(No Model.) 3 Sheets—Sheet 1.

E. THOMSON.

ELECTRIC MOTOR.

No. 438,204. Patented Oct. 14, 1890.

Fig. 1,

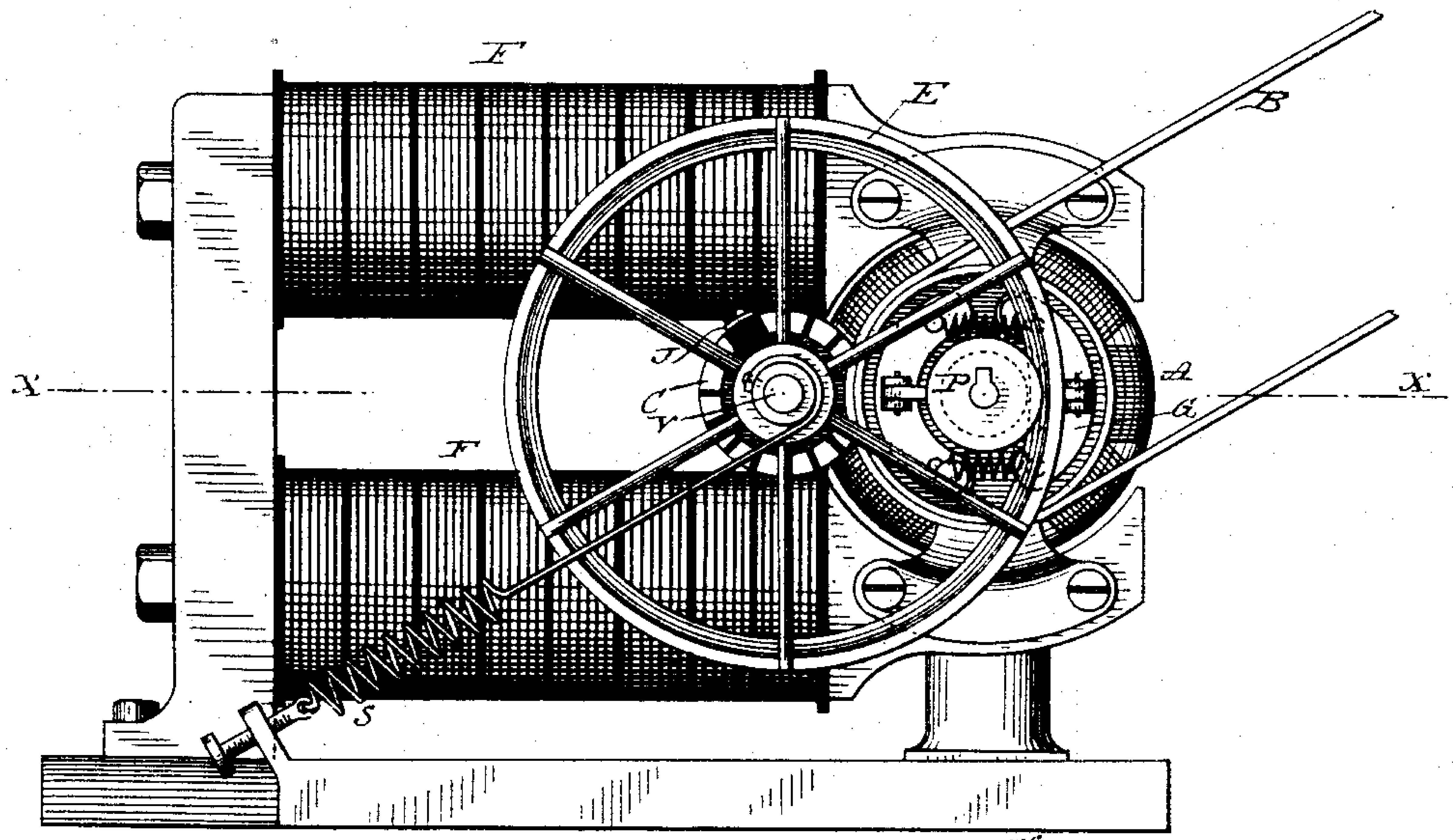
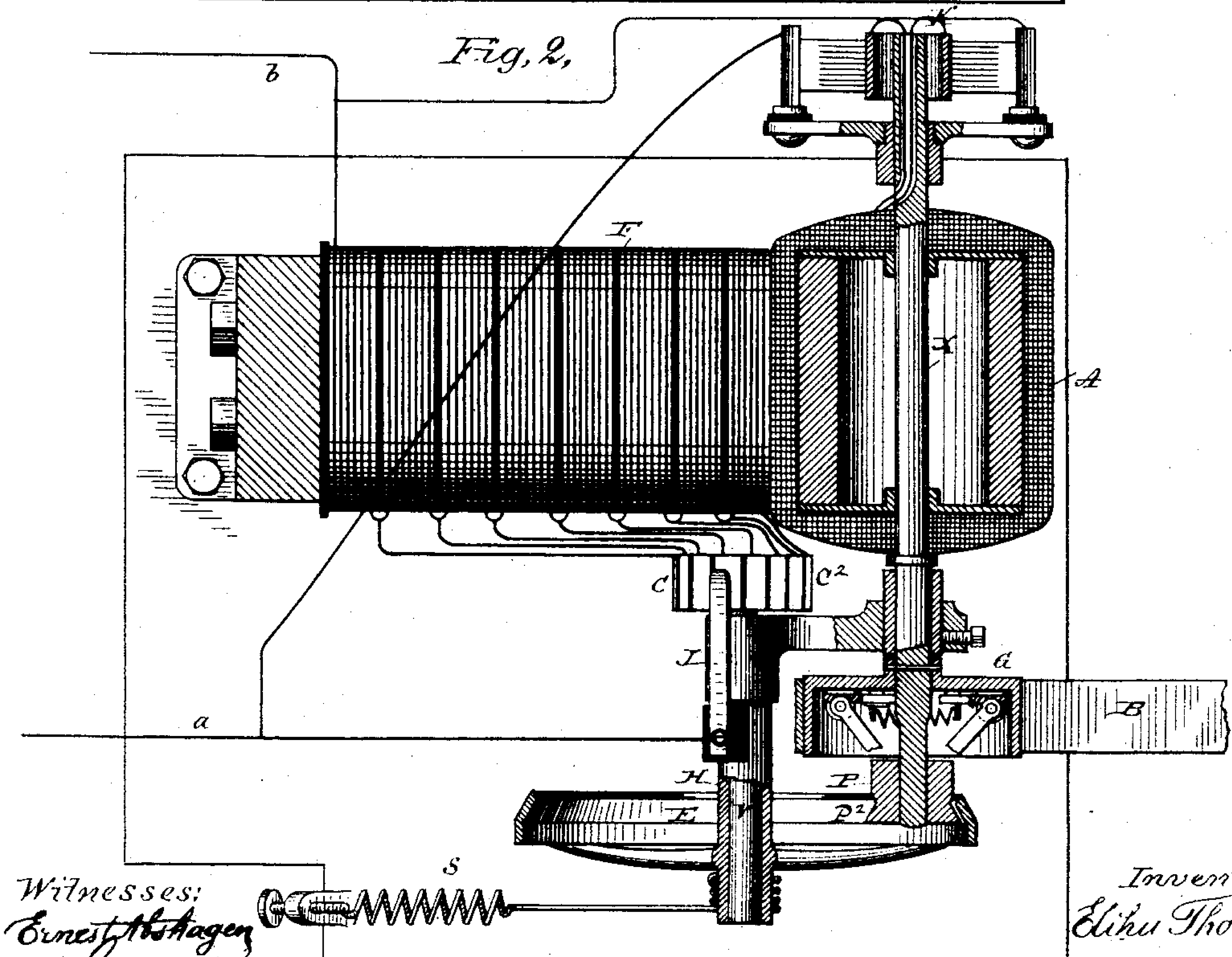


Fig. 2,



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Thos Toomey

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By his Attorney: H. C. Townsend

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

(No Model.) 3 Sheets—Sheet 2.

