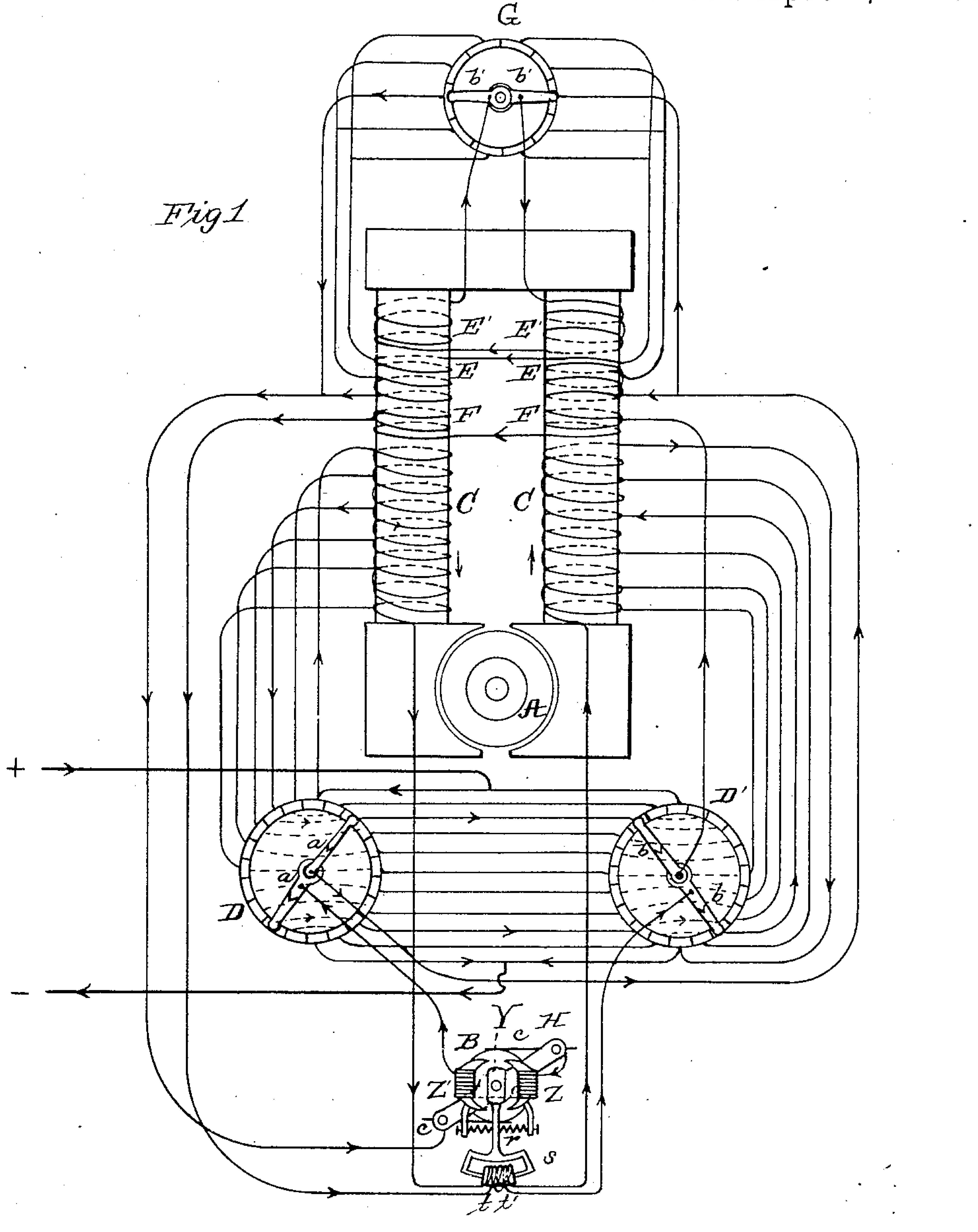
(No Model.) 2 Sheets—Sheet 1.

F. J. SPRAGUE.

ELECTRO DYNAMIC MOTOR.

No. 315,183. Patented Apr. 7, 1885.



ATTEST:
E. H. Rowland
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INVENTOR:
Frank J. Sprague
By Dyer & Seely
Attys

(No Model.) 2 Sheets—Sheet 2.

F. J. SPRAGUE.

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Fig. 2.

