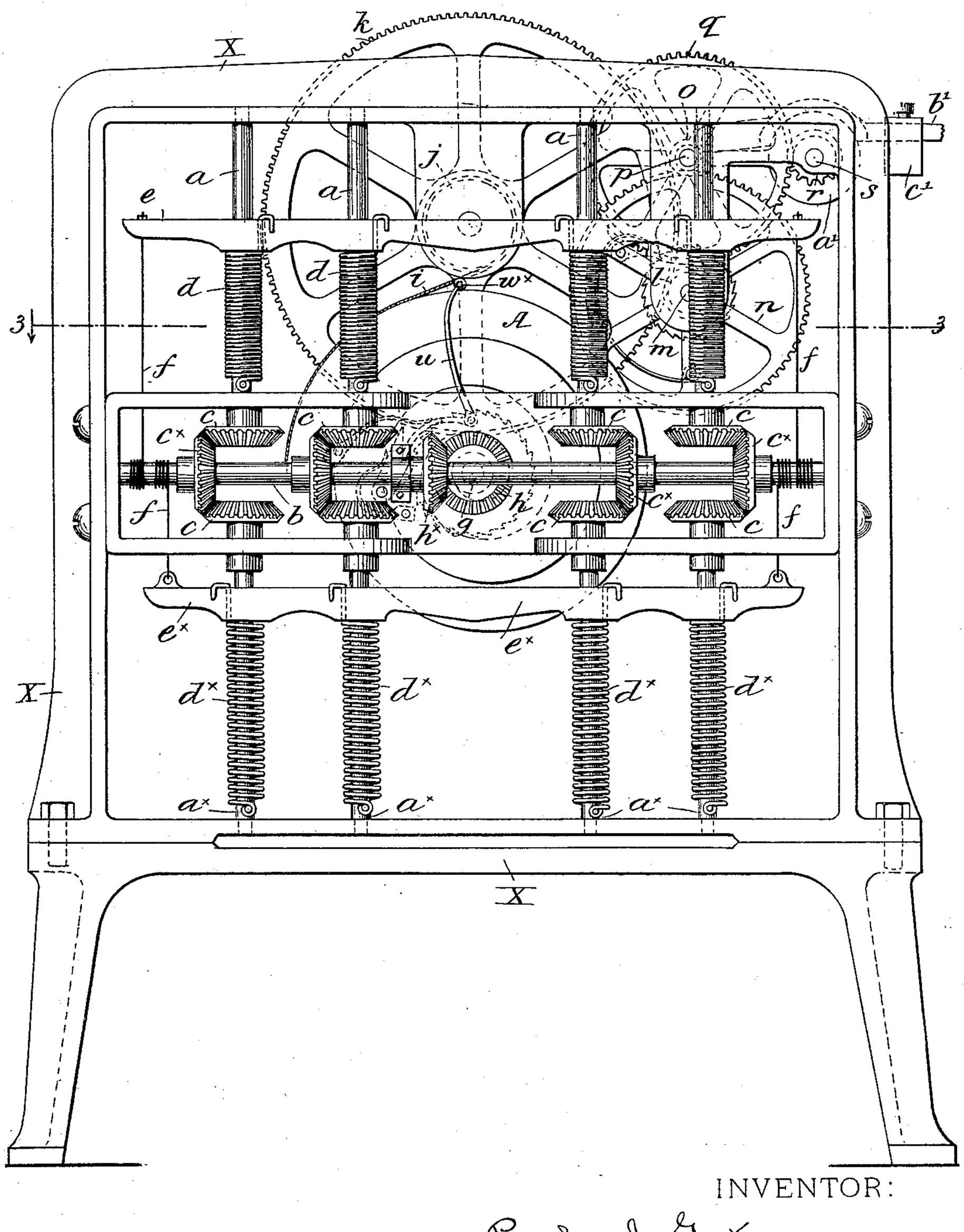
(No Model.) 5 Sheets—Sheet 1.

P. J. & E. H. GATES.

SPRING MOTOR.

No. 411,099. Patented Sept. 17, 1889.

Fig: 1.



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(No Model.) 5 Sheets—Sheet 2.

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SPRING MOTOR.

No. 411,099. Patented Sept. 17, 1889.

Fig: 2.

