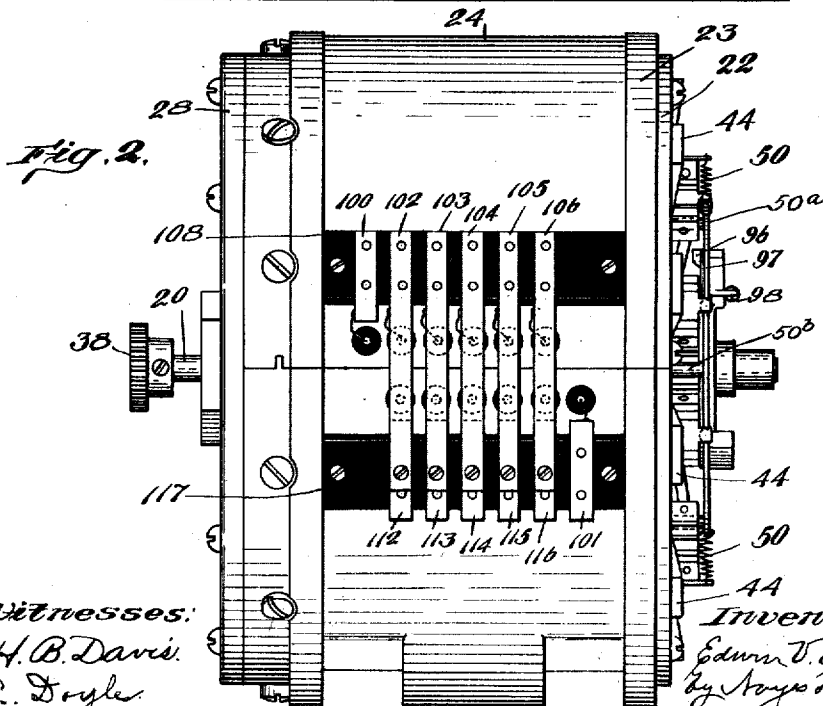
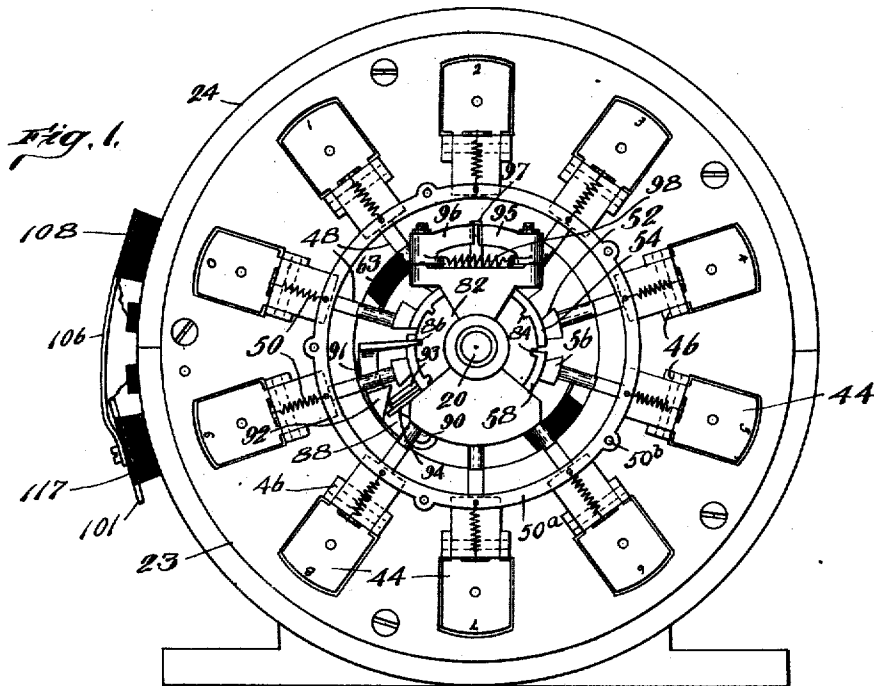


1,301,050.

3 SHEETS—SHEET 1.



Witnesses:
H. B. Davis.
C. Doyle.

Inventor:
Edwin V. Hagman
By *James J. Harriman*
attys

1,301,050.

