

(No Model.)

4 Sheets—Sheet 1.

E. E. RIES & G. J. SCOTT.
ELECTRIC MOTOR.

No. 519,272.

Patented May 1, 1894.

Fig. 1.

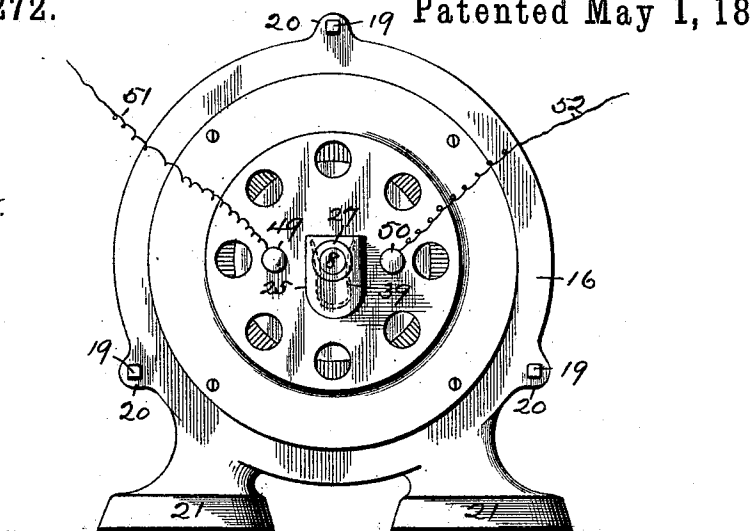


Fig. 2.

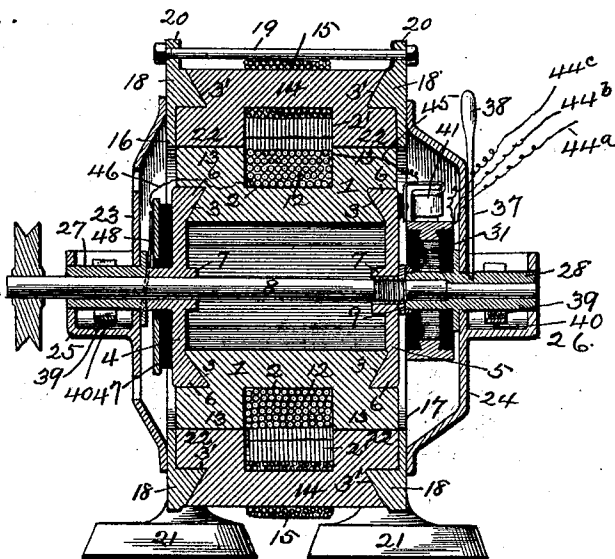
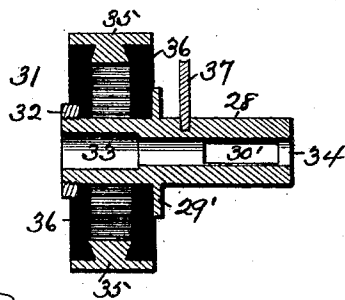


Fig. 10.



Witnesses

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Fig. 3.

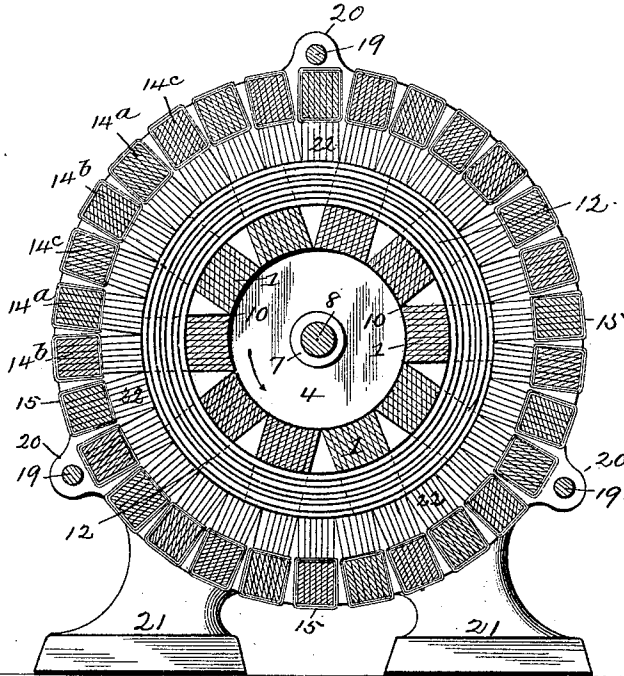


Fig. 4.

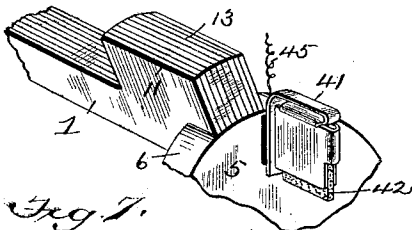


Fig. 5.

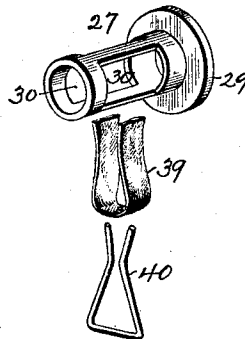


Fig. 7.

