(No Model.) 4 Sheets—Sheet 1.

L. BOCK, Jr.

ELECTRIC MOTOR.

No. 424,535. Patented Apr. 1, 1890.

Fig. 1.

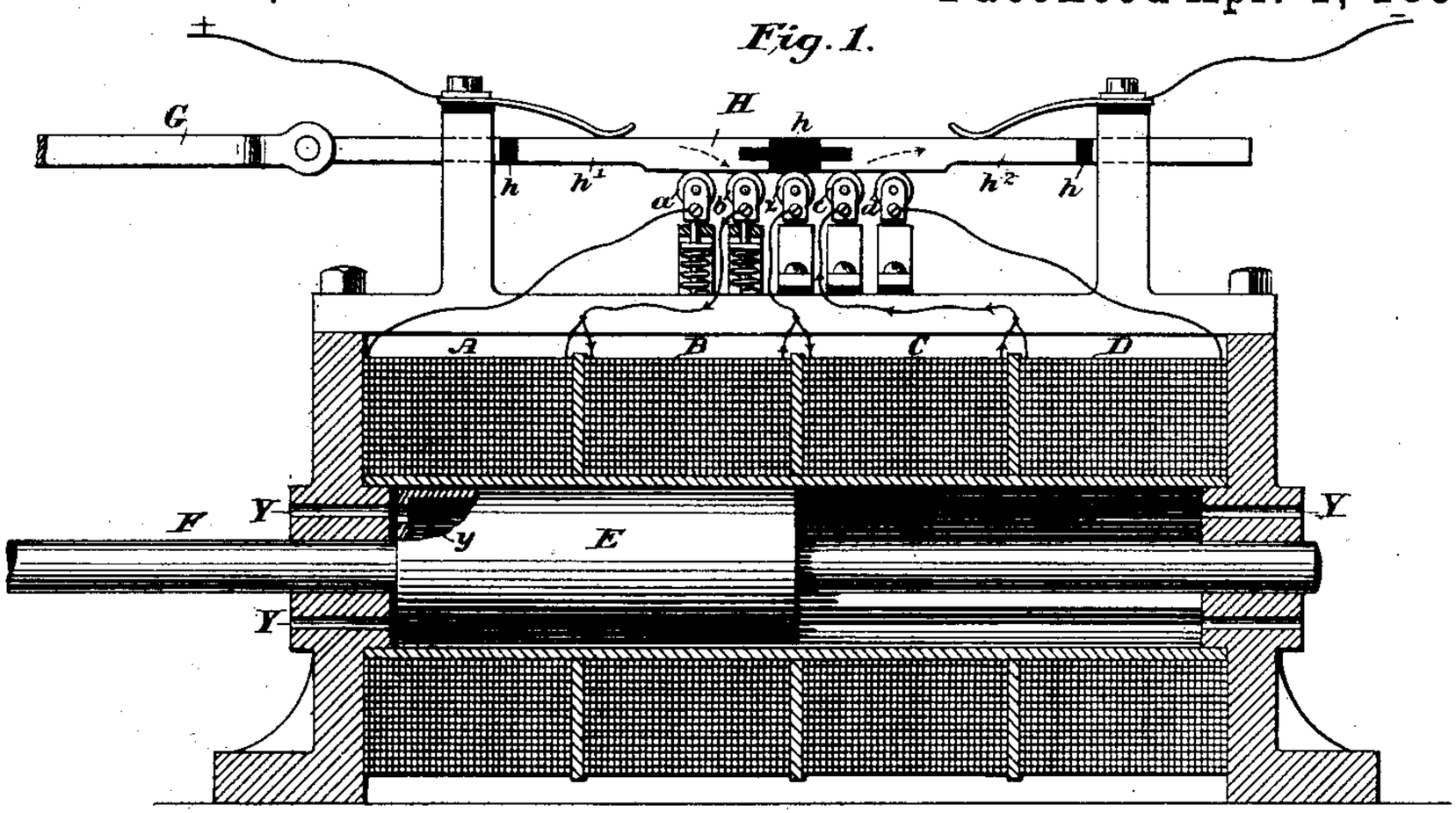


Fig. 2.