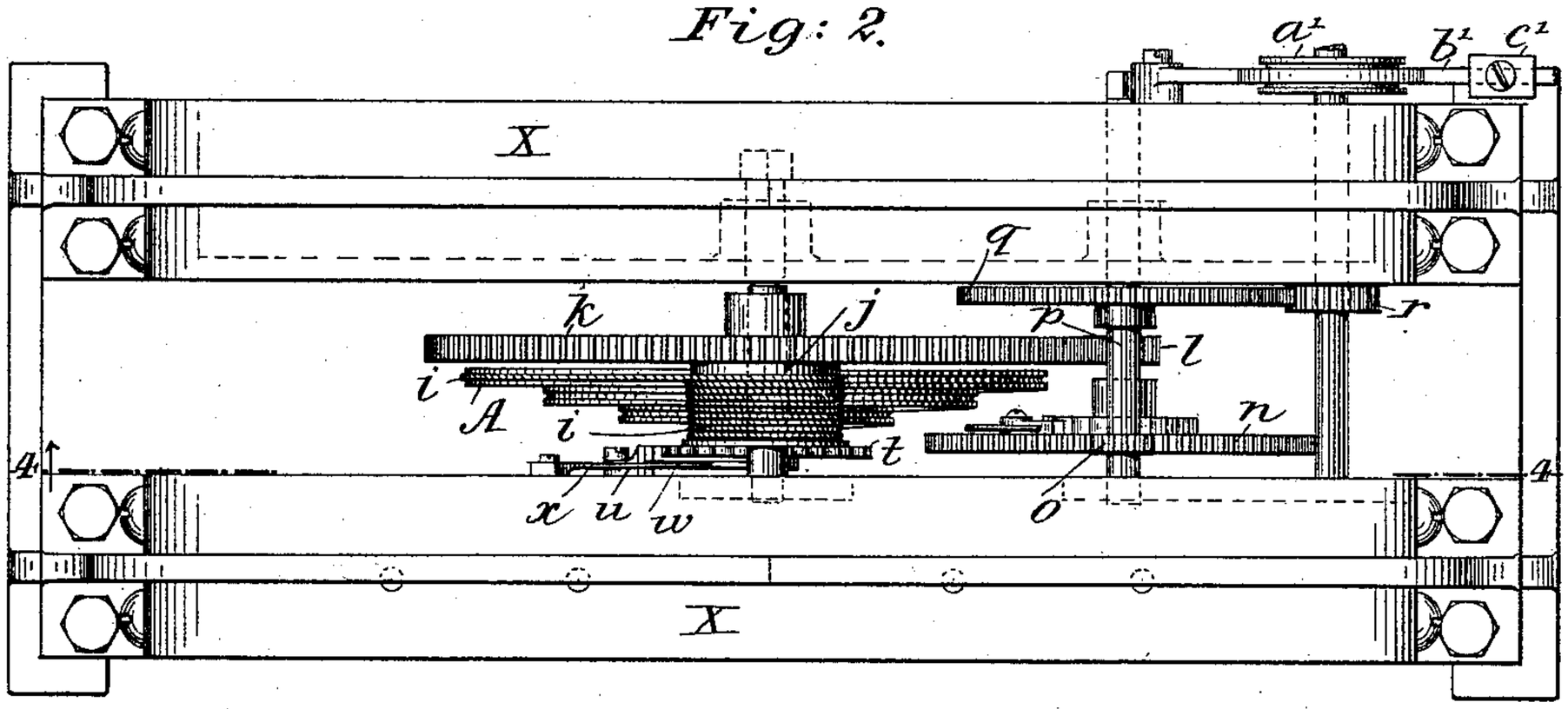
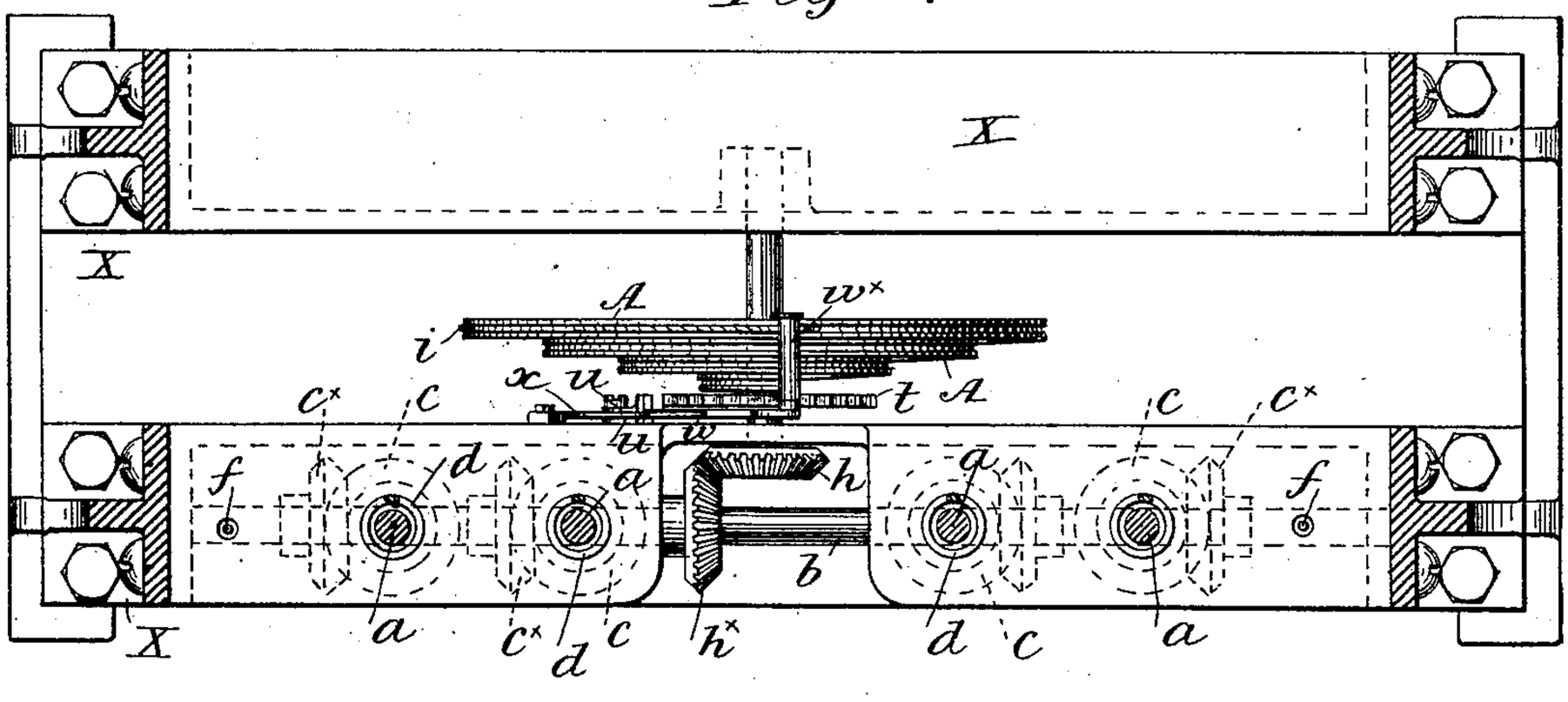


Fig: 3.



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(No Model.) 5 Sheets—Sheet 3.

P. J. & E. H. GATES.

SPRING MOTOR.

