No. 814,259. PATENTED MAR. 6, 1906.

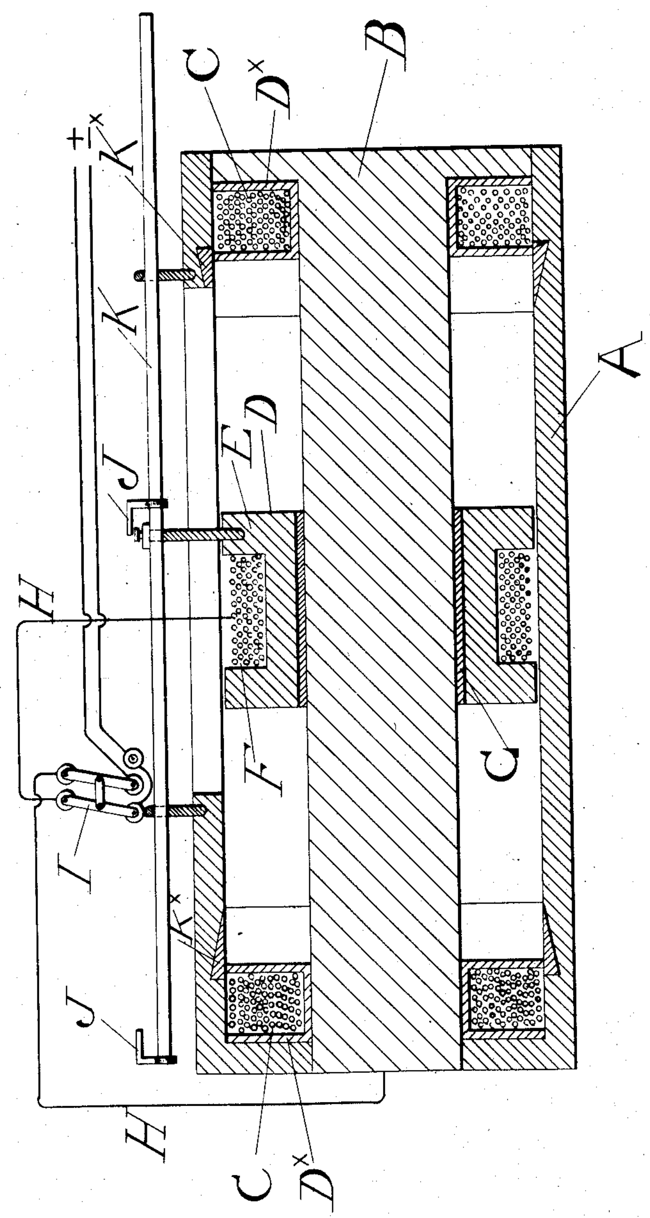
T. H. ALDRICH.

RECIPROCATING ELECTRIC MACHINE.

APPLICATION FILED APR. 5, 1905.

2 SHEETS—SHEET 1.

Fig. 1.