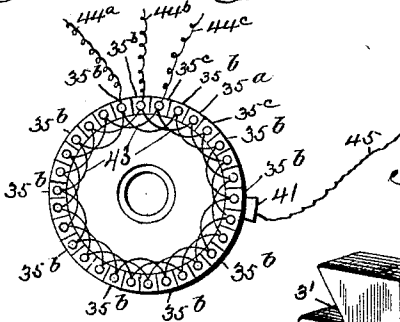
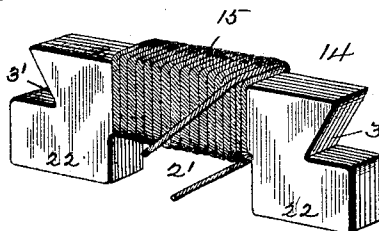


Fig. 6.



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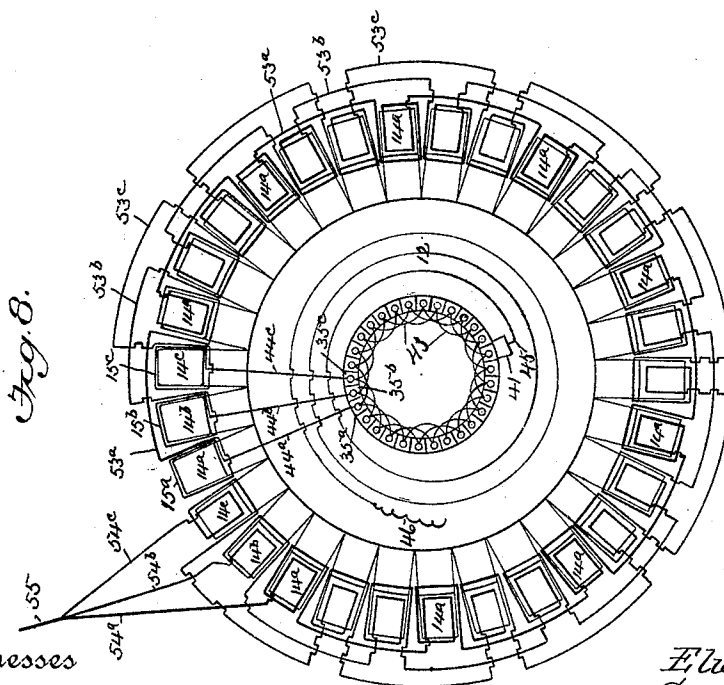
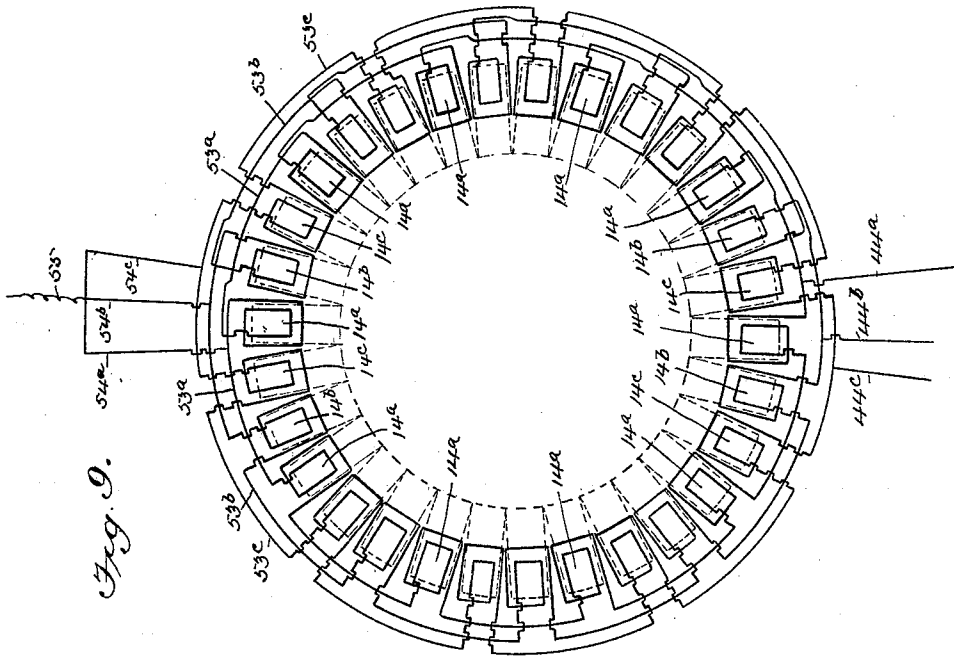
(No Model.)

4 Sheets—Sheet 3.

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ELECTRIC MOTOR.

No. 519,272.

Patented May 1, 1894.