E. THOMSON.
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Fig. 3,

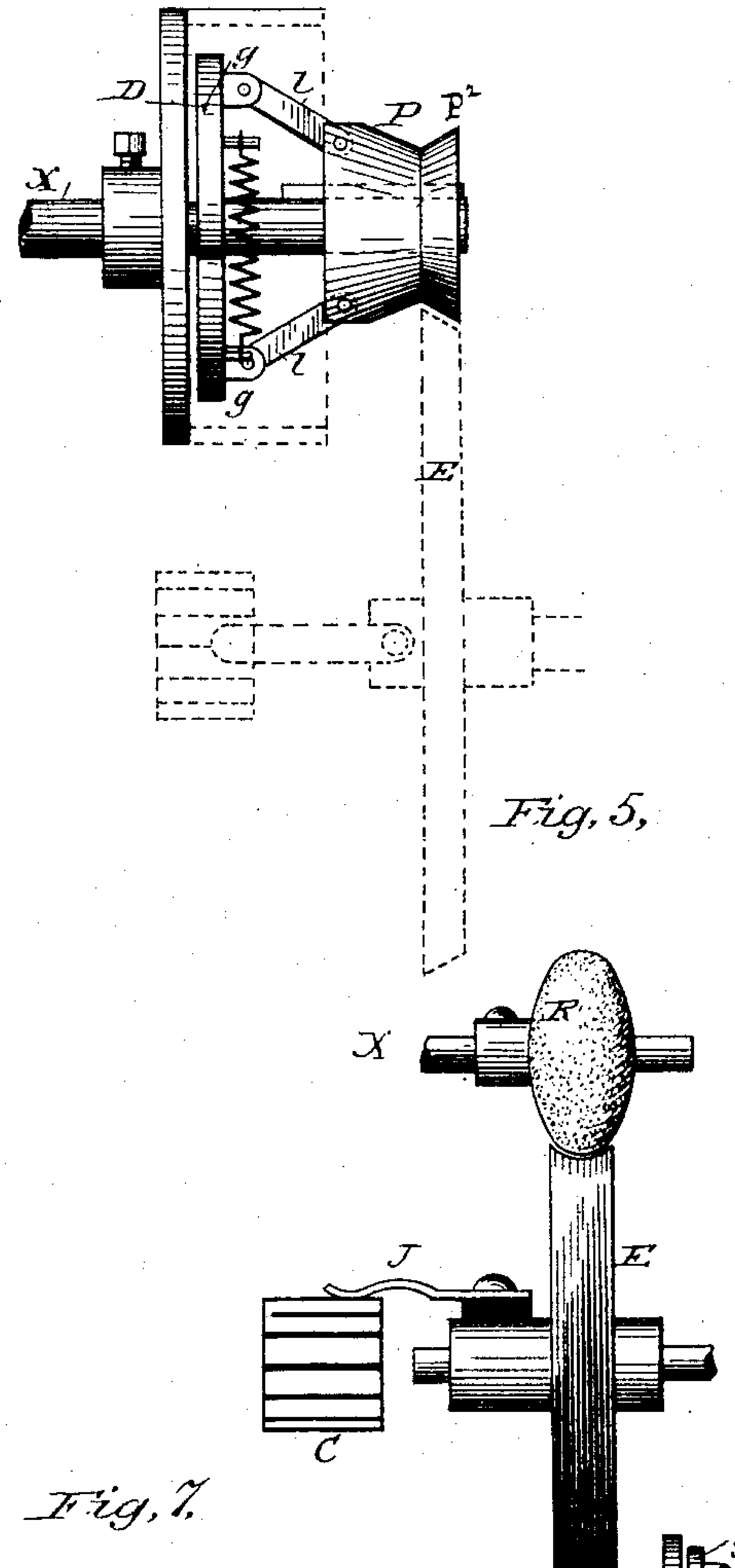

Fig. 5,

Fig. 4,

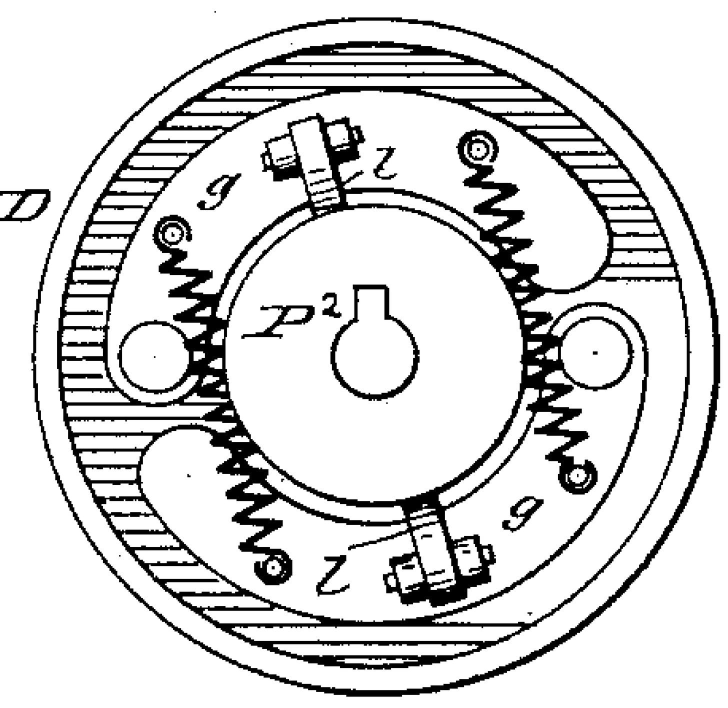

Fig. 19,

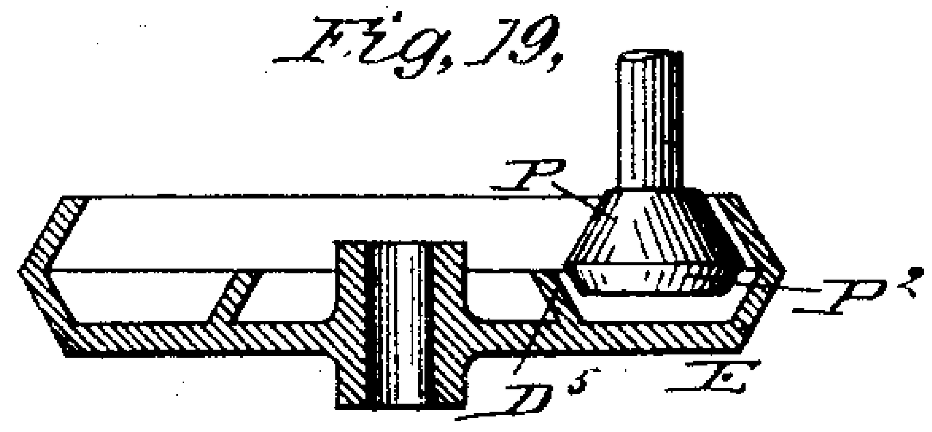

Fig. 6.

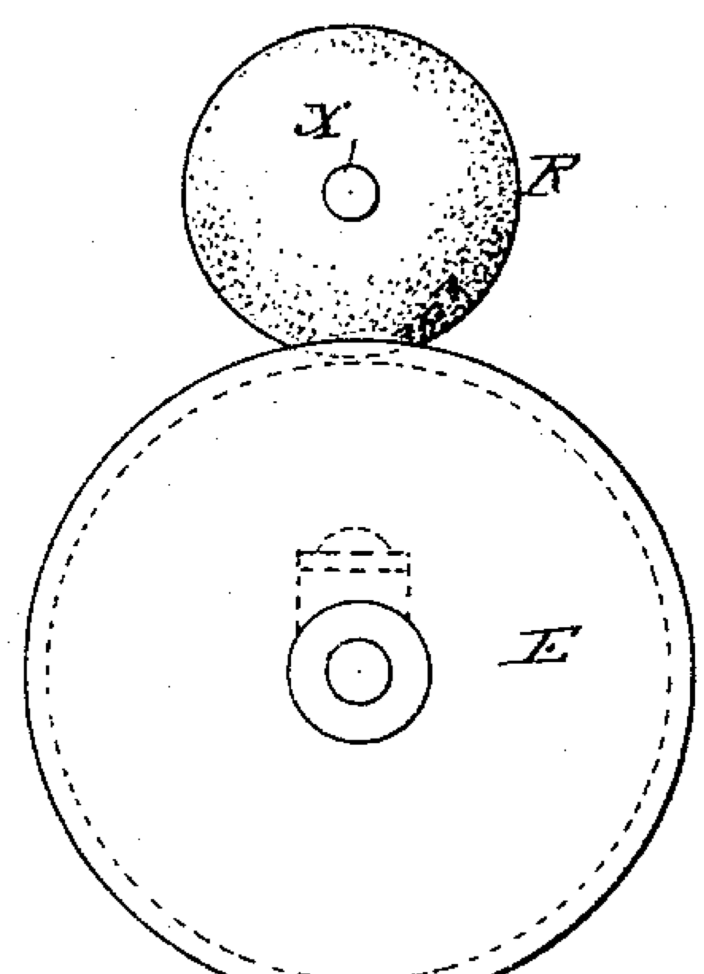

Fig. 7.

