(No Model.) 2 Sheets—Sheet 1.

H. CUSHMAN & J. P. HALL.

DYNAMO ELECTRIC MACHINE.

No. 324,752. Patented Aug. 18, 1885.

Fig: 1.

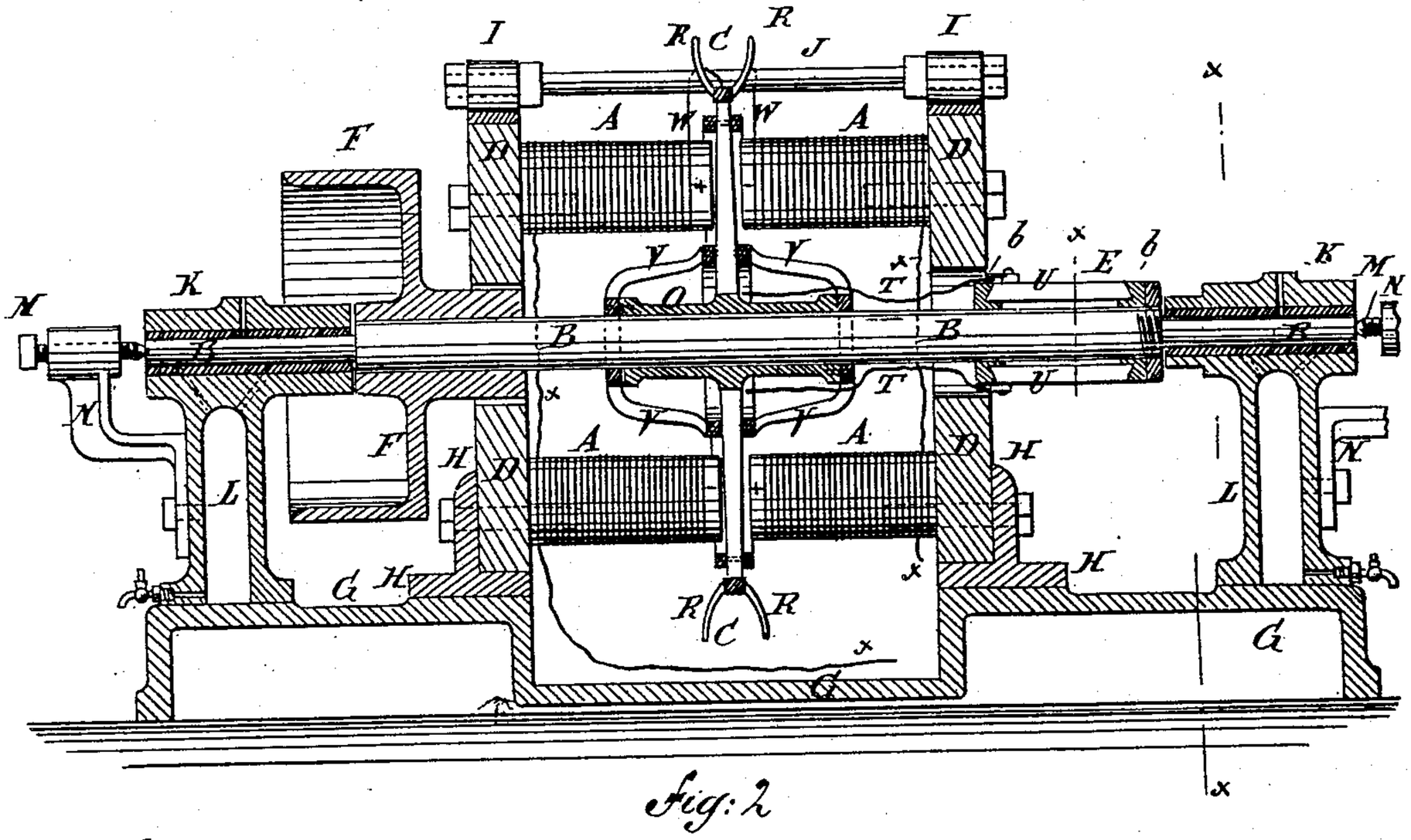
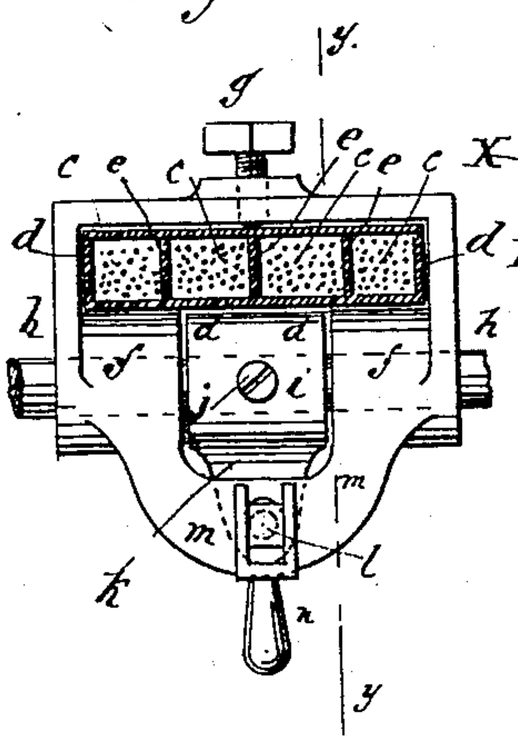
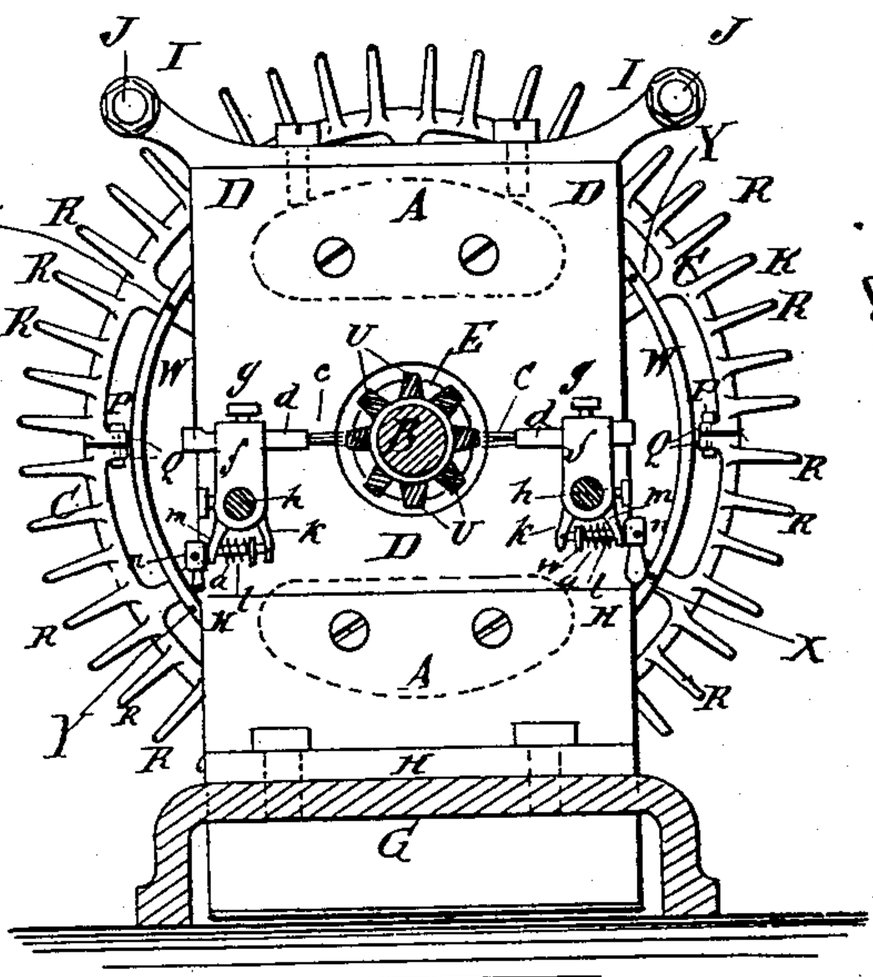