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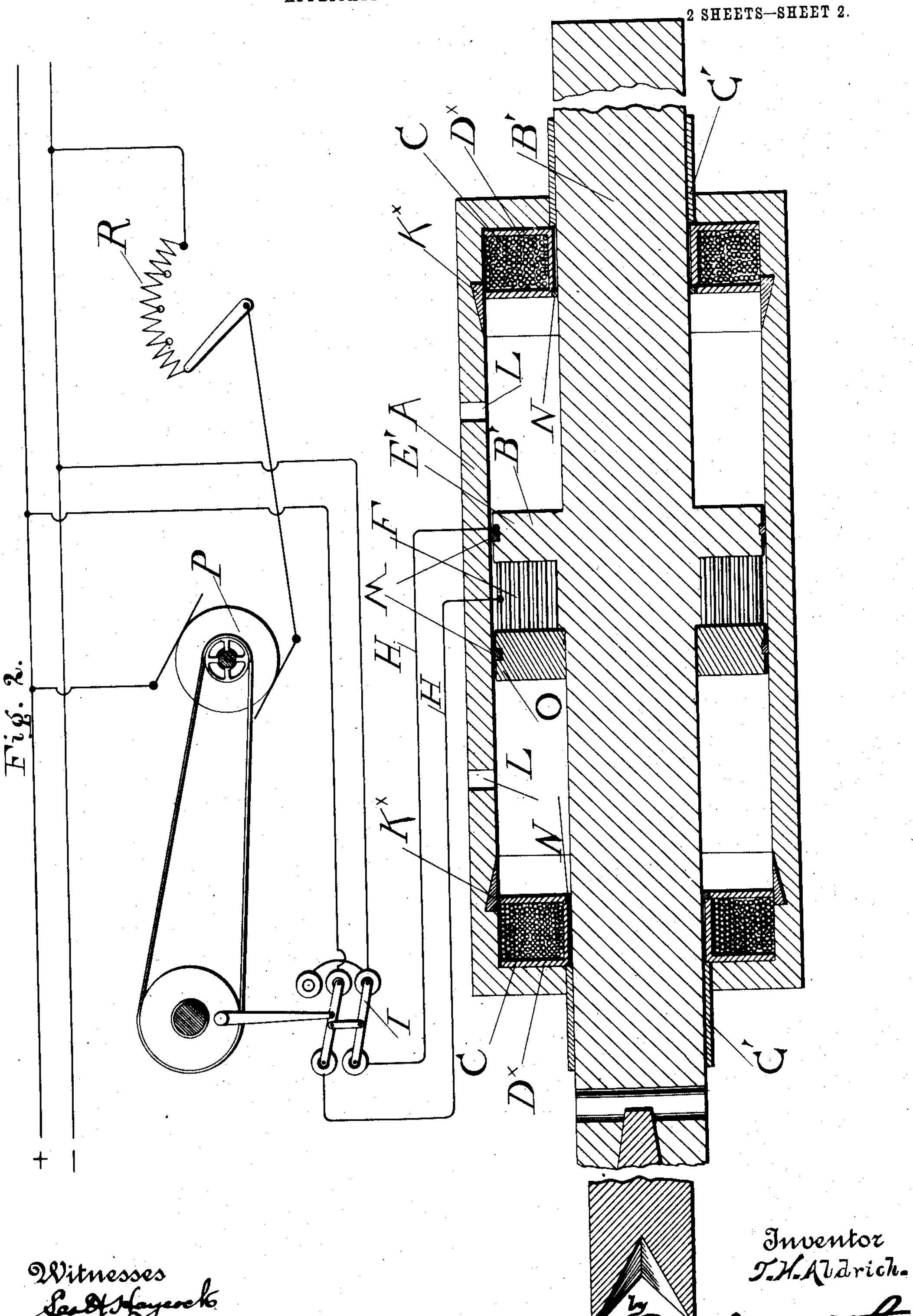
2 SHEETS—SHEET 2.

Fig. 2.



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UNITED STATES PATENT OFFICE.

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RECIPROCATING ELECTRIC MACHINE.

No. 814,259. Specification of Letters Patent. Patented March 6, 1906

Application filed April 5, 1905. Serial No. 253,959.

To all whom it may concern:

Be it known that I, TRUMAN HERBERT ALDRICH, a citizen of the United States, residing at Birmingham, in the county of Jefferson and State of Alabama, have invented certain new and useful Improvements in Reciprocating Electric Machines; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

This invention relates to reciprocating electric machines, and is intended for embodiment more particularly in motors, though it may be equally applied to dynamos.

In its application to motors the invention is particularly adapted for employment in connection with the operation of drills, diggers, punchers, and other tools requiring reciprocatory motion and great power. The object is to provide a machine which may be utilized for such purposes that will have a high degree of efficiency.

I am aware that hitherto motors have been proposed in which the field-magnet consists of a cylindrical outer pole-piece and an inner axial pole-piece of opposite polarity, and the armature is mounted to slide on the inner pole-piece longitudinally of the annular space between the pole-pieces, reciprocation of the armature being produced by feeding the coil thereof with current that is periodically reversed. While for purposes of illustration I have shown a motor of this general type that is somewhat similar in that it has a cylindrical pole-piece and an axial pole-piece of opposite polarity, combined with an armature reciprocable in the space between the two pole-pieces, I do not by any means limit myself to a cylindrical form of motor or even to a completely-inclosed form. All that I consider of importance in this regard is that there be outer and inner pole-pieces of opposite polarity arranged parallel to each other, with a longitudinally-reciprocable armature. There are, however, essential differences between the present construction and the former types referred to. In these the armature consists simply of a coil of wire in which the periodically-reversed current through its influence on the magnetic flux produces reciprocation of the armature. With such a construction it is impossible to secure satisfactory efficiency, since there is such a large air-gap between the pole-pieces.