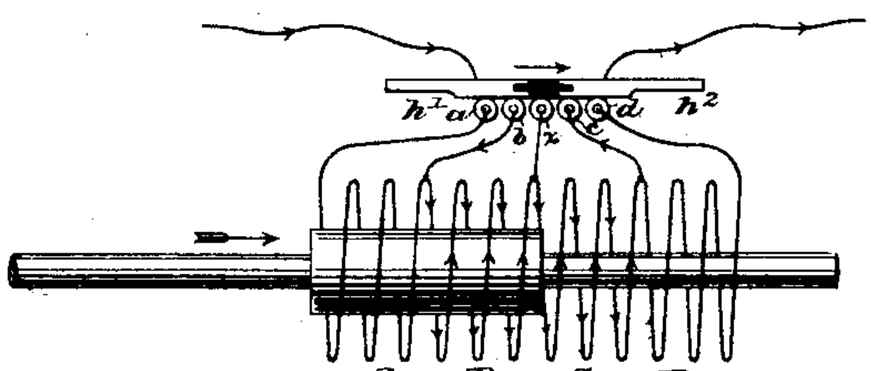


Fig. 3.

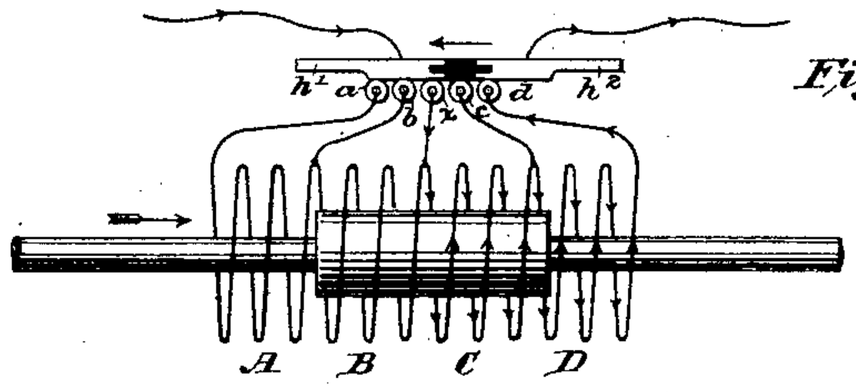


Fig. 4.

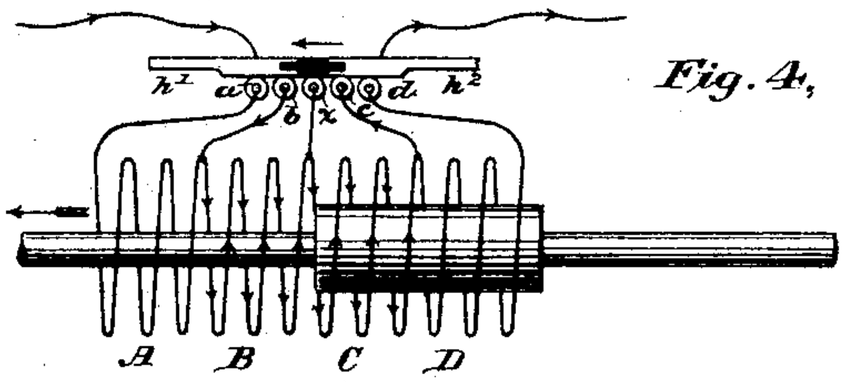
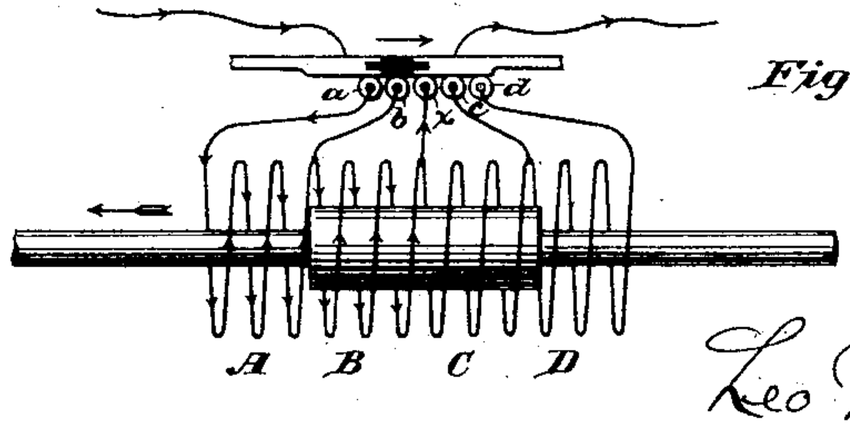


Fig. 5.



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(No Model.) 4 Sheets—Sheet 2.

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ELECTRIC MOTOR.

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Fig. 6.

