(No Model.)

# H. H. HOSFORD.

## SOLENOID AND ITS ELECTRICAL CONNECTIONS.

No. 473,929. Patented May 3, 1892.

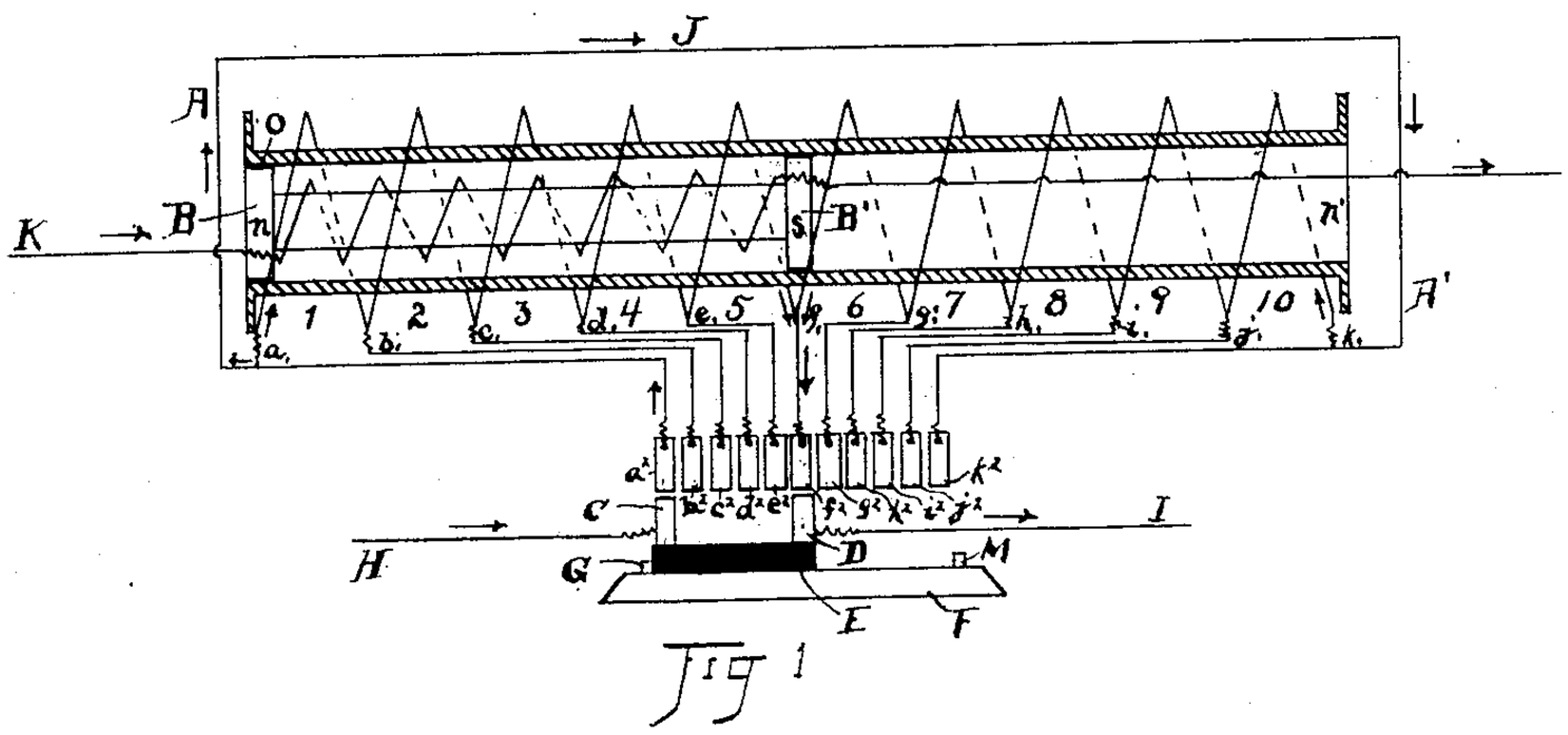