Fig: 2

Fig: 3.





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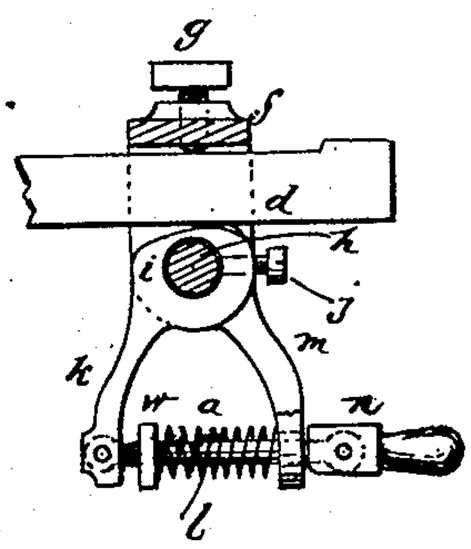
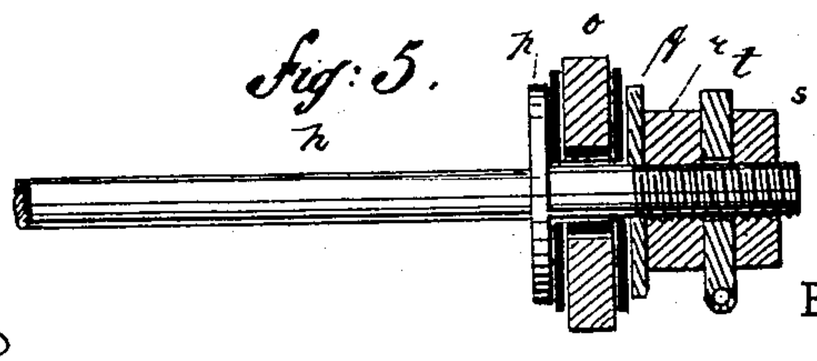


Fig: 5.



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(No Model.) 2 Sheets—Sheet 2.

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DYNAMO ELECTRIC MACHINE.

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Fig: 6.

