be practically the same.

Having described my invention, what I claim, and desire to secure by Letters Patent, is—

1. In a speed-governor, the combination of a screw and nut, one of them connected to and actuated by the motor, both nut and screw being capable of motion in two directions, revolution upon their axis and motion in the direction of their axis, the motion in the direction of the axis being independent of rotation, means for controlling the motor, means connecting either the nut or the screw with the controller, the nut and screw being connected by a spring, through which the motion of the one which is driven is communicated to the other, the intervening spring permitting a temporary difference in speed of revolution, a centrifugal governor device attached to the nut or screw, and actuated thereby, substantially as described.

2. In a speed-governor, the combination of a screw and nut, one of them connected to and actuated by the motor, both nut and screw being capable of motion in two directions, revolution upon their axis and motion in the direction of their axis, means for controlling the motor, and means connecting the screw with the controller, the nut being threaded upon the screw and connected thereto by a spring, through which the nut may be driven by the screw, while permitting a temporary difference of speed of revolution, a centrifugal governor device attached to the nut and actuated thereby, substantially as described.

3. In a speed-governor the combination of a screw, connected to, and actuated by the motor, and capable of motion in two directions, revolution upon its axis, and motion in the direction of its axis, means for controlling the motor, and means connecting the screw with the controller, a nut threaded upon the screw, and connected thereto by a spring, through which the nut may be driven by the screw, while permitting a temporary difference in speed of revolution between the nut and the screw, a pair of centrifugal governor-weights connected at one end to the nut, and at the other end to a permanent support, and adapted when moved by centrifugal force to lift the nut and its connected parts.

4. In a speed-governor the combination of a screw, connected to, and actuated by the motor, and capable of motion in two directions, revolution upon its axis, and motion in the direction of its axis, means for controlling the motor, and means connecting the screw with the controller, a nut threaded upon the screw, and connected thereto by a spring through which the nut may be driven by the screw while permitting a temporary difference in speed of revolution between the nut and the screw, a pair of centrifugal governor-weights and a fly-wheel, the governor-weights being connected at one end to the nut, and at the other end to the fly-wheel, the fly-wheel being supported so as to resist the pull of the centrifugal governor-weights, and permit them to lift the nut and its connected parts.

5. In a speed-governor the combination of a screw connected to, and actuated by the motor, and capable of motion in two directions, revolution upon its axis, and motion in the direction of its axis, means for controlling the motor, and means connecting the screw with the controller a nut threaded upon the screw, and connected thereto by a spring, through which the nut may be driven by the screw, while permitting a temporary difference in speed of revolution between the nut and the screw, a pair of centrifugal governor-weights one end of which is supported against axial motion, the other end of which is connected to the nut so as to move it and its connected parts, as the weights are moved outward by centrifugal force, and a compression-spring one end of which bears upon the nut, and the other upon a stationary part to resist the pull of the governor-weights upon the nut.

6. In a speed-governor the combination of a screw connected to, and actuated by the motor, and capable of motion in two directions, revolution upon its axis, and motion in the direction of its axis, means for controlling the motor, and means connecting the screw with the controller, a nut threaded upon the screw, and connected thereto by a spring through which the nut may be driven by the screw, while permitting a temporary difference in speed of revolution between the

nut and the screw, a pair of centrifugal governor-weights and a fly-wheel, the weights connected at one end to the fly-wheel, and at the other end to the nut, the fly-wheel being supported so as to resist motion in the direction of the nut, but to move freely in the opposite direction, a compression-spring bearing at one end upon a chair which rests upon the nut and covers the end of the screw, and the other end of which bears upon the fly-wheel, substantially as described.

Signed by me at Baltimore city, State of Maryland, this 11th day of April, 1900.

FRANCIS ELLICOTT.

Witnesses:
CHARLES H. MILLIKIN,
E. R. BERKELEY.