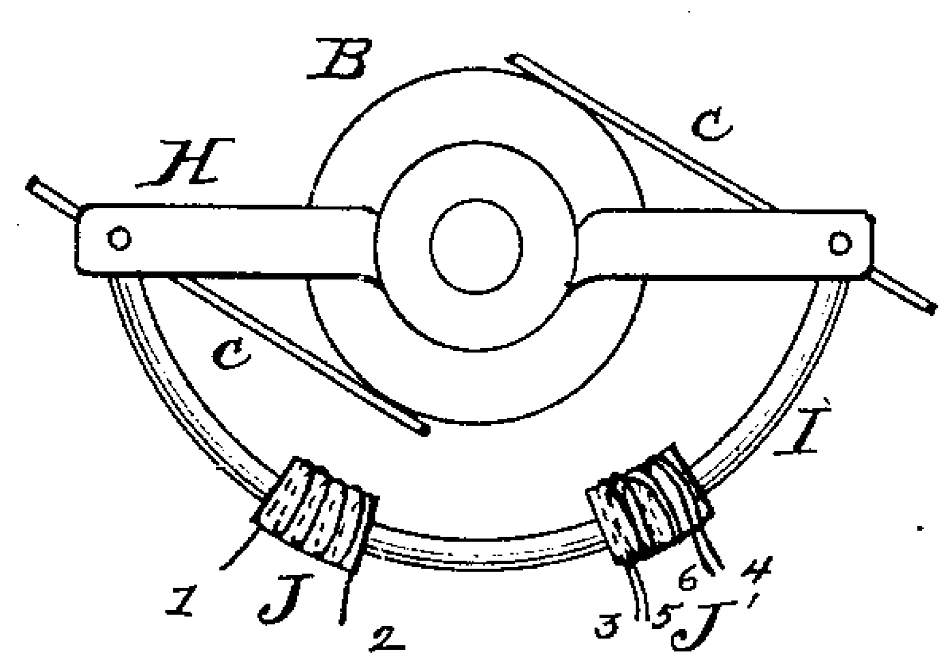


Fig. 3.

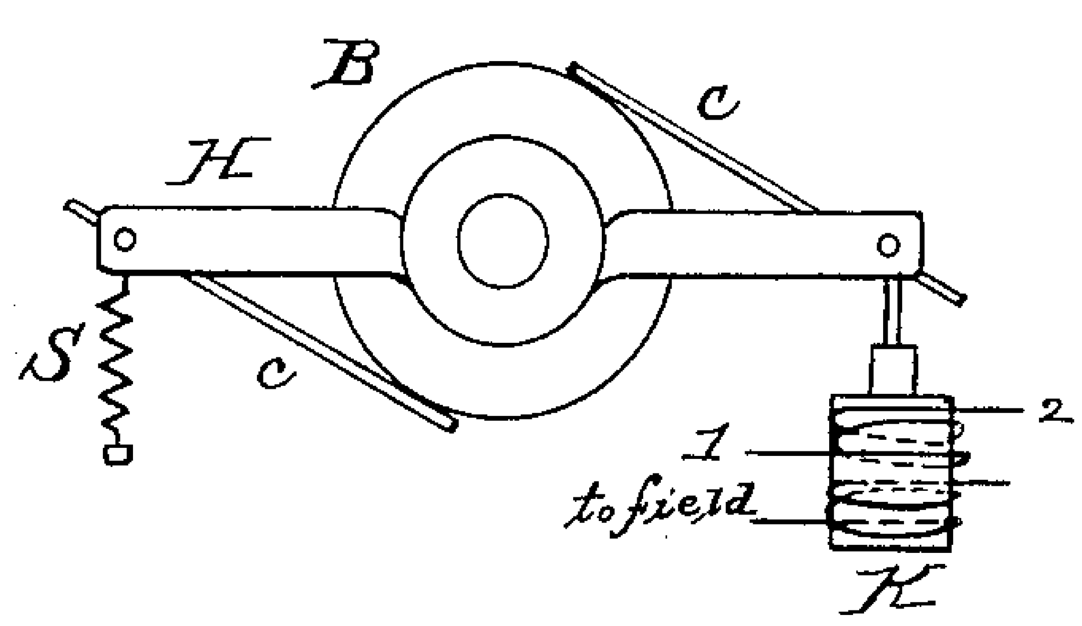


Fig. 4.