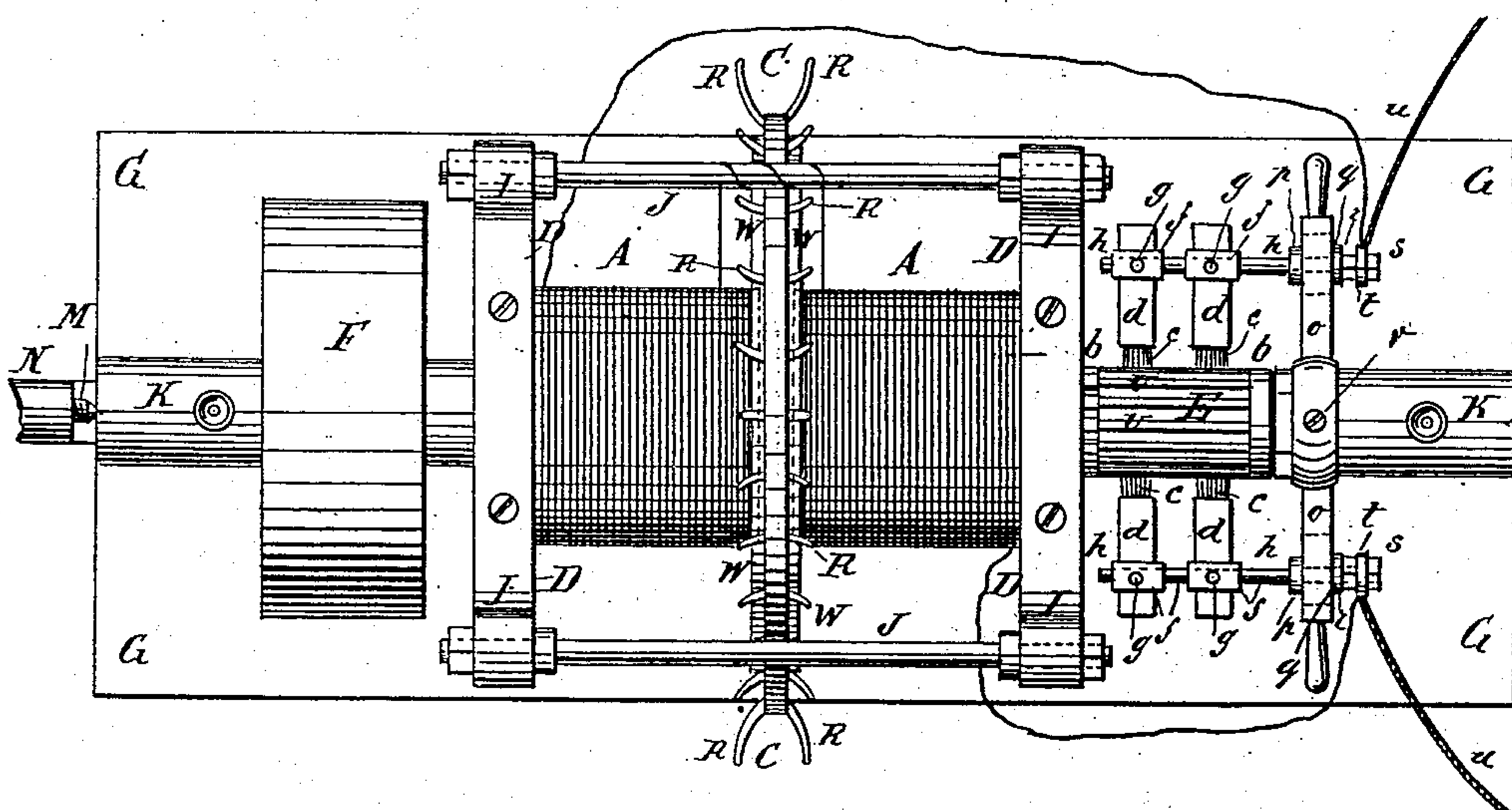


Fig: 7.

