(No Model.) 4 Sheets—Sheet 1.

A. MILLAR.

ELECTRIC MOTOR.

No. 271,502. Patented Jan. 30, 1883.

FIG. 2.

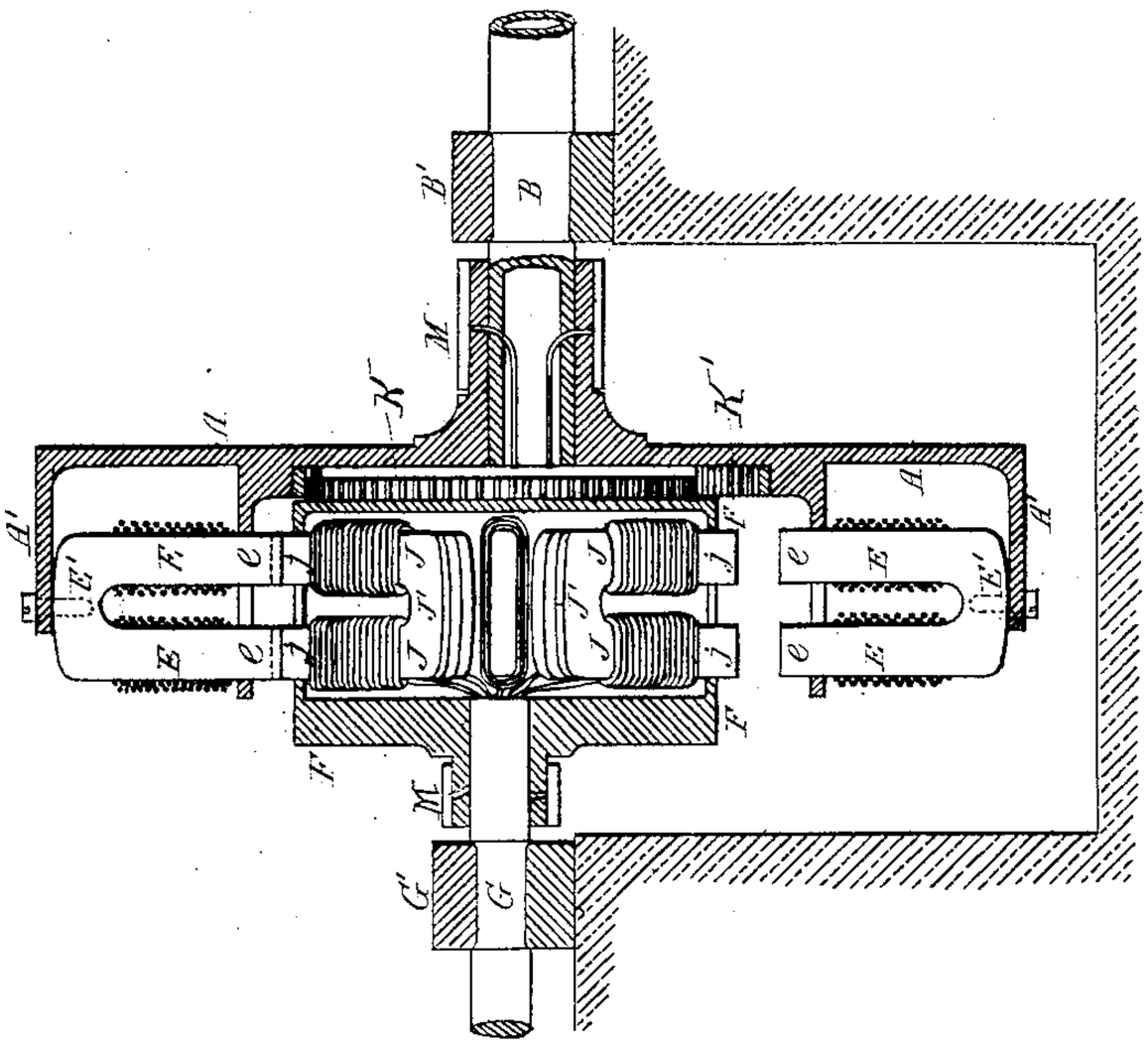


FIG. 4.