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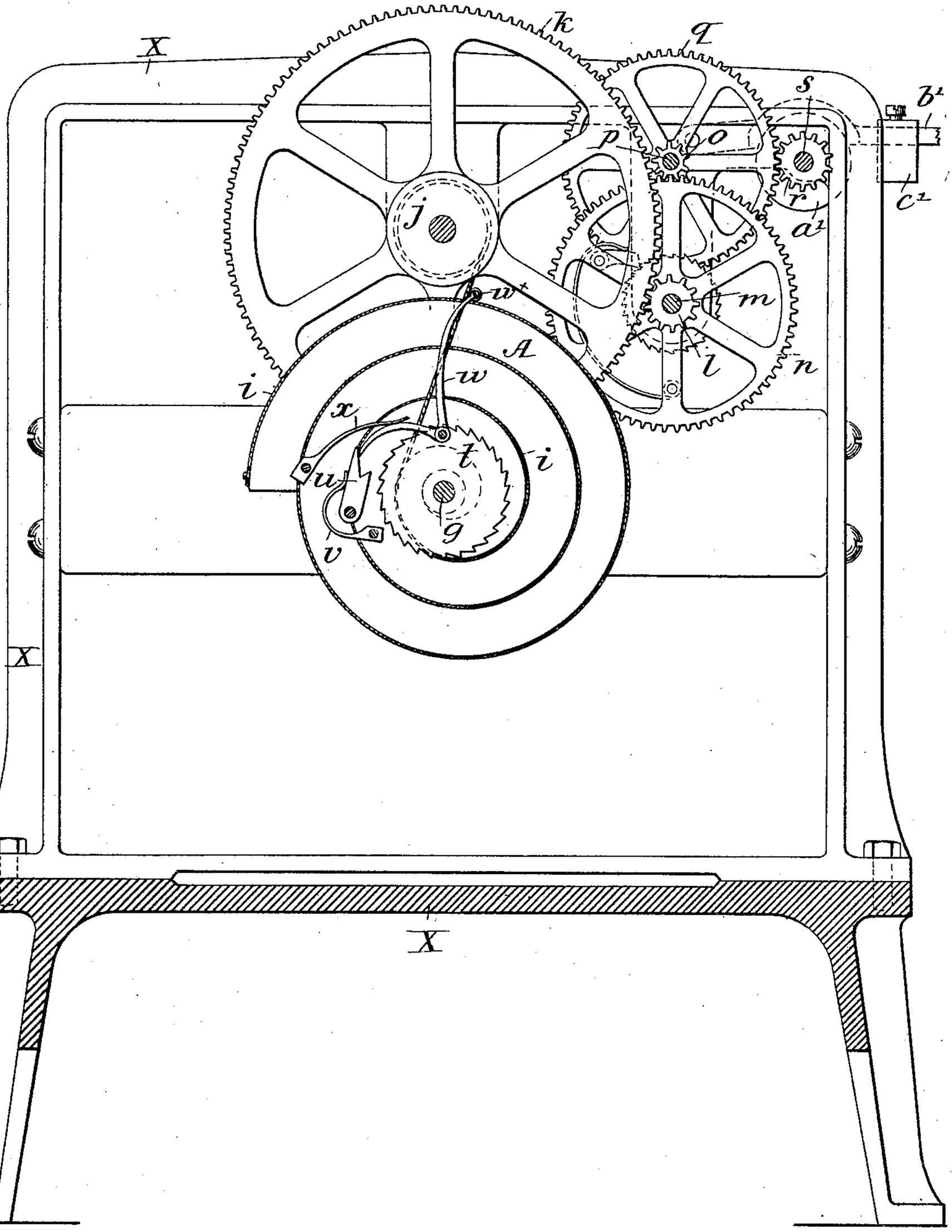
Fig: 4.



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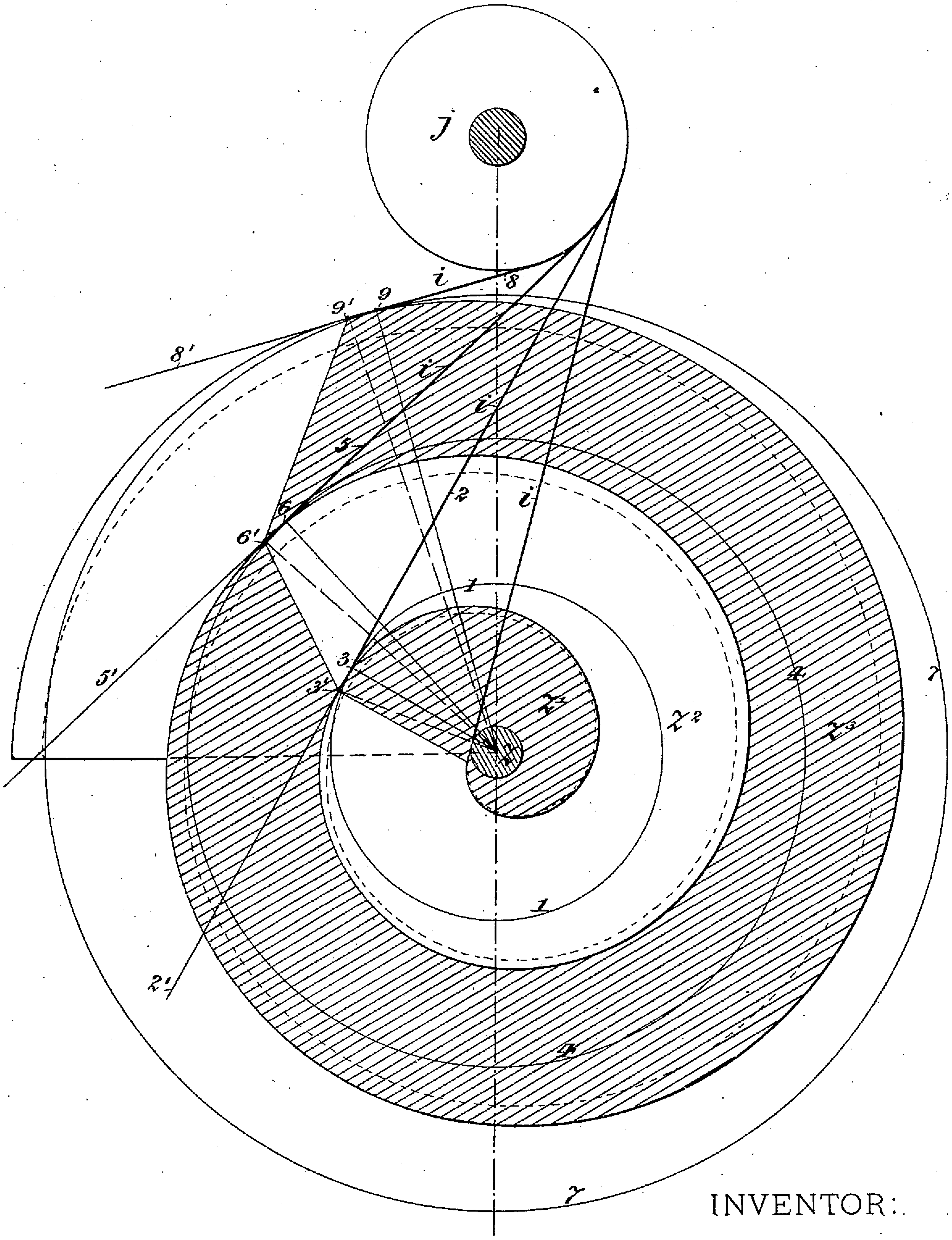
SPRING MOTOR.