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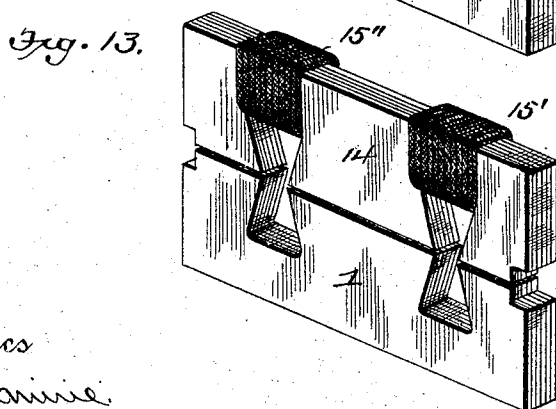
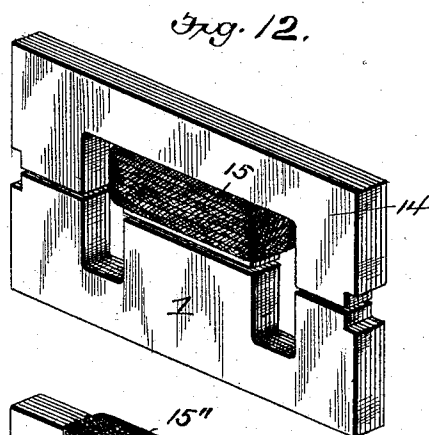
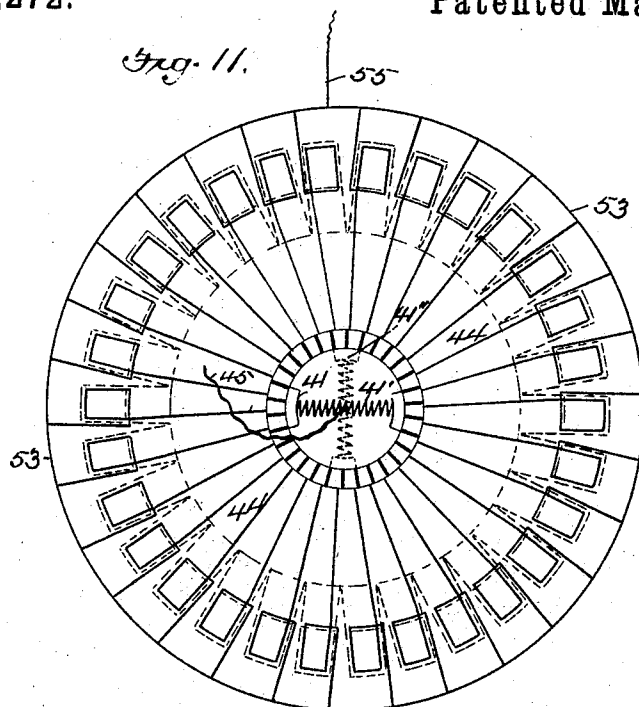
(No Model.)

4 Sheets—Sheet 4.

E. E. RIES & G. J. SCOTT.
ELECTRIC MOTOR.

No. 519,272.

Patented May 1, 1894.



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UNITED STATES PATENT OFFICE.

ELIAS E. RIES AND GORDON J. SCOTT, OF BALTIMORE, MARYLAND.

ELECTRIC MOTOR.

SPECIFICATION forming part of Letters Patent No. 519,272, dated May 1, 1894.

Application filed July 27, 1893. Serial No. 481,623. (No model.)

To all whom it may concern:

Be it known that we, ELIAS E. RIES and GORDON J. SCOTT, citizens of the United States, and residents of Baltimore, in the State of Maryland, have invented certain new and useful Improvements in Electric Motors, of which the following is a specification.

Our invention has reference to improvements in electric motors, designed primarily to be operated by single phase alternating currents such as are derived from ordinary lighting circuits, but which motors are also capable of being operated by two- and multiphase alternating currents, as well as by continuous or straight current. As a single phase alternating current motor, our machine is distinguished from those heretofore known in that it is self-starting under any load, and will run with any speed with great power and efficiency, without heating. The speed can be regulated at will and the motor can be reversed almost instantaneously, whereby it is particularly adapted for the propulsion of vehicles.

Another important feature of our motor, arising from the peculiar and novel principle of its construction, is that it can be efficiently operated on alternating current circuits of comparatively high frequency, thus permitting great economy in the use of the current and in the weight of iron and copper in a motor of a given output.

In alternating current motors heretofore constructed, the most serious difficulty experienced was that by reason of the great counter-electro-motive force generated in the coils of the motor, the amount of current which could be passed through the motor was very small in comparison with the size of the motor, so that these motors had to be made much larger than straight current motors of the same power. This difficulty was so great that it became impracticable to build and run alternating current motors of sufficient power to work heavy machinery and especially for electric locomotion. Self starting, non-synchronous, single-phase alternating current motors could not heretofore be made, with the exception of motors of exceedingly small powers operating with low efficiency; but as soon as these types of motors were attempted upon a larger scale, the excessive self induc-

tion of the same would invariably prevent the passage of sufficient current. Other difficulties present themselves in the operation of such motors, due to the imperfect magnetic circuit and great leakage of the magnetic lines of force, and these difficulties increase with the frequency of alternations of the current and with the size of the motor. With our invention these imperfections are very greatly reduced, if not entirely abolished, and more especially, is the self induction of the motor reduced to a minimum, whereby a large amount of current is allowed to pass through the motor, and the efficiency of translation of the current into motive power largely increased, so that the size of the motor, for any given power, need not be larger, and in many cases may be smaller than that of a continuous current motor having the same power. These results we accomplish by the employment of two or more sets of subdivided field and armature magnets arranged to form substantially closed magnetic circuits of exceedingly short length; by so arranging the field and armature magnets that they have the relation of a divided or two-part transformer or transformers, in the preferred type of which, however, the windings of the two parts are connected in series, the moving portions of these divided magnets being rotated under the action of two or more progressively shifting fields, in such manner as to simultaneously exert the rotating effort at different circumferential points; by so winding and locating the subdivided magnets that their energizing coils are in such inductive relation to each other as to neutralize or counter-act the self-induction of the coils, thereby allowing a practically unrestricted flow of current and permitting the generation of an exceedingly intense magnetic field, by distributing the magnet windings over a large number of independent laminated cores of comparatively small cross-section instead of winding them upon a few massive cores of large cross-section; and lastly by practically eliminating the losses due to hysteresis and eddy currents in the iron by maintaining the iron of the field and armature magnets, or a portion thereof, in a continuous state of stress or magnetic neutrality and thereby transferring the energy that would thus be wasted into useful

work in the coils of the motor. These are the principal features of our improved motor and we have found in practice that the fundamental idea of our invention may be embodied in a variety of ways.