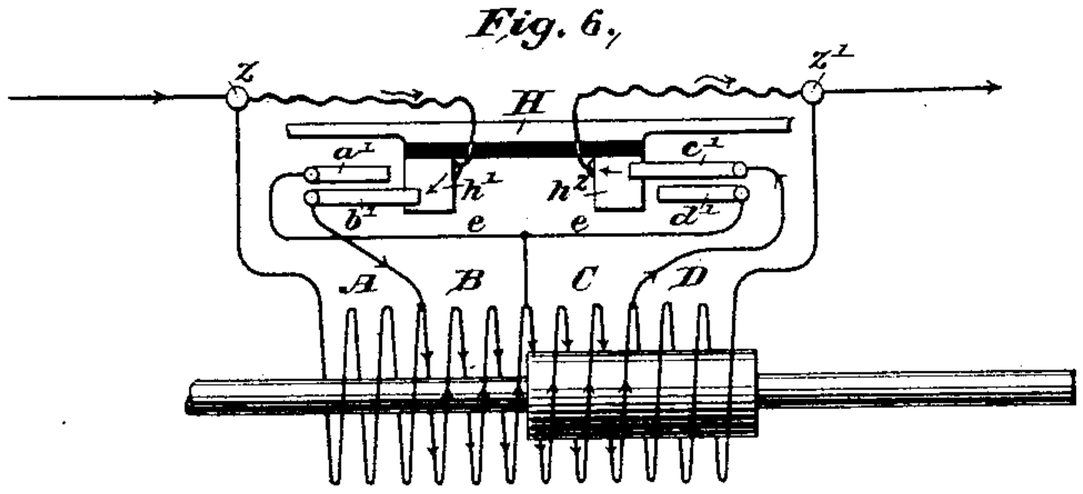


Fig. 7.

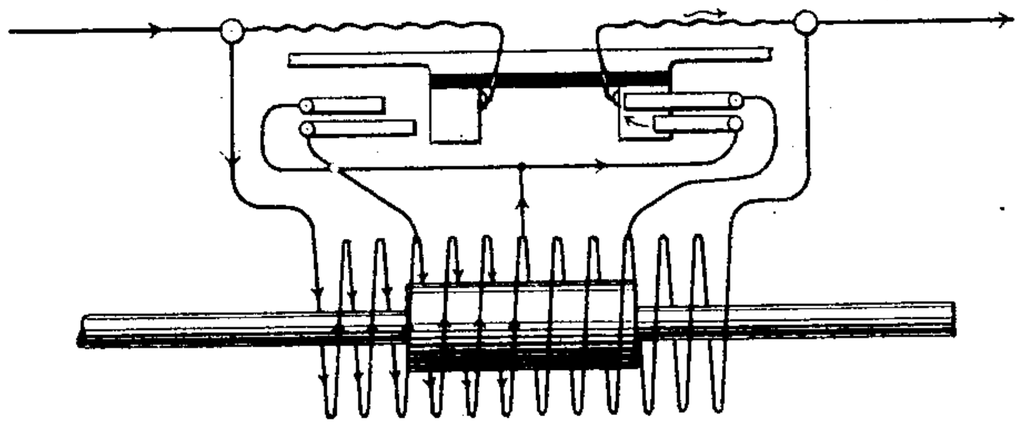


Fig. 8.

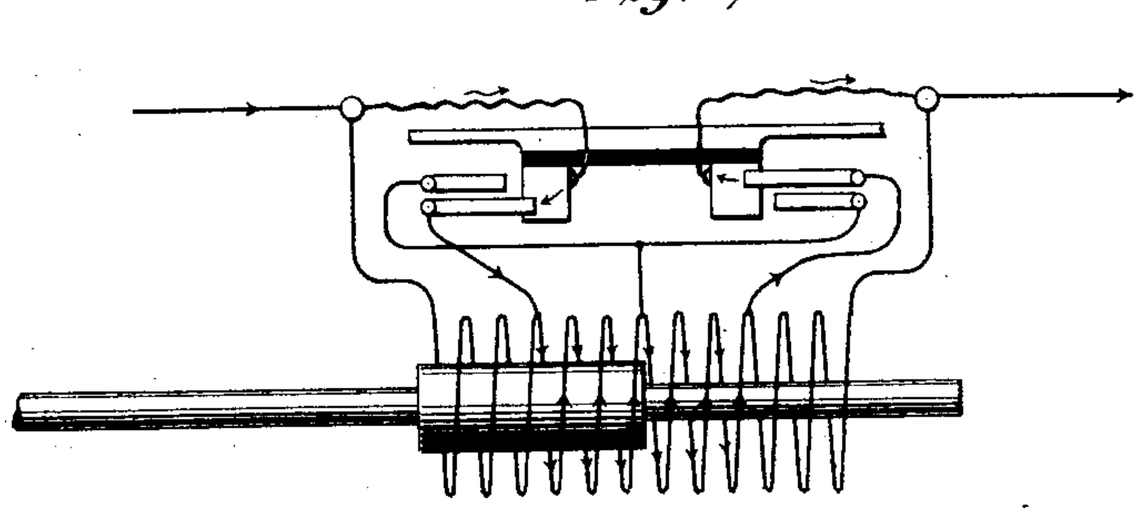
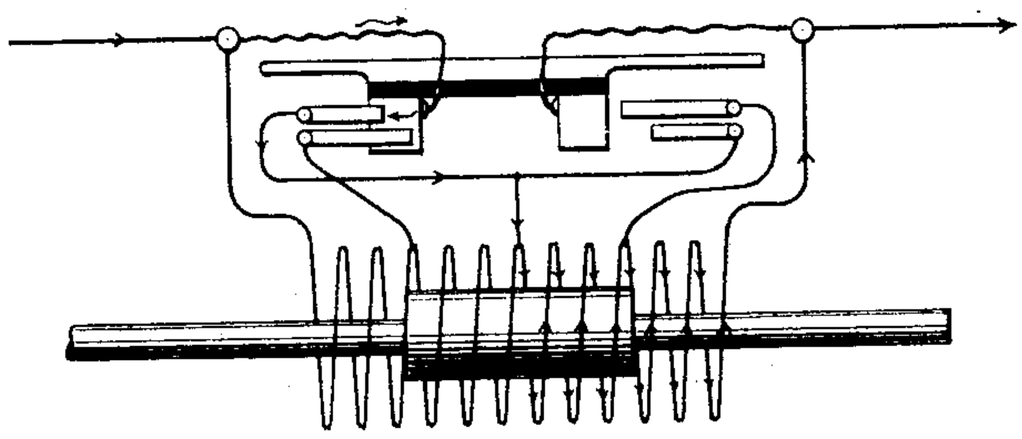