No. 411,099. Patented Sept. 17, 1889.

Fig: 5.



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(No Model.) 5 Sheets—Sheet 5.

P. J. & E. H. GATES.

SPRING MOTOR.

No. 411,099. Patented Sept. 17, 1889.

Fig: 6.

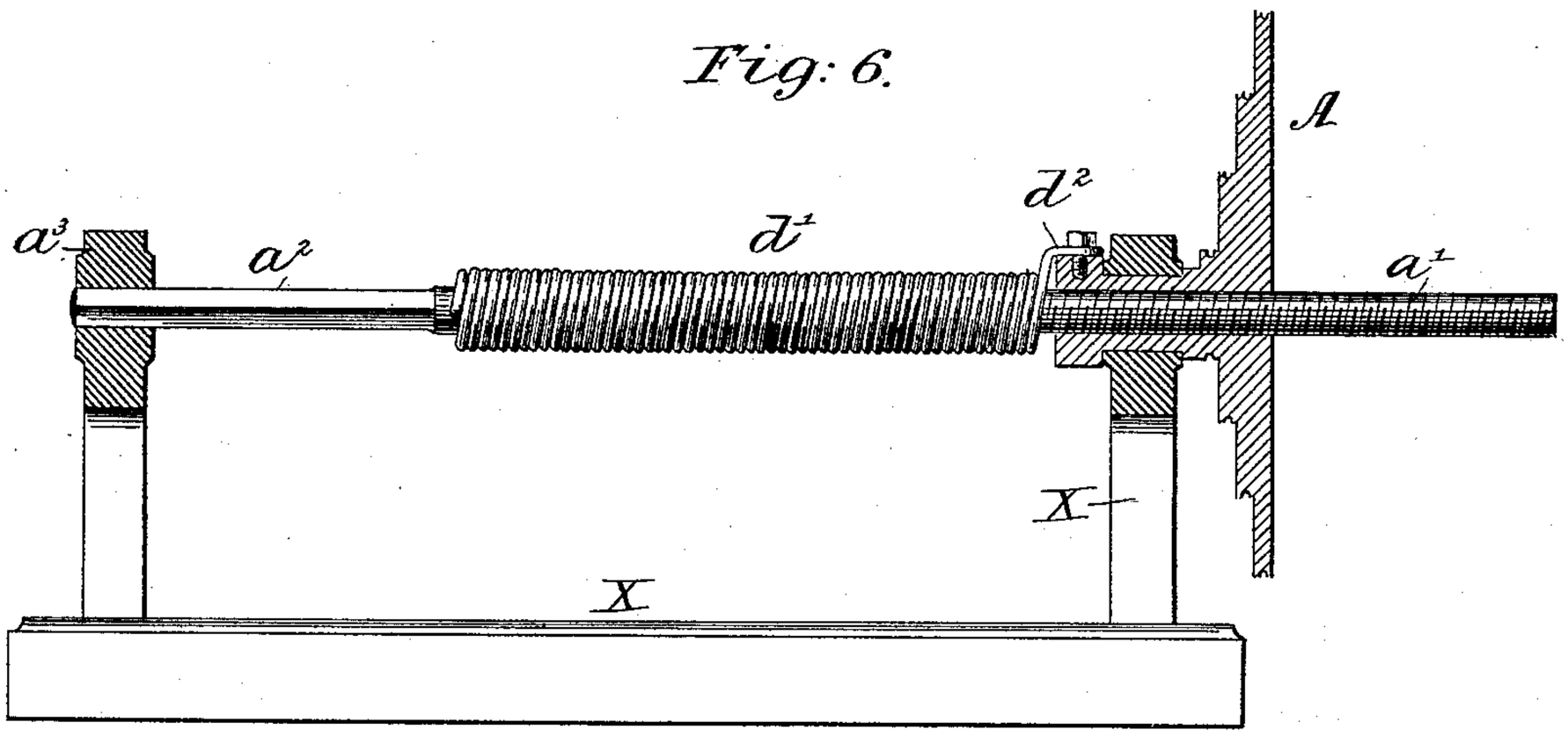


Fig: 7.