In one type of our motor we employ both attraction and repulsion of the field magnets upon the armature magnets; in another type the attractive force only is employed to produce rotation. In one form of our motor we may subdivide each field magnet system, or in some cases the armature magnet system, into a large number of sections or poles, thereby producing a slow-speed motor, developing a high torque, such as is required for railway and power work, while in another form of our motor, we subdivide the field or the armature system into a lesser number of sections, thus obtaining high speed with correspondingly diminished torque, as is suitable—for example—for operating ventilating fans. In some cases, especially in larger motors running under variable loads, where self regulation is desirable, both the fixed and the rotating elements are provided with suitable windings which are usually connected in series with each other; in other cases either the fixed or the movable element of the motor is alone provided with a winding. In the first case the motor after self-starting, will run up to synchronism with the generator at which point it will tend to remain, and in the latter case the motor will run at any desired speed, either below or above synchronism.

From all this it will be seen that motors constructed in accordance with our invention may be of many different types and we therefore desire it to be understood that we do not limit ourselves to the specific forms and construction herein shown and described.

All this will more fully appear from the following detail description with reference to the accompanying drawings, in which—

Figure 1, represents an end view of one form of our motor with the pulley for transmitting motion removed. Fig. 2, is a vertical axial section of this motor. Fig. 3, represents a central transverse section of the same; Fig. 4, a perspective view of a portion of one armature core and head, with the commutator brush mounted on the latter; Fig. 5, perspective views of details of one shaft bearing and lubricator. Fig. 6, is a perspective view of one field magnet. Fig. 7, is an end view of the commutator. Figs. 8 and 9, are diagrams showing two forms of winding and connection of the field magnets, and Fig. 10, is a longitudinal section of the commutator and its support. Fig. 11, is a diagram illustrating the field magnet connection and commutator of another type of motor embodying our invention, and Figs. 12 and 13, represent perspective views of different forms of field magnets and armature cores or armature magnets. Like numerals of reference indicate like parts all throughout the drawings.

We shall first describe our invention with

reference to the structures illustrated in Figs. 1 to 10, inclusive.

The armature of the motor is composed of a series of laminated iron cores 1, the laminæ of which are magnetically separated, either by special insulations, such as sheets of paper or by the natural or artificial oxides covering the surfaces of the laminæ. These laminæ extend across the motor in a direction parallel with the motor shaft and are made quite thin and of the softest sheet iron, and by preference, of iron that is free of carbon although we have found that sheet steel will in many cases answer the purpose quite as well. The shape of an element of these cores is shown in Fig. 2, where it is represented as a plate which in the main is a rectangle, with a rectangular recess 2, cut in the middle of one side, and a dove-tail notch 3, at each end. A number of such blanks are assembled in the manner shown in Fig. 4, to form a prismatic body, and they are bound together by a thin tape, which in the drawings has been omitted for the sake of clearness of illustration. These individual armature core sections 1 are mounted between two heads 4, 5, each formed with a wedge-shaped circumferential flange 6, which matches the dove-tail notches 3, and with a hub 7, through which the armature shaft 8, passes. The head 4, is keyed to the shaft, while the hub of the head 5, passes loosely upon the shaft, which is screw-threaded at that point, as shown, and a nut 9, clamps this head and the core sections together. The thickness of the core sections is such that when a certain number of them are radially mounted between the heads, their inner edges 10, are in contact, as shown in Figs. 2 and 3, while their outer edges 11, 11, are widely separated. The recesses 2, of the laminæ, form in the aggregate a circumferential channel in the assembled core sections, and in this channel is wound a single coil 12, so that the armature becomes a bar electro-magnet, composed of individual prismatic groups 1 of laminæ, each group in magnetic contact with the adjacent groups along the two inner edges only, while the laminæ of each group are magnetically separated. The assembled edges 11, 11, of the laminæ constitute at the outer side of each end of each core section a polar projection 13, and since all core sections are energized by the same coil 12, the polar projections at the same end of the armature will all be north- or south-magnetic at the same time; these polar projections will henceforth be called the "armature poles."

In the drawings we have shown ten armature core sections, but any other number may be used as will appear further on.

In accordance with our invention this type of motor has three times as many field magnets as there are armature core sections; in the instance here shown there are consequently, thirty field magnets 14, formed and mounted as shown in Figs. 2 and 6. It will be seen that each field magnet core is shaped

exactly like the armature core sections, built up of laminæ formed with central rectangular recesses 2', and dovetail notches 3'. Each of these field magnets has a separate winding 15, and all these field magnets likewise extend across the motor in a direction parallel with that of the motor shaft and are mounted between heads 16, 17; these heads are made of non-magnetic material and are formed with annular wedge-shaped flanges 18, which engage the dovetail notches 3' of the field magnets, and the heads are held together and clamp the field magnets between them, by means of binding rods 19, 19, 19, passing through ears 20, 20, 20, on the heads. The heads are also shown as formed with feet 21, 21, to support the machine, but this feature is only an incident, and is omitted or changed as circumstances may require. Owing to the central position of the recess 2', each field magnet has two polar projections 22, 22, corresponding to the like polar projections 13, of the armature core sections, and the dimensions of the parts are such that the armature pole faces are exceedingly near the field pole-faces, only sufficient clearance being left to insure freedom of motion of the armature. Owing to this close proximity of the armature and field pole faces as well as their relative length, and owing to the fact that each armature core and each field core is a straight and comparatively short magnetic prism, the resistance to the passage of the lines of force or the reluctance for each field core, when the armature and field poles are similarly energized, is increased to a maximum, and when dissimilarly energized, is reduced to a minimum; indeed for all practical purposes it may be said that the magnetic circuit although in two parts, is normally complete or closed, so that there is no, or practically no, leakage of magnetic lines of force, and thus both the opposing and attracting forces are used to their fullest extent.