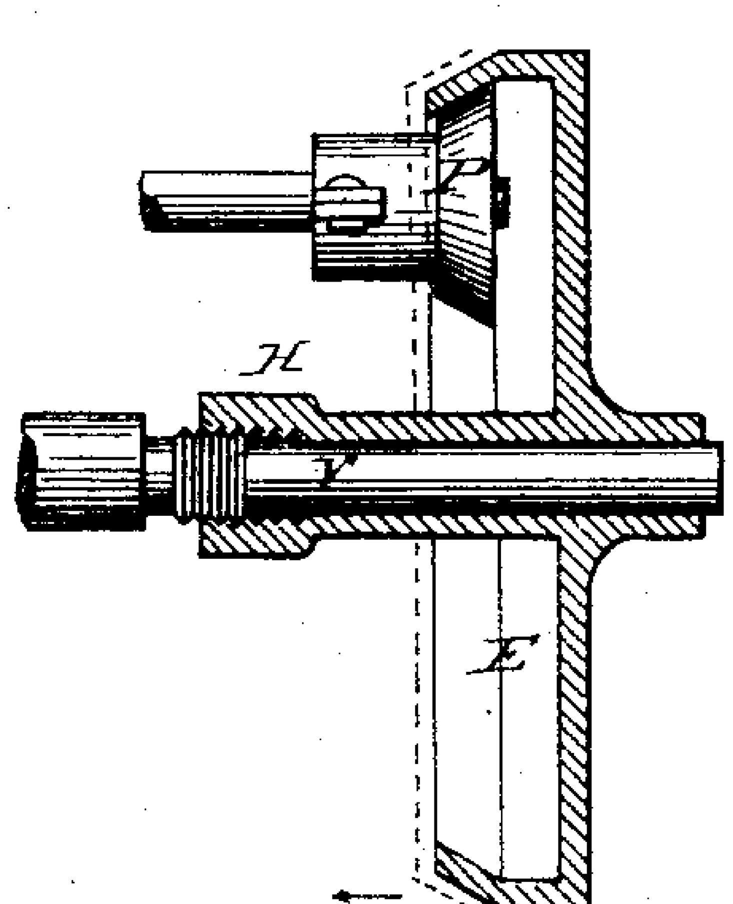

Fig. 8,

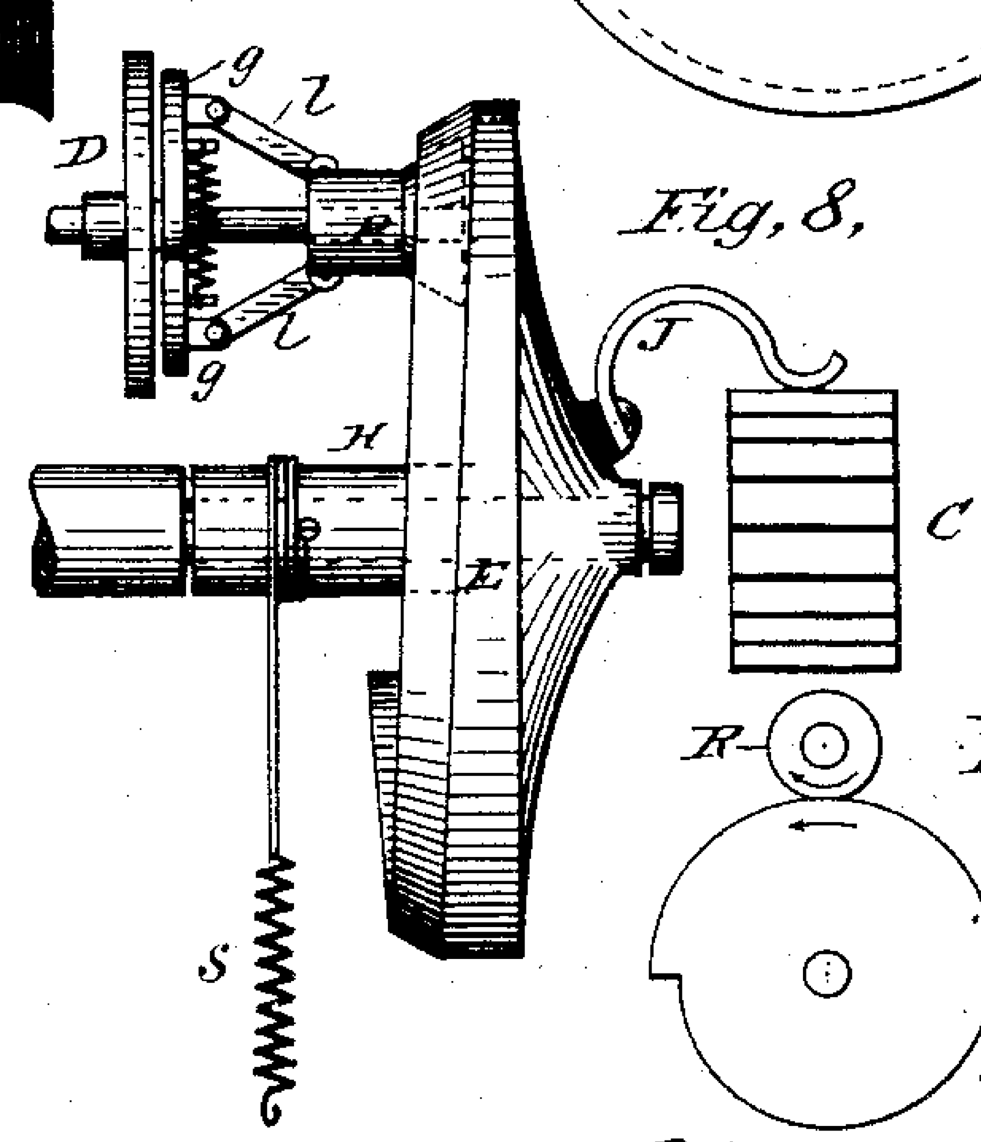

Fig. 9,

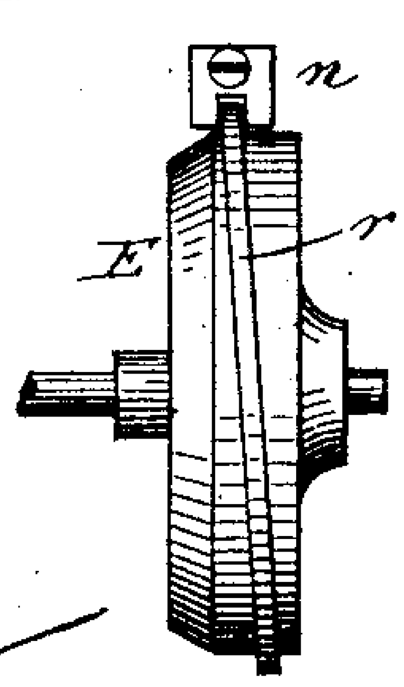

Fig. 10,

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(No Model.)

3 Sheets—Sheet 3.

E. THOMSON.

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Fig. 11.