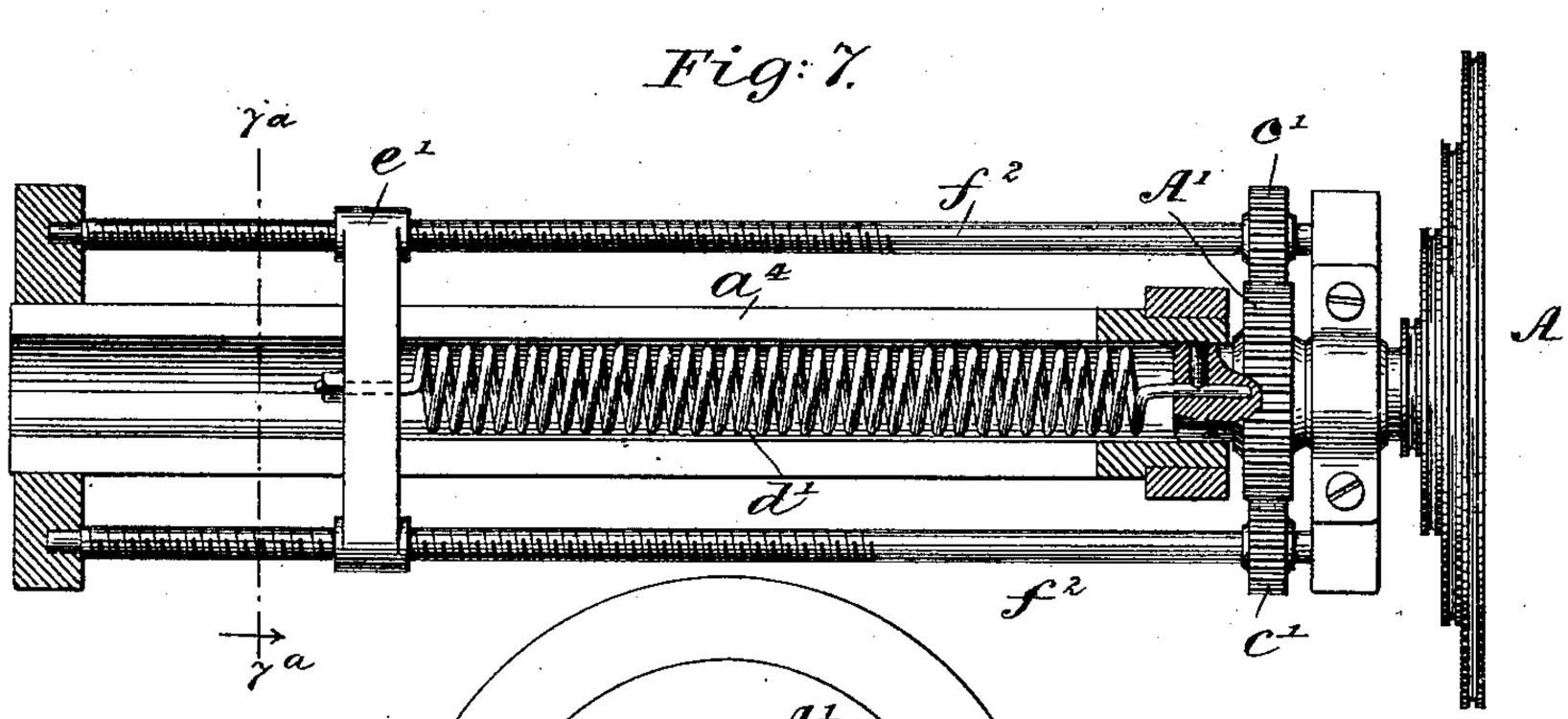
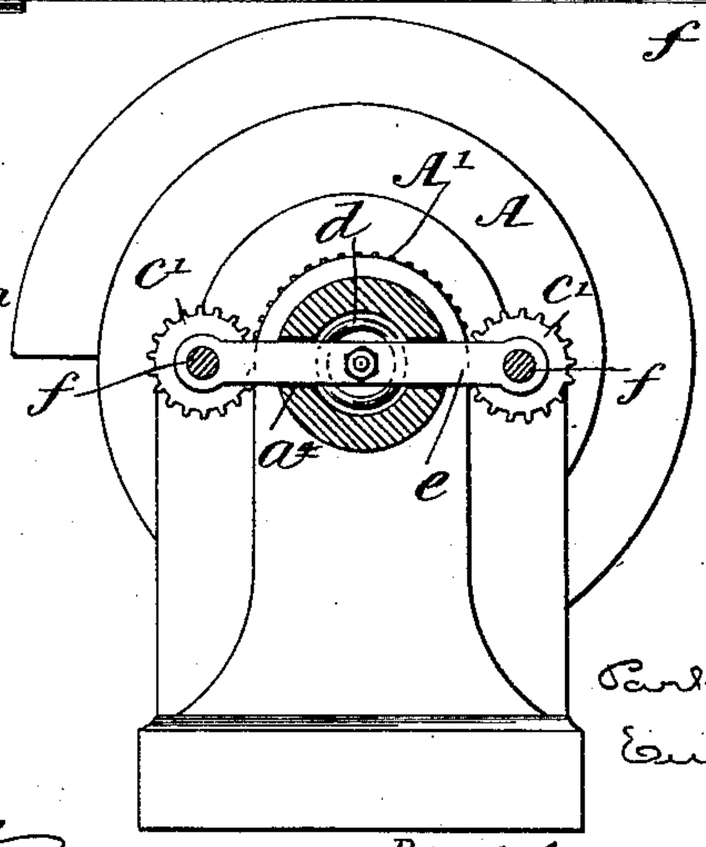


Fig: 7a



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UNITED STATES PATENT OFFICE.

PARKER J. GATES, OF DURYEA, PENNSYLVANIA, AND EUGENE H. GATES, OF BROOKLYN, NEW YORK.

SPRING-MOTOR.