Fig 1

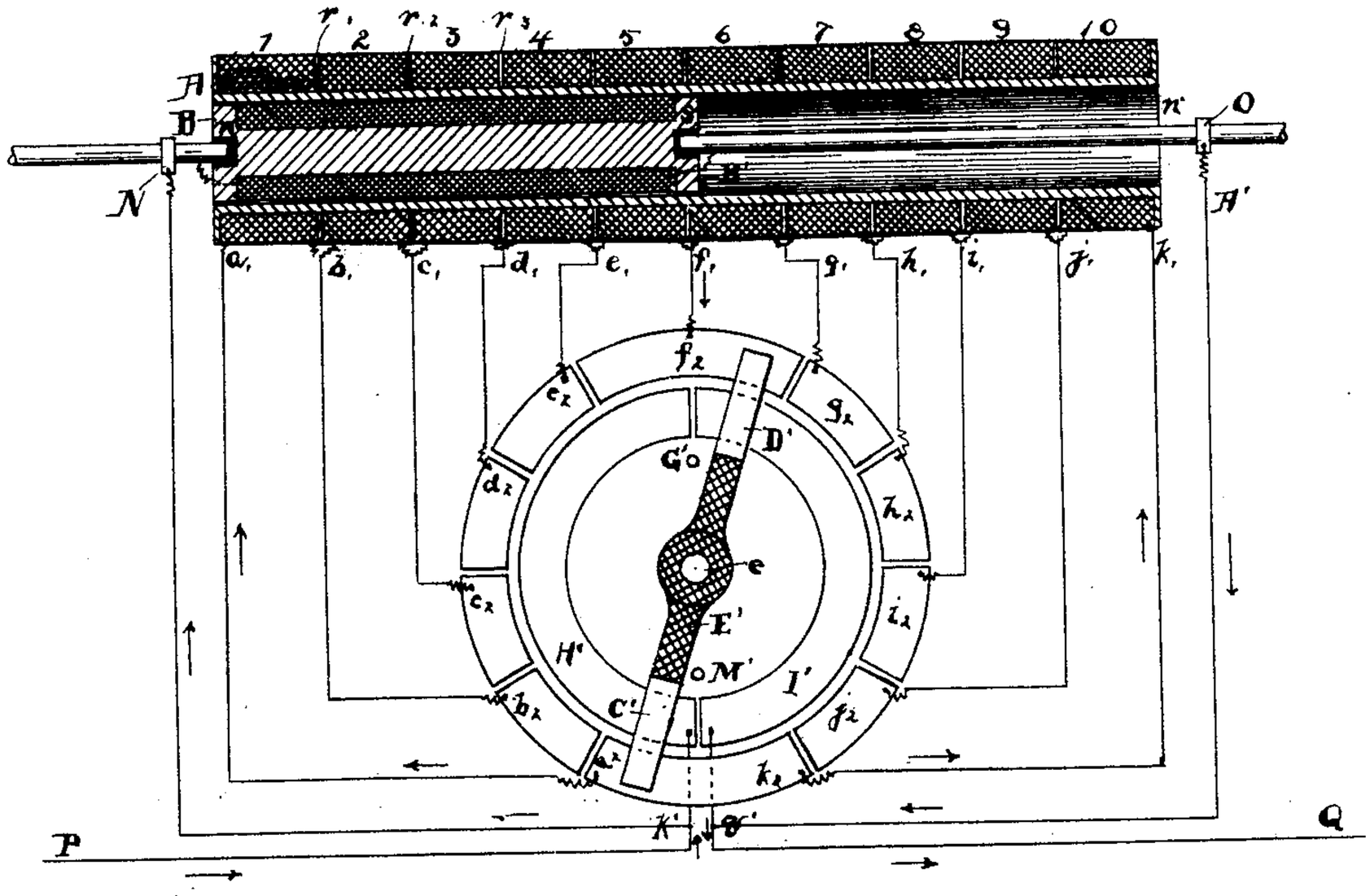


Fig 2

Witnesses
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# UNITED STATES PATENT OFFICE.