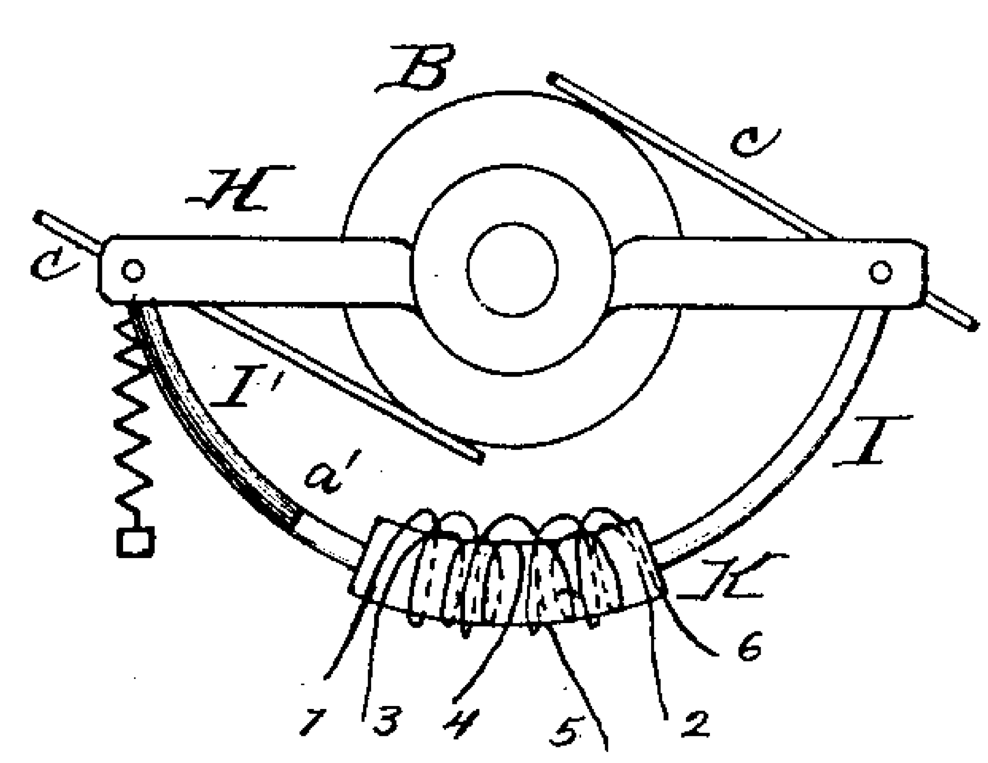


Fig. 5.