SPECIFICATION forming part of Letters Patent No. 411,099, dated September 17, 1889.

Application filed March 29, 1889. Serial No. 305,220. (No model.)

To all whom it may concern:

Be it known that we, PARKER J. GATES, of Duryea, Luzerne county, Pennsylvania, and EUGENE H. GATES, of Brooklyn, Kings county, New York, both citizens of the United States, have jointly invented certain Improvements in Spring-Motors, of which the following is a specification.

Our invention relates to motors or powers for driving machinery wherein a spring or springs under tension furnish the necessary power; and the object of our invention is in part to obtain from the helical springs employed in the motor a greater percentage of power or energy than can be obtained from them as ordinarily employed, and in part to improve the fusee or intermediate regulator, whereby it is made to more accurately govern the applied power or energy of the springs than it will as ordinarily constructed.

Our invention will be fully described hereinafter, and its novel features carefully defined in the claims.

In the accompanying drawings, illustrative of our invention, Figure 1 is a front elevation, and Fig. 2 a plan, of a spring-motor embodying our improvements. Fig. 3 is a sectional plan taken substantially in the plane indicated by line 3 3 in Fig. 1. Fig. 4 is a sectional elevation taken substantially in the plane indicated by line 4 4 in Fig. 2. Fig. 5 is a diagrammatic view illustrating the manner of constructing the volute of the fusee or regulator. Figs. 6, 7, and 7ª illustrate modified constructions that will be hereinafter described.

In order to increase the energy of the spring or springs employed over that utilized in the ordinary forms of spring-motors, we employ a helical spring and mount it on a rotating mandrel, to which one end of the spring is attached, the other end being secured to a bar or block which slides along said mandrel and longitudinally of the same. If the mandrel be rotated and the said bar or block be moved along the same simultaneously, the spring will be twisted or rotated about its axis in the manner of the spring of a shade-roller, and will also be compressed (or distended) in the direction of its axis. Now, in resuming its normal status, a spring under tension, as above described, will exert an amount of energy equal to the sum of the energy tending to rotate the mandrel backward and that tending to move the bar or block along said mandrel, and by suitable intermediate mechanism these energies may be combined and applied to the rotation of a power-shaft, for example. We find that where the maximum tension of a helical spring made to coil about a mandrel or core is one hundred the maximum tension of the same spring produced by distending it lengthwise will be about fifty, and that the effective maximum energy of such a spring will be, in our motor, equal to the sum of these energies, or one hundred and fifty.

In carrying out our invention we may arrange the parts or elements of the motor in a great variety of ways; but that illustrated in the drawings will suffice to fully attain the objects and purposes of the invention, and this we will now describe.

X represents a suitable stout frame of any kind. In this frame are rotatively mounted two sets of spring-mandrels—namely, the upper mandrels $a\,a$ and the lower mandrels $a^{\times}\,a^{\times}$. There may be any number of these mandrels, the number being dependent on the size or power of the motor. These mandrels are driven, in winding, from a cross-shaft b, through the medium of bevel or miter gears c on the respective arbors and similar wheels $c^{\times}$ on the shaft b. On the spring-mandrels a are helical springs d, and on the mandrels $a^{\times}$ are similar helical springs $d^{\times}$. The springs d $d^{\times}$ are secured to their respective mandrels at their lower ends in the arrangement represented in the drawings, and at their other ends they are secured to slide-bars e and $e^{\times}$. The slide-bar e is mounted to slide on the upper mandrels a, the latter playing through holes in said bar. The bar $e^{\times}$ is mounted in a similar manner upon the lower mandrels $a^{\times}$. At their ends (or at some point or points) the bars e and $e^{\times}$ are connected to the cross-shaft b through the medium of cords, chains, or other flexible connectors f, which latter wind up on the said shaft, as on a windlass-barrel, when the motor is wound up. Now, if the shaft b be rotated in the proper direction, the effect will be to rotate all the spring-mandrels

in such a manner as to twist or wind up the several springs thereon about their longitudinal axes, and simultaneously, by reason of the movement of the bars *e* and $e^{\times}$ along the mandrels, (due to the winding of cords *f* about shaft *b*,) the upper springs *d* will be compressed longitudinally and the lower springs $d^{\times}$ distended longitudinally. Of course both sets of springs may be so arranged as to be compressed, or both may be arranged to be distended; or either set may be arranged to be compressed and the other to be distended. The arrangement represented in Fig. 1 suffices to illustrate both of these modes.

A is the fusee or intermediate regulator, which is fixed to a shaft *g*, arranged in the same horizontal plane with the cross-shaft *b*, but with its axis at right angles to that of the latter. A bevel-wheel *h* on the shaft *g* gears with a similar wheel $h^{\times}$ on the shaft *b*. A flexible connector *i*, which may be a chain, cord, or the like, is attached to the fusee A, at the outer end of the volute groove therein, and extends to and is wound on a drum or barrel *j*, arranged above the fusee. Fixed on the shaft of the drum *j* is a large wheel *k*, which gears with a pinion *l* on the winding-arbor *m*. On this arbor is ratcheted, in a well-known way, a wheel *n*, which gears with a pinion *o* on an intermediate shaft *p*, on which is another wheel *q*, which gears with a pinion *r* on the shaft *s*, from which power is taken to run the machine to be driven by the motor.

The object of the train of gears described is merely to increase the speed, or to "speed up" the shaft *s*, and of course this train may be increased, diminished, or varied at will.

The winding device may be, and is, as herein shown, very much the same as that used in clocks.

The power may be taken from the shaft *s* in any way thought desirable. It has not been thought necessary to show any means for effecting this.

So far as has been described the operation is as follows: The springs are wound up by applying a key or crank to the winding-arbor *m* and winding up the connector *i* on the drum *j*. This connector having been before wound up on the fusee A, in unwinding therefrom it revolves the fusee and its shaft, and, through the medium of the bevel-gearing described, this rotation of the fusee imparts rotation to the cross-shaft *b*. The effect of the rotation of this shaft is to wind up or put under tension the several springs *d* $d^{\times}$, as before described.