The field magnets are mounted radially, like the armature core sections, with this difference, that while in the latter the polar extensions are turned outwardly, these are turned inwardly in the case of the field magnets, and in the type of motor now under consideration they are so crowded together that the side edges of the adjacent pole extensions are either actually in contact, as shown, or are very close together. The proportionate thickness of the field core and armature core sections is such that each pole extensions of the latter faces one and one-half pole extensions of the former as shown in Fig. 3.

Owing to the great number of field magnets, and notwithstanding the radial position of the same, the sides of any two consecutive field magnets and the coils of the same are very nearly parallel to each other and are so close together that, when any two magnets or sets of magnets are simultaneously energized by the field current, each will act inductively

upon the other. This is an important feature of our invention as will appear farther on.

To the face of the head 16, is screwed a circular hood 23, and to the face of the head 17, is secured a similar but deeper hood 24, and either secured to or in one piece with these hoods are the cups 25, 26, respectively, in which the shaft bearings 27, 28, are mounted, as shown. One of these bearings 27, together with its appurtenances is shown in perspective in Fig. 5; it is a cylindrical sleeve with a flange 29, at one end, and formed with two diametrically opposite, wide slots 30. This bearing 27, is fixed in any suitable manner in the cup 25, so that its axis is in alignment with the axis of the hubs of the two heads 4, 5. The bearing 28, is represented upon a somewhat enlarged scale, in section, in Fig. 10; it serves at the same time as a means for holding the commutator 31. These parts are constructed as follows: The bearing 28, is a cylinder, formed with a flange 29', which in this case is intermediate between the two ends, and at one end the cylinder is screw-threaded for the reception of a nut 32. This cylinder is bored out, with a wide bore 33, and a reduced bore 34, as shown, and the armature shaft 8, is stepped at one end so as to fit the stepped bores of the bearing 28, and is thereby prevented from shifting laterally toward the right.

Between the flange 29', and the nut 32, the commutator 31, is mounted upon the cylinder 28. This commutator may be constructed in any suitable manner, but is shown in the drawings as composed of a series of metal bars 35, each formed with two dove-tail incisions on the under side, as shown, and these metal bars are assembled and clamped between two insulating heads 36, 36, each formed with a circumferential wedge-shaped flange. The commutator bars 35, are separated by thin sheets of mica or other suitable insulating material, as usual. The bearing cylinder 28, has also two diametrically opposite wide slots 30' similar to the slots 30, in the bearing cylinder 27. The cylinder 28, is journaled in the end walls of the cup 26, as shown, and a rod 37, projecting from the cylinder and provided with a handle 38, permits this cylinder, and with it the commutator, to be turned in either direction to a limited extent. The rod 37, may engage a rack fixed to the face of the hood 24, or may be held in any adjusted position, by any other well known means. Ordinarily, it will be sufficient to make the rod 37, elastic and so mount it on the cylinder 28, as to bear with considerable friction against the face of the hood 24; for this reason no special means for holding the commutator in its adjusted positions are illustrated. In the cups 25, 26, the lubricating oil for the armature shaft is poured, and is kept at a level below the bearings 27, 28; in these cups is placed a suitable looped wick 39, which loosely embraces the bearings, with

its two ends reaching into the slots, 30, 30', where they are held and are gently pressed against the armature shaft, by an elastic wire clip 40. The loop of the wick dips into the lubricator oil and the latter rises in the wick by capillary action. To the head 5, is secured, but insulated therefrom, an elastic brush holder 41, in which the brush 42, is so mounted, that it bears upon the face of the commutator with moderate pressure. There are as many commutator bars as there are field magnets, consequently in the instance here shown there are thirty commutator bars, and they form three groups; the bars belonging to one group are marked 35^a, those belonging to the next group 35^b, and those belonging to the third group are marked 35^c. The commutator bars belonging to the same group are all connected by wires 43, or in any other suitable manner. From each group of these commutator bars extends a wire 44^a, 44^b, 44^c, respectively, for connection with the field magnet coils, and from the brush holder 41, extends a wire 45, for connection with one terminal of the armature coil, the other end of which is connected by a wire 46, to a collector disk 47, mounted upon but insulated from the face of head 4, as shown in Fig. 2. Upon this collector disk 47, bears a spring brush 48, which is secured to an insulated binding post 49, mounted upon the hood 23; upon this hood is also another insulated binding post 50, to which the wires coming from the field magnets are connected, as will appear further on, and from the binding posts 49, 50, the leading conductors 51, 52, extend.

The diagram, Fig. 8, illustrates one mode of connecting the field coils, and at the same time the whole internal circuit of the motor.

The thirty field magnets are formed into three groups, corresponding to the three groups of commutator bars, and the magnet cores and coils are marked according to the groups to which they belong with the reference numerals 14^a, 14^b, 14^c, and 15^a, 15^b, 15^c, respectively. The coils 15^a, are all connected in series, by the wires 53^a, the coils 15^b, are connected in series by the wires 53^b, and the coils 15^c, are connected in series by the wires 53^c. The series of field coils 15^a has one end connected to a commutator bar 35^a, by means of the wire 44^a; the series of field coils 15^b has one end connected with a commutator bar 35^b, by means of the wire 44^b, and the series of field coils 15^c has one end connected to a commutator bar 35^c, by means of the wire 44^c. The other ends of these three series of coils are formed by the wires 54^a, 54^b, 54^c, which are united upon one conductor 55, which in turn is connected to the binding post 50. The commutator brush 42, is of a width equal to the width of one commutator bar plus the thickness of two insulating partitions between these bars; the result of this construction is that, as the brush rotates, it will bear, during by far the greater portion of the time, upon two commutator bars, only during

exceedingly short intervals upon a single bar, and never upon three bars. The intervals during which the brush bears upon a single commutator bar only, are so very short that they may be disregarded, and for all practical effects the construction may be said to be such that the brush always bridges two commutator bars.