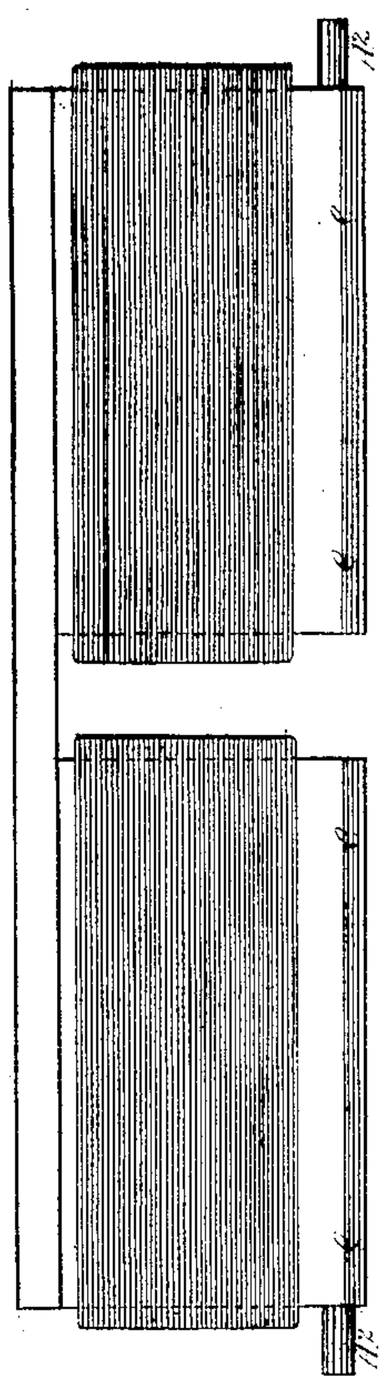


FIG. 1.

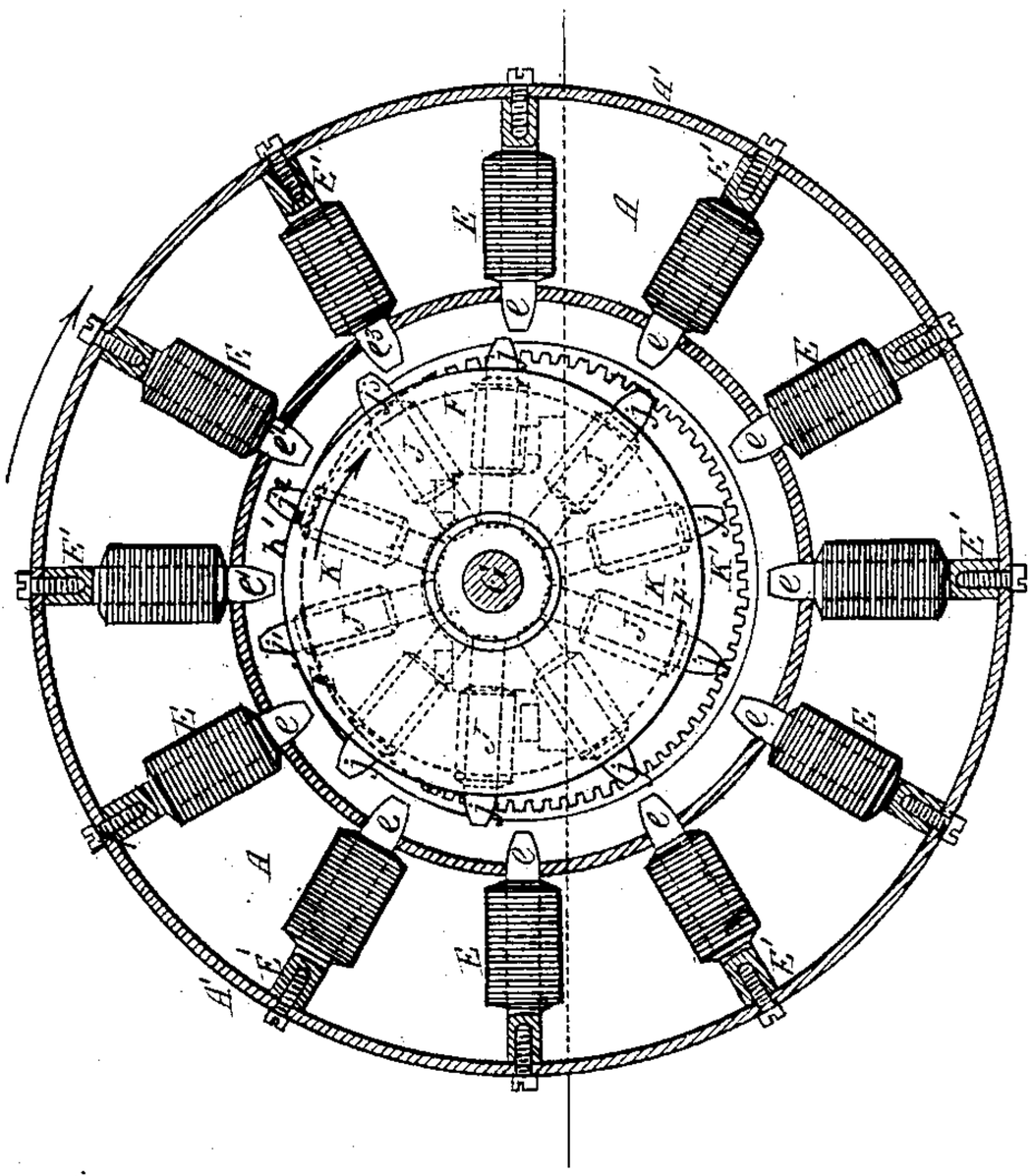
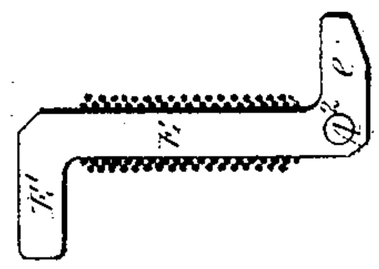


FIG. 3.