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## SOLENOID AND ITS ELECTRICAL CONNECTIONS.

SPECIFICATION forming part of Letters Patent No. 473,929, dated May 3, 1892.

Application filed June 3, 1891. Serial No. 394,917. (No model.)

*To all whom it may concern:*

Be it known that I, HENRY H. HOSFORD, a citizen of the United States, residing at Cleveland, in the county of Cuyahoga and State of Ohio, have invented certain new and useful Improvements in Solenoids and their Electrical Connections; and I do hereby declare that the following is a full, clear, and exact description of the invention, which will enable others skilled in the art to which it appertains to make and use the same.

My invention relates to solenoids and their electrical connections; and the object of the invention is to provide means whereby to shift the position or change the sign of the magnetic poles of a solenoid without making and breaking the energizing-current and without abruptly changing the direction of said current, and, in consequence of the foregoing, without injurious sparking at the contact-points. It is obvious that such a device may be advantageously used to produce a reciprocating motion, and it might also be used in other forms of apparatus where it is desired that magnetic poles may be formed and caused to change their position or to be reversed in polarity without making and breaking the energizing-current.

In the accompanying drawings, Figure 1 is a diagrammatic longitudinal section of a solenoid and its core and the means for connecting the energizing-coils with a source of current, and Fig. 2 is a longitudinal sectional view of a modified form of a solenoid and its core and the means for connecting the energizing-coils with a source of current.

Referring to Fig. 1, A is a solenoid. It is formed by winding upon a tube or support *o* of non-magnetic material the coils 1 2 3, &c. These coils are all wound in the same sense or direction and may be formed of a single continuous conductor having loops thrown out at points *b c d j*, or they may be wound separately and joined by placing the terminals of the adjoining sections in electrical connection at the points *b c d j*, as in Fig. 2. The free ends *a k* of the outer sections or coils 1 and 10 are joined, as here shown, by the loop J. Thus the conductor of the energizing-coils, with the connecting-loop J, forms a permanently continuous or closed circuit without an electrical break. In order to admit the current to the coils and so energize them, I employ the contact plates or segments $a^2$ $b^2$ $c^2$, &c. These contact plates or segments are electrically connected to the conductor at the extreme ends of the solenoid at the points *a* and *k* and between each two adjoining section at the points *b c d j*, respectively. C and D are brushes insulated from one another, but mechanically united by the bar E. This bar is capable of longitudinal reciprocating movement on the supporting-plate F, and the said bar E is so placed with respect to the segments $a^2$ $b^2$ $c^2$, &c., that as it is moved back and forth on its support the brushes C and D are carried over the segments $a^2$ $b^2$ $c^2$, &c., and make contact with them successively. Furthermore, the segments or plates $a^2$ $b^2$ $c^2$, &c., are so arranged that as the brush C makes contact with $a^2$ the brush D makes contact with $f^2$, and as the brush C leaves $a^2$ and makes contact with $b^2$ the brush D leaves $f^2$ and makes contact with $g^2$, and so on, as will be understood from the figure. The segments or plates $a^2$ $b^2$ $c^2$, &c., are separated by air-spaces or insulating material and are so constructed with respect to the brushes C and D that the brushes do not break contact with one pair of segments or plates until after they have established contact with the pair of segments next adjoining. The brushes C and D are permanently connected with a source of electrical energy. G and M are stops so placed as to limit the movement of the bar E. The sections or coils 1 2 3, &c., are made as nearly alike as possible and have substantially the same resistance.