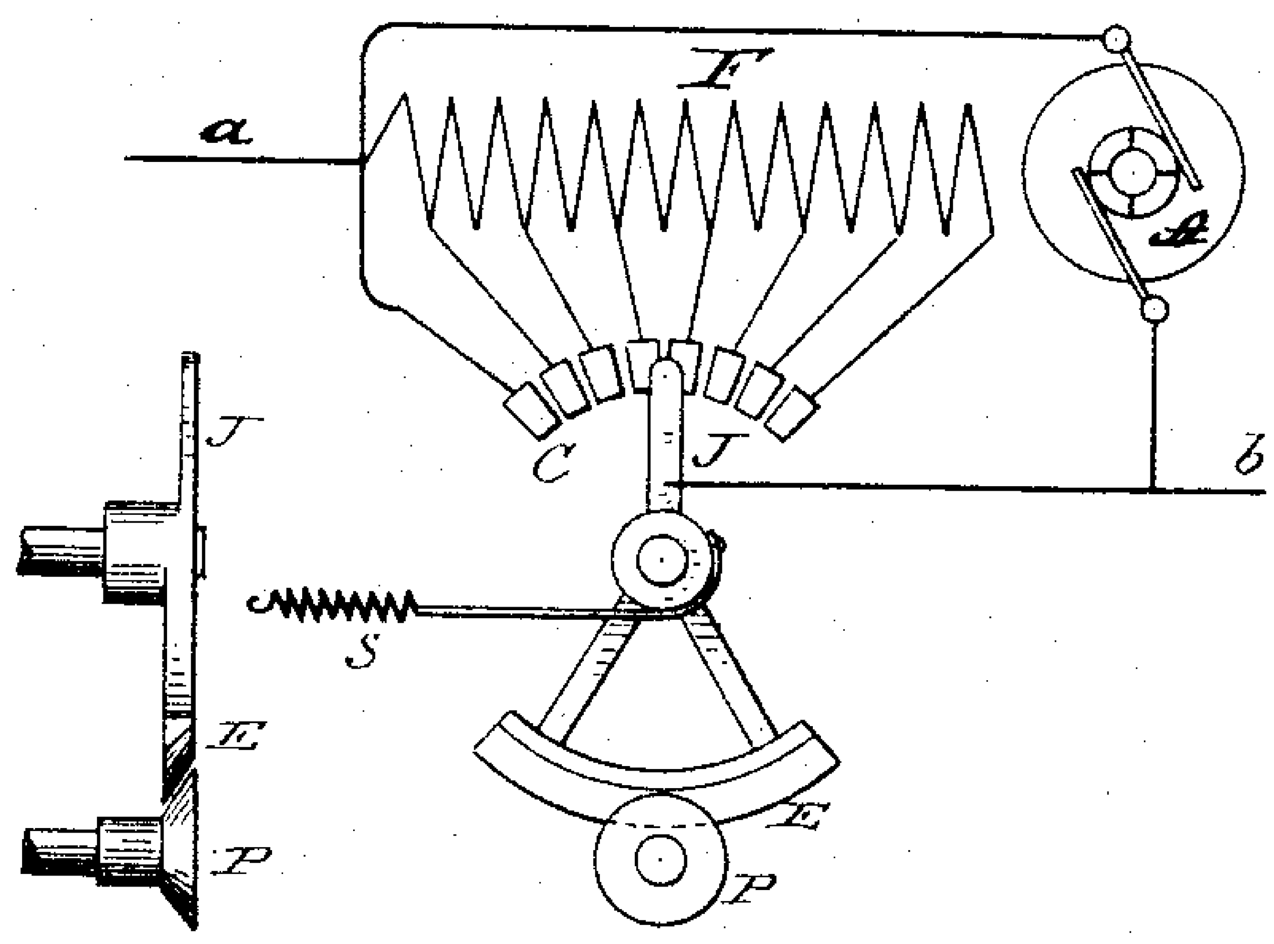


Fig. 12.

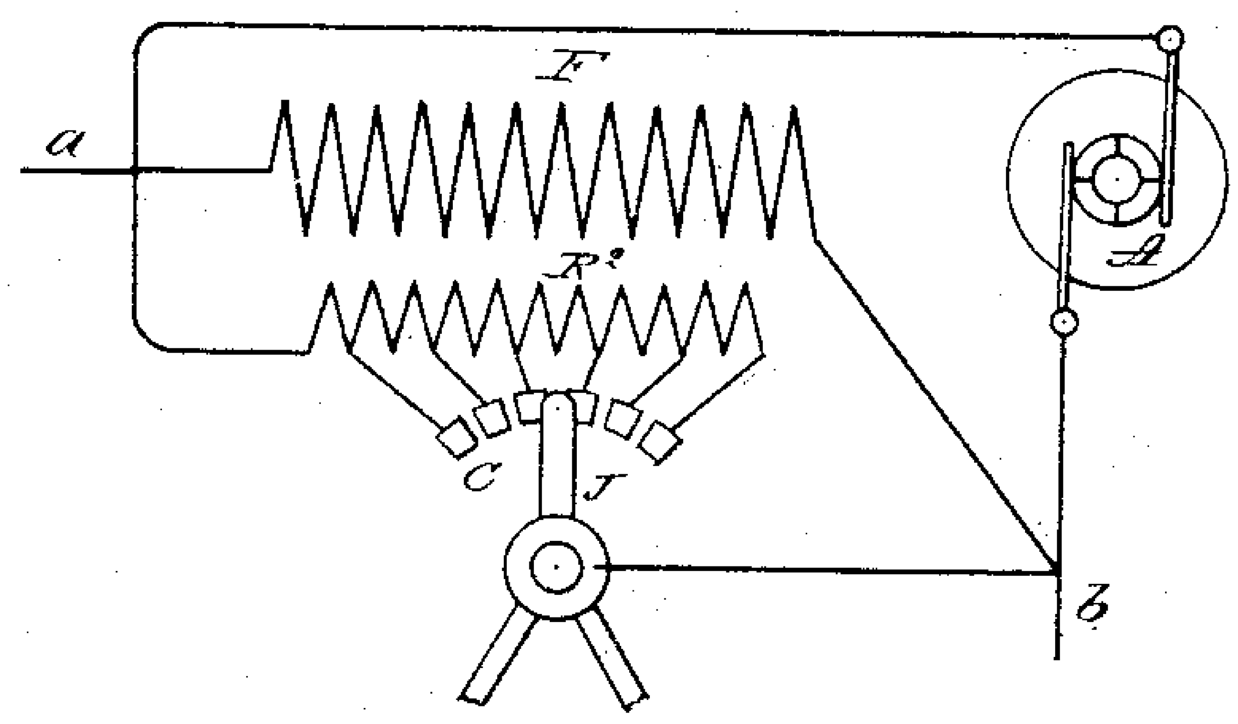


Fig. 13.

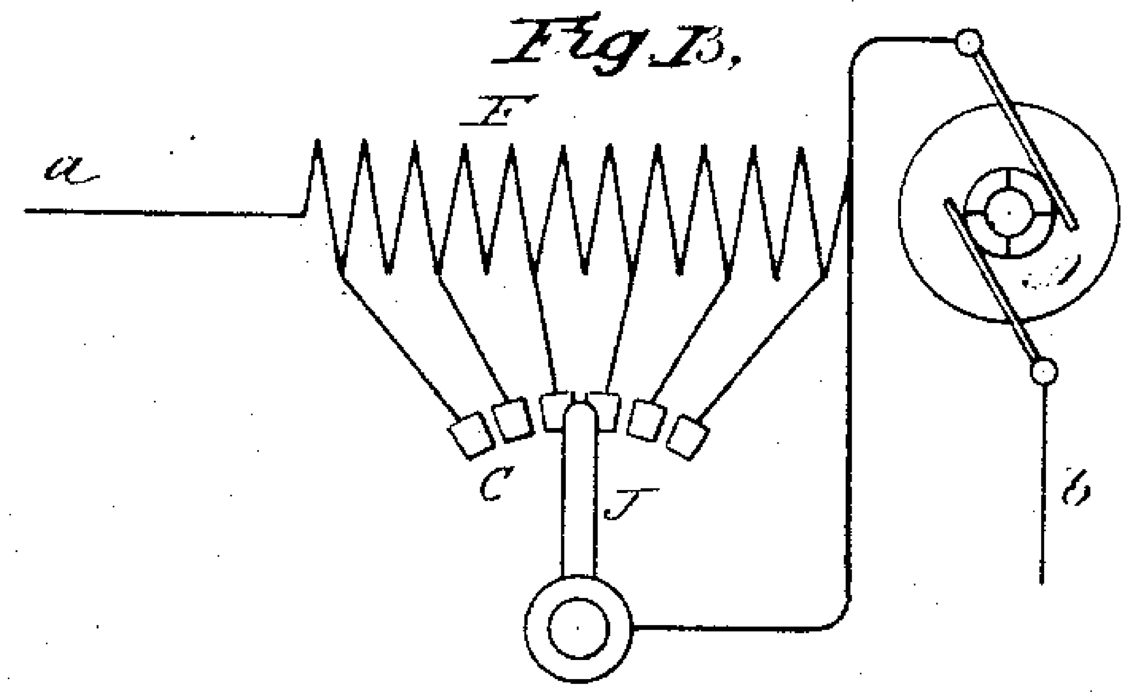


Fig. 14.

