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M. J. WIGHTMAN.

METHOD OF REGULATING ELECTRICALLY OPERATED MECHANISM.

No. 435,958. Patented Sept. 9, 1890.

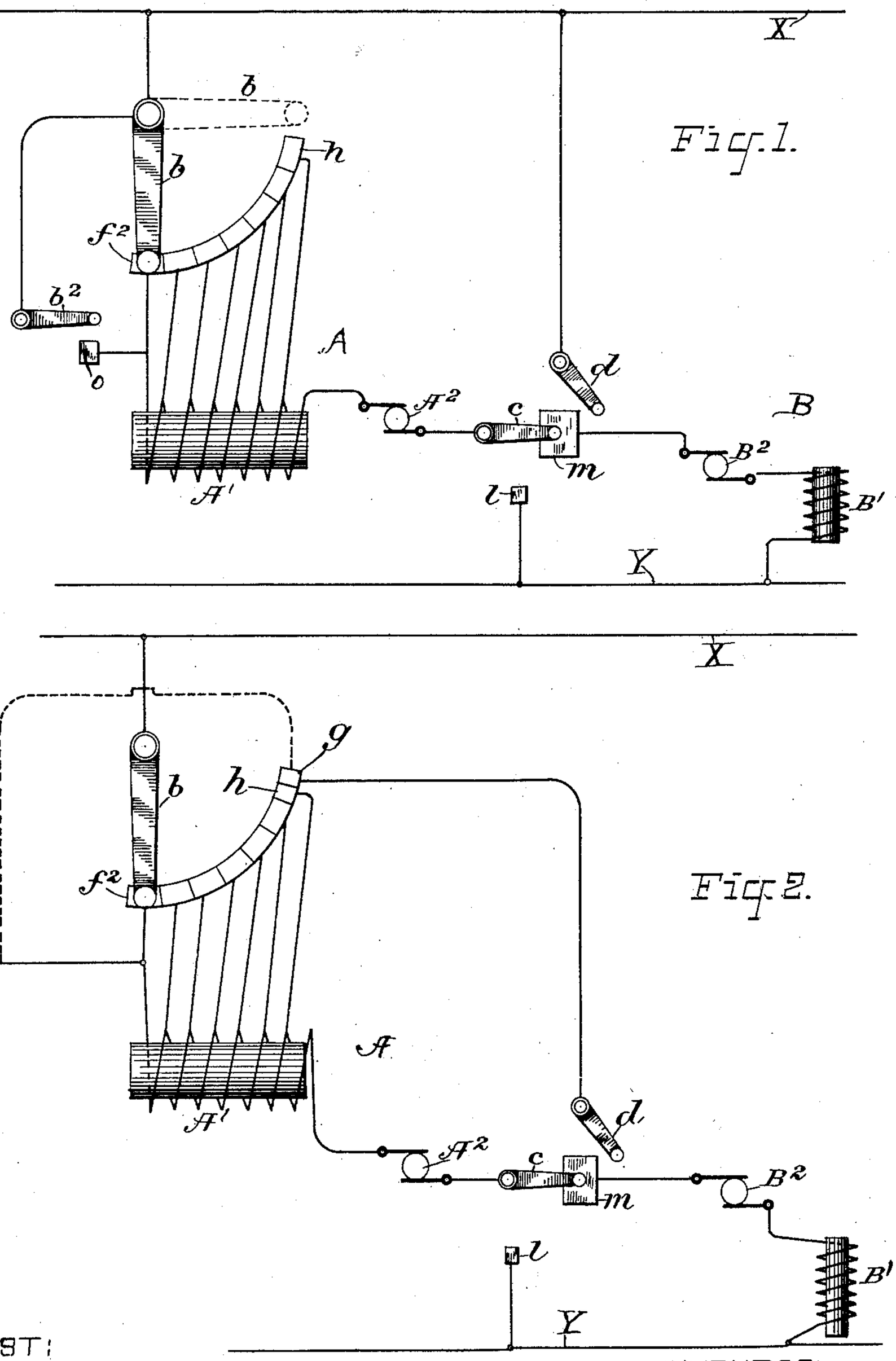

Fig. 1.

Fig. 2.