Fig. 9



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(No Model.) 4 Sheets—Sheet 3.

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No. 424,535. Patented Apr. 1, 1890.

Fig. 10.

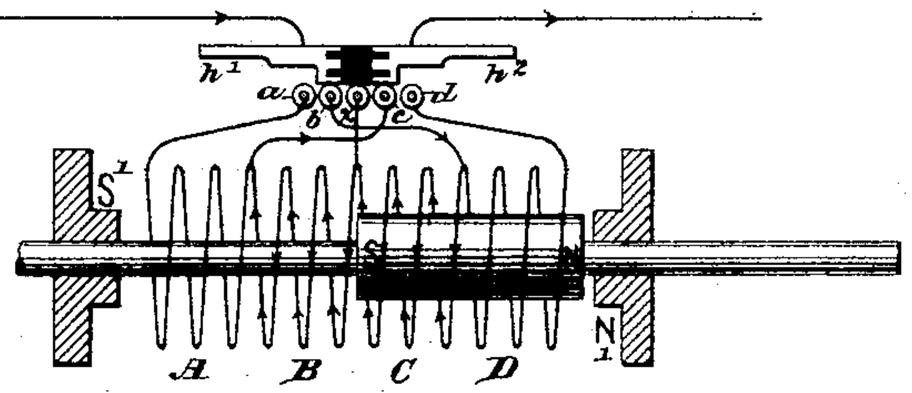


Fig. 11.

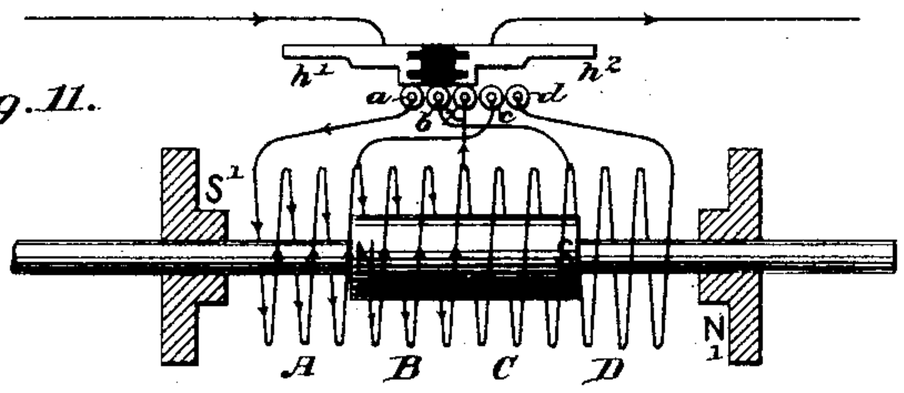


Fig. 12.