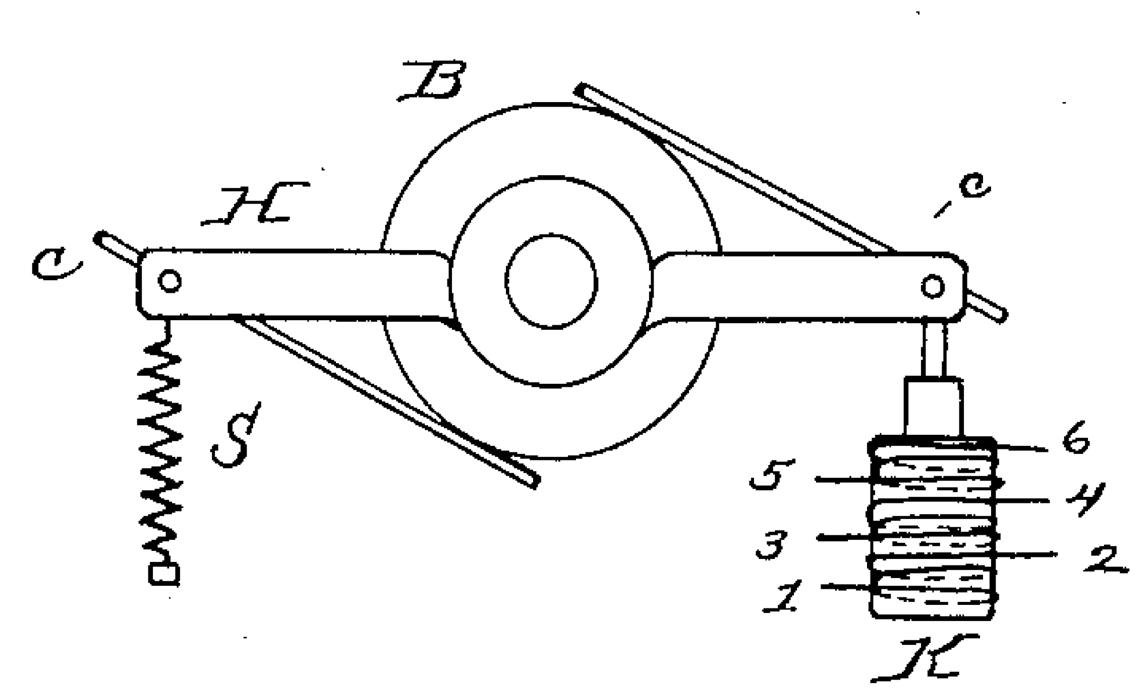


Fig. 6.

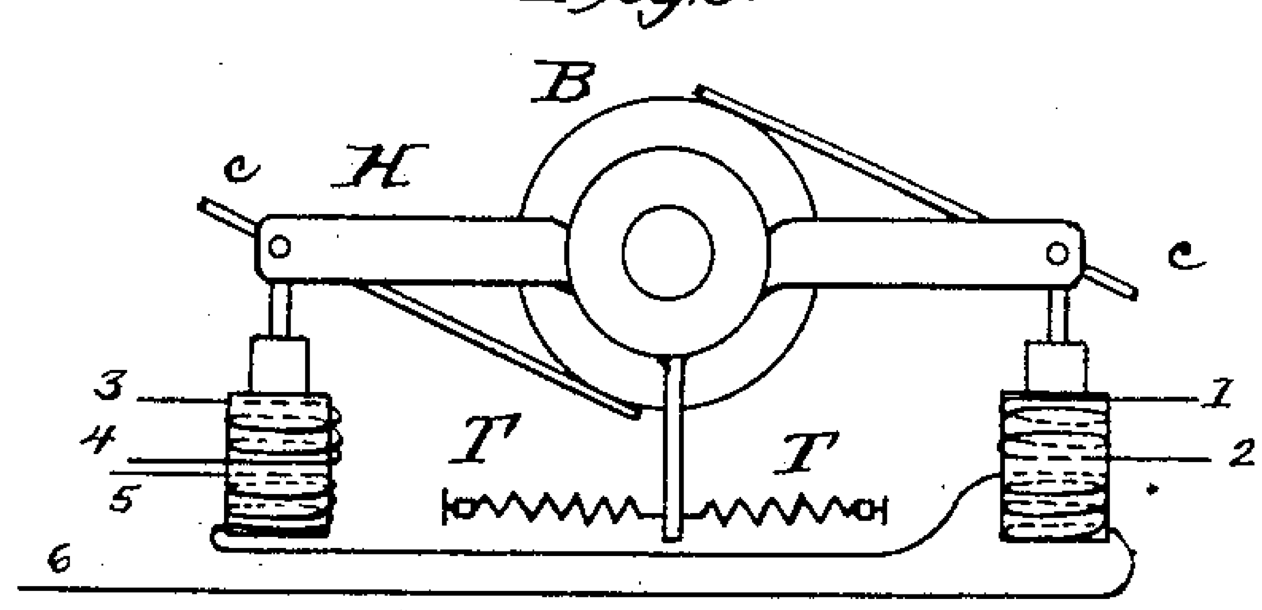


Fig. 7.