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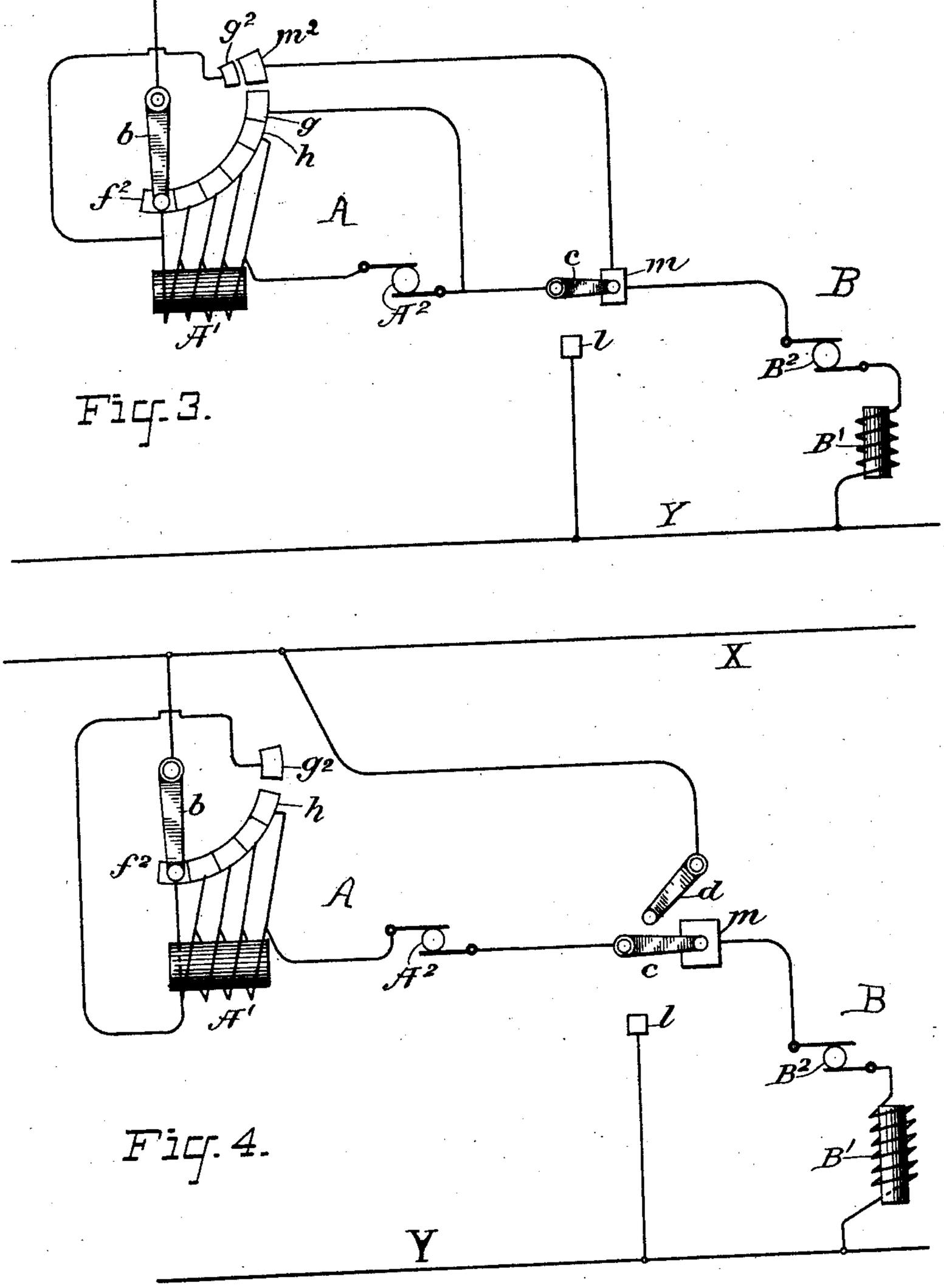

Fig. 3.

Fig. 4.