The function of a fusee in a spring-motor is too well understood to require any explanation herein.

In order to prevent injury to the motor in case the connector *i* should break while under strong tension, a safety-catch is provided which will now be described with special reference to Fig. 4.

Fixed on the same shaft with the fusee A is a ratchet-wheel *t*, and pivoted to the frame X is a pawl *u*, adapted to be put into engagement with the teeth of the ratchet-wheel *t* by a spring *v*. This pawl *u* is held out of engagement normally by a lever *w*, also pivoted on the frame X. One end or arm of this lever *w* engages the pawl *u*, and the other end or arm is provided with a laterally-projecting stud $w^{\times}$, which takes under or behind the strained connector *i*. This connector while intact holds the lever *w* at all times in such a position that the pawl *u* cannot engage the teeth of the ratchet-wheel *t;* but should the connector break the pawl will be instantly freed, and its spring will put it at once into engagement with the ratchet-wheel, and thus stop the rotation of the fusee-shaft. The function of the lever *w* is to allow the necessary change of position and angle of the strained connector as it winds up on the fusee, and it will be observed that when the motor is fully wound up and the springs under their greatest tension, the pawl *u* will stand very close to the teeth of the ratchet-wheel. This is somewhat important, as at this time the connector *i* is most likely to break, and the pawl should be in position to instantaneously engage the ratchet-teeth without the necessity of moving far.

The lever *w* may be provided with a spring *x* to supplement the action of the pawl-spring *v;* but this supplementary spring is not at all essential.

In order to regulate the speed of the shaft *s*, a brake-wheel a' may be fixed on this shaft and furnished with a brake-lever b' and adjustable weight c'. This brake device is best seen in Fig. 2.

We do not claim this safety device and brake above described, as they have been employed before.

The form given to the fusee A, in order that it may perfectly regulate the power derived from the springs, will be best understood from an inspection of the diagram Fig. 5 and the following description.

As the energy of a spring wanes gradually and regularly in "running down," it follows that if the connector *i* remained always parallel with a given line as it is unwound from the fusee the latter should have the form of a volute, which increases in an arithmetical ratio, and which has a uniform pitch; but as the connector *i* could only fulfill these conditions when the drum *j* was placed at an infinite distance from the fusee, it follows that, in order to obtain the correct pitch and form for the volute of the fusee, the varying angles of the connector *i* must be considered in constructing the volute. The principles upon which this construction is based will be best understood by an inspection of Fig. 5, which is a somewhat diagrammatic view designed to make clear the mode we adopt in constructing the volute for our fusee. The following directions will serve to produce the proper curve of the volute. In this diagram Fig. 5

the spiral of a volute with a uniform pitch—such as would be employed if the drum *j* were placed at an infinite distance from the fusee—is indicated by a finely-dotted line, and the sections of the true volute, such as we employ, are indicated by the letters Z′ Z² Z³, respectively, two of said sections Z′ and Z³ being shaded in the diagram for the sake of distinction. *z* is the nave of the fusee, and *i* is the connector which winds from the fusee onto the drum, and vice versa. The angle which the strained intermediate portion of the connector *i* makes with a line passing through the centers of the drum and fusee will vary as the connector is wound on or is unwound from the fusee, and this variation will depend on the distance of the drum from the fusee and the diameter of the drum.

The pitch of the first section Z′ of the volute may be arbitrarily chosen. In the present case we will suppose it to be two inches, or what would correspond to a two-inch pitch were the spiral regular, as represented by the dotted line. Draw the circle of the nave *z* with a circumference equal to this pitch—that is, equal to two inches. From the same center, and with a radius equal to the pitch (two inches) plus the radius of the nave, draw the circle 1. Then draw the line 2 2′ tangent to the circle 1 and to the drum *j*, prolonging it toward 2′. Then on the line 2 2′ measure off from the point of tangency 3 toward 2′ a distance equal to the radius of the nave *z*. This gives the point 3′ as a point in the volute and the terminal point of the section Z′. To complete this section, draw a regular volute from the point 3′ to the terminal at the nave, as shown, by any of the well-known graphic methods.

To construct the proper volute curve that bounds the second section Z² of the volute with the center of the core as a center, and with twice the pitch (four inches) plus the radius of the core, draw the circle 4. Then draw the line 5 5′ tangent to the circle 4 and the drum *j*, prolonging it toward 5′. Then on the line 5 5′ measure off from the point of tangency 6 toward 5′ a distance equal to the radius of the nave *z*. This gives the point 6′ as a point in the volute and the terminal point of the section Z². A true spiral must now be drawn from the point 3′ to the point 6′, and this will complete the second section of the volute.

The third section of the volute Z³, and all the succeeding sections, if any, will be constructed in the same manner as the section Z², just described.

It will be seen that the respective lines 2 2′ 5 5′ 8 8′ coincide with the different positions occupied by the connector *i*, and that the radii from the several points of tangency of these lines with the volute correspond to the leverage with which the fusee acts. If the angle of the connector did not vary, this leverage would increase to the extent of the pitch at each complete revolution of the fusee; but in the present case it increases to an extent equal to the pitch in less than a complete revolution, and the pitch increases in passing from one section of the volute to the next larger section in proportion to the angle formed by the radius drawn to the point where the connector *i* is first tangent to the lesser section, with the radius drawn to the point where the said connector is last tangent to this section—that is to say, from the beginning to the end of the section Z² of the volute the pitch increases in proportion to the angle included between two radial lines passing, respectively, through the points 3′ and 6′.