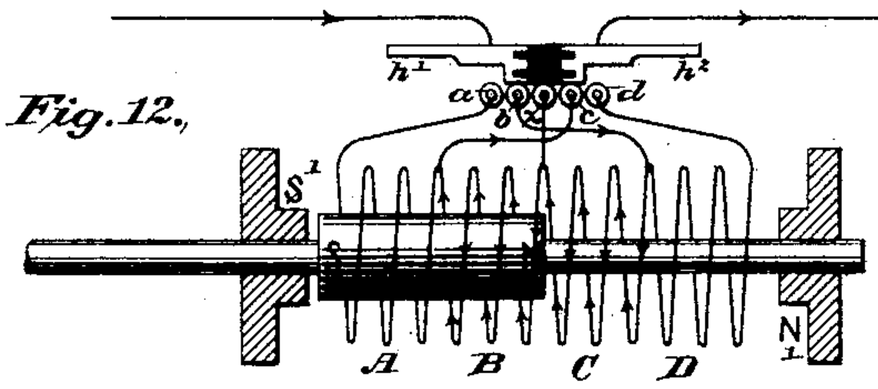


Fig. 13.

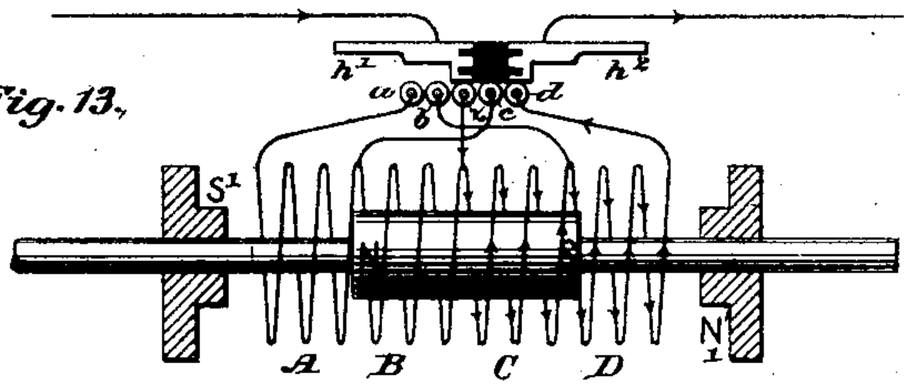
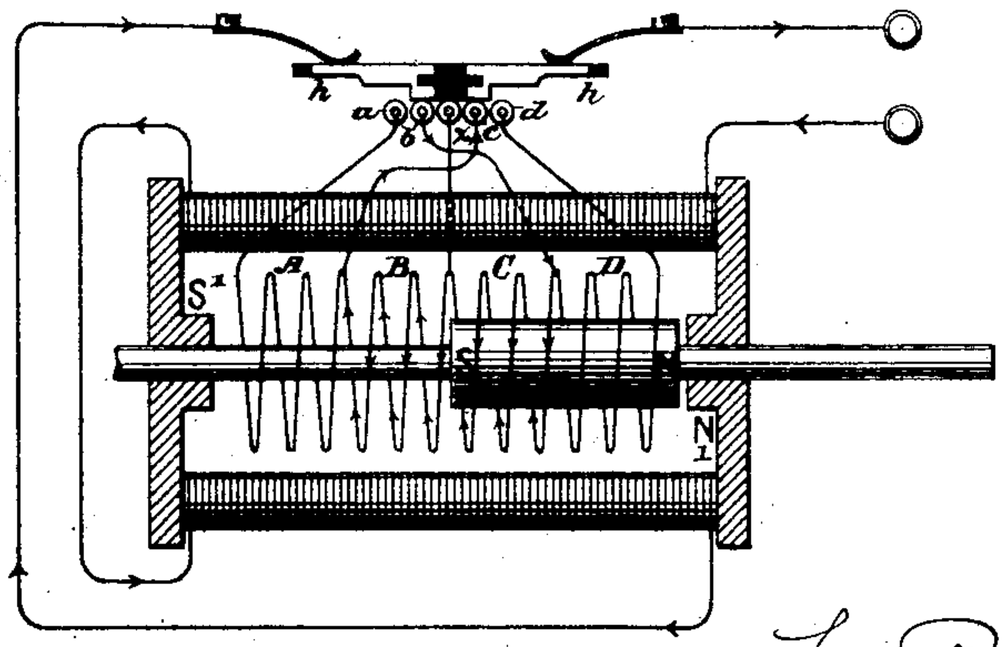


Fig. 14.