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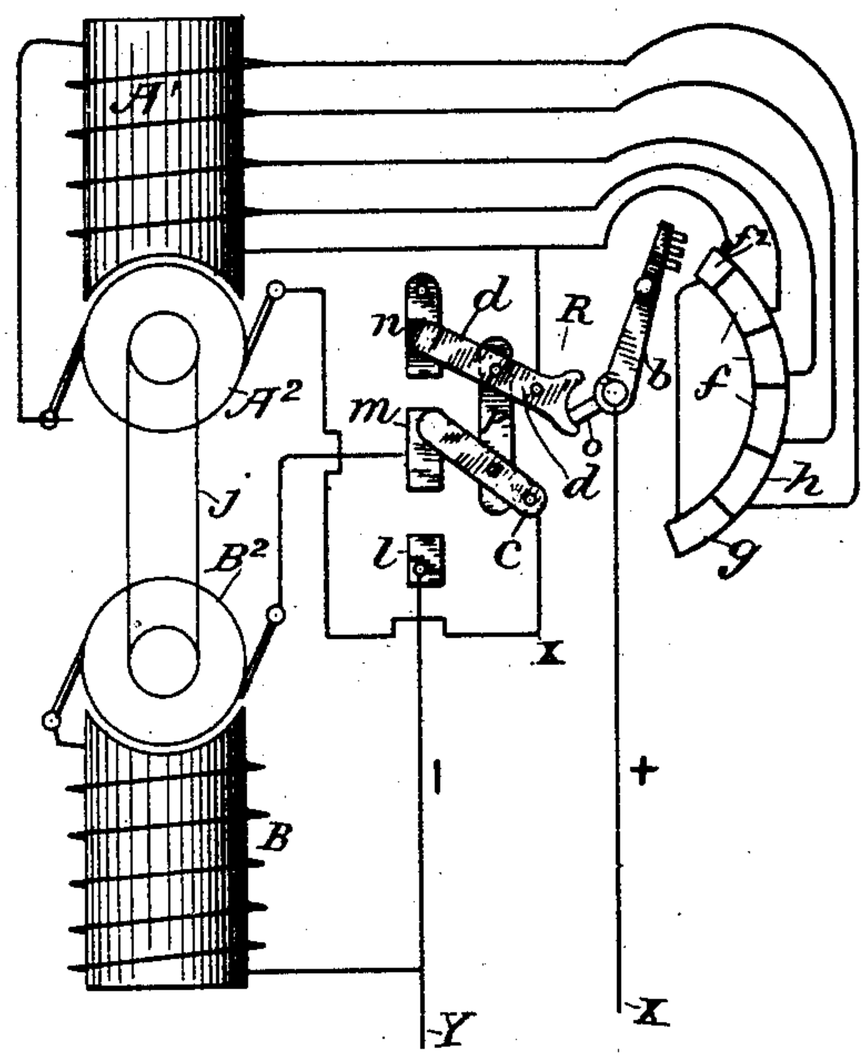
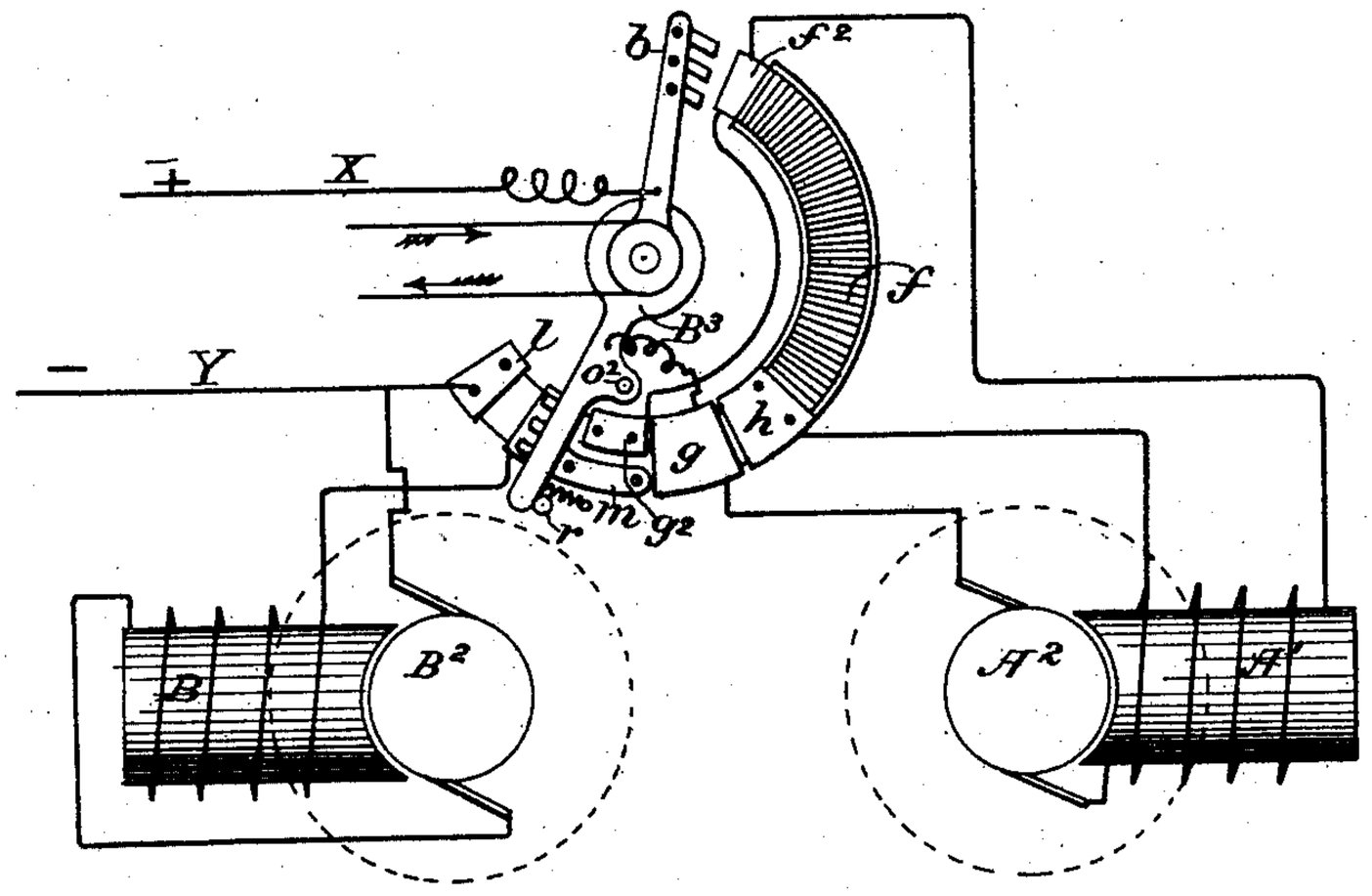