Witnesses
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(No Model.)

4 Sheets—Sheet 2.

A. MILLAR.

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FIG. 6.

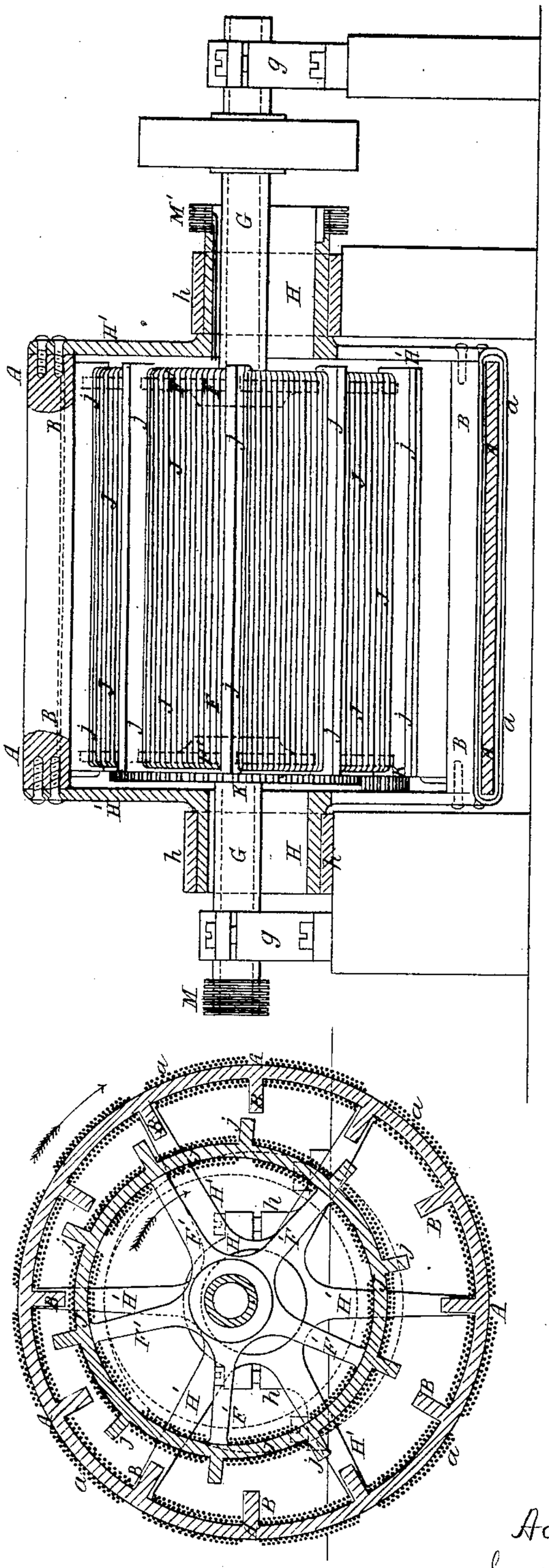

FIG. 5.

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FIG. 7.