Patented Apr. 15, 1919.

3 SHEETS—SHEET 2.

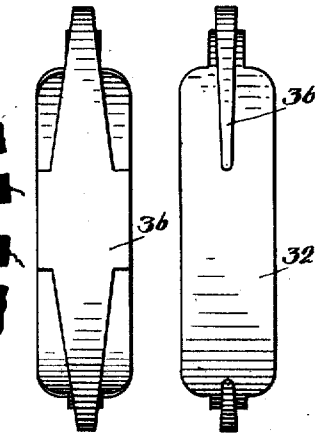
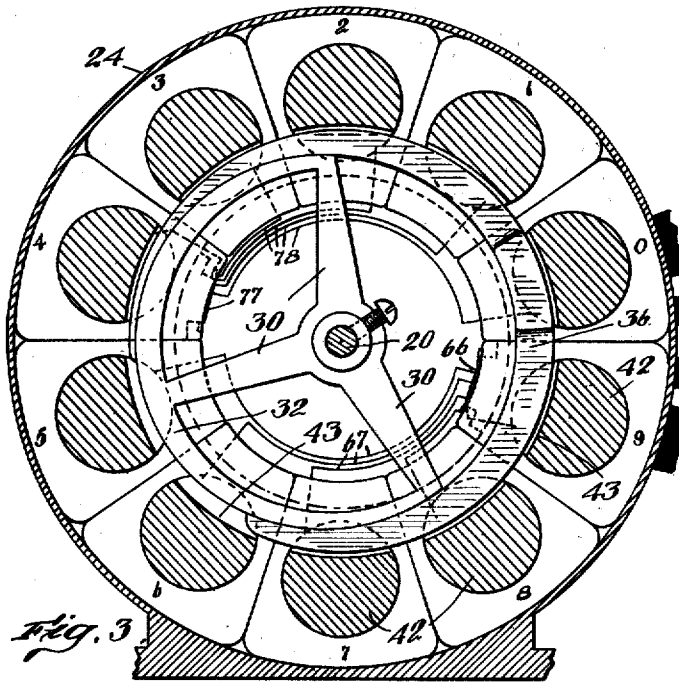
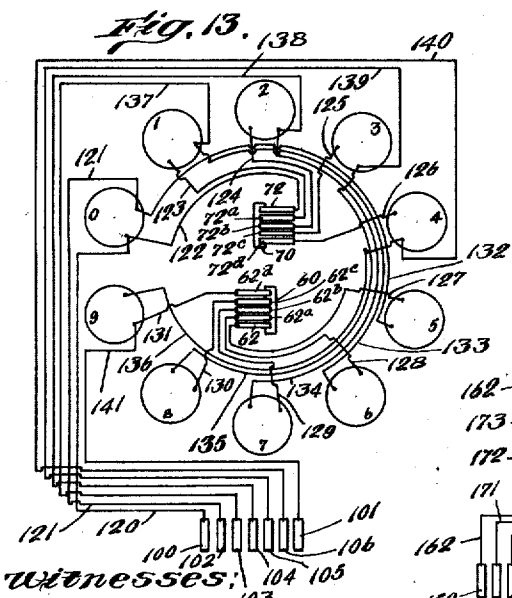
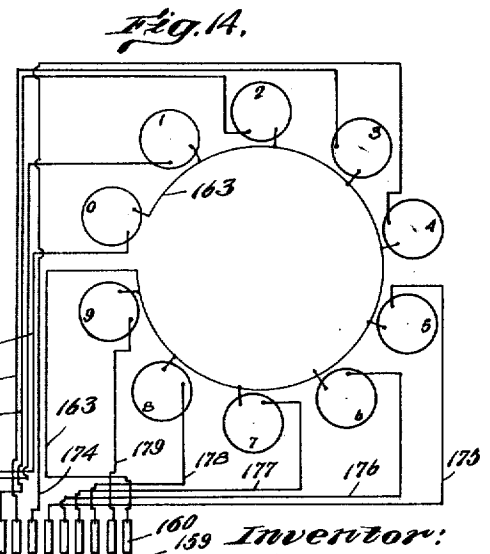


Fig. 4. Fig. 5.