From the foregoing description and Fig. 1 it will be understood that the segments $a^2$ $b^2$ $c^2$, &c., are so arranged with respect to the brushes C and D that the brushes in all positions include between them one-half of the magnetizing-coils—that is, the points of the closed circuit with which brushes C and D are in connection are always electrically opposite—*i. e.*, divide the closed circuit into two parts of equal resistance. It follows that the current will be equally divided and follow two electrically-parallel paths through the coils. The assumed direction of the current is shown by the arrows. It will be seen that to the

current entering by the brush C two paths are open, and as these paths are of the same resistance the current will divide equally, one half passing by the coils 1, 2, 3, 4, and 5 in succession to the brush D, and one half by the coils 10, 9, 8, 7, and 6 in succession to the brush D. Now as the coils are all wound in the same sense or direction it is evident that the current circulates in the coils 1, 2, 3, 4, and 5 in a direction opposite to that in the coils 10, 9, 8, 7, and 6. Hence magnetic poles of the same sign will be formed at the ends of the solenoid at the points $n\ n'$, and a consequent pole of opposite sign will be formed half-way between them adjacent to the point $s$. If the direction of the current be as assumed, north poles will be formed at $n n'$ and a south pole at $s$. Now by moving the bar E back and forth upon its support it is evident that the poles $n\ n'$ at the ends of the solenoid may be caused to alternate in polarity and that the intervening consequent poles may be caused to move to and fro longitudinally. Hence a magnetic core B', which is free to move longitudinally, may be caused to move back and forth under the influence of the shifting and changing poles $n\ s\ n'$. The core B' is preferably wound with a magnetizing-coil traversed by a continuous current, so as to give the core a constant polarity. However, the magnetizing-coil is not absolutely necessary, and either a permanent magnet or a soft-iron core may take the place of the electro-magnet B'.

In the form of apparatus shown in Fig. 1 it will be seen that in all positions of the brushes C and D magnetic poles will be formed at the ends of the solenoid, and also one or two consequent poles at intermediate points, the position of the consequent poles at any particular time depending on the position at that time of the brushes C and D. From the principle of the apparatus it will be seen that when the proper connections are made with a source of electrical energy a current will traverse all the coils of the solenoid, circulating in one half of the coils in one direction and in the other half in the other direction. At no time during the operation of the apparatus will any of the coils be cut out of the circuit, except that a single coil or pair of coils may be momentarily short-circuited by the brushes as they pass from one contact-segment to another. For instance, as the brush C moves from $a$ to $b$ it may for an instant make contact with both of the segments and so momentarily short-circuit the coil 1.

The arrangement of the bar E with its attached brushes and the contact plates or segments $a^2\ b^2\ c^2$, &c., is shown as a simple and effective means of admitting current to the coils. However, other arrangements are possible, and for certain purposes or in certain combinations might be preferable. For instance, the bar E might be mounted on a pivot on which it could rock or revolve, thus carrying the brushes C and D over the segments $a^2\ b^2\ c^2$, &c., arranged in disk-like or cylindrical form. An arrangement of this sort is shown in Fig. 2.

Referring to Fig. 2, the construction of the solenoid and core are shown substantially as already explained for Fig. 1. In this instance we have disks $r'\ r^2$, &c., of non-magnetic material placed between the coils or sections 1 2 3, &c., on the tube or support $o$. Similar disks might be employed between the coils in Fig. 1, and they might also be omitted in Fig. 2. The permanent connection of the outer terminals $a'\ k'$ of the end sections 1 and 10 (represented by J in Fig. 1) is shown in Fig. 2 as made through the plate or segment $a^2\ k^2$. Any equivalent of these ways may be adopted. C' and D' are brushes insulated from one another, but mechanically connected by the bar E' and adapted to make contact with the segments $a^2\ k^2\ b^2\ c^2$, &c., successively as the contact-bar E is rocked or revolved on its pivot $e$. G' and M' are stops to limit the motion of the bar E', the same as in Fig. 1. H' and I' are segments permanently connected with the terminals of a source of electrical energy and adapted to make contact with the brushes C' and D', respectively, in all their positions. As will be understood by this figure, the arrangement of the segments and brushes is such that by rocking bar E on its pivot the same ends are served as by moving bar E, Fig. 1, to and fro on its support.