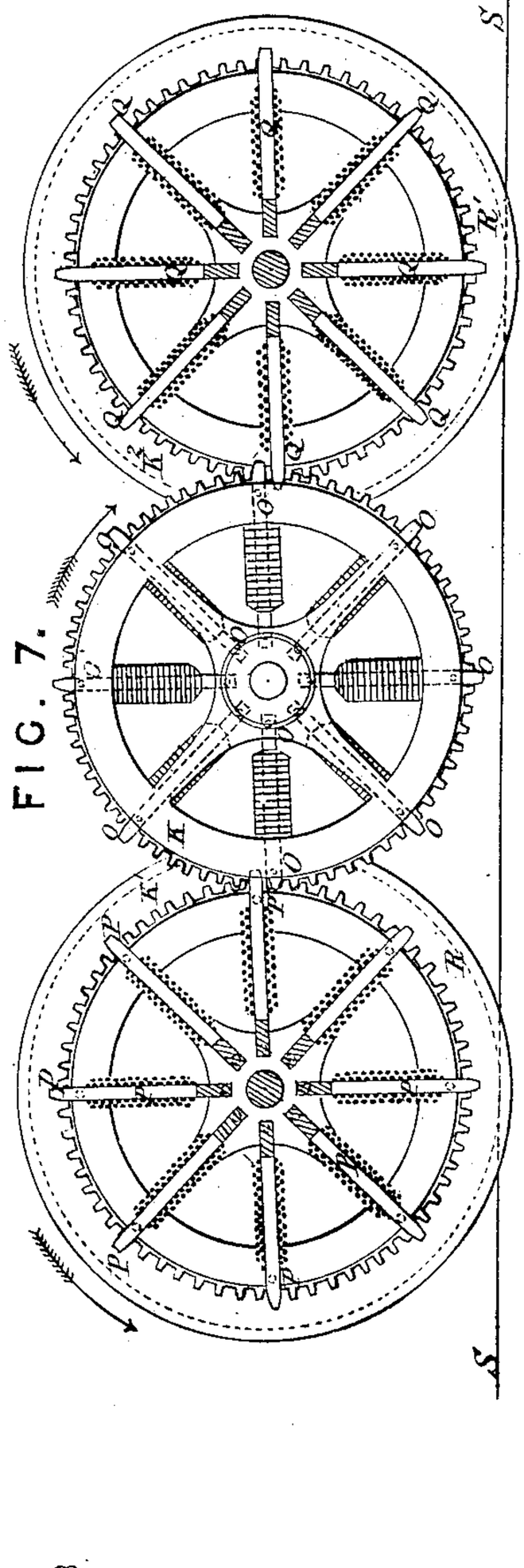
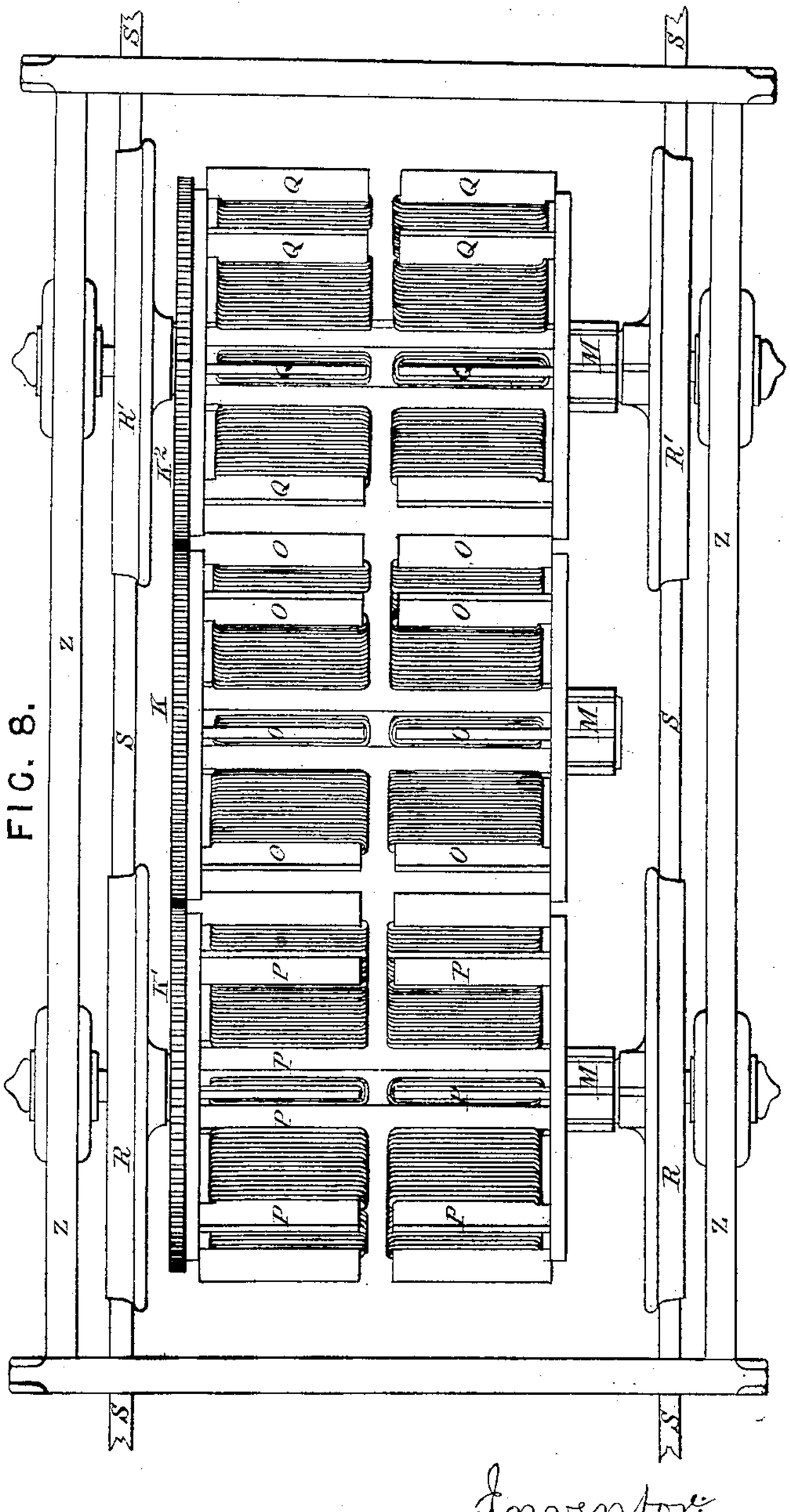


FIG. 8.



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(No Model.) 4 Sheets—Sheet 4.

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ELECTRIC MOTOR.

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FIG. 11.