According to my invention the body of the armature is of suitable magnetic material, the air-gaps being reduced to a minimum, and with this magnetic body is associated the armature-coil. Under these conditions the armature constitutes practically a traveling bridge for the lines of force passing between the pole-pieces. Moreover, while I do not limit myself to mounting the armature-coil on the armature-body, since it might be stationary with reference to the latter, yet when the coil is carried by the magnetic body said body affords a superior path for the lines of force just where they will be most directly within the influence of the armature-current.

It is true that it has been proposed previously to form the armature of a motor of this general description of a coil or coils of soft-iron wire; but aside from the fact that iron-wound armatures have proved unsatisfactory it will be readily recognized that when the insulation around the individual turns of wire and the spaces between these turns are taken into account an air-gap of such dimensions is represented that the advantages obtained by my construction are quite lost. It is essential that the conductor of the armature shall be distinct from the magnetic body thereof. Thus in carrying my invention into effect I prefer to form the armature with a slotted body of magnetic material with a coil of non-magnetic material built up in the slot or slots thereof, all air-gaps being as small as practicable. With such an armature it is possible to exert a tremendous pull.

In a motor such as I have proposed I find it of considerable importance that the magnetic field shall be evenly balanced. Otherwise as the armature reaches the strongest part of the field the lines of force from this region will tend to take the shortest path through the magnetic body of the armature and resist the rupturing of this path on the return movement of the armature. This balancing of the field may be conveniently effected by mounting an exciting coil or coils at each end of the magnetic field, and in this way a practically even field may be obtained.

In the accompanying drawings I have illustrated diagrammatically certain embodiments of my invention.

Figure 1 represents a vertical longitudinal section through a motor constructed after my invention, and Fig. 2 is a similar representation of another embodiment.

Referring more particularly to Fig. 1, A represents the outer pole-piece, preferably, though not necessarily, in the form of a hollow cylinder, and B is the inner pole-piece, shown as an axial core rigid with the outer cylinder. The pole-pieces are constructed of iron, steel, or other suitable magnetic material and are energized by field-coils C, located at opposite ends of the annular space between the pole-pieces. These coils are so wound as to induce a polarity of one sign in the outer pole-piece and a polarity of the opposite sign in the inner member. To get the best results, the coils at the two ends should have the same number of turns and be arranged to balance the magnetic field. However, it is to be understood that the particular location and construction of the energizing-coils is not essential, and while I have shown the coils at the ends of the field outside of the path of the armature D they may be caused to overlap the path of the armature, if desired. The energizing-coils may be mounted in any suitable manner to prevent accidental displacement. They are shown as carried in spools $D^{\times}$, of brass or other non-magnetic material, and should be securely anchored in place.

The armature D comprises a body E of magnetic material slotted to receive the coil F. The air-gap between the magnetic body of the armature and the face of the outer pole-piece is extremely small, and to prevent sticking of the armature on the inner pole-piece, on which it slides, a sleeve G, of brass or any suitable non-magnetic material, is inserted between these two members. The armature-coil is to be connected with the feeding-circuit in any suitable manner. One end of the coil may terminate on the magnetic body E, in which case one of the feed-wires H may connect with the inner pole-piece, while the other feed-wire connects with the other end of the coil, as desired. However, it will be understood that the particular manner of connecting the armature is an immaterial matter.

It will be readily understood that when current of constant direction is fed to the energizing-coils in any suitable manner (not shown) and the armature is supplied with current that is periodically reversed the armature will have a reciprocating movement longitudinally in the space between the pole-pieces. The particular means for effecting the reversal of the armature-current is not for the present of particular importance; but I have shown the reversal as being effected by a pole-changer I, which is operated at suitable points in the cycle of movement by fingers J, mounted on a longitudinal rod K, carried by the armature outside of the outer pole-piece. While I have referred to the armature as being the member supplied with the periodically-reversed current, it will be obvious without illustration that the field-coils instead may have the direction of current therein reversed.

In order to assist in the equalizing of the magnetic field, it may be considered advisable to provide means for neutralizing the slight increase in density toward the ends of the field. While this may be effected in a variety of ways—very simply by increasing the air-gap at these points—I consider that a collar of non-magnetic material inserted on one of the pole-faces at each end in advance of the energizing member at this point serves the purpose excellently. I have illustrated such collars at $K^{\times}$ on the inner surface of the outer pole-piece. For best results such collars may be caused to increase in thickness, as shown, toward the field-coils.