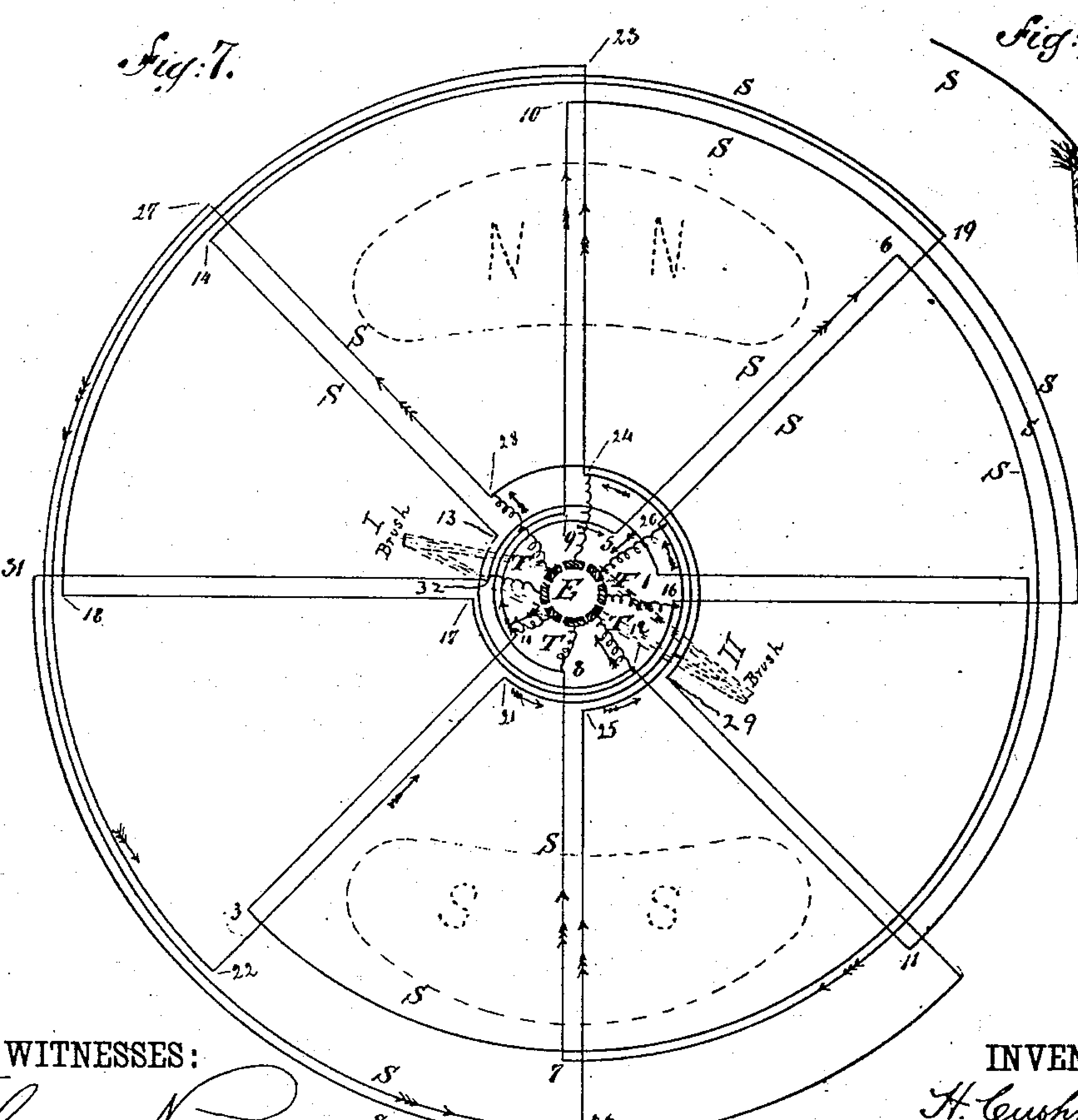
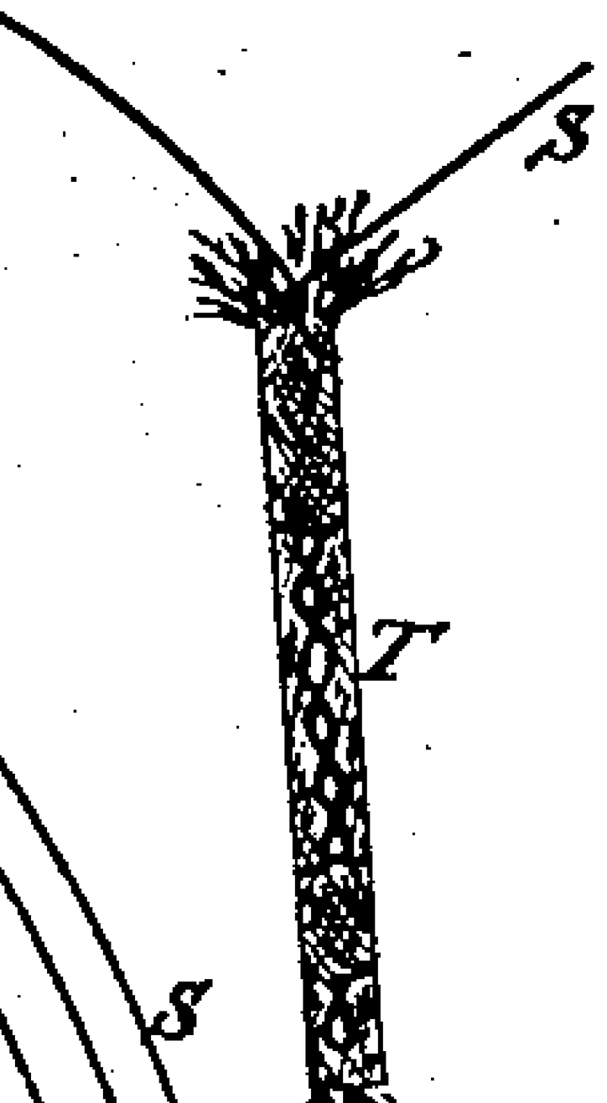