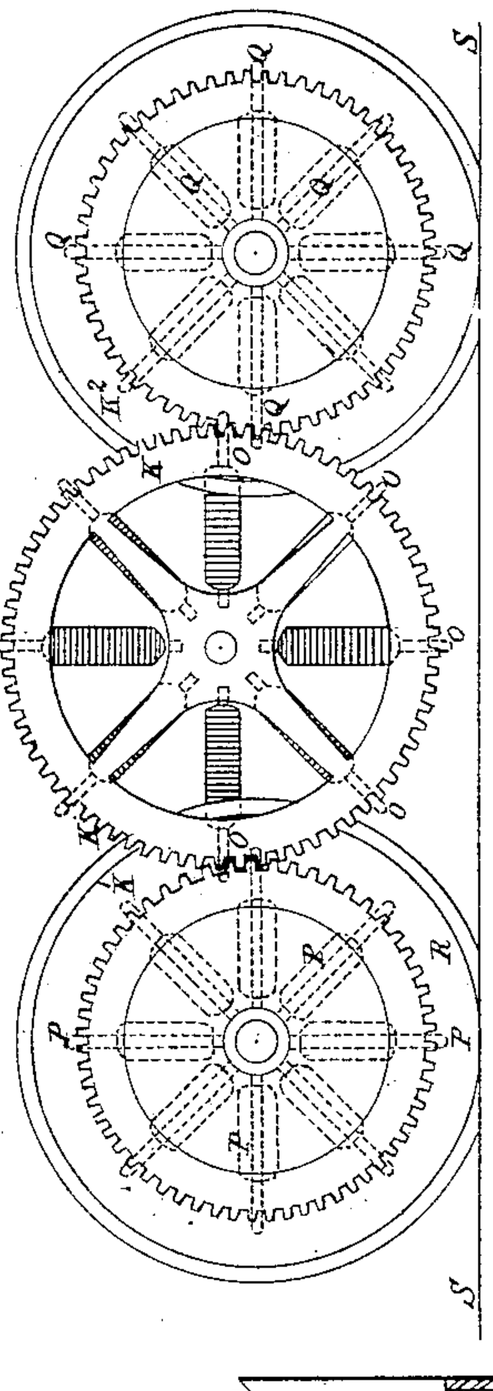


FIG. 10.