Fig. 5.

Fig. 6.



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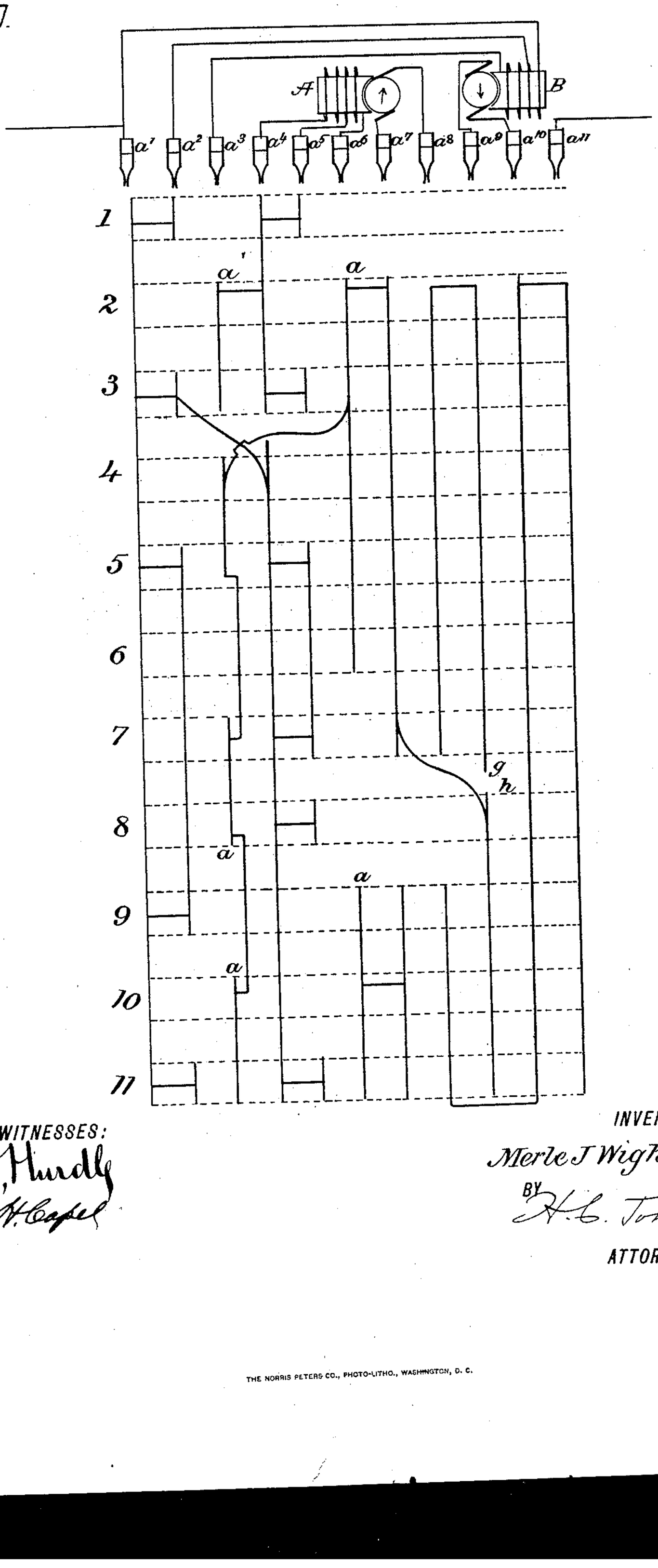
METHOD OF REGULATING ELECTRICALLY OPERATED MECHANISM.

No. 435,958. **Patented Sept. 9, 1890.**

Fig. 7.