In Fig. 2 I have shown a form of my invention particularly adapted to reciprocating tools. The essential difference between this and the preceding form is that the armature-body E′ is secured to the inner pole-piece B′, which of course is now slidable in the outer pole-piece A′. With this construction the sleeve between the armature and the inner pole-piece is naturally omitted; but similar sleeves are inserted between the reciprocating pole-piece and the ends of the outer pole-piece, in which it has its bearings. These sleeves are indicated at G′. The form of motor illustrated in this view has the important advantage that the armature is prevented from canting and sticking, since the bearings are located so far apart. In a motor applied to a tool that is used for heavy work it is advisable to provide some cushioning means. I have made such provision by making the outer pole-piece an inclosed cylinder, with the exception of vents L, located somewhat in advance of the extremes of movement of the armature. It will be obvious that as the armature advances from mid position toward one end the air will at first escape through the vent ahead until the armature passes this vent, when the air will be compressed. In order to increase the cushioning effect, packing-rings M of non-magnetic material, or even of magnetic material, if sufficiently small, are let into the periphery of the armature, and other packing-rings N are secured to the spools of the field-coils, so as to bear against the reciprocating pole-piece. It will be noted that the vents serve not only for the cushioning effect, but also to provide ventilation for the interior of the motor. Even with some cushioning means provided there is considerable tendency for the armature-coil of such a motor to become loosened, and in this figure I have illustrated one way in which the loosening may be avoided. According to this expedient the coil F′ consists of copper tape wound in the slot in the armature, each turn extending for the entire width of such slot. The tape is

anchored in place by a disk O, forming one side of the slot and bearing forcibly against one side of the coil of tape, being suitably clamped, shrunk, or otherwise secured in position.

Another feature of great importance and value for motors used for the kind of work indicated is shown in connection with Fig. 2. This feature is the provision of external means for automatically reversing the armature-current. The advantage of this will be readily appreciated. In coal-diggers, for instance, it frequently happens that the tool becomes wedged in the material being operated upon, and with the armature-current under the control of the armature itself, as shown in Fig. 1, the armature would be incapable of releasing itself. However, if a separate controller is provided which will continue to reverse the current even when the armature is held against movement the armature will be caused to vibrate until it finally pulls the tool loose. I have shown this separate controller as being embodied in an auxiliary motor P, which operates the pole-changer. By means of resistance R the movement of the pole-changer may be tuned to the normal stroke of the main motor or the operation of the pole-changer may be varied to any degree desired. For instance, the armature-current may be reversed at such times that toward the end of the stroke of armature D′ the current will oppose the movement of the armature, thus aiding in the cushioning effect, besides using but a small amount of current. In this way not only the length but also the intensity of the stroke may be regulated. I consider this separate adjustable controller an improvement of great importance.

What is claimed as new is—

1. In a reciprocating electric machine, the combination with the field having outer and inner pole-pieces of opposite polarity disposed parallel to each other; of an armature reciprocable longitudinally in the space between the pole-pieces and comprising a body of magnetic material and a coil of conductor distinct from but associated with said body.

2. In a reciprocating electric machine, the combination with the field-magnet having inner and outer pole-pieces of opposite polarity disposed parallel to each other; of an armature reciprocable longitudinally in the space between the pole-pieces and comprising a body of magnetic material disposed in close magnetic relation to said pole-pieces and a conductor distinct from but associated with said body.

3. In a reciprocating electric machine, the combination with the field-magnet having inner and outer pole-pieces of opposite polarity disposed parallel to each other; of an armature reciprocable longitudinally in the space between the pole-pieces and comprising a body of magnetic material disposed in close magnetic relation to said pole-pieces and a conductor distinct from but associated with said body, and of a spacing member of non-magnetic material inserted between said body and one of the pole-pieces.

4. In a reciprocating electric machine, the combination with a field-magnet having outer and inner pole-pieces of opposite polarity arranged parallel to each other; of an armature reciprocable longitudinally in the space between said pole-pieces and consisting of a slotted core of magnetic material disposed in close magnetic relation to the pole-pieces and a conductor wound in said slotted body.

5. In a reciprocating electric motor, the combination with a field-magnet having outer and inner pole-pieces of opposite polarity arranged parallel to each other; of an armature reciprocable longitudinally in the space between said pole-pieces and consisting of a body of magnetic material disposed in close magnetic relation to the pole-pieces and a conductor distinct from but associated with said body, and of means for automatically reversing the current in the conductor periodically during the cycle of movement.