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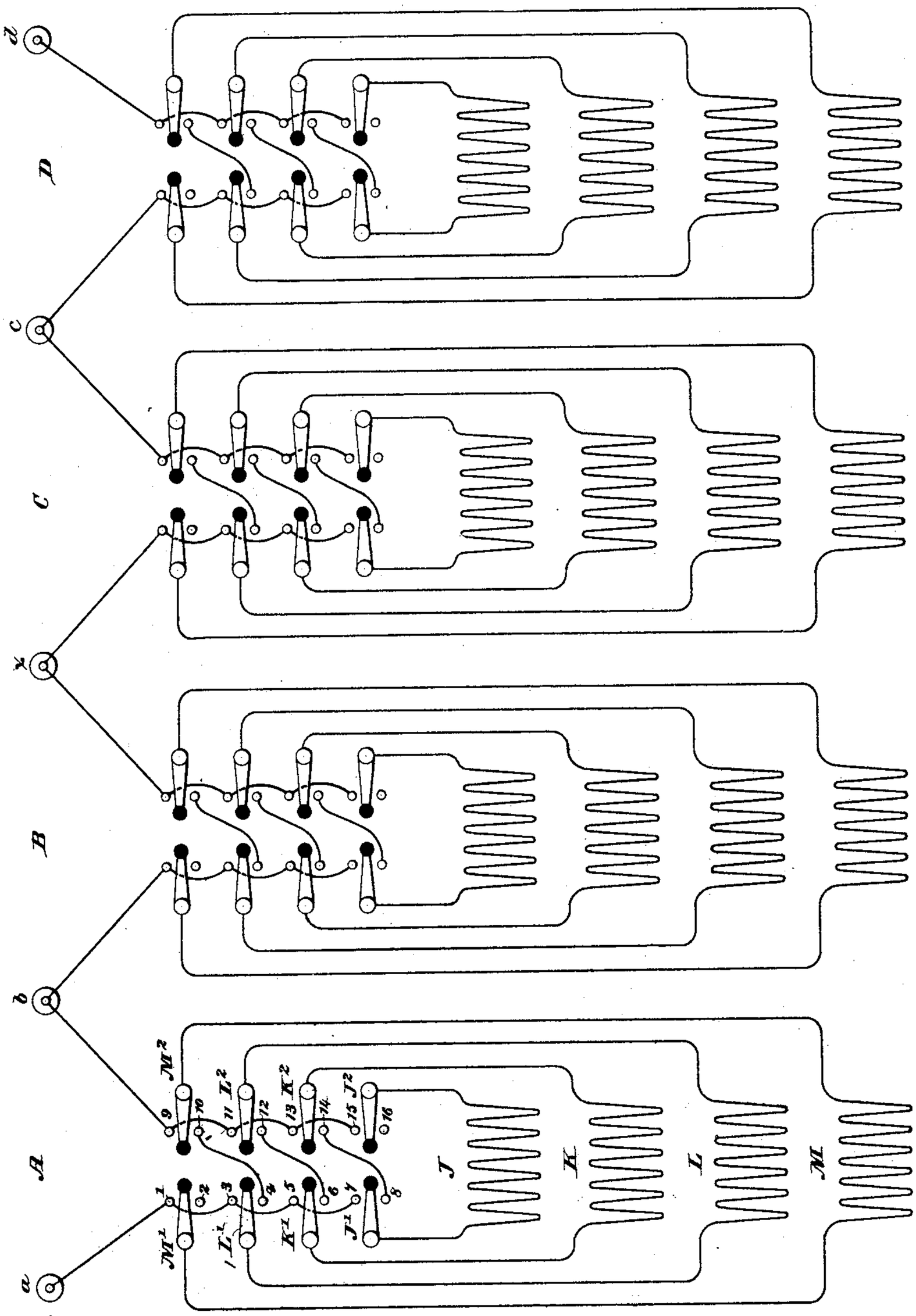

Fig. 15.

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Edward Thorpe.

Inventor
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UNITED STATES PATENT OFFICE.

LEO BOCK, JR., OF NEW YORK, N. Y., ASSIGNOR, BY DIRECT AND MESNE ASSIGNMENTS, TO HIMSELF, AND CHARLES L. WRIGHT, OF SAME PLACE.

ELECTRIC MOTOR.

SPECIFICATION forming part of Letters Patent No. 424,535, dated April 1, 1890.

Application filed April 13, 1889. Serial No. 307,139. (No model.)

To all whom it may concern:

Be it known that I, LEO BOCK, Jr., of New York city, State of New York, have invented certain new and useful Improvements in Electric Motors, of which the following is a specification.

My invention relates to the class of motors shown in Letters Patent No. 357,374, granted William H. Darling and myself, February 8, 1887, in which an armature reciprocates within solenoids or coils.