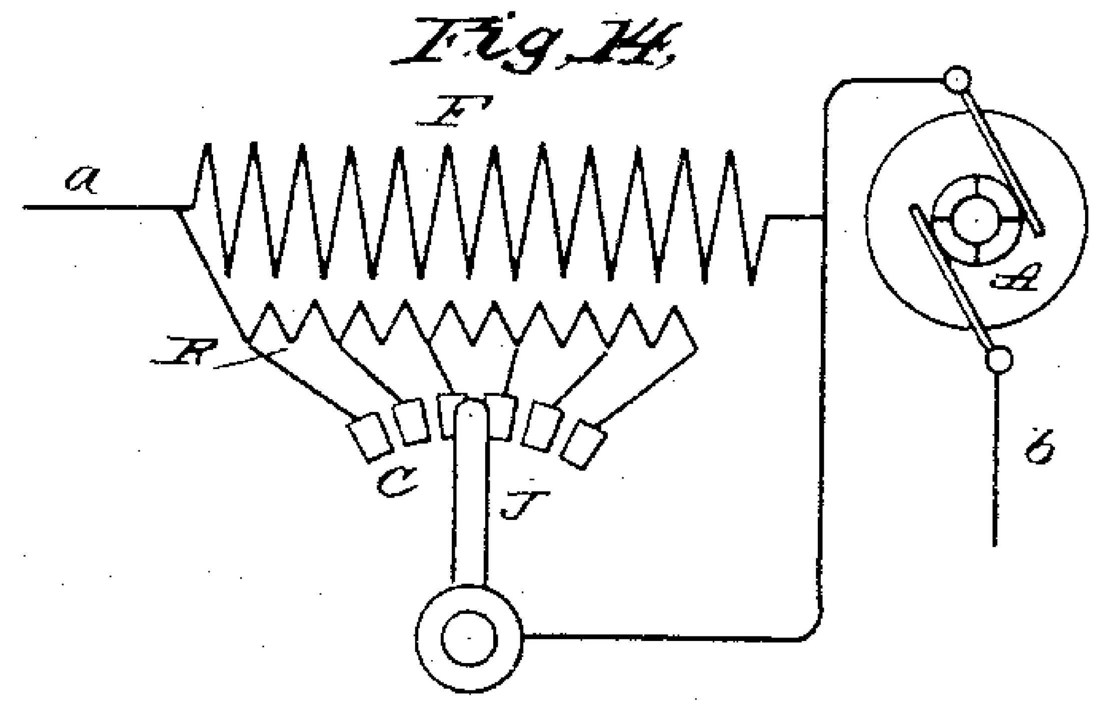


Fig. 15.

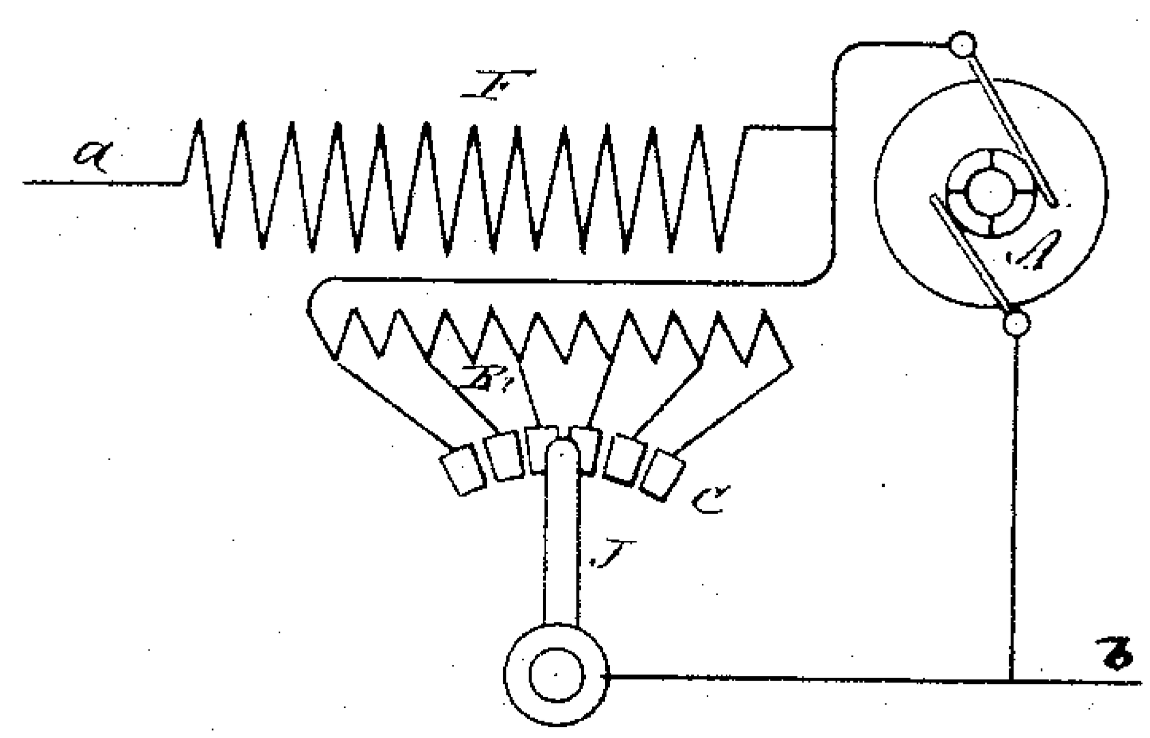


Fig. 16.

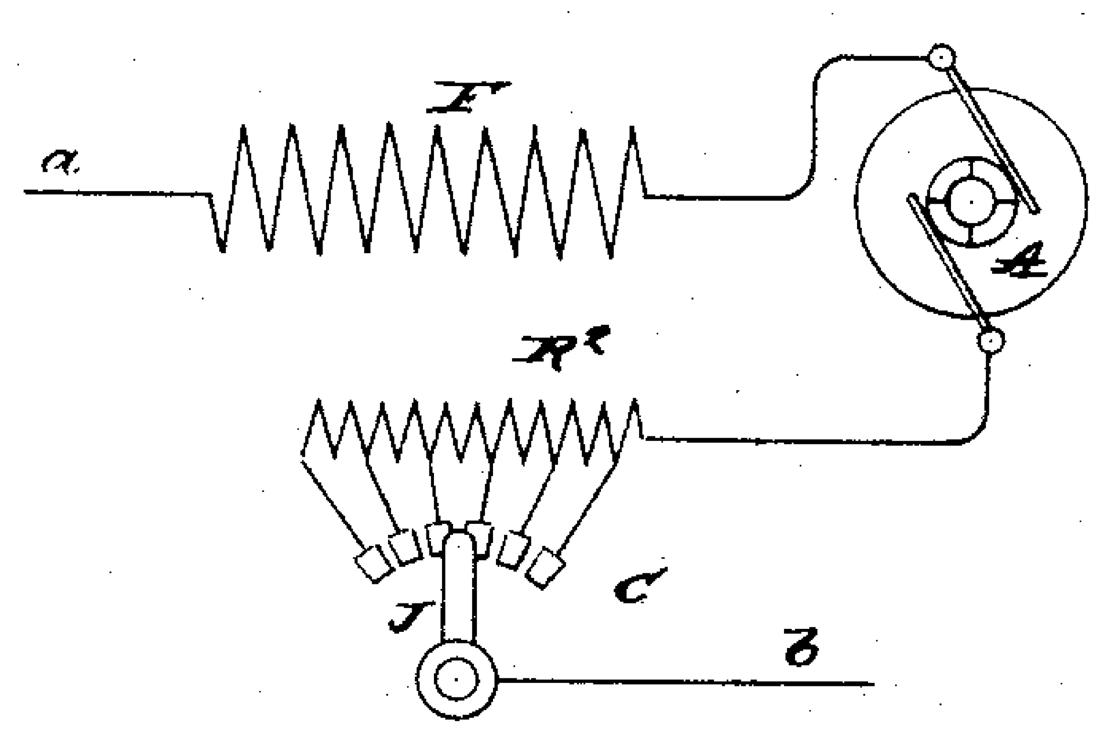


Fig. 17.