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METHOD OF REGULATING ELECTRICALLY OPERATED MECHANISM.

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Fig. 8.

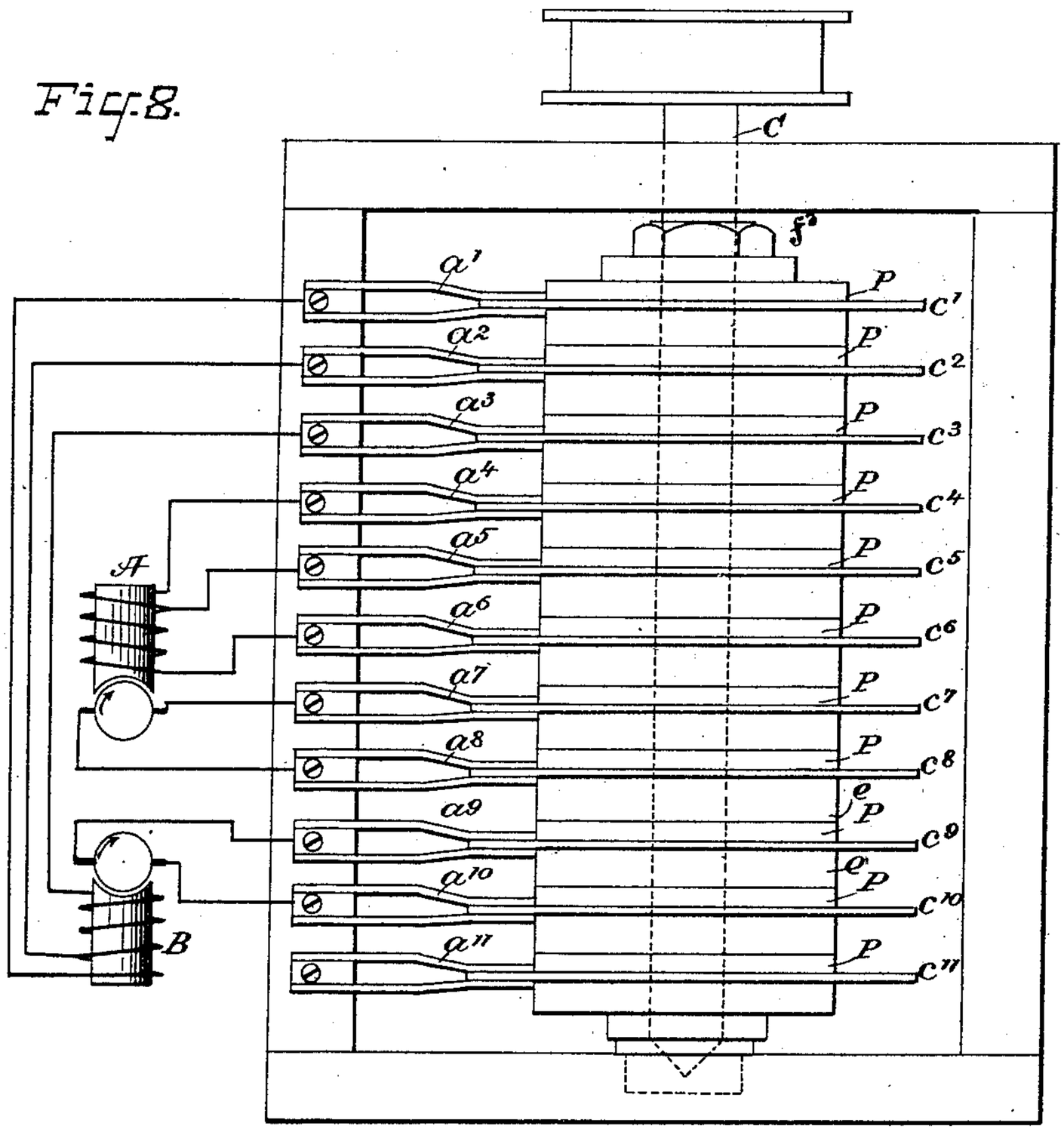

Fig. 10.