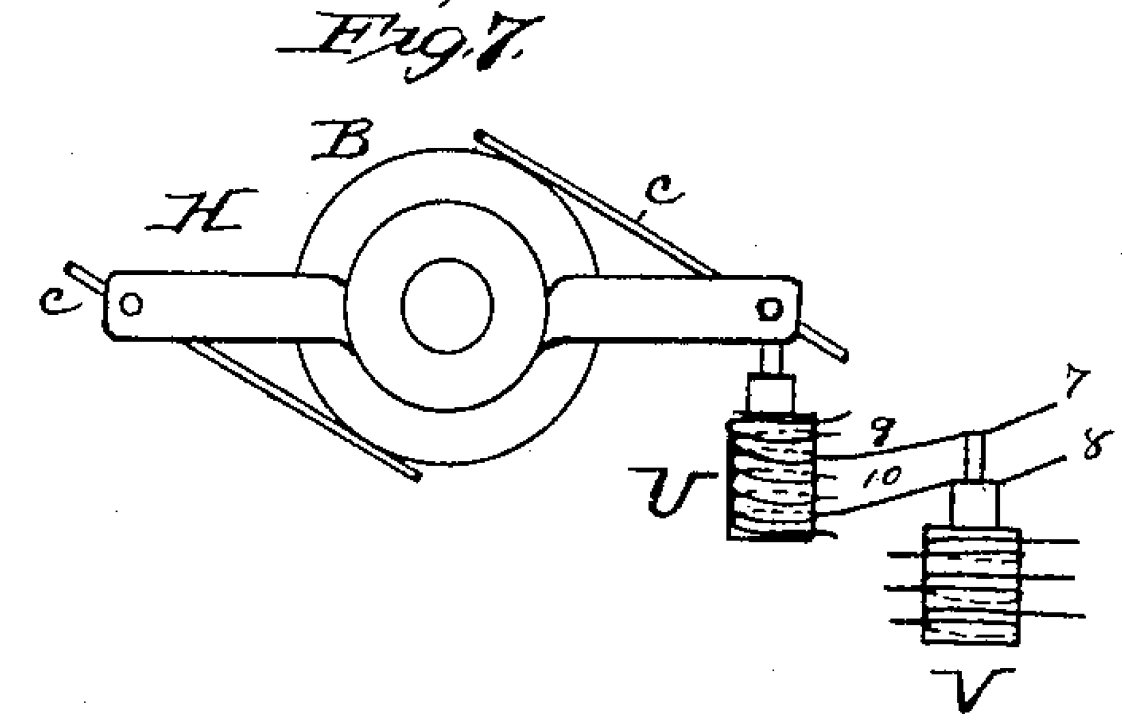
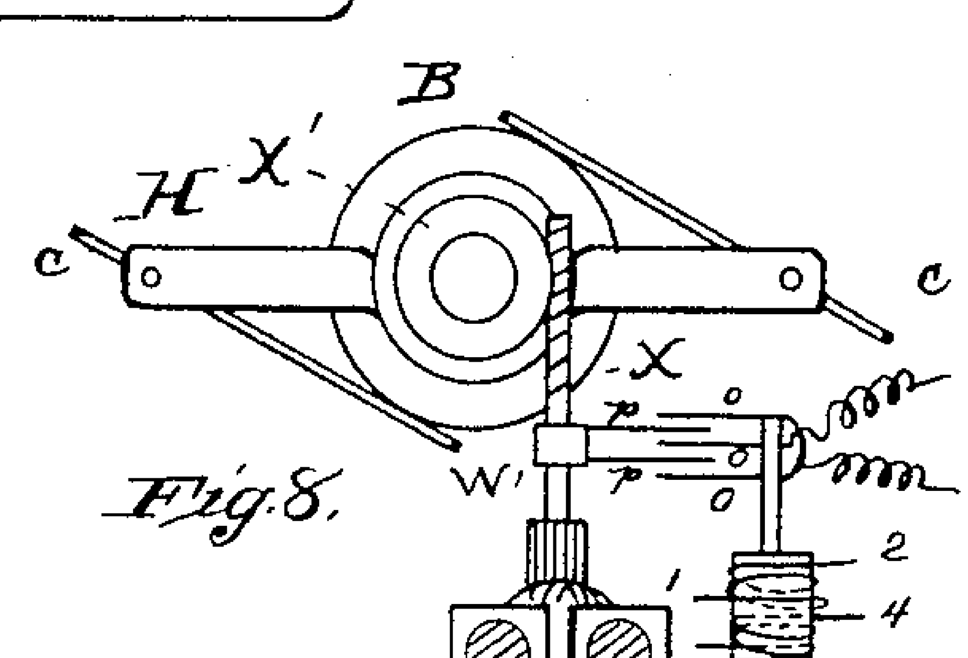


Fig. 8.



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UNITED STATES PATENT OFFICE.

FRANK J. SPRAGUE, OF NEW YORK, N. Y.

ELECTRO-DYNAMIC MOTOR.

SPECIFICATION forming part of Letters Patent No. 315,183, dated April 7, 1885.

Application filed January 19, 1885. (No model.)

To all whom it may concern:

Be it known that I, FRANK J. SPRAGUE, of New York, in the county and State of New York, have invented a certain new and useful Improvement in Electro-Dynamic Motors, of which the following is a specification.