6. In a reciprocating electric machine, the combination with outer and inner pole-pieces, and with energizing-coils arranged to create opposite polarities in the pole-pieces and to maintain the field balanced; of an armature reciprocable parallel to the pole-faces and comprising a body of magnetic material disposed in close magnetic relation to the pole-pieces and a conductor associated with but distinct from said body.

7. In a reciprocating electric machine, the combination with inner and outer substantially parallel pole-pieces, and with energizing-coils located at opposite ends of the pole-pieces and arranged to create opposite polarities in said pieces and to maintain the field balanced; of an armature reciprocable longitudinally in the space between the pole-pieces, and including a slotted magnetic body disposed in close magnetic relation to the pole-pieces and a conductor wound in said slotted body.

8. In a reciprocating electric machine, the combination with an outer pole-piece, and an inner pole-piece of opposite polarity reciprocable longitudinally in the outer pole-piece; of an armature secured to said inner pole-piece to move therewith and consisting of a body of magnetic material arranged contiguous the face of the outer pole-piece and a conductor associated with but distinct from said body.

9. In a reciprocating electric machine, the combination with an outer pole-piece, and an inner pole-piece of opposite polarity reciprocable longitudinally in bearings in the ends of the outer pole-piece, and with spacing mem-

bers of non-magnetic material inserted between the pole-pieces at such bearings; of an armature secured to the inner pole-piece and including a suitable conductor.

10. In a reciprocating motor, the combination with an outer pole-piece and an inner pole-piece of opposite polarity reciprocable longitudinally with reference to said outer pole-piece; of an armature secured to the inner pole-piece and including a body of magnetic material and a conductor, and of means for automatically reversing the current in the armature-conductor periodically during the cycle of movement.

11. In a reciprocating motor, the combination with an outer inclosed pole-piece and an inner pole-piece of opposite polarity; of an armature reciprocable longitudinally with reference to the pole-pieces and consisting of a body of magnetic material and a conductor, and of means for automatically reversing the armature-current periodically during the cycle of movement, an air-cushion being provided at each end of the outer pole-piece.

12. In a reciprocating electric machine, the combination with an outer and an inner pole-piece of opposite polarities arranged substantially parallel to each other, and with energizing-coils located at the ends of the pole-pieces, and with an armature reciprocable in the space between the pole-pieces; of an insert of non-magnetic material at each end of one of the pole-faces in advance of the adjacent energizing-coil.

13. In a reciprocating electric machine, the combination with outer and inner pole-pieces of opposite polarities and arranged substantially parallel to each other, and with energizing-coils located at the ends of the field, and with an armature longitudinally movable in the space between the pole-pieces; of an insert of non-magnetic material at each end of one of the pole-faces in advance of the adjacent energizing-coil and increasing in thickness toward said coil.

14. In a reciprocating motor, the combination with pole-pieces of opposite polarity arranged substantially parallel to each other, said pole-pieces constituting a primary member having suitable energizing-coils, and with an armature reciprocable longitudinally within the influence of said primary member, said armature constituting a secondary member provided with a suitable conductor; of independent means for reversing the current in the conductor of one of said members periodically during the cycle of movement.

15. In a reciprocating motor, the combination with pole-pieces of opposite polarity arranged substantially parallel to each other, and with an armature reciprocable longitudinally within the influence of said pole-pieces and provided with a suitable conductor; of means independent of the movement of the armature for automatically reversing the current in the armature thereof periodically during the cycle of movement.

16. In a reciprocating electric machine, the combination with the field having inner and outer pole-pieces of opposite polarity disposed parallel to each other; of an armature reciprocable longitudinally in the space between the pole-pieces and comprising a body of magnetic material and a coil of conductor of non-magnetic material associated with said body.

17. In a reciprocating electric machine, the combination with inner and outer substantially parallel pole-pieces, and with an energizing-conductor arranged to create opposite polarities in said pieces, and with an armature reciprocable longitudinally in the space between the pole-pieces and comprising a body of magnetic material and a conductor of non-magnetic material associated with said body; of means for automatically reversing the current in one of said conductors periodically during the cycle of movement.

In testimony whereof I affix my signature in the presence of two subscribing witnesses.

TRUMAN HERBERT ALDRICH.

Witnesses:
J. F. BRANDENBURG,
EMORY H. BOGLEY.