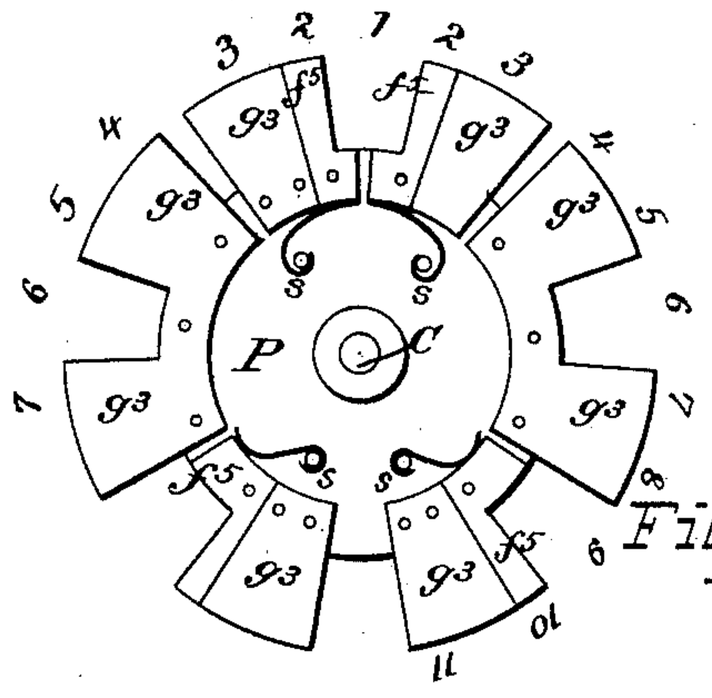

Fig. 9.

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UNITED STATES PATENT OFFICE.

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METHOD OF REGULATING ELECTRICALLY-OPERATED MECHANISM.

SPECIFICATION forming part of Letters Patent No. 435,958, dated September 9, 1890.

Application filed September 9, 1889. Serial No. 323,365. (No model.)

To all whom it may concern:

Be it known that I, MERLE J. WIGHTMAN, a citizen of the United States, residing at Lynn, in the county of Essex, State of Massachusetts, have invented certain new and useful Improvements in the Method of Regulating Electrically-Operated Mechanism, of which the following is a specification.

My invention consists in providing for any machinery which it is desired to operate by electricity with varying speed and power two electric motors, which are connected to the machine so as to co-operate in driving it. As it is well known that the regulation of an electric motor depends upon the relation between the direct and the counter electro-motive forces, it becomes necessary on a constant potential circuit that a motor must be regulated in its speed either by varying its counter electro-motive force with relation to the speed, or else by inserting a resistance to compensate for any decrease of counter electro-motive force when the said counter electro-motive force corresponds with the speed of the motor and cannot be varied independently thereof. In the method which I have invented the two armatures constitute each a source of electro-motive force, which may be placed either in series or in multiple arc, so that the total electro-motive force of the motors may be varied independently of the speed of the driven mechanism and no artificial resistance be required.

My invention therefore consists in a method by which different degrees of speed in the driven mechanism may be obtained by, first, placing the two motors in series; secondly, regulating the counter electro-motive force of one or both of the motors by changes in the field-magnet strength so as to produce a higher rate of speed; thirdly, short-circuiting one motor after its counter electro-motive force has been reduced to a point where the short-circuiting may be accomplished without sparking; fourthly, connecting the two motors in multiple arc with their normal field-magnet strength, and, fifthly, regulating the field-magnet strength of one or both of said motors to obtain the highest rate of speed. More or less of these steps may be taken, as desired.

My invention is illustrated in the accompanying drawings, in which—

Figures 1, 2, 3, and 4 are diagrams illustrating the various modifications of my invention. Fig. 5 is a diagram illustrating apparatus that can be used in practicing my invention. Fig. 6 is a diagrammatic view of a modified form of apparatus. Fig. 7 is a diagram of the circuits in a switch mechanism of still another form of construction that may be used in practicing my invention. Fig. 8 is a plan view of the switch mechanism whose circuits are diagrammatically illustrated in Fig. 3. Fig. 9 is an end view of the switch-cylinder shown in Fig. 8. Fig. 10 is a perspective view of one of the spring-contact disks of the switch-cylinder.

Referring to Fig. 1 of the drawings, X and Y represent the two main lines of a constant potential circuit.

A and B represent two electric motors.

A′ and B′ represent the field-magnets, and A^2 B^2 represent the armatures of the respective motors. In Fig. 1 these motors are shown connected in series with switches for changing connections as may be necessary in carrying out my method. A switch is also provided for cutting out more or less of the field-magnet coils of motor A. The circuit may be traced from line X to switch *b*, to contact f^2, to magnet A′ of the motor A, and by switch *c m* to the second motor B. The two motors will thus be in series and adapted for the lowest rate of speed. By operating switch-lever *b* more or less of the coils of A′ will be thrown out of circuit. This will tend to increase the speed by decreasing the total counter electro-motive force of the two motors. *b* may be moved until substantially all of the coils of A′ are cut out, when the counter electro-motive force of A will be substantially reduced to zero, and it may then be safely short-circuited without producing any arc at the contact. This will be accomplished by turning the switch *d* onto the contact-plate *m*, when only the motor *b* will be actually in circuit.