In my application, Serial No. 129,892, of which this application is a division, is set forth an apparatus for automatically maintaining the commutator-brushes of an electro-dynamic motor at the points of least spark of the commutator-cylinder. The present application relates to the method of operation of such apparatus.

I am aware that many different methods have been proposed for shifting automatically the brushes of a dynamo-electric generator for different purposes. No one of these, however, is adapted for use with an electro-dynamic motor. One proposed method is to keep the brushes at such points as will give a constant potential with a varying load, as in some incandescent electric-light circuits. This does not keep them at the non-sparking points. Another is to differentiate the action of three or more armature-coils to maintain a constant current. This does not prevent sparking. A third proposes the use of one or more accessory-brushes and regulating apparatus in the circuit between the accessory and the main collecting brushes. Such apparatus would equate the potentials at the main and the accessory brushes, and would not keep either at the true non-sparking point. Another method makes the movement of the brushes depend upon the armature-current to give a positive lead in the direction of rotation. In this connection I wish to point out the marked difference between the action of generators as ordinarily wound with continuous armature-windings of the Pacinotti or Alteneck systems and motors similarly wound, and such as will be used in practice.

Dynamos may be generally classed as series or shunt machines. In both, if the speed is increased with a fixed external resistance, the field and the electro-motive force are both increased and the brushes must be given an increased lead in the direction of rotation. In a machine for incandescent lighting, generally excited on the shunt system, a decrease of external resistance is attended with an increase of current and a lead is given to the brushes in the direction of rotation. All methods of automatic regulation of brushes on this principle with which I am acquainted depend for the positive movement upon the current in the armature, which is the total current in the circuit. Two distinct influences, however, determine the proper position for the brushes, and these influences are differential. With any given field the displacement is fairly proportional to the current in the armature. With a given armature-current and displacement, if the strength of field is increased, the displacement is diminished. Now, in a dynamo the variations in the strength of the armature-current and of the field are of the same character, both being increased or both being diminished by the same causes, though not necessarily in the same ratio.

In a motor designed to run at any given speed with varying loads, and regulated in any way by the field, the armature-current and the strength of the field must vary inversely, and whatever the lead given to the brushes, it is a negative one. A further distinction between generators and motors is that in the generator the direction of the current in the field is opposed to that in the armature, in the armature the current flowing toward what is ordinarily termed the "positive brush," and in the field away from it, while, if the machine is used as a motor to run in the same direction, the direction of the current in the field may remain the same, while that in the armature is reversed, which of course reverses the polarity of the armature.

In the dynamo the field is properly a part of the external circuit, and after polarization there can be no reversal of a self-excited dynamo, except by a reversal of the direction of rotation and shifting of the field-terminals, and such reversal of direction would reverse the lead of the brushes and shift the non-sparking point to the opposite side of the middle position.

In a motor with shunt or series field the polarity of the terminals of the machine can be reversed as rapidly as desired without changing the direction of rotation or the lead of the brushes.

If a dynamo with an electro-magnetic device for shifting the brushes be used as a motor to run in the same direction, the action of the shifting device will cause the brushes to spark badly, and the entire reversal of its action would be necessary.

From the above it will be seen that no method which has been used of shifting the brushes of a dynamo to the non-sparking point can be employed for the same purpose with an electro-dynamic motor

In motors designed to run at a definite constant speed, and motors having fixed strength of field, the brushes may be regulated by the variations in armature-current alone, an electro-magnetic device being placed in the armature-circuit and connected with the brushes, so that an increase of armature-current causes the shifting of the brushes to increase their negative lead; but in a motor in which the field-magnet strength is varied to change the speed it is necessary to also cause this variation of the field to affect the brushes, so that an increase in field-strength acts oppositely to an increased armature-current—that is, it diminishes the negative lead of the brushes, for as the magnetic field is due both to the armature and the field-magnet strength, a variation in either of these factors causes a change of the non-sparking point and necessitates the shifting of the brushes. My method of regulation for the brushes consists then in automatically increasing the negative lead of the brushes simultaneously with an increase of the armature current, and vice versa, and decreasing automatically the negative lead simultaneously with an increase of field-magnet strength, and vice versa.