Witnesses:
H. B. Davis.
C. Doyle.

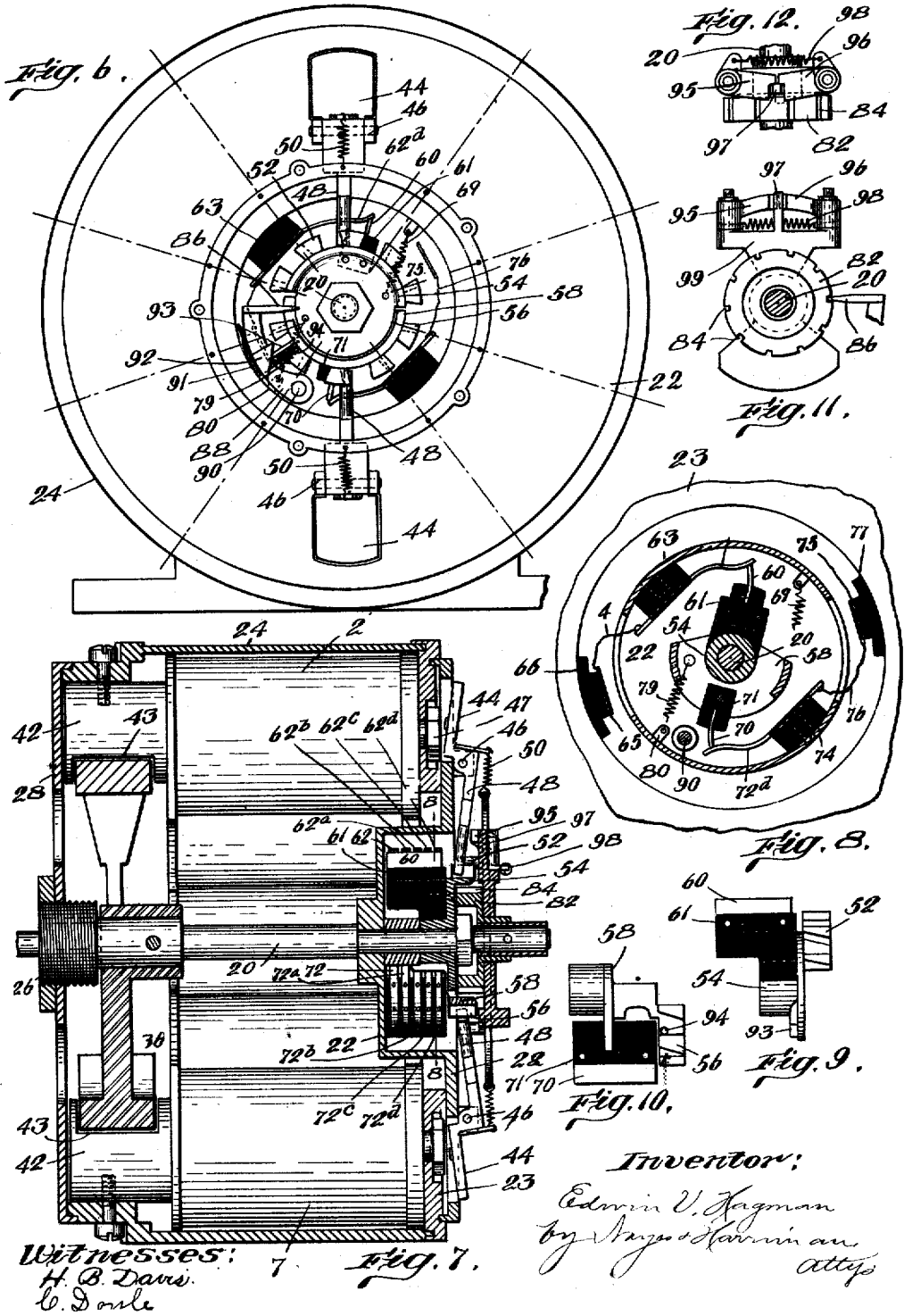


Inventor:
Edwin V. Hagman
By *Raymond H. Harrison*
attys.

E. V. HAGMAN.
ELECTRIC MOTOR.
APPLICATION FILED MAY 13, 1.

1,301,050.