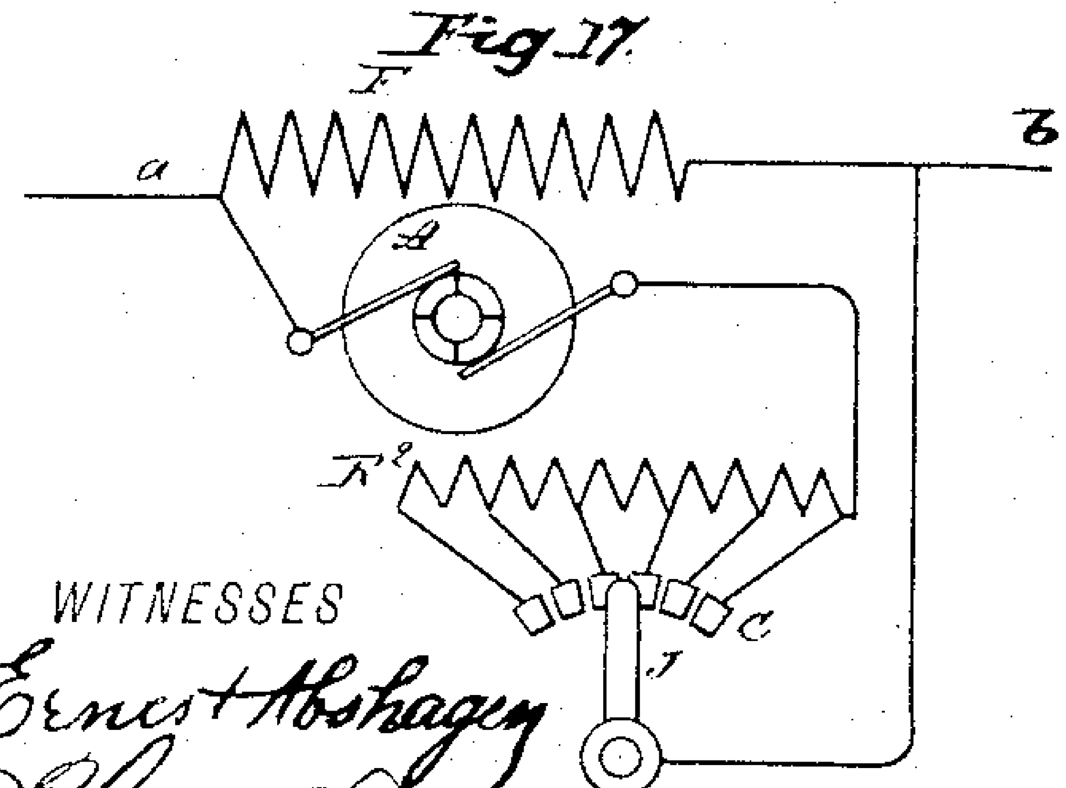
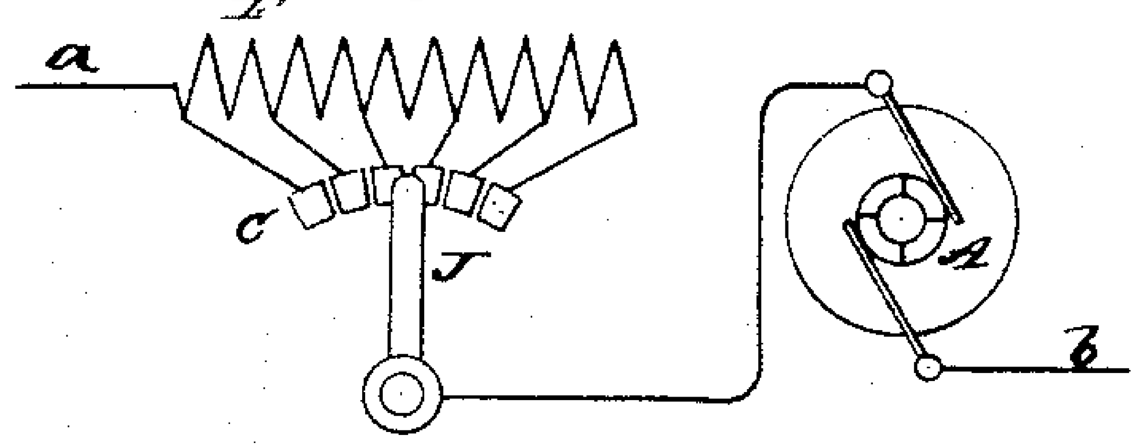


Fig. 18.



WITNESSES

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UNITED STATES PATENT OFFICE.

ELIHU THOMSON, OF LYNN, MASSACHUSETTS, ASSIGNOR TO THE THOMSON-HOUSTON ELECTRIC COMPANY, OF CONNECTICUT.

ELECTRIC MOTOR.

SPECIFICATION forming part of Letters Patent No. 438,204, dated October 14, 1890.

Application filed March 5, 1885. Serial No. 157,841. (No model.)

To all whom it may concern:

Be it known that I, ELIHU THOMSON, a citizen of the United States, and a resident of Lynn, in the county of Essex and State of Massachusetts, have invented certain new and useful Improvements in Electric Motors, of which the following is a specification.

My invention relates to devices for determining or governing the speed of electric motors under varying loads; and its object is to maintain in the motor a practically uniform speed under such varying conditions.

My invention is applicable to motors run in series upon lines with practically constant current, though it is not limited to such application.

My invention consists, first, in the combination, with an electric motor, of electrical devices for determining or adjusting the speed of the same under a given strength of current, a speed-indicator or other suitable device responsive to change in the speed of the motor, and suitable mechanism governed by said speed-responsive device, whereby when the speed of the motor increases to a predetermined point the running power of the motor may be applied to move the electrical adjusting devices.

As the best means of carrying out my invention, I prefer to employ as the electrical adjusting devices a series or set of contacts, over which moves a brush spring or contact operated at the required time by any suitable power, preferably the power of the motor itself, said set of contacts having electrical connections to the field-magnet or other connections, such that by movement of the spring or contact over them the strength of the magnetic field for the motor may be determined. I do not, however, desire to limit myself to any special plan of making such movement of the switch govern the strength of the field, and I will in a subsequent part of this specification describe various ways in which the same end may be effected by the arrangements and combinations forming the invention herein claimed.

My invention consists, also, in a special arrangement of the field-magnet, the armature, and the field-adjusting devices, the main characteristic of which is that the field and the armature are in parallel arc, while the field-adjusting devices also are in a branch or derived circuit around the armature through the field branch or through a branch in parallel arc therewith, so that when they act to adjust the strength of the magnetic field there will be simultaneously a diminution of the current in the armature by reason of an increased shunting of currents therefrom through the field-adjusting devices and its circuits.

My invention consists, also, in the combination, with an electric motor, of a variable electric shunt whose terminals are connected to the armature-terminals, and whose adjusting devices are operated or controlled through variations in the speed of running of the armature.

My invention consists, further, in a means for preventing over movement or adjustment of the devices, whereby the speed of running of the motor under a constant current is determined, the essential or leading principle of which consists in producing an automatic disconnection of the mechanism through which such devices are operated from any given power at the moment after the power and the intermediate mechanism are brought into gear by the action of the centrifugal governor or other mechanism responsive to changes in the speed of the motor.

My invention consists, also, in certain combinations and improvements, which will be described in connection with the accompanying drawings, and will then be specified in the claims.

In the accompanying drawings, Figure 1 is an end elevation of a motor and governor constructed in accordance with my invention. Fig. 2 is a plan and partial section of the same. Fig. 3 is an elevation of the speed-governor mounted upon the armature-shaft. Fig. 4 is an end view of the same. Fig. 5 shows a modified friction-gearing for mechanically connecting the driving-power with the motor-adjusting devices upon an increase of the speed of the motor to a predetermined point. Fig. 6 is an end elevation of the same device. Fig. 7 is a partial section of a friction engaging device constructed so as to produce a disengagement after a limited movement of the parts under the action of the driving-power. Figs. 8, 9, and 10 illustrate equivalent ways of securing the same results. Figs. 11, 12, 13, 14, 15, 16, 17, and 18 are diagrams of the connections, which will be described more particularly farther on. Fig. 19 illustrates a modified form of the friction-clutch or engaging mechanism whereby the devices for adjusting the speed of the motor are mechanically connected so as to be moved in a proper way from any suitable power—as, for instance, the power of the motor itself.

A indicates the armature of a motor, and K the commutator and brushes therefor.

The field-magnet of the machine is indicated at F, and is preferably wound in sections, as indicated, although, as will be described farther on, other arrangements may be employed in place of such sectional winding. The arrangement here shown is, however, preferable on the score of economy of current.

The armature-shaft of the motor is indicated at X, while G indicates the driving-pulley, and B a belt by which the power of the motor is transmitted.