The circuit through the motor can now be readily traced by reference to Figs. 2 and 8. The currents entering by leading conductor 51, and binding post 49, proceed by spring 48, collector disk 47, and wire 46, to and through the armature coil 12; leaving this coil by conductor 45, Fig. 2 they proceed by brush holder 41, and brush 42, to the commutator 31. Since the brush bears upon two adjacent commutator bars, the current divides at the commutator and passes in two parallel branches through two of the three series groups of field magnet coils, leaving the same by two of the three wires 54^a, 54^b, 54^c, and by conductor 55, binding post 50, out by leading conductor 52.

Since the operation of the motor is the same, whether the current flows in one direction or the other, the alternations of current may be disregarded in contemplating, at this stage, the polarities developed and their reactions; it is, therefore, admissible to consider the current as a straight or continuous current. Under this assumption it will be seen that the armature poles at one end will all be north-magnetic, and those at the other end south-magnetic, while the corresponding poles of the two series of field magnet cores through the coils of which current is flowing at a given moment, will likewise be north and south-magnetic, respectively. From the construction of the machine it follows that there are always, or practically always, pairs of field magnets directly energized by the current through their coils, separated by single field magnets which are not directly energized by the current. Supposing now, that the current be turned on when the armature and field poles are in the relation shown in Fig. 3, and that the commutator at that moment be so adjusted that the brush is in contact with two bars of the series 35^a and 35^b. In that case the field magnets 14^a and 14^b, will receive current, while the magnets 14^c will be apparently idle. The resultant magnetic meridian (or polar line) of any of the pairs of field magnets 14^a, 14^b, passes through the contacting edges of the same, while the polar lines of the armature sections bisect the width of these sections. At the phase of operation here considered, each armature pole covers a field pole 14^b entirely and in addition thereto one half of a field pole 14^a, so that the polar lines of the energized pairs of field magnets and of the corresponding sections of the armature do not coincide, but are separated by a small arc (an arc of three degrees) from each other. The consequence of this is that the armature sections are repelled by the field magnets 14^a 14^b, and at-

tracted by field magnets 14^c , and the armature rotates in the direction of the arrow indicated, until the poles of the armature fully cover the poles 14^c of the field magnet, at which time the field magnets 14^c are magnetized by induction from the armature poles receiving opposite polarities than the latter, and consequently opposite polarities to the field magnets 14^a 14^b whereby the armature poles are attracted by the field magnets 14^c , so as to produce motion in the same direction in which they are repelled by the field magnets 14^a 14^b . The armature is thus acted upon by all field magnets at the same time, so that there are in reality no idle field magnets. At the moment when this occurs the armature brush leaves the commutator bar 35^a , still remaining on bar 35^b and passes on to the bar 35^c , whereby current is now admitted to the coils of field magnets 14^b and 14^c and the poles of the field magnets are shifted accordingly. Field magnets 14^b and 14^c , now act upon the armature by repulsion, while field magnets 14^a , now act by attraction. When the brush passes on to the next commutator bar, the field magnets 14^c and 14^a act by repulsion and field magnets 14^b act by attraction, and so forth.

It will be seen at once that the direction of rotation of the armature depends upon the position of the commutator bars with reference to the field magnets. If, when the machine is in the condition shown in Fig. 3, the commutator were so shifted that current is first admitted to the coils of field magnets 14^b and 14^c , the armature would rotate in the opposite direction, so that by a very small shift of the commutator the motor can be reversed. It will also be clear, without further explanation, that at intermediate positions of the commutator the motor will run with reduced speed, but with greater power.

There is one critical position of the commutator with reference to the field magnets and the armature sections, when the motor cannot start. This position is that which sends current to such pairs of field magnets with the resultant polar lines of which the polar lines of the armature sections coincide, when the armature is at rest; it is then only necessary to shift the commutator to the right or to the left, no matter how little, in order to start the motor in one or the other direction. This is a peculiarity of our motor which permits the stopping and reversing of the same without breaking the circuit, for when, while the motor is running, may be at its highest speed, the commutator is turned to the critical position, the armature rapidly slows down and comes to rest; and if the commutator is turned beyond the critical position, the armature will at once turn in the opposite direction.

It requires no further explanation to see that alternating currents will act upon this motor precisely the same as straight currents, since the armature coil is in series with the

field magnet coils, so that the relations of the polarities remain unchanged. In fact this motor, while well adapted to be worked with straight currents, is particularly and especially useful with alternating currents owing to the novel and peculiar reaction between the armature and field magnet system which its construction provides and which we have found by actual test are of such a nature that it heats only very moderately even after long continued use under heavy loads.