Fig: 8.



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UNITED STATES PATENT OFFICE.

HOLBROOK CUSHMAN, OF NEW YORK, N. Y., AND JOSEPH PLATT HALL, OF OLDHAM, COUNTY OF LANCASTER, ENGLAND.

DYNAMO-ELECTRIC MACHINE.

SPECIFICATION forming part of Letters Patent No. 324,752, dated August 18, 1885.

Application filed February 19, 1885. (No model.) Patented in England December 13, 1884, No. 16,417.

To all whom it may concern:

Be it known that we, HOLBROOK CUSHMAN, of the city, county, and State of New York, and JOSEPH PLATT HALL, of Oldham, in the county of Lancaster, England, have invented certain new and useful Improvements in Dynamo-Electric Machines, (patented in England December 13, 1884, No. 16,417,) of which the following is a full, clear, and exact description.

Reference is to be had to the accompanying drawings, forming part of this specification, in which similar letters of reference indicate corresponding parts in all the figures.

Figure 1, Sheet 1, is a sectional front elevation of one of our improved machines. Fig. 2, Sheet 1, is a sectional end elevation of the same, taken through the broken line *x x x*, Fig. 1. Fig. 3, Sheet 1, is a rear elevation of the brush-holder, showing the brush in section and a part of the spindle. Fig. 4, Sheet 1, is a sectional side elevation of the same, taken through the line *y y*, Fig. 3. Fig. 5, Sheet 1, is a sectional elevation of the parts connected with the outer end of the brush-holder spindle, a part of the spindle being shown in side elevation. Fig. 6, Sheet 2, is a plan view of one of our improved machines, the conductor on the armature being omitted. Fig. 7, Sheet 2, is a diagram illustrating the method of applying the conductor to the armature. Fig. 8, Sheet 2, is a diagram showing one of the twisted loops of the conductor.