The method which has thus far been described is one which may be employed in any instance where it is desired to remove one

motor from series-connection with another motor without producing sparking at the contact, as would be the case where an active armature is suddenly short-circuited.

The next step in the method of regulating will be to place motor A in multiple-arc connection with motor B, with its field-magnet restored to its full strength. This will be accomplished by moving switch *b* to the position shown in dotted lines, where the circuit of A is entirely interrupted. The switch *c* will then be turned to contact-plate *l* and the switch b^2 turned to contact-plate *o*. The switch-arm *b* may then be rapidly brought to contact f^2, where it will give the same connection as is obtained by b^2. For the final step, motor A alone or motor B also may again have its field-magnet strength reduced to obtain a greater speed than would be possible with the two motors in multiple arc with their full field-magnet strength.

In Fig. 2 substantially the same arrangement of circuits is shown. The switch b^2, however, is omitted, its function being performed by moving the arm *b* onto a supplementary contact *g*, which is connected both to the switch *d* and to the outer field-magnet coil of A.

In Fig. 3 another arrangement for accomplishing the same results is illustrated. In this instance, however, the motor A is short-circuited by moving the switch *b* onto the contact *g*, and it is then thrown into multiple-arc connection by a further movement of the switch *b*, so as to connect the plates g^2 m^2.

Fig. 4 shows the same arrangement as Fig. 2, except that the switch *d* has a connection to main line X independent of the contact-piece g^2.

In Fig. 5 I proceed to show how the connections illustrated in the previous figures may be successively made by a single movement of the switch. In other words, the switch-arm *b* is provided with an operating connection to switches *d* and *c*, so that they may be turned automatically after the switch *b* has reached the point where it has cut out the whole of field-magnet A′. In this figure also I have shown the two armatures connected by a belt *j*, which indicates that they are both connected to the same driven mechanism, so as to cooperate in their action upon it. In the position of the switch shown in the figure both motors are in series. The arm *b* is then moved so as to short-circuit successive sections of magnet A′, and then as it passes from plate *g* the radial projection *o* throws the connected switches *d c* onto the plates *l m*, respectively. The two motors will then be in multiple arc.

Fig. 6 shows an arrangement by which the field-magnet strength of motor A is reduced by a resistance *f*, which is gradually withdrawn from a shunt around the field-magnet. In this arrangement the arm *b* gradually short-circuits the field-magnet A, then cuts it out of circuit, and by coming in contact with pin o^2 it moves the arm B^3 along with it until the latter connects with *l*, while the former rests upon *m* and g^2. This produces the same results accomplished by the arrangements previously described.

For practical use—as, for instance, in the controlling of electric-railway motors—I have devised the apparatus illustrated in Figs. 7, 8, 9, and 10. This consists of a cylinder-switch made up by placing a number of disks P upon the same shaft C, so as to be operated together. Each of these disks consists of an insulating center, upon the periphery of which are placed a series of projections g^3, spaced so as to make the desired connections when brought into contact with the respective stationary contact-pieces. One of these is illustrated in Fig. 10, and consists of two plate-springs riveted to a conducting-block and adapted to extend into the path of the projections g^3, so as to be separated and press upon the opposite sides of the said piece, making thus a good electrical connection therewith. The said stationary contacts are connected to various parts of the circuits, as will be seen, at the top of Fig. 7, where they are marked a' a^2 a^3, &c. a' and a^{11} are connected to the two terminals, respectively, the former being also connected to the end coil of the field-magnet of motor B. a^2 is connected to an intermediate point of the said field-magnet, and a^3 to its opposite terminal. a^4 is connected to one terminal of the field-magnet of motor A, a^5 to an intermediate point of the said magnet, and a^6 to the opposite terminal. a^7, a^8, a^9, and a^{10} are connected, respectively, to the four terminals of the armature-circuits.

The lower part of Fig. 7 indicates the connections which are established between the said stationary contacts a' a^2 a^3, &c., by means of the projections g^3 as they are turned by shaft C. The figures 1 2 3, &c., on the left of Fig. 7, indicate the successive positions of the switch, and consequently the different conditions. There are eleven different arrangements of the connections shown, although I am not confined to this number in the practice of my invention.

The same letters in different figures represent corresponding parts.