We do not limit ourselves to the exact construction and arrangement of the spring-motor herein shown. Any similar or equivalent means of simultaneously utilizing the tension of the spring in the direction of its axis and the torsional tension and the application of these combined forces to the rotation of a shaft or the like may be employed. The bar *e* is mounted on the spring-mandrels for convenience only, as it might be guided in other ways; but it is designed in any case to prevent the spring from revolving axially on its arbor. The connector *f* may wind up on a spool or drum on the shaft *b* in lieu of winding directly on the shaft.

We have illustrated in Figs. 6, 7, and 7ª certain modified arrangements of the spring in order to utilize the longitudinal and twisting tension simultaneously, and these we will now describe.

Fig. 6 illustrates in longitudinal sectional elevation an embodiment of our invention wherein the simultaneous twisting of the spring about its axis and the longitudinal extension thereof is effected by means different from that we have just described. In this construction the spring *d′* is mounted on a screw-threaded rod or mandrel *a′*, to which the spring is attached at one end. This screw-mandrel is prevented from rotating by a squared or flattened portion *a²* thereof sliding or playing in a bearing at *a³*. The fusee A has a collared bearing in the frame X, and a screw-threaded bore or eye at its center, through which is screwed the mandrel *a′*. The other end of the spring *d′* is secured to the boss of the fusee at *d²*. It will be readily seen that when the fusee A is rotated in winding up the spring the arbor *a′* will be driven endwise in a manner to distend the spring longitudinally. In returning to its normal status both forces of the spring will act in conjunction to rotate the fusee.

Figs. 7 and 7ª illustrate another embodiment of the invention, the former being a longitudinal sectional plan, and the latter a transverse section on line 7ª 7ª in Fig. 7. In this construction no spring-arbor is employed; but in lieu thereof the spring *d′* is embraced by a sleeve *a⁴*, which performs the functions of a guide to keep the spring straight in the same manner as the arbor. The fusee A is mounted

rotatively, as in Fig. 6, and has a toothed wheel A′ secured to or formed with it. One end of the spring is attached to this wheel or its boss, and the other end to a slide-bar e', which plays in guides formed by slotting the sleeve a^4. The longitudinal distending mechanism for the spring comprises two screws f^2 f^2, rotatively mounted in suitable bearings parallel with the spring, and each bearing a pinion c', which gears with the wheel A′. These screws screw through the respective ends of the bar e'. It will readily be seen that rotation of the fusee will put the spring under tension simultaneously about its axis, and longitudinally thereof.

These devices will serve to illustrate two of the many ways in which our invention may be carried out.

The intermediate mechanism between the helical spring and the power-shaft, whereby the spring is compressed or extended longitudinally and through which the tension of the spring reacts on the power-shaft, we denominate the "longitudinal-tension applier," and the intermediate mechanism between the helical spring and the power-shaft, whereby the spring is twisted axially and through which the tension of the spring reacts on the power-shaft, we denominate the "torsional-tension applier." These tension-appliers or intermediate mechanisms will vary in specific construction according to the construction of the motor, as we have shown.

By our peculiarly-formed fusee we accomplish perfect regulation with an ordinary cylindrical drum. This is not attained by any apparatus with which we are acquainted.

Having thus described our invention, we claim—

1. In a spring-motor, the combination, with a rotatively-mounted shaft, as b, of a rotatively-mounted spring-arbor geared therewith, a helical spring on said arbor and secured at one end thereto, a slide-bar secured to the other end of said spring and adapted to move in a direction parallel to the longitudinal axis of the spring, and a flexible connector attached at one end to said slide-bar and secured at its other end to said shaft b, and adapted to wind about said shaft, as set forth, whereby said spring is caused to exert two forces tending simultaneously to rotate said shaft.

2. In a spring-motor, the combination, with a rotatively-mounted shaft, as b, of a rotatively-mounted spring-arbor geared to said shaft b, a helical spring on said arbor and secured at one end to the same, a slide-bar secured to the other end of said spring and adapted to move in a direction parallel to the longitudinal axis of the spring, a flexible connector attached at one end to the slide-bar and secured to and winding about the shaft b at its other end, the fusee and its shaft geared to the shaft b, the drum j, the connector i, which connects and winds on said fusee and drum, the power-shaft s, and the train of gears intermediate between said drum and power-shaft, substantially as set forth.

3. In a spring-motor, the combination, with the shaft b, of the rotating spring-arbors a, two or more, geared to said shaft b, the springs d on said arbors, secured at one end to the respective arbors, the bar mounted to slide on the spring-arbors and secured to the springs thereon, and the flexible connectors secured to the respective ends of said slide-bar and winding on the shaft b, substantially as set forth.

4. In a spring-motor, the combination, with the spring from which the power is derived, a drum j, and a flexible connector winding on said drum, of a fusee driven by said spring and communicating its motion to said drum through said connector, said fusee being in the form of a volute of the character described, and having a pitch which varies with the variations in the angle made by the intermediate portion of the connector i with a line which passes through the axes of the fusee and drum, whereby the regulation effected by the fusee is rendered uniform, as set forth.

5. In a spring-motor, the combination, with a drum j and a flexible connector i, of a fusee A in the form of a volute whereof the pitch varies with the variations in the angle made by the straight intermediate portion of the connector i with a line which passes through the axes of said drum and fusee, whereby the regulation effected by the fusee is rendered uniform, as set forth.

6. In a spring-motor, the combination, with a helical spring from which the power is derived, of a longitudinal-tension applier and torsional-tension applier, whereby the spring may be put under longitudinal and torsional tension, for the purpose set forth.

7. In a spring-motor, the combination, with a helical spring from which the power is derived, and the power-shaft, of intermediate mechanism between said spring and power-shaft, whereby the spring is put under longitudinal and torsional tension and reacts under both tensions simultaneously on the power-shaft, said mechanism consisting of a longitudinal-tension applier and a torsional-tension applier, substantially as described.

In witness whereof we have hereunto signed our names in the presence of two subscribing witnesses.

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EUGENE H. GATES.

Witnesses:
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