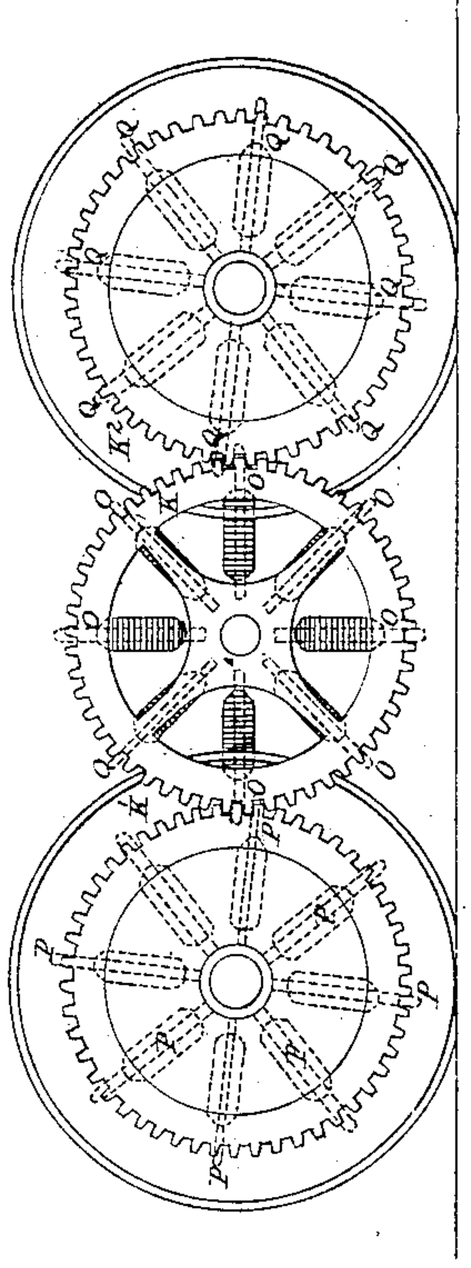
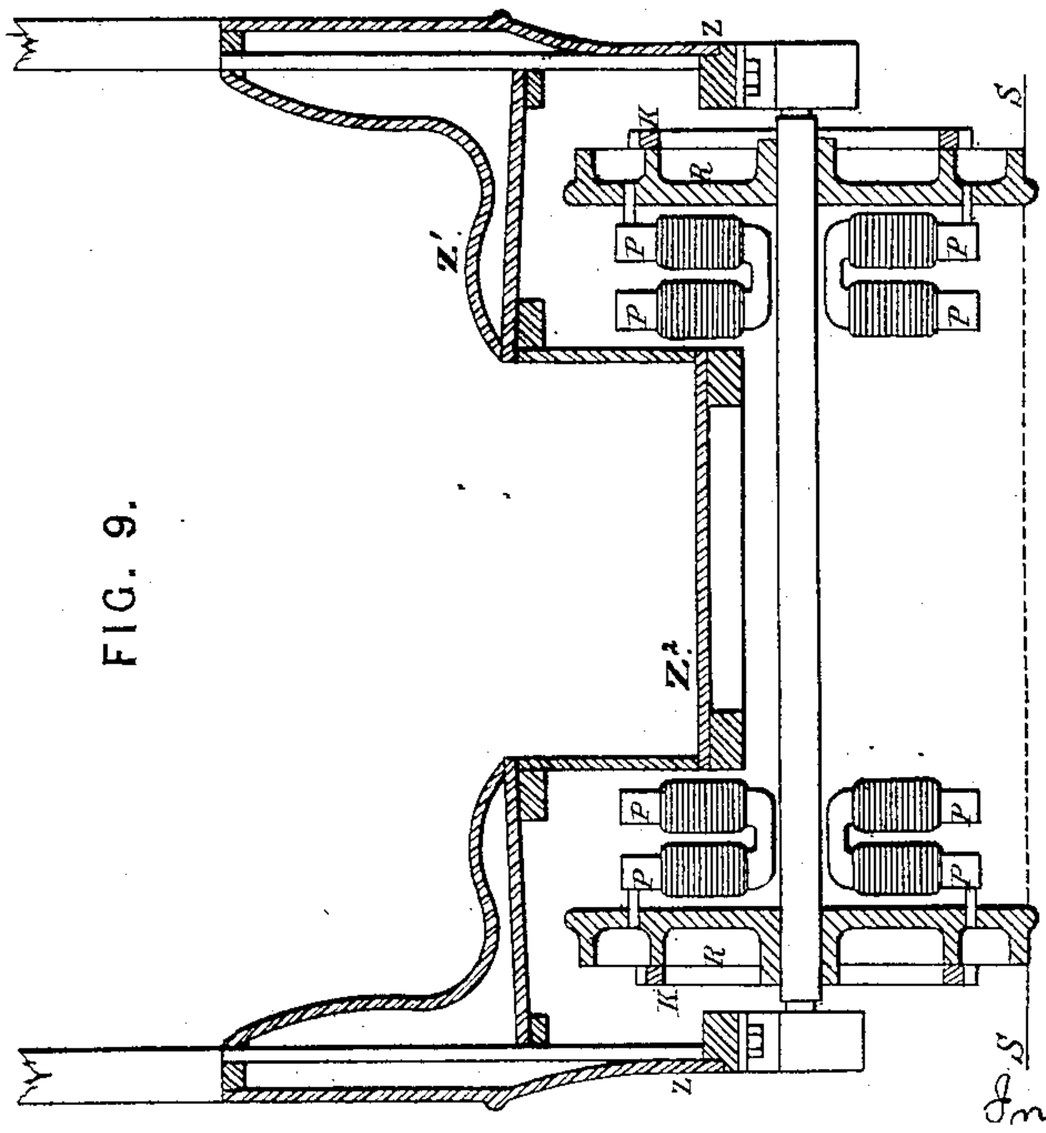


FIG. 9.



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Harry Smith

Inventor
Adam Millar
by his Attorneys
Howson and Sons

UNITED STATES PATENT OFFICE.

ADAM MILLAR, OF GLASGOW, SCOTLAND.

ELECTRIC MOTOR.

SPECIFICATION forming part of Letters Patent No. 271,502, dated January 30, 1883.

Application filed July 3, 1882. (No model.) Patented in England October 20, 1881, No. 4,592.

To all whom it may concern:

Be it known that I, ADAM MILLAR, of Glasgow, Scotland, have invented certain Improvements in Electric Motors, of which the following is a specification.