Still other arrangements of the brushes and contact-segments are possible. For instance, the segments might be so arranged as to admit of making the desired connections by a continuous revolution of the bar E in the same direction. Again, the segments might be so arranged as to present to the brushes a cylindrical surface; but these and all such obvious variations of the arrangements of parts, though not expressly set forth in this description, are regarded as within the scope of the invention and as covered by the claims.

In the diagrammatic view, Fig. 1, each convolution of the wire about the tube O represents what is termed a "coil" or "section" of the solenoid.

The invention set forth in the foregoing description and covered by the claims may be expressed in a further modification, in which there is a solenoid having a magnetic core fitted to have magnetic poles induced not only at its extremity but also at one or more intermediate points, and surrounding coils capable of being placed in such connection with the terminals of a source of electrical energy that the current will divide itself to pass through the coils by more than two electrically-parallel paths of equal resistance, thus forming a multipolar or compound solenoid.

Having thus described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. In a solenoid, a series of energizing-coils

formed of a conductor closed from one coil to the other and having the outer extremities of said conductors closed on each other, thereby forming a closed or unbroken electrical circuit, substantially as described.

2. A solenoid consisting of two or more coils, conductors from one coil directly to the other, and a conductor between the outer ends of the two outer coils, substantially as described.

3. A solenoid having energizing-coils electrically connected directly one to another, and a conductor connecting two of said coils located in different parts of the solenoid and having other coils between them, substantially as described.

4. A solenoid composed of a series of electrically-connected coils and contact-points, having each a conductor connected directly with two of said coils, substantially as described.

5. A solenoid composed of electrically-connected coils and separate contact-points and conductors for said coils, in combination with an independent conductor connecting two of said coils, and brushes to engage said contact-points, substantially as described.

6. In a solenoid, a series of energizing-coils having the terminals of adjoining coils in permanent electrical connection and the outer terminals of the extreme or end coils in permanent electrical connection, thereby forming a closed electrical circuit, substantially as described.

7. In a solenoid, a magnetic core, a non-magnetic shell or support for the coils, a conductor forming the coils and wound in the same direction around such support and having the outer terminals of the end coils in permanent electrical connection, so as to form a closed electrical circuit, substantially as described.

8. In a solenoid, a magnetic core capable of longitudinal movement, a series of motor-coils having the terminals of the sections in electrical connection to form a closed electrical circuit, and means for connecting the closed circuit at two or more points to a source of electrical energy, substantially as described.

9. In a solenoid, a series of coils forming a continuous conductor and permanent electrical connection of the terminals of the conductor, so as to form a closed electrical circuit, substantially as described.

10. In a solenoid, a series of coils with permanent electrical connection through the coils and outside of the same to form a complete or closed electrical circuit, contact-points for admitting current to the coils, means, such as movable brushes, for connecting the said contact-points with a source of electrical energy and to make successive contact with said points, substantially as described.

11. In a solenoid, a movable magnetic core, motor-coils so united as to form a permanently-closed electrical circuit, and means for connecting the circuit at two or more points with a source of electrical energy, substantially as described.

12. In a solenoid, a magnetic core, coils around the core so united as to form a closed electrical circuit, and means for connecting the coils or sets of coils with the two terminals of a source of electrical energy, substantially as described.

13. In a solenoid, energizing-coils so united as to form a permanently-closed electrical circuit, means for connecting the terminals of a source of electrical energy to the closed circuit at such points as to divide the closed circuit into electrically-parallel paths of substantially equal resistance, and means for shifting the connections of said terminals from one set of such points to another set of such points on the closed circuit, substantially as described.

Witness my hand to the foregoing specification this 29th day of May, 1891.

HENRY H. HOSFORD.

Witnesses:
H. T. FISHER,
NELLIE L. MCLANE.