In practice, for motors in which the field is varied, I prefer to employ as a brush-shifter an electro-magnetic device in which armature and field-magnet currents oppose each other, so that an increased armature-current and a decreased field-current have the same effect on the brushes.

I have devised several different ways of carrying my invention into effect. These are illustrated in the accompanying drawings, in which—

Figure 1 represents one form of brush-shifting mechanism applied to a motor. Figs. 2 to 8 represent other forms, only the commutators of the motors being shown.

The motor shown in Fig. 1 is such as is set forth in the application of which this is a division. The arrows on the circuit-lines show direction of current.

A is the armature. The commutator B is shown detached from the armature for convenience of illustration. The field-magnet has main coils C C wound in sections connected together. Connections from these sections are brought on one side to blocks of a commutator, D, and on the other side to a commutator, D′, and the two commutators are connected together in the manner shown. Arms *a a* on commutator D are connected with the armature-terminals, and the armature is thus shunted upon a number of the main field-coils, which number is variable by moving said arms. The armature-shunt includes also the field-coils E, which oppose the main field-coils and form the differential or governing coil. A motor with such a coil is a self-regulating constant speed-motor when wound in the proper proportions; but the motor shown is provided with other field-regulating means. These are the independent field-coils F F, whose terminals are connected with the arms *b b* upon the commutator D′, so that these independent coils are, like the armature, shunted upon a variable number of the main field-coil sections. By thus variably shunting these coils their magnetizing effect is increased or diminished, and the field-strength is thus regulated; or by reversing the terminals on the commutator the magnetizing effect of these coils is reversed, so that they oppose the main field-coils. I have shown also means for varying the magnetizing effect of the differential coils E, consisting of connections from said coils to blocks of a commutator, G, and extra coils E′, connected with arms *b′ b′* on said commutator. The effect of the extra coils E′ can thus be varied or reversed. All these features of field-regulation are fully set forth in the application referred to, and they form no part of the invention claimed in the present application.

The brush-regulator shown in Fig. 1 will be presently described.

Fig. 2 represents a form of brush-regulator for use with a motor, such as illustrated in Fig. 1, in which brushes *c c* are carried by a pivoted arm, H. A semicircular arm, I, of magnetic metal is connected with both ends of arm H, and forms the movable core of two hollow electro-magnets or solenoids, J and J′. The coils of magnet or solenoid, J are in the armature-circuit 1 2 of the motor, and the magnet J′ has two sets of coils—one set in the circuit 3 4 of the independent variable field-coils, the other set in the circuit 5 6 of the main field-coils. If the armature-current increases, the magnet J moves the brushes against the influence of both coils of magnet J′, so as to increase, the negative lead of the brushes. If the field-strength is increased, by increasing the current in the independent field-coil circuit 3 4, the coil of magnet J′ in that circuit moves the brushes in the opposite direction so as to decrease their negative lead; or, if the current in the independent coil is decreased, the magnet J′ permits the brushes to increase their negative lead, and if the current of the independent coils is finally reversed and the current then strengthened in these coils, the main field-coil circuit acts upon the brushes to still maintain the negative lead.

In a motor in which the independent variable field-coil is not used as a means of regulation, but which has a simple field-circuit provided with an adjustable resistance or other current-regulating device, the brush adjustment is performed by the armature-current and this main field-current only. Such an arrangement is shown in Fig. 3. The brush-arm H has a spring, S, at one end, and to its other end is connected the movable core of a hollow electro-magnet or solenoid, K, having two opposing sets of coils, one set in the armature, the other in the field-circuit. An increased armature-current or a decreased field-current act similarly upon the brushes, and the spring opposes both. From this it will be evident that my method of brush adjustment is applicable to all electro-dynamic motors; but it is to be understood that it is not necessarily for an increase in field-current, but for an increase in field-magnet strength that the negative lead of the brushes is diminished. An extended portion of the field-magnet might be used in some cases to oppose the electro-magnetism established by the armature-current.

Fig. 4 shows a single magnet or solenoid, K, controlling the curved core I, which ends at a', the part I′ being of non-magnetic material. The solenoid has three sets of coils. Coil 1 2 is in the armature-circuit. 3 4 is in the independent field-circuit, and 5 6 is in the main field-circuit. The influence of coil 3 4 is changed as its terminals are changed to regulate the field, and it opposes either the armature or the main field current, as the case may be.