This invention relates to an improved construction of electromotor operated by electricity, which may be derived from magneto-electric machines, or from any other source. This electromotor comprises a shaft, working in suitable bearings, carrying on one end a disk, on the face of which are arranged a series of electro-magnets having their poles shaped at the inner ends to resemble teeth of spur-wheels. The magnets are arranged in a circle concentric with the shaft, with the poles pointing inward and resembling a wheel with internal teeth. A second shaft, working in suitable bearings, also carries a disk on one end, considerably smaller than the first disk, this disk also carrying a series of electro-magnets within those on the other disk, and with their poles shaped as in the first series, arranged with their poles pointing outward and in a circle concentric with the shaft, and presenting some resemblance to an ordinary spur-wheel. The bearings of the shaft are fixed to the common bed-plate, so as to bring the one disk in the same plane as the other disk, but with the shafts eccentric to each other or rotating in different axial lines, so that the circle of the tooth-shaped poles of the series of the electro-magnets on the smaller disk cuts into the circle of tooth-shaped poles of the outer electro-magnet on the other disk, somewhat in the manner of a pair of toothed wheels gearing together. The number of magnets on the one axis or disk is greater than on the other axis or disk—as, for example, in the ratio of twelve to ten—and on account of this difference in number, and also owing to the eccentricity of the shafts, the poles of the electro-magnets on each disk are near each other as they come to the position where they fit or cut into each other like the teeth of geared spur-wheels, and approach each other until the point at which the eccentricity of the shaft causes the tooth-like electro-magnets to diverge. The poles of one pair of magnets are thus a considerable distance apart, the next pair nearer together, the third pair still nearer, and the fourth pair are passing each other. A current of electricity sent through the coils of the electro-magnets causes the poles to be attracted together, and as they can approach each other only when the two disks are made to rotate simultaneously in one direction a motion of rotation is established. In case the actual contact of the electro-magnets at the point of divergence should be found to be a disadvantage, the relative positions of the two series of magnets may be governed by gearing the shafts together, so as to insure that they shall not touch each other at this point, or otherwise the sides of the magnets where contact would take place may be covered by a non-magnetic substance, such as copper. An arrangement of commutators in connection with the shafts causes the currents of electricity to magnetize the teeth of the respective disks during the parts of the rotation where the poles of the magnets approach each other in pairs, as described, and the current ceases to pass through the coils and the tooth-shaped poles cease to attract each other at the point where the poles of the electro-magnets pass each other and diverge. As one pair of the electro-magnets becomes inactive another pair in the opposite side becomes magnetized by the current being sent through them by the action of the commutator, and a continuous rotary movement is thus maintained. As the poles of the magnets intersect each other's circular paths, the attractive force which they exert upon each other is in a direction nearly parallel with the tangents of both circular paths. Therefore nearly the whole of the attractive force is expended in producing rotation, and this construction of the two wheels, so that the lines of movement of the poles of the magnets shall intersect to give a tangential attraction, forms the main feature of my invention.

In place of each of the two disks carrying electro-magnets, one disk may carry permanent steel magnets, in which case the current causing the mutual attraction should be reversed at the point in the rotation of the two disks where the tooth-shaped poles begin to diverge from each other, so that while they are mutually attracted up to this point they will become mutually repellent to each other immediately on passing this point, and the repul-

sive action so produced will also produce a rotary motion in the same direction as is produced by the attraction of the poles previous to the current being reversed. In place of the disks referred to, arms radiating from a central axis may be employed, and, when necessary, the series of magnets may be supported at each end. The one series of magnets may be so placed in relation to each other that they intersect each other only in the circular paths of the poles.

The power produced by means of this motor may be employed for driving machines in the same manner as in the case of other prime movers.

Referring to the drawings, Figures 1 and 2 are sectional end and side elevations, respectively, showing one form or arrangement of an electromotor constructed in accordance with my invention.

A disk or plate, A, of bronze, is fixed to the shaft B, which works in suitable bearings, B′. A series of twelve electro-magnets, E E E, of horseshoe form, are secured to the inside of the rim A′ of the disk A, the poles *e* pointing inward toward the center. The electro-magnets are placed so that their poles are at the same distance from the center of the disk and at a uniform distance from each other. A second disk or hollow drum, F, on a second shaft, G, works in suitable bearings, G′. The diameter of the disk or drum F is considerably less than the circle formed by the poles *e* of the electro-magnets E E. A series of ten electro-magnets of horseshoe form, J J J, are carried by the disk or drum F, the bends or neutral parts J′ being placed toward the center, and the poles *j* projecting outward beyond the periphery of the disk. The bearings G′ are so placed that the disks A and F are parallel to each other, but not concentric to each other, the shaft G being eccentric to the shaft B, and to such a degree that the circular paths of the poles *e e* and *j j* of the two series of magnets E E E and J J J intersect each other, somewhat similar to the action of toothed wheels working together. Suitable commutators, M, are carried by each disk, so as to cause the electric currents to circulate in the coils of the electro-magnets E E and J J as they arrive in succession at the positions shown by e' and j', and continue till they reach the positions e^3 and j^3. The mutual attractions between the electro-magnets E and J produce a motion of rotation of both disks with their respective shafts B G, and both in the same direction, as indicated by the arrows in Fig. 1. The currents should cease in the magnets E and J before actual contact takes place, and beyond the position of contact they may slide or roll upon each other at their polar extremities similar to the action of the teeth of the wheels. The commutators are merely indicated in the drawings. In order that the motion obtained may be regular and free from any jerking, the shafts G and B are geared together by a toothed wheel, K, on the shaft G in front of the electro-magnets J J, and an internal-toothed wheel, K′, carried on the disk A. A pulley may be fixed to either shaft for the purpose of giving motion by a belt to any machine; or any other convenient mode of transmitting power may be adopted.

In cases where the large diameter of the exterior series of magnets E E is found objectionable, the form of electro-magnets shown in sectional end and side view in Figs. 3 and 4 may be adopted, the limbs E of the magnets being at right angles to the poles *e*, and with the bend or neutral portion E′ projecting outward from the limbs on the side opposite to the poles. *e e* are the poles; E E, the limbs with their coils of wire, and E′ the neutral portion or bend of the horseshoe. The electro-magnets are attached to their disks by means of projecting studs A^2.