A very important feature of our invention is the small angle at which the adjacent field magnets, and consequently field magnet coils are inclined toward each other. This is owing to the fact that we use a comparatively great number of field magnets of rather small cross-section, crowded together as closely as practicable so that the adjacent sides of the field coils are very nearly parallel. It is within our invention to make these coils perfectly parallel, in which case, of course, the magnet cores instead of being rectangular in cross section, will be segmental. By reference to Fig. 8, it will be seen that the currents passing through the coils of the field magnets are in opposite directions in the adjacent sides of any two adjacent magnets, and we have found that from this results a partial or complete neutralization of self induction of each magnet coil. The practical result of this is that the counter electromotive forces which otherwise would be generated in these coils when alternating currents are passed through the same, are very greatly reduced, so that a far greater amount of current can now be passed through these coils. This neutralization of self induction, therefore, is due to the close inductive proximity of the adjacent magnet coils, to the parallelism, or nearly parallelism of these coils, and to the fact that the currents pass through the adjacent sides of the adjacent magnets in opposite directions. The counter-electromotive forces will, therefore, be reduced so much more as these conditions are more closely fulfilled.

It will further be seen that since the armature, during a great portion of its rotation is acted upon by repulsion from the field magnets both the field and the armature magnets are, when in repelling relation, partly neutralized by each other, that is to say, they present poles of the same name to each other and are at these times approaching the condition of magnetic neutrality, and therefore very little counter-electromotive force is generated in their coils which consequently will permit an unimpeded flow of effective current through the same.

We have found by practical experience that an alternating current motor built in this manner will permit the passing of a much greater amount of current than has heretofore been possible, and as a result of this a motor of a given size constructed in accordance with our invention develops much greater power than

other alternating motors of the same size. As a result of this construction, as well as the fact that the magnetism between the opposing field and armature poles is under a continual state of opposing or neutral stress, the frequency of the alternating current can be very much increased and may be almost disregarded.

Another mode of connecting the field coils is indicated in Fig. 9. The coils of magnets 14^a are connected in one closed circuit by the wires 53^a, and the coils of magnets 14^b and 14^c are similarly connected in independent closed circuits, by the wires 53^b and 53^c, respectively. At diametrically opposite sides these three closed circuits are tapped by the wires 44^a, 44^b, 44^c and 54^a, 54^b, 54^c, respectively, the former leading to the groups of commutator bars 35^a, 35^b and 35^c, respectively, while the latter are joined upon the conductor 55, which connects with the binding post 50. With this construction each group of field magnet coils is split into two parallel series, whereby the internal resistance of the motor is considerably reduced, and it will be evident to those skilled in the art, that the division of the field coils into multiple series may be carried still further.

It will be evident to those skilled in the art that it is not absolutely necessary that the armature cores be provided with a winding, or that a single winding common to all the armature core sections, be used; for it is quite practicable, and for certain purposes, even desirable, that the armature cores are left bare without winding, in which case the motor will work purely by magnetic attraction and it is equally practicable to provide each armature core section with a separate coil, in which case these coils may be connected either in series or in multiple arc, but preferably in series with the field coils.

We have found by actual work that when the armature cores in the arrangement and with the connection of magnets shown in Fig. 8, are provided with a coil or coils the armature, when started, will run up to synchronism with the generator, with a slight tendency to maintain synchronism, while when there are no coils on the armature, there is no tendency toward synchronism, and the motor works equally well with any speed.

In Fig. 11, we have illustrated another mode of connecting the field coils and consequently another mode of carrying current to and from the same. In this case the conductor 55, which leads to the binding post 50, is directly connected to a single circular distributing wire 53, from which multiple arc branches pass to all the magnet coils, as shown, the other ends of these coils being connected by wires 44, each to one commutator bar. There are in this case two or more commutator brushes 42, as will presently be seen. If only two commutator brushes are used, as shown in solid lines, they are disposed for contact at diametrically opposite sides of the commutator.

These brushes are connected by a conductor 41', from which the wire 45, leads either to one terminal of the armature coil or coils, if such are used, as in the constructions heretofore described, or directly to the collector disk 47, when no armature coils are used. In the drawings the brushes 42, are shown of such width that they extend over three commutator bars and over the insulations separating the terminal bars from those beyond them. With this construction, it is evident that most of the time there will be current through two sets of four field magnets, and only during exceedingly short moments through two sets of three field magnet coils. Now it is within our invention to give to these brushes any desired width; thus each brush may be expanded so as to cover one-half the number of commutator bars minus one, or each brush may be made so narrow as to cover only one bar.

In the drawings we have shown in dotted lines an additional set of brushes 41'', each spanning only two commutator bars, and these brushes may be used either alone or together with the brushes 42, and any additional number of pairs of commutator brushes may be used. It will be seen that in this manner we are enabled to adapt the motor either for low speed and great power or for high speed and small power by simply changing either the width or the number of pairs of commutator brushes, or both.

In Figs. 12 and 13, we have illustrated modified forms of field and armature cores, in which the magnetic resistance is reduced to a minimum, and which provides a double magnetic circuit. In Fig. 12, the cores are E-shaped with a coil on the middle bar of the E of each field magnet, while the armature core is represented bare, that is to say, without a coil, although, as has heretofore been explained, it may also have a coil upon its middle bar. In this case at any given moment one pole of the magnet is at the middle bar while the other is found in the two end-bars, so that there is a double magnetic circuit, resembling two multiple arc branches of an electric circuit, and each branch, being very short, has an exceedingly low reluctance. The middle bar is of such length that a large proportion of the coils are in inductive parallelism. In Fig. 13, the cores are also E-shaped, but in this case the middle bar as well as the end bars are dovetails, whereby the reluctance is still further reduced. In this construction there are two coils 15', 15'' on the main stem of the E, one in each space between the middle and end-bars. These two coils must be wound in opposite directions in order to produce the same polarities as are produced in the construction shown in Fig. 12, as will be readily understood by those skilled in the art.