Fig. 5 is an arrangement similar in principle. The differential magnet or solenoid K, in which coils 1 2 and 5 6 oppose each other, acts on one end of the brush-holding arm, while a spring, S, acts on the other. The independ-field-coil 3 4 opposes either the coil 1 2 or 5 6, and moves the brushes in one direction or the other.

In Fig. 6 adjustable springs T T tend to hold the brush-arm centrally. The coil 1 2 in the armature-circuit acts on one end of the arm, while coil 3 4 in the main field-circuit opposes it at the other end. Coil 5 6 of the independent field-circuit includes both magnets, and acts in one way or the other, according to the position of its terminals. This device would be operative to a certain extent without the springs T T.

In Fig. 7, U is a sectionally-wound solenoid, the position of whose core is determined by the sections in circuit, and said core is attached to one end of the brush-arm H. The solenoid is energized, preferably, by a circuit, 7 8, separate from the motor-circuit. V is another magnet or solenoid having a movable core which carries contacts 9 10. The magnet V is energized by opposing armature and field currents, and as its core moves up or down it places different sections of solenoid U in circuit, and so changes the position of the brushes.

In Fig. 8, W is the armature of a small electro-dynamic motor. Upon its shaft is a worm, X, meshing with a worm-wheel, X′, upon the pivot of the brush-arm H of the regulated motor. An insulating-block, W′, carrying contacts *p p*, is so placed as to be moved up or down by the worm X. The movable core of magnet V carries contacts *o o o*. Magnet V is included differentially in the armature and field circuits. When its core is pulled down, circuit is closed to armature W in such a direction as to move the worm so as to give the proper lead to the brushes, and to move block W′ so as to again break the motor-circuit. If more movement is necessary, the current will of course cause the contacts *o* to follow contacts *p* down and maintain the circuit the proper length of time. The upward movement of the core closes circuit to motor W in the opposite direction, causing an opposite movement of all the parts.

The brush-shifting apparatus shown in Fig. 1 operates equally well, no matter in which direction the current is sent through the motor.

The centrally-pivoted arm H carries the commutator-brushes *c c*, which bear on the commutator B.

Upon the arm H is a polarized armature, Y, situated between two curved pole-magnets, Z Z′, the coils of both of which are in the armature-circuit.

When the armature-current is in one direction, armature Y moves toward Z, and when in the other direction toward Z′. An arm, *r*, extends below the armature Y, and carries the core *s*, upon which are wound the coils *t* and *t′* included, one set in circuit of the main or sectional field-coils B, the other in the circuit of the independent varibly-shunted field-coils D. These field-circuit coils *t t′* tend to hold the polarized armature Y centrally, but armature-circuit coils Z and Z′ tend to move it in one direction or the other. The coil *t* will be omitted in a motor having a simple field-circuit provided with a current-regulating device, and then the position of the brushes depends upon variations in the main field-strength and in the armature-current. If the field is strengthened, the coil in the main field-circuit acts to diminish the negative lead of the brushes for the increased counter electro-motive force and decreased speed occasioned by the strengthening of the field, and a diminution of the armature-current has a like effect upon the brushes, for the coil *t′* opposes either the coil Z or Z′. The influence of coil *t* in the independent field-coil circuit is changed as its terminals are changed to regulate the field, and it opposes the influence either of the armature or the main field current, as the case may be.

This apparatus acts the same, no matter in which direction the current is sent through the motor, the lead given to the brushes being in the right direction, in whichever direction the current may be.

I do not claim herein the method, *per se*, of regulating the brushes of electro-dynamic motors by automatically decreasing their negative lead simultaneously with an increase of field-magnetism; but I reserve this feature to be claimed in another application.

What I claim is—

1. The method herein described of maintaining the commutator-brushes of an electro-dynamic motor at the points of least spark, which consists in automatically increasing the negative lead of the brushes simultaneously with an increase in the armature-current, and the reverse.

2. The method herein described of maintaining the commutator-brushes of an electro-dynamic motor at the points of least spark, which consists in varying the negative lead of the brushes by the differential action of the armature and field currents, an increase in the said armature-current causing an increase of the negative lead, and an increase in the field-current causing a decrease in the negative lead, (or the reverse,) substantially as set forth.

This specification signed and witnessed this 8th day of January, 1885.

FRANK J. SPRAGUE.

Witnesses:
T. G. GREENE, Jr.,
E. C. ROWLAND.