The object of this invention is to provide dynamo-electric machines constructed in such a manner that the conductor on the armature will be exposed to the inductive influence of the magnetic field under the most favorable conditions, and which shall be simple in construction and less expensive in manufacture than ordinary dynamo-electric machines.

The invention relates, especially, to the construction of the armature hereinafter set forth, whereby great simplicity and economy in manufacture are attained, and the easy renewal of parts liable to deterioration is allowed.

A are the field-magnets, which are so wound as to constitute a complete magnetic circuit or circuits, and are arranged with the poles of respectively opposite polarity in close proximity. In the machine illustrated in the drawings only one pair of field-magnets is used, the magnetic circuit is single and complete, and the lines of force induced in the cores of the said magnets, as well as those between the poles, are parallel with the shaft B, on which the armature C is mounted. The armature C is of circular form, and is arranged to rotate between the opposite poles of the magnets A, as shown in Fig. 1, in a plane at right angles to the lines of force passing horizontally and directly from the pole of one magnet to the opposite pole of the other magnet. The construction of the armature C will be hereinafter fully described.

The field-magnets A consist of soft-iron cores formed in one piece with or mounted upon connecting-plates D, the sectional areas of which are approximately equal to those of the said cores. The connecting-plates D form the backs of the magnets, and are perforated to allow the driving-shaft B to have a free passage and to receive the ends of the commutator E and the hub of the driving-pulley F, which are placed upon the said shaft at the opposite ends of the machine, and are secured thereto by keys, set-screws, or other suitable means.

The magnets A are wound to give the polarity indicated in Fig. 1, and their plates D are secured to the bed-plate G by rigid brackets H, to which they are bolted, as shown in Fig. 1, and which are bolted to the said bed-plate, as shown in Fig. 2.

To the tops of the connecting-plates D are attached brackets I, the outer ends of which project outward and upward, and to them are secured the ends of stay-rods J. By this construction the magnets are supported against the intense attraction due to the close proximity of their poles, and the said magnets are held securely at the required distance apart.

The shaft B is mounted in bearings K, carried by the standards L, attached to the bed-plate G, and its ends rest against the points of screws M, passing through screw-holes in brackets N, attached to the standards L, so that the said shaft can be moved longitudinally to adjust the position of the armature C, mounted upon the said shaft with respect to the faces of the field-magnets A.

The armature C consists of a wheel or circu-

lar frame of metal, preferably brass, mounted centrally upon or formed solid with a long hub, O, which is secured to the shaft B by a key, a set-screw, or other suitable means. The spokes of the frame of the armature C are insulated at one end to prevent the said frame from being heated by the currents of electricity induced in the spokes or radial portions of the said frame when cutting the lines of force. Preferably the frame of the armature C is formed by casting the hub, spokes, and rim in one piece, and then dividing the rim between the successive spokes by radial saw-cuts. The adjacent ends of the rim-sections are then connected by screws P, passing through lugs Q, formed upon or attached to the inner sides of the said ends, the said ends and screws being insulated by hard rubber, mica, or other suitable non-conducting material.

The rim of the armature C is provided with horns or forked arms R at regular intervals, to assist in winding and properly arranging the conducting-wire S, as will be hereinafter described. The conducting-wire S consists of a number of fine wires laid together or side by side, and the whole covered with insulating material—for example, woven or braided fabric—to form a single conductor.

In winding the armature, beginning at a point—as, for instance, 1—of the hub O, the conductor S is led radially to the rim of the armature, is passed over an arm, R, is led circumferentially along the rim for one hundred and thirty-five degrees, (135°,) is bent inward around an arm, R, and is led radially to the hub O, where it is doubled into a loop, T, of such a length that when twisted into a cord it will extend to the commutator E. The conductor S is then led around the hub O, through an arc of one hundred and eighty degrees, (180°,) and is then bent outward to the rim of the armature, is bent over an arm, R, is led circumferentially along the said rim, then inward to the hub and cut to the commutator, as before described, and so on until the entire space between the spokes of the armature is filled with radial strands. The two ends of the conductor S are then brought together and soldered or otherwise suitably connected. The insulating material is removed from the outer ends of the twisted loops or cords T, and the said ends are connected with the bars U of the commutator by solder, clamping-screws, or other suitable means. The insulating material is removed from the conductor S at the inner ends of the twisted loops, T, and the fine wires forming the said conductor are soldered together at those points.