Figs. 5 and 6 are a vertical end and side section of a still more compact arrangement of electromotor. A is a hollow casting of iron, the outer surface being cylindrical and the inner surface having a series of ribs, B B, projecting inward toward the axis. The ribs are parallel to the axis of the cylinder, and extend from end to end. These ribs B form the poles of the electro-magnets A, forming the body of the magnet between the ribs or poles B B. Insulated copper wire *a a* is wound round the body parts of the cylinder A between the ribs B B in a direction parallel to the axis. The wires *a* are coiled so as to produce a north pole in the one rib B, and a south pole in the next rib, and so making the ribs alternate north and south poles.

The above-described cylinder A is for the exterior series of magnets. The cylinder J for the interior series has the ribs *j* projecting outward. The interior cylinder, J, is carried by a hollow shaft, G, fixed to the bosses F, (one at each end,) which have five radial arms, F′, secured to the ribs *j*. The exterior cylinder, A, is carried by hollow trunnions H at each end, from which six arms, H′, extend, and are secured to the alternate ribs B of the cylinder A. The trunnions H work in suitable bearings, *h*, on suitable supports, *h*′. The trunnions H are sufficiently large to permit the shaft G of the interior cylinder to pass through them to their bearings *g* on suitable supports outside the trunnions H, the interior shaft, G, being eccentric to the axis of the outer cylinder, as described in reference to Figs. 1 and 2. The commutators M of the interior series of electro-magnets J are carried by the shaft G, and the wires leading from the commutators M to the electro-magnets are carried through the interior of the hollow shaft G, past the boss F and arms F′, and are joined to the wires of the electro-magnets J. The commutators M′ of the exterior series are carried by a projecting part of the trunnion H. The internal cylinder, J, like the outer cylinder, A, is formed into electro-magnets, with alternate north and

south poles *j j*, by suitably coiling the wires round the body part J between them.

The gearing-wheels K and K′, for steadying the motion, are shown attached to arms F′ and H′, and the action is otherwise similar to that of the motor described in reference to Figs. 1 and 2.

Figs. 7 and 8 are respectively a sectional elevation and plan, showing an arrangement suitable for a locomotive-engine or for a tramway-car, the framing Z of which is shown in Fig. 8. The series of electro-magnets O O are so placed as to act on the two series P P and Q Q—one on each side. The circles described by the series of poles P P and O O intersect each other, and on the other side O O and Q Q also intersect each other. The magnets are of a horseshoe form, and the gearing-wheels are all of one form—viz., spur-wheels. The shafts of the series P and Q carry flanged wheels R for traveling on the rails S. Each shaft or axle carries an arrangement of suitable commutators, M. The intermediate series, O O, is necessary in order that the series P and Q shall rotate in the same direction, as indicated by the arrows in Fig. 7.

The gearing-wheels K K′ K² are necessary to insure that the electro-magnets shall be carried round by the shaft or axle in their proper relative positions.

The commutators should be so arranged that the current ceases from each electro magnet before it arrives at the point of nearest approach to the corresponding electro-magnet of the adjoining series.

In this arrangement or form of motor the repelling force of magnets of similar polarities may be employed in addition to the attractive force already described for producing rotary motion. In adapting this modification the commutators should be so arranged that the electro-magnets should attract each other up to the position of nearest approach, and shall repel each other immediately after they have passed the point or position in their circular paths at which they are nearest to each other and have begun to recede from each other.

Figs. 9, 10, and 11 show an arrangement in which the electro-magnets do not extend across the whole of the space between the pair of wheels R R′ of each axle, but only occupy the space under the seat Z′ of the carriage Z, and so permit of the floor Z² of the carriage to be brought close to the axles to which the wheels are fixed.

The currents of electricity which actuate these locomotive-engines may be obtained from secondary batteries (also known as "storage-cells") carried by or upon the locomotive-engine; or the currents may be supplied from a source of electricity at some distance off, and in connection with conductors extending along the lines of the route in which the locomotive is made to travel.

I am aware of Boulton's British Patent No. 926 of 1879, and do not desire to claim anything therein shown and described; but

I claim as my invention—

1. The combination of a wheel carrying an annular series of magnets with inwardly-projecting poles with a second wheel having a corresponding series of magnets with outwardly-projecting poles within the first series, the two wheels being mounted on axes eccentric to each other, and the circular path of movement of one set of poles intersecting that of the other, substantially as described, whereby the magnetic attraction is in a direction approximately tangential to the said paths of movement.

2. The combination of an annular series of electro-magnets with a second annular series, each series mounted on an axis, and the poles of the magnets of the two series projecting radially toward each other, and the circular path of one series intersecting that of the other, substantially as and for the purpose set forth.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

ADAM MILLAR.

Witnesses:
W. R. M. THOMSON,
JOHN SIME,
Both of 96 *Buchanan Street, Glasgow.*