The field and armature sections may be assembled either in the manner shown in Fig. 2, or in any other convenient manner.

From what has been said it will be appar-

ent that numerous other modifications may be made without departing from the fundamental ideas upon which our invention is based, and we are therefore not confined to the identical forms of motors hereinbefore described.

Having now fully described our invention, we claim and desire to secure by Letters Patent—

1. An alternating current motor composed of several groups of sectional, laminated and interlaced circularly arranged field-magnets, a concentric sectional laminated armature and circuit connections and a commutator for shifting the polar lines of the field of force, substantially as described.

2. An alternating current motor having a number of interlaced groups of circularly arranged field magnets, with the energizing coils of each group in inductive relation to the coils of the adjacent group or groups, as described, so as to reduce the counter electro-motive force of self induction in each; a concentric, sectional, laminated armature, and circuit connections and a commutator for shifting the polar lines of the field of force, substantially as described.

3. An alternating current motor having a number of interlaced groups of circularly arranged field magnets with the adjacent sides of the coils of adjacent groups substantially parallel and in inductive proximity, circuit connections for passing the energizing currents simultaneously through the adjacent sides of adjacent groups of magnet coils in opposite directions, an armature composed of sections arranged concentric with the field magnets and a commutator for shifting the polar lines of the field in continuous succession, substantially as described.

4. An electric motor composed of interlaced groups of parallel field electro magnets, circularly arranged and in inductive proximity to each other, an armature composed of a circular series of magnetic sections and a commutator and brush for passing current through some of the adjacent groups of field magnet coils in progressive succession, and circuit connections substantially as described whereby the energized field magnets act upon the armature by repulsion and the non-energized field magnets by attraction, substantially as described.

5. An electric motor composed of three interlaced groups of parallel field electro-magnets, circularly arranged and in inductive proximity to each other, an armature having a circular series of as many parallel sections as there are field magnets in each group and a commutator and brush for passing current through two adjacent groups of field magnet coils in progressive succession whereby two groups of field magnets act upon the armature by repulsion and one group by attraction, substantially as described.

6. In an alternating current electric motor the combination of a field magnet system com-

posed of groups of circularly arranged electro magnets each group being connected to a separate group of connected commutator bars; with an armature likewise composed of a number of circularly arranged electro magnets, and connections for including the armature winding in circuit with groups of field windings in regular succession, substantially as described.

7. In an alternating current motor, the combination of a field magnet system composed of groups of circularly arranged electro-magnets, each group being connected in series and to a separate group of connected commutator bars; with an armature likewise composed of a number of circularly arranged electro-magnets, and connections for including the armature winding in circuit with groups of field windings in regular succession, substantially as described.

8. In an alternating current motor the combination of a field magnet system composed of three groups of circularly arranged electro magnets, each group being connected to a separate group of connected commutator bars; with an armature likewise composed of a number of circularly arranged electro-magnets, and connections for including the armature winding in circuit with two adjacent groups of field windings in regular succession, substantially as described.

9. In an alternating current electric motor, the combination of a field magnet system composed of groups of circularly arranged electro magnets, each group being connected to a separate group of connected commutator bars; with an armature likewise composed of a number of circularly arranged electro magnets having a single winding common to all, and connections for including the armature winding in circuit with successive groups of field windings in regular succession, substantially as described.

10. In an alternating current electric motor, the combination of a field magnet system composed of separate groups of circularly arranged electro magnets, the magnets of each group being connected in series and to a separate group of connected commutator bars; with an armature likewise composed of a number of circularly arranged electro-magnets having a single winding common to all, and connections for including the armature winding in circuit with successive groups of field windings in regular succession, substantially as described.

11. In an alternating current electric motor, the combination of a field magnet system composed of three groups of circularly arranged electro magnets, the magnets of each group being connected in series and to a separate group of connected commutator bars; with an armature likewise composed of a number of circularly arranged electro magnets having a single winding common to all, and connections for including the armature

winding in circuit with two adjacent groups of field windings in continuous succession, substantially as described.

12. In an alternating current electric motor, the combination of a field magnet system composed of interlaced groups of circularly arranged electro magnets, the energizing coils of which are all wound in the same direction and each core and coil in inductive relation and proximity to the next adjacent cores and coils of the adjacent groups; with an armature likewise composed of a circular group of electro magnets having a coil or coils wound in the same direction as the field coils, and a commutator and circuit connections for passing currents through the armature and through successive adjacent groups of field magnets in continuous succession, substantially as described.

13. In an alternating current electric motor, the combination of a field magnet system composed of three interlaced groups of electro magnets, circularly arranged, and a concentric group of armature sections, each field magnet core being in inductive relation and proximity to the cores of the adjacent magnets of the adjacent groups; with a commu-

tator and circuit connections for passing currents in the same direction through the armature and through two adjacent groups of field magnets in continuous succession; whereby the armature is rotated by simultaneous repulsion from the active and attraction by the passive field magnets, substantially as described.

14. An alternating current motor having groups of sectional field bar electro magnets, circularly arranged, whose poles, when directly energized, are of like denomination at each end and of opposite denomination in the middle, and an armature composed of circularly arranged bar sections in close proximity to the poles of the field bars, whereby the magnetic lines of force of each magnet form two short parallel circuits of normally low reluctance, substantially as described.

In testimony whereof we have signed our names to this specification in the presence of two subscribing witnesses.

ELIAS E. RIES.
GORDON J. SCOTT.

Witnesses:

STEPHEN S. CLARK,
LEOPOLD RIES.