I have found by experiment that the greatest attraction is exerted upon a cylindrical armature moving in a solenoid when the armature has entered the solenoid about halfway, and that the maximum effect is produced during the time the armature is moving from such a position in the solenoid into a position where the transverse central line of the armature coincides with the like line of the solenoid. To increase the efficiency of motors of this type, to give the armature a longer stroke, and to provide for a more uniform and continuous effect of the current traversing the field or solenoid about the armature, I provide a series of solenoids and work them in pairs in such manner that when the armature is moved into a position where its transverse center coincides with a like central line of any two solenoids or coils which are being worked as one, I cut out or short-circuit one of the coils of said pair, that one at or toward the rear of the armature, and throw into circuit the solenoid or coil at or toward the front of the armature. By such an arrangement I am enabled to construct an electric cylinder of solenoids in such manner that any desired stroke may be given to the piston and a practically uniform pull be exerted upon the armature during its entire movement in either direction. I also so arrange the motor that the polarities of the ends of the armature and the cylinder-heads are such that the separating-poles repel each other and the approaching poles attract each other when the armature is moving in either direction. I also provide a sectional winding of the solenoids and switch mechanism for connecting the layers or sections of the solenoid in different ways.

In the accompanying drawings, Figure 1 is a vertical section through an electric cylinder, showing the circuit-connections and contact mechanism corresponding with the ordinary valve mechanism of a steam-engine. Figs. 2, 3, 4, and 5 are diagram views illustrating the armature in different positions during its movement in both directions. Figs. 6, 7, 8, and 9 are like views showing a somewhat different arrangement of switch devices. Figs. 10, 11, 12, 13, and 14 are diagram views showing an arrangement in which the polarity of the armature is reversed during its movements to operate efficiently with magnets placed at each end of the electric cylinder. Fig. 15 is a diagram indicating each solenoid as composed of a number of separate layers or windings—or, in other words, concentric solenoids and switch mechanism—by which the layers of any solenoid may be connected in series or multiple or partly in series and partly in multiple.

An electric cylinder, having four solenoids A B C D, is shown in connection with an unwound cylindrical armature E, mounted upon a reciprocating piston-rod F.

G is the circuit-shifting rod corresponding with the valve-rod of an ordinary engine, and H the contact-slide operated thereby. The movement of the circuit-shifting rod may be derived from the main shaft of the motor, as in a steam-engine, and as shown in the patent above mentioned.

a b x c d are contacts mounted in a line upon the cylinder, and in contact with which the contact-slide H reciprocates, the slide being divided by insulation *h* into two contact-plates *h' h²*.

In Figs. 1, 2, 3, 4, and 5 the outer end of the solenoid A is connected with the contact *a*, and the outer end of the solenoid D with the contact *d*. The adjoining ends of the solenoids A B are both connected with the contact *b*, the adjoining ends of the solenoids B C are connected with the contact *x*, and the adjoining ends of the solenoids C D are both connected with the contact *c*. One terminal of the circuit is carried to the reciprocating plate *h'* by means of a rubber or brush, and the other terminal is in like manner connected

with the contact-plate h^2, as clearly seen in all the figures.

In Figs. 1 and 2 the armature is in position for the commencement of a stroke. The circuit will be, as indicated by the arrow-heads, from the contact-plate h' and contact b through the solenoids B and C and out by contact c, the solenoids A and D being short-circuited. When the armature is moved into the position indicated in Fig. 3, the solenoids A and B are both short-circuited, the circuit being from contact-plate h' through contact x, solenoids C and D and out by the contact d, and the armature completes its stroke. In Fig. 4 the circuit is now through contact b and solenoids C and B and out by contact c, solenoids D and A being short-circuited. In Fig. 5 the circuit is through a, solenoids B and A, and out by the contact x, solenoids C and D being short-circuited, and the armature completes its stroke. Air-passages Y are provided in the ends of the cylinder, and as the armature reciprocates a circulation of air is maintained to cool the parts. The armature, which is preferably hollow, has apertures y in its ends for a like purpose.

In Figs. 6, 7, 8, and 9 the same action takes place, the contact or switch mechanism only being changed. The slide H carries as before two contact-plates h' h^2. Upon each of them bears a pair of fingers a' b' c' d'. The fingers in each pair are of different length, b' and c' being the longer, and the shorter fingers a' and d' are joined by a wire e, connected with the adjoining ends of the solenoids B and C. The outer ends of the solenoids A and D are in direct connection with the main circuit at the binding-posts z z'. The adjoining ends of A and B are connected with b', and the adjoining ends of C and D are connected with c'. With this arrangement of contacts the changes in the circuit will be precisely the same as in Figs. 2, 3, 4, and 5, the arrow-heads showing the direction of the current, and further description is unnecessary.