The conductor S is confined in place around the hub O, and the inner parts of the radial strands are forced into and confined in the spaces between the spokes and in the same plane with the said spokes by cages or frames V, secured at their outer and smaller ends to the ends of the hub O, with their inner and larger ends held against the spokes of the armature C. The outer parts of the radial strands of the conductor S are forced into and held in the spaces between the spokes and in the same plane with the said spokes by two rings, W, placed upon the opposite sides of the said spokes and connected with each other by rivets Y, and are fastened to the two opposite spokes of the armature C by rivets X. The cages V and rings W and their fastening-rivets are insulated from the armature C by mica or other suitable material.

With this construction of armature ample space is available around the hub on either side of the spokes of the wheel or frame for the inner and bent portions of the conductor, while the outer or circumferential portions of the said conductor are securely held by the forked arms R, and are drawn tightly against the rim by the pressure of the clamping-cages V and rings W against the radial portions of the conductor, which are thus pressed into and held in the plane of the spokes of the said wheel or frame.

The armature thus constructed has a globular center and an enlarged rim, and is thin between the said center and rim where the strands of the conductor are radial.

The radial portions of the armature when it is properly wound and is rotated cut the lines of force in a plane at right angles to the direction in which the said lines of force are induced in the magnets, so that great simplicity and economy in manufacture and efficiency in operation are obtained.

In winding the armature the conductor S can be disposed in several ways shown without departing from our invention, which consists in the disposition of a single conductor upon an induction-proof metallic driving-frame in such a manner that a web composed of radial strands or portions of the said conductor is formed with the several convolutions so arranged with reference to the magnetic field in which the said armature is to be used that when the armature is revolved the said convolutions follow each other consecutively through the said field, as in the Gramme or Alteneck machines, whereby electrical currents similar to those in the Gramme machine are produced.

In our improved armature a single continuous and previously-insulated conductor is so disposed that a complete web of radial wire arranged in a single layer fills the space between the hub and rim of the said armature, and the electric current induced in the radial portions of the said conductor will be in such a direction as will yield a continuous electric current at the terminals of the machine. By this construction is avoided the necessity of making repeated connections and joints by solder or other means when disposing the copper conductors in place upon the armature-frame. By this construction is also avoided the necessity for inserting or apply-

ing separate insulations in building up or constructing the armature.

An especial advantage of this construction is that the faces of the magnets forming the field through or across which the radial strands of the conductor are to be moved by the rotation of the armature can be set very closely together, and the said radial portions of the conductor will be subjected to a very powerful inductive action.

We are aware that magnets have been arranged to form a field substantially the same as hereinbefore described; but in such machines armatures of elaborate construction, comprising many separately-wound coils or bobbins, are used.

We are also aware that armatures have been formed of conductors built up of radial bars and segmental connecting-plates which embody the Gramme principle of successive convolutions, producing two sets of opposing currents; but such armatures are used in connection with field-magnets, whose lines of force are induced by the electric current in the convolutions of wire on said magnets in a direction parallel to the plane of rotation of the armature, instead of transversely to such plane, as in our machine, the radial bars in said armatures cutting the lines of force at a point in the magnetic circuit where the said lines of force are diminished in power by passing through a length of inactive iron and by a change of direction in order to reach the armature. Such armatures are complicated in construction, expensive in manufacture, and require great accuracy in fitting together the various parts.

We are also aware of the application of the Gramme or Siemens-Alteneck system of winding to the Arago disk-machine. These constructions we do not claim.

The bars U of the commutator E are made with beveled ends, which rest in rabbets, having undercut shoulders in the collars *b*, placed upon and secured to the shaft B, the said bars being insulated by mica.

The brushes are formed of groups *c* of fine wires, placed in holders *d*, and separated by partitions or division-plates *e*. The outer ends of the brushes *c d* are passed through the upper parts *f* of the holders, where they are secured in place by set-screws *g*. The lower bars of the parts *f* are perforated to receive the spindles *h*, and the middle portions of the said lower bars are cut away to receive the lower parts, *i*, of the said holders, which are also perforated to receive the spindles *h*, and are secured to the said spindles by set-screws *j*. Upon the forward sides of the bottoms of the lower parts, *i*, are formed downwardly-projecting arms *k*, to the lower ends of which are attached the forward ends of rearwardly-projecting pins *l*. The pins *l* pass through holes in the lower ends of arms or flanges *m*, formed upon the rear sides of the bottoms of the upper parts, *f*, of the holders. To the rear ends of the pins *l* are hinged lever-cams *n*. By this construction by operating the lever cams *n* the upper parts, *f*, of the holders can be rocked upon the spindles *h* to raise the brushes out of or lower them into contact with the commutator E. The flanges *m* are held against the lever cams *n* by spiral springs *a*, placed upon the pins *l* between the said flanges *m*, and collars *w*, placed upon and secured to the said pins *l*.