Two similar sets of contacts may be arranged in reverse order upon each half of the switch-cylinder, permitting the same order of connections to be established in whichever direction the cylinder may be rotated, the currents through the armature being reversed with the opposite directions of rotation. This is shown in Fig. 9, but in the diagram of Fig. 7 only one-half is shown, for simplicity. Position one is the zero-point, the only connection being a short circuit around a portion of each field-magnet for the purpose of absorbing the extra current upon the breaking of the motor-circuit. In position 2 the armatures and fields of both machines are con-

nected in series. In position 3 the same connections are shown as in position 2, with the exception that a portion of the field of each motor is short-circuited. Position 4 throws the fields of the motors in multiple, the armatures remaining in series. Position 5 short-circuits a portion of each field-winding. Position 6 detaches one of the fields (that of B) from the circuit, leaving both the armatures in series with one field. Position 7 is the same as position 6, with the exception that fields are substituted, each for each, in order that the changes in the field-magnet strength may not always be made upon one magnet only. Position 8 cuts out entirely one of the motors, (in the diagram motor A,) leaving one-half of the field of B in circuit. It should be mentioned that in passing from 7 to 8 the distance between contacts *g* and *h* being less than the width of the contact-strips, the armature of the motor A is momentarily short-circuited. Position 9 is the same as position 8, with the motors interchanged each for each. In position 10 both motors are in multiple, and in position 11 sections of the motor-fields are cut out for producing the final degree of speed. It will be seen that steps 6 and 7 produce no difference in speed, likewise steps 8 and 9. The mutual substitution of the motor in these instances is for the purpose of more nearly equalizing the total amount of work which each motor is called upon to do—that is, equalizing the heat developed in each motor, should one motor at a time be called upon to do an excessive amount of work.

It is evident that the method of connection may be very greatly varied without departing from the principles of my invention—for instance, more than one extra coil on the field-circuit could be used where but one is shown in this diagram. This method of coupling may also be applied to more than two motors.

The mechanisms hereinbefore described I do not make claim to herein, as they will be made the subject of another application.

What I claim as new, and desire to secure by Letters Patent, is—

1. The method of removing an electric motor from series-connection with another motor connected to the same mechanism, which consists in reducing the counter electro-motive force in the armature of the motor to be removed and then short-circuiting the said motor.

2. The method of removing an electric motor from a circuit in which it is in series with another motor geared to the same load, which consists in reducing the counter electro-motive force in the armature of the motor to be removed and then short-circuiting the said motor.

3. The method of removing an electric motor from a circuit in which it is in series with another motor connected to the same mechanism, which consists in reducing the counter electro-motive force of the motor to be removed by changing the field-magnet strength of the said motor and then short-circuiting it.

4. The method of controlling electrically-propelled mechanism which consists in providing two motors which are connected to said mechanism so as to co-operate in driving it, and then regulating the two motors by, first, placing them in series for a slow speed; secondly, increasing the speed by changing the field-magnet strength of one or both motors, and, thirdly, short-circuiting one motor after the counter electro-motive force in its armature has been reduced to a safe degree.

5. The method of controlling electrically-propelled mechanism, which consists in providing two motors which are connected to said mechanism so as to co-operate in driving it, and then regulating the two motors by, first, placing them in series for a slow speed; secondly, increasing the speed by changing the field-magnet strength of one or both motors; thirdly, short-circuiting one motor after the counter electro-motive force in its armature has been reduced to a safe degree, and, fourthly, placing the two motors in multiple-arc connection.

6. The method of controlling electrically-propelled mechanism, which consists in providing two motors which are connected to said mechanism so as to co-operate in driving it, and then regulating the two motors by, first, placing them in series for a slow speed; secondly, increasing the speed by changing the field-magnet strength of one or both motors; thirdly, short-circuiting one motor after the counter electro-motive force has been reduced to a safe degree; fourthly, placing the two motors in multiple-arc connection, and, fifthly, increasing the speed still further by varying the field-magnet strength of one or both of said motors after they have been placed in multiple-arc connection.

7. The method of changing two motors from series to multiple-arc connection, which consists in reducing the counter electro-motive force in the armature of one or both of said motors, short-circuiting one motor when its counter electro-motive force has been reduced to a safe degree, and then connecting the two motors in multiple arc.

8. The method of controlling electrically-operated mechanism, which consists in providing an electro-motive apparatus having two sources of counter electro-motive force, connecting these sources in series, reducing the electro-motive force of one of said sources and short-circuiting it, and then connecting the two sources in multiple arc with their normal electro-motive force.

9. The method of controlling electrically-operated mechanism, which consists in providing an electro-motive apparatus having two sources of counter electro-motive force, connecting these sources in series, reducing

the electro-motive force of one of said sources and short-circuiting it, and then connecting the two in multiple arc with their normal electro-motive force, and, finally, reducing the counter electro-motive force of one or both of the said sources for the last degree of regulation.

Signed at Lynn, in the county of Essex and State of Massachusetts, this 4th day of September, A. D. 1889.

MERLE J. WIGHTMAN.

Witnesses:

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A. B. NORRIS.