The contacts of an electric switch that is constructed in a manner to be presently described are indicated at C, arranged, preferably, in the form of a cylinder. The brush or contact that moves in the circumference of a circle over said contacts is indicated at J. Said brush is suitably mounted upon a sleeve H, that rotates upon a hub or spindle and has secured to it a wheel E, through which by any suitable clutching or engaging mechanism the power of the motor or other device is applied at suitable times to turn the spring or contact J, so as to determine the strength of the magnetic field or to otherwise modify the electrical conditions in the motor, so as to determine the speed at which the armature shall rotate with a given strength of current. The clutching or engaging devices, which are mechanical in their nature, are governed in their action by any change in the speed of rotation of the armature acting through an ordinary centrifugal governor or other device responsive to changes in speed. A preferred construction of speed-responsive devices and of a mechanical clutch or engaging mechanism controlled thereby, so as to connect the wheel E with a driving-power, is shown in Fig. 2 and in detail in Figs. 3 and 4. A centrifugal governor is by preference mounted directly upon the armature-shaft X and within the pulley G. It consists of a plate or disk D, secured to the shaft and having mounted upon it two plates or arms *g g*, pivoted at one end, but free at the other, and arranged as shown, so that under the centrifugal action their free ends will move outward against the influence of coiled restraining-springs, and will thereby through links *l* move a sleeve P. The sleeve P is suitably mounted on the shaft, so as to be capable only of longitudinal movement thereon, it being prevented from moving around upon the same by a key and spline or other guiding device. The sleeve P is suitably formed or provided with an attachment P^2, such that it may act as a friction roll, wheel, or clutch. Upon the longitudinal movement of the sleeve upon the shaft, due to increased speed of rotation, the clutch P^2 will come into engagement with the wheel E, so as to turn the same under the power of the motor.

The friction engaging surface is indicated at P^2 and is suitably beveled, as shown, where it engages with a corresponding bevel upon the wheel E. The friction-surface is usually faced with leather. In the form of the device here shown the spring S, connected with a cord wound upon the hub H, serves to return the wheel E to a normal or starting position when the disk or roll P is disengaged from E, Figs. 1 and 2. A stop (not shown) is employed to determine this position, which is such that the spring J will rest upon a contact of the switch, where the power of the electric motor under a given current will be at its maximum.

The circuits and connections of the machine as thus far described are as follows: The field-magnet being wound in sections, one terminal of the whole field-coil is connected to the contact C^2, and the other terminal of the whole field-coil to the circuit-wire *b*. The coil-sections are connected, consecutively, to the plates of the switch in regular order, starting with the contact of the switch C next to C^2. The current entering at *a* branches, one part passing to the spring J and thence through the switch and the coil of the field-magnet, the other part passing to and through the commutator and the armature of the machine to the point *b*, where it joins that part passing through the field-magnet. It will be obvious that as spring J moves over the contacts the coil-sections are removed from circuit in the regular order, thus diminishing the strength of the magnetic field in which the armature revolves, and therefore the power or speed of the motor under a given current. When the wheel E is rotated by the spring S, the contact J is moved back, so as to include all the sections of the field-magnet in the circuit; but when said wheel is acted upon by the friction-roller P or other clutch device connecting the same to a driving-power the spring is moved or rotated so as to cut out the coil-sections, one after another, to the last.

It is to be understood that other devices may be employed instead of the particular governor and friction-gearing described, and in this respect I do not wish to be understood as limiting myself to the particular construction shown, the principle consisting in the combination, with any device that will respond to changes in the speed movement of the motor, of a suitable mechanism controlled thereby, so as to connect the wheel E with the power that is used for turning it and to automatically disconnect when such adjustment shall have been effected that the speed of the motor resumes its normal.

In Figs. 5 and 6 I have illustrated a mechanism that may be used in place of the particular construction of centrifugal speed-governor and clutch device already described. In these figures the shaft X, which may be the armature-shaft of the motor or a shaft driven by it, is provided with a soft india-rubber ball or spheroid R, which is capable of expansion circumferentially when the speed of rotation rises, so as to increase the centrifugal action. When thus expanded by an increase in speed of rotation, the edge of the ball or disk runs upon the edge of a wheel E and thus imparts the necessary motion to the latter for giving motion to the speed-adjusting devices of the motor—such as the spring J, moving over the contacts C.

I will now briefly describe the operation of the motor, reserving till afterward some further details of construction.

On current being sent through the motor, Figs. 1 and 2, the field-coils receive current, because the spring J has been so placed as to give circuit to the proper contact C under the action of the spring S when the apparatus is at rest. When the field-coils receive current, a portion branches through the armature-coils A by the commutator K when properly constructed and sets the machine in motion. If the motor is now required to do less than its maximum work, it will (on constant-current lines) continue to increase in speed, when finally the centrifugal device G may be called into action to move the clutch or connecting mechanism P, so as to gear the motor to the switch. This is effected by the disk P^2 running in contact with the rim of E, the set of parts having been such that this will not occur except when the speed is above the normal. The running of the disk or roller P^2 upon the wheel E causes its rotation or movement, thus moving the spring J so as to cut out sections of the field-coils successively. This continues until the field is of such strength that it is just adapted to the work required of the motor. Readjustments are automatically made to follow every change of load. It is a very useful feature of the device that it utilizes the movement of the motor, as described, to effect the adjustment in two ways—to set the roller P^2 according to speed and to turn the wheel or other contact-controlling device by its rotation. In practice with the best working there should be maintained at normal speed a light rubbing of roll P^2 on the wheel E, sufficient to maintain it at the position requisite to keep the speed normal. To secure this result more effectually and avoid oscillations of speed, it is best to so construct the mechanism by which the adjusting-spring J or other device is moved, or by which the driving-power therefor is connected to the wheel E, that under rotation by such power the parts shall be moved in a direction to automatically disconnect themselves from one another. This may be effected by moving the wheel E in a longitudinal direction upon the shaft when it is rotated by the roller B, so that it shall disengage itself from the roller. Some of the devices by which such disengagement may be effected will be now described. One of the best is to cut a rather fine thread upon the fixed axis V and provide the hub H of the wheel E with a nut fittting the thread loosely. By this means, upon rotary movement being communicated from P to E at high speed, the wheel E screws itself slightly along the fixed shaft V and moves away from the roll E. The spring S moves it back. In Fig. 8 a slightly different but equivalent construction is shown. The hub H rotates without lateral movement; but the interior of the rim of E, upon which wheel P impinges, is made to follow a slightly helical course, which carries it away from impingement as E is rotated. In the construction shown in Fig. 9 there is a helical rib *r* upon the outer portion of the rim of E, which is made to move in a stationary notch *n*. Upon rotation E is thus caused to move slightly laterally. In the construction shown in Fig. 10 the same effects are obtained by a modification of the device, Figs. 5 and 6. The wheel E is provided with a rim slightly spiral in outline, as shown, so that as the disk or wheel R rotates it will rotate E, but the periphery of E will recede from R slightly during such rotation.

The object of the devices, Figs. 7, 8, 9, and 10, providing for the receding of the impinging surfaces during rotation one by the other, is to give stability to the speed-governing devices, or rather to lessen the sensitiveness, so as to check undue oscillation of speed. This results from the fact that a somewhat higher speed will with such devices be needed to effect a complete sweep of the contact-spring J over the whole of its range of contacts than to effect its movement over a portion only of them. Without the devices, as in Fig. 7, for rendering such slightly higher speed necessary to effect a complete sweep of J, as described, the action that would be apt to take place would be such that as soon as the speed rose so as to bring P, Fig. 2, into impingement upon E a complete sweep of J would follow over its whole range of contacts before the speed could fall. On the speed falling, so as to permit of no impingement of P on E, a complete back-sweep would take place by the action of the spring S. This would tend to produce oscillation of speed of the motor, which is obviated by the devices, such as Fig. 7, or their equivalents. My invention is applicable to any device for determining the speed of an electric motor under a given strength of current. Some of the arrangements of circuits, rheostats, switches, &c., whereby such adjustment may be effected, and to which my invention is applicable, will be now described.

In Fig. 11 the circuits illustrated are the same as those shown in Fig. 1, the armature and field-circuits being in parallel arc between the points a and b, and the switch-contact J serving to determine the number of field-coil sections that shall be at any given time in circuit. In this figure the parts E P are shown in side view and in detail in edge view. This arrangement is a preferable one on the score of economy of current and is suitable for lines or circuits in which a current of constant strength is supplied to the motor. By it an adjustment is effected in two ways—first, by diminishing the strength of the magnetic field through a diminution of the number of coils in action, and, second, by the diversion of the current from the armature, the latter adjustment being due to the fact that as the switch moves over contacts C to cut down the number of coil-sections in circuit it thereby, through the diminution in the number of coils included in series in the circuit of the branch, diminishes the resistance to the flow of current and thereby causes a simultaneous diversion of the current from the armature A to a greater extent than is the case when all of the coil-sections are connected in the branch. A nearly equivalent but less economical arrangement for effecting this result is shown in Fig. 12, in which the switch J and the circuit controlled thereby are, as in Fig. 11, a branch or shunt around the armature, which also in this case is independent of the field-circuit branch instead of being coincident therewith. In this instance there are three branches, one including the armature, the other the field-coils F, all of which are at all times in circuit, and the third an adjustable or variable resistance of any desired description, that shown being the well-known one, comprising a series of resistances connected to a series of contacts over which the spring J moves with the effect of shunting the current in variable degree from the field-magnet coil F, so as to cut down the power of the field-magnet and simultaneously, as is obvious, to divert the current in greater degree from the armature. By this arrangement it will be seen that the same result is produced as above, Fig. 11, since the adjustment of the brush J to vary the strength of the magnetic field is productive also of a variation in the amount of current shunted or diverted from the armature. This arrangement is, however, less economical than that of Fig. 11; but it is suitable also for motors used upon lines on which the current supplied is kept constant by the employment of any suitable means—such, for instance, as devices applied to the generating-machine. The spring J and contact C might be applied for adjusting the speed of the motor by the arrangement of the circuit shown in Fig. 13, in which the armature and the field-coils are placed in series instead of being placed in parallel arc, and the strength of the field is adjusted by causing the current to circulate through a greater or less number of sections of the field-coil either by shunting or open-circuiting them.