The outer parts of the spindles *h* pass through holes in the ends of the cross-bar *o*, and are secured in place by collars *p*, formed upon the said spindles at the inner sides of the said cross-bar *o*, and washers *q*, and nuts *r*, placed upon the said spindles at the outer sides of the said cross-bar *o*. The spindles *h*, the collars *p*, and the washers *q* are insulated from the cross-bar *o* by mica, hard rubber, or other suitable non-conducting material. Upon the outer ends of the spindles *h* are secured, by nuts *s*, clamps or eye-plates *t*, to which are secured the ends of the cables *u*.

The cross-bar *o* has an aperture through its center to receive the inner end of bearing K of the shaft B, where it is secured in place by the set-screw *v*, so that by loosening the set-screw *v* the bar *o* can be turned upon the bearing K, to bring the brushes *c d* into any desired position with reference to the commutator E.

By arranging the brushes or sets of brushes on each side of the commutator in such a manner that one brush or series of brushes on each side of the commutator will meet the commutator-bar connected to the radial conductor which has just emerged from the magnetic field, and the other brush or series of brushes will meet the commutator-bar connected to the radial conductor which is just entering the opposite field, a high electrical efficiency will be obtained, both sets of brushes of similar sign being joined, so that a large portion of the conductor while it is inactive will be cut out and the electrical resistance of the armature will be diminished.

Referring to diagram Fig. 7, the currents are induced in the wires passing before the field-magnet faces N S in the direction shown by arrows. One current is induced in the portion of wire marked 7 8, and augmented by the current induced in the portion marked 9 10. By following the numerals 5 6 7 8 9 10 11 12 it will be seen that the current flows from brush 1 to brush 2, which latter rests on a different commutator-bar. The second current is induced in the portion of wire marked 26 25, and augmented by the current induced in the portion marked 24 23. This current flows from brush 1 along the course indicated by numerals 27 26 25 24 23 22 21 20 to brush 2. Both parts of brush 1 are in contact or electrical connection, and the same is true of brush 2. There are no currents in the portion of wire marked 28 29 30 31 32 1 2 3 4, this being cut out by brush 1; nor is there any in

the portion 12 13 14 15 16 17 18 19 20, which is cut out by brush 2. This wire is therefore to be subtracted from the electrical resistance of the armature, thereby increasing the efficiency of the machine.

The cores of the magnets A are provided with helix-wires *x*, which are connected with each other in the ordinary manner, and the ends of which are connected with the eye-plates *t* or the spindles *h*.

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

1. The skeleton-frame of the armature, consisting of the hub O and the radial insulated spokes, provided with forks R at their outer ends; as shown and described.

2. The combination, with the field-of-force magnets, of the armature-wheel wound with a single insulated conductor, S, which passes along a portion of the periphery, then inward to the hub, thence to the commutator, then back to the periphery, along another portion of the same, and again inward to the hub, and so on, all as shown and described, for the purpose specified.

3. The combination, with the skeleton armature-wheel and conductor S wound thereon and extending from periphery to hub, of the rings W and cages V, which are arranged on opposite sides and serve to compress the radial wires adjacent to the hub, and to hold and protect the wires when the armature is in use or being transported, as specified.

4. In a dynamo-electric machine, the combination, with the armature-wheel having long hub and having forked arms upon its rim, of a single continuous insulated conductor, S, insulated side cages, V, and insulated fastening rings W, substantially as herein shown and described, whereby the said conductor will be clamped and retained in position, as set forth.

5. The armature-wheel wound with a single previously-insulated conductor, the latter extending radially from the hub to the rim, then along the rim and radially back to the hub, and extending thence in the form of a twisted loop to the commutator, also around a portion of the hub, then again to the rim, and so on until the spaces between the spokes of the wheel are filled with a web composed of a single layer of radial strands, as set forth.

6. In a dynamo-electric machine, the combination, with the armature-wheel wound with a single previously-insulated conductor and the commutator E, of brushes *c d*, grouped in double series, substantially as herein shown.

HOLBROOK CUSHMAN.
JOSEPH PLATT HALL.

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Witnesses to the signature of Joseph Platt Hall:

THOS. CHEETHAM,
ARTHUR B. WEBB,
Both of Salford Iron Works.