In Figs. 10, 11, 12, 13, and 14 contact devices similar to those shown in Fig. 1 are employed, but the connections of the solenoids with the rollers a b x c d is different—that is, the outer ends of A and D are respectively connected to a and d, and the adjoining ends of B and C are connected with x, as before; but the adjoining ends of A and B are connected with c and the adjoining ends of C and D are connected with b. The effect is to produce two reversals in the polarity of the core during its movement from one end of the cylinder to the other, as clearly shown, the direction of current in the different coils being indicated by the arrow-heads. The purpose is to produce an efficient co-operation between the armature and magnet-poles N′ S′, respectively, located at the opposite ends of the cylinder. The magnet or magnets may be either permanent or electro-magnets, and, as shown in the drawings, they form the heads of the cylinder, the piston passing through apertures in the inwardly-projecting pole-pieces. Fig. 14 shows the magnet-coils in series with the switch devices, and the poles are of unchanging polarity. Of course they can be connected in other ways. When the armature is at one end of its stroke, as in Fig. 10, the polarity of the armature is the same as that of the pole-piece N′, and consequently there is a tendency to repel the armature which assists it in starting. When the armature is in the central position, Fig. 11, its polarity has been reversed and the pole approaching S′ will be attracted by it until the armature has reached the limit of its stroke, and then the reversal takes place, Fig. 12. The operation is the same when the armature moves in the opposite direction. If the polarities of the field pole-pieces N′ S′ were reversed at proper times, reversal in the armature would be unnecessary.

As indicated in Fig. 15, each solenoid A B C D may be composed of several layers or concentric solenoids J K L M, and by means of suitable switch devices the several layers of any solenoid may be connected in multiple or series or partly in multiple and partly in series. In this figure a b x c d indicate contact-rollers corresponding with those in the other figures. The terminals of the layers J K L M on one side run to switches J′ K′ L′ M′, arranged in suitable relation to a series of contacts 1, 2, 3, 4, 5, 6, 7, and 8, and on the other side the terminus run to switches J^2 K^2 L^2 M^2, arranged in suitable relation to a series of contacts 9, 10, 11, 12, 13, 14, 15, and 16. Referring to the connection of the solenoid A, the contact-roller is connected with the alternate contacts 1, 3, 5, and 7, in one series of contacts, and the roller b is connected with the alternate contacts 9, 11, 13, and 15 in the other series. The contact or switch points 4 and 10, 6 and 12, and 8 and 14 are united by cross-connections, as shown in the diagram. It will be obvious that the several layers of the solenoid may by this means be included in multiple or in series, or partly multiple or partly in series, and as the diagram is perfectly plain it is unnecessary to incumber the specification by tracing the circuits.

In starting the motor the layers of the solenoids, which work together, may be connected in series and a minimum quantity of current will therefore be taken by the machine, and excessive sparking will not occur. The layers of the respective solenoids may then by a successive manipulation of their switches be thrown into multiple, and the machine will then be taking its maximum amount of current. Of course this manner of connection is applicable to all the diagrams above described.

I claim as my invention—

1. The combination, with a reciprocating armature, of a series of solenoids acting thereon to cause its reciprocation, and circuit connections and contact devices whereby the direction of current in the solenoids is reversed

and the polarity of the armature thereby reversed during its reciprocation, substantially as set forth.

2. An electric cylinder having polarized cylinder-heads or pole-pieces at each end, a reciprocating armature and circuit connections and contacts, whereby as the armature leaves either end of the cylinder the polarity of the cylinder pole-piece and the adjacent pole of the armature are caused to be the same, and as the armature approaches the opposite end of the cylinder the polarity of the pole-piece at that end of the cylinder and of the adjacent end of the armature are caused to be unlike, substantially as set forth.

3. The combination, with a reciprocating armature and a series of solenoids acting thereon in pairs, of circuit connections and contacts whereby a solenoid is thrown into circuit or energized at the front of the armature and another solenoid is thrown out of action at or toward the rear of the armature and the direction of the current in the coils reversed to reverse the polarity of the armature during the passage of the armature from one end of the cylinder to the other.

4. The combination of the solenoids composing the cylinder, the magnet pole-pieces at the ends of the cylinder, the coils of said magnet independent of the solenoids included in the motor-circuit, and circuit connections or contacts whereby the solenoids are energized to cause the reciprocating of the armature within the cylinder, substantially as set forth.

5. The combination of three or more solenoids, circuit-connections whereby they are energized in pairs and the direction of the current reversed, a reciprocating armature acting within the solenoids, and magnetic pole-pieces at the ends of the cylinder of unchanging polarity.

6. In an electric cylinder composed of solenoids acting upon an armature reciprocating within them, the combination, with the several independent layers of which each solenoid is made up, of switch mechanism whereby said layers may be connected in multiple or series, or partly in multiple and partly in series, substantially as set forth.

7. The combination of the solenoids, each composed of independent layers, switch mechanism by which the layers may be connected in multiple or series, a reciprocating armature acting within the solenoids, and contact mechanism and circuit-connections whereby the solenoids are energized in pairs, substantially as set forth.

In testimony whereof I have hereunto subscribed my name.

LEO BOCK, JR.

Witnesses:
EDWARD C. DAVIDSON,
M. J. KELLEY.