The shunting of the coils is effected by the arrangement of the circuits shown in Fig. 13, while by the arrrangement shown in Fig. 18 they are simply open-circuited. These two arrangements are well known in the art and need not be described further in detail. The arrangement of Fig. 14 differs from that of Fig. 13 only in that the strength of the field is determined by variably shunting the current from the whole number of the coils on the field-magnet, instead of by varying the number of coil-sections through which the current shall flow, as is done by the arrangements of Figs. 11, 12, 13, and 18. The arrangements of Figs. 13 and 14 are less economical in respect to driving current than those of Figs. 11 and 12, but are somewhat simpler to construct and arrange. They are suitable for motors used upon constant-current lines.

In Fig. 15 the armature and the field coils are in series; but the armature is variably shunted by such an arrangement as has been before described. It is obvious from an inspection of the figure that when the speed of the motor unduly increases the spring J is made to move, so as to lower the resistance in R^2, so as to decrease the power of the armature by shunting the current from it.

In Fig. 16 the variable resistance is placed in series with the armature or the field coils, so that upon an adjustment of the spring by reason of an increase of speed the effect is to increase the resistance in the circuit, including the armature of the motor, and to thus diminish the flow of current. This arrangement is best adapted for use with motors arranged in parallel on a circuit on which a constant difference of potential is maintained.

In Fig. 17, between a and b, the armature and the field-magnet are in parallel arc from a to b, and the variable resistance R^2 is placed in the armature branch. Under this arrangement the spring J upon an increase of speed is moved so as to put more resistance in the branch circuit containing the armature, and vice versa to diminish such resistance under diminution of speed. This arrangement also is suitable for use with the motor when there is a constant difference of potential between a and b. Instead of a spring, as S, to effect a counter adjustment or movement of the speed-adjusting devices, the same result may be attained by the positive action of clutching or engaging mechanism brought into engagement and serving to move the said devices by the positive influence of the driving-power when the speed falls. One construction of such a device is shown in Fig. 19, where the disk P is provided with a clutching or friction surface adapted to engage with a flange or surface D^5 on the wheel E, so as to turn the latter backward or toward the point where the power of the motor will be at its maximum with a given current.

I make no special claim herein to the arrangements shown in Figs. 12 to 18, inclusive, of the drawings, as they will form the subject of separate applications for patent.

What I claim as my invention is—

1. The combination, with an electric motor, of a device responding to changes in the speed of said motor, an electric switch, and an intermediate mechanical clutching or engaging device for operating the switch from the power of the motor, the parts of said device being brought into engagement by a change of speed of the motor, as and for the purpose described.

2. The combination, in an electric motor, of an electric switch having a series of contacts, a device responding to change in the speed, a friction disk or wheel governed thereby, and a driven wheel or disk arranged in proper mechanical relation to said friction-wheel to be operated thereby when the parts are brought into engagement by the action of the speed-responsive mechanism, said driven wheel being connected to a traveling contact adapted to move over the series of contacts.

3. In an electric motor, the combination, with the adjusting devices and the driving or operating power therefor, of an intermediate engaging or connecting device governed by changes of speed, the engaging or connecting parts having a traverse or movement that will cause them to separate under the action of the driving-power, as described, so that a higher speed shall be required to cause a complete movement of the adjusting devices than is required to produce a limited movement.

4. The combination, with an electric motor, of a speed-adjusting and a speed-controlling device, both run from the motor, and connecting mechanism for gearing the speed-adjusting device to the motor, said mechanism being governed by the speed-controller, as and for the purpose described.

5. The combination, with an electric motor, of a controlling-switch governing the strength of the magnetic field and operated or driven by the motor and an intermediate connecting mechanism responsive to changes in the speed and serving upon an abnormal increase of speed to connect the motor to the switch, as and for the purpose described.

6. The combination, with a variable field-magnet in an electric motor, of a controlling electric switch and an actuating mechanism driven from the motor and brought into engagement with the switch, so as to move the same upon an increase in the speed of the motor to a predetermined extent, whereby said switch may be turned or operated so as to cut down the magnetic field, and thereby compensate for the tendency to increased speed.

7. The combination, with the adjusting devices for determining the speed at which the motor shall run under a given current, of mechanism for operating the same and a gear or clutch for connecting the same to the adjusting devices, said gear being normally out of engagement, but controlled by an increase in the speed of the motor, so as to bring the parts into mechanical connection, and thereby effect a movement of the adjusting devices.

8. The combination, with an electric motor, of a set of switch-contacts controlling the strength of the field-magnet and mechanism for throwing the running power of the motor into gear with said switch, said mechanism being controlled by changes in the speed of the motor, as and for the purpose described.

9. The combination, with the field-magnet and the armature in an electric motor arranged in parallel arc, of a switch for cutting down the strength of field-magnet, the circuit through said switch forming a shunt or branch around the armature, as described, so that simultaneously with a decrease in the strength of the field by the action of the switch current shall be diverted in increased measure from the armature.

10. The combination of an electric motor having its field-magnetism sustained by variable field-magnet coils placed in one branch of the circuit, an armature placed in another or separate branch, and a circuit-controller placed in the field-magnet branch for lessening the number of sections of coil in action on the field-magnet and simultaneously decreasing the resistance in the field-magnet branch, so as to shunt an increased amount of current from the armature, as and for the purpose described.

11. The combination, with an electric motor, of a variable shunt whose terminals are connected directly to the two sides of the armature and means for lessening the resistance of said shunt when the power of the motor is to be decreased, said means being placed in the shunt branch, as and for the purpose described.

12. The combination, with an electric motor, of an adjustable or variable shunt around the armature, an armature branch of constant resistance, and a speed-indicator or other suitable device responsive to the variations in the speed of the motor due to changes of load, said device being connected to variable shunt devices and operating to decrease the shunt-resistance on an increase in the speed of the motor.

13. The combination, with an electric motor having a sectional field-magnet coil whose sections are arranged in series and an armature arranged in one branch of the circuit, the other branch of which contains the field-magnet coils, of an electric switch or circuit-controller for varying the number of coils through which the current shall flow in series, so as to reduce the resistance in the field branch as compared with that of the armature branch, while decreasing the number of coils in action.

14. The combination, with an electric motor, of a centrifugal speed-governor mounted on the armature-shaft, the friction-clutch connected therewith and sleeved upon the shaft, and a wheel, disk, or other suitable device,

arranged to be engaged by the friction clutch or disk on an increase of speed to a predetermined point and connected mechanically with the device, whereby the speed of the motor under a given strength of current is adjusted or determined.

15. The combination, with an electric motor, of a centrifugal speed-governor, the friction clutch or disk having a longitudinal movement upon the support, a wheel or disk adapted to be engaged by said clutch and having means whereby its engaging surface may be caused to move out of engagement when said disk or wheel is turned by the clutch, and electrical adjusting devices operated by said wheel for determining the speed of the motor under a given current.

16. The combination, with an electric motor, of a field-magnet winding of said motor electrically divided into sections arranged in series with one another, an electric switch for governing the number of coils in action, and a speed-indicator or other suitable device responsive to the variations in the speed of the motor due to changes of load, said device being connected to the electric switch and operating to decrease the number of coils in circuit and the electric resistance in the field-magnet on an increase in the speed of the motor.

Signed at Lynn, in the county of Essex and State of Massachusetts, this 26th day of February, A. D. 1885.

ELIHU THOMSON.

Witnesses:
W. O. WAKEFIELD,
E. H. KITFIELD.