Patented Apr. 15, 1919.
3 SHEETS—SHEET 3.



UNITED STATES PATENT OFFICE.

EDWIN V. HAGMAN, OF BOSTON, MASSACHUSETTS, ASSIGNOR TO ALFRED A. ZIEGLER, TRUSTEE, OF BOSTON, MASSACHUSETTS.

ELECTRIC MOTOR.

1,301,050.

Specification of Letters Patent.

Patented Apr. 15, 1919.

Application filed May 13, 1914. Serial No. 838,253.

To all whom it may concern:

Be it known that I, EDWIN V. HAGMAN, a citizen of the United States, residing at Boston, in the county of Suffolk and State of Massachusetts, have invented an Improvement in Electric Motors, of which the following is a specification.

This invention relates to an electric-motor for imparting a rotary motion to a shaft in either direction through different predetermined arcs.

One of the objects of the invention is to provide a motor which will turn a shaft quickly a half-revolution or fraction thereof, and in such manner as to bring it to any desired predetermined position in a complete circle by the least amount of rotary movement, either forward or backward, as the case may be; and another object is to provide the motor with a series of electro-magnets which are adapted to be separately energized in any indiscriminate manner for the purpose of moving the armature with the least angular movement to the position corresponding to the magnet energized. And another object is to arrange a balanced armature on the shaft which will cause the shaft to remain in whatever position it may be set; and another object is to provide for arresting the shaft and locking it in whatever position it may be caused to occupy upon cessation of its rotary movement.

The invention consists essentially in an electric-motor comprising a shaft rotatable in either direction, a plurality of electro-magnets arranged in a circle concentric to said shaft and equidistantly disposed, each magnet having a pole-piece preferably formed with a curved face likewise arranged concentric with the shaft, and a crescent-shaped armature carried by said shaft and arranged to enter the fields of all said magnets so as to be influenced by any of them. A crescent-shaped counter-balancing piece of non-magnetic material is or may be arranged between the two horns of the crescent-shaped armature and attached thereto, or otherwise supported on the shaft in a corresponding relative position with respect to the armature, so that the armature will have a normal tendency to remain in whatever position it may be moved. The magnets are separately energized to move the armature

to bring its portion of greatest thickness into the field of the energized magnet, thereby to turn and predetermine the position of the shaft. Arresting-means is provided for arresting the armature-carrying shaft when it arrives at the different predetermined positions with respect to the magnets; and locking-means is provided for the armature-carrying shaft for holding it in predetermined position with respect to the magnets.

Figure 1 is a right hand end-elevation of a motor embodying the invention.

Fig. 2 is a side elevation of the same.

Fig. 3 is a left hand vertical sectional elevation.

Figs. 4 and 5, respectively, are left and right side-elevations of the armature and counterbalancing-piece.

Fig. 6 is a right-hand end-elevation, with some of the parts removed.

Fig. 7 is a central longitudinal vertical section through the motor.

Fig. 8 is a transverse vertical section taken on the line 8—8, Fig. 7.

Figs. 9 and 10 are side-elevations of parts of the locking-mechanism and circuit-controlling means for the two sets of magnets.

Fig. 11 is an end-elevation of the locking-mechanism and arresting-mechanism.

Fig. 12 is a plan view of the locking-mechanism and arresting-mechanism.

Fig. 13 is a diagrammatic view of one form of circuit-connections.

Fig. 14 is a diagrammatic view of a modified form of circuit-connections.

In the present embodiment of the invention 20 represents the motor-shaft, which is rotatably mounted at one end in a plate 22, and at the other end in a box 26, and is free to rotate in either direction. The plate 22 is circular and is formed with a recess in its outer face and is set into or arranged to engage an annular plate 23, and said plates 22, 23, together form the right hand end-wall of a cylindrical casing 24. The box 26 is centrally disposed in the other end-wall 28 of said casing 24. The casing 24, is, for convenience, composed of two semi-cylindrical portions. Secured to the shaft 20 is the armature-support, here shown as a spider, preferably of brass or other non-magnetic material, having three arms 30 and a crescent-shaped web 32, formed integral with

the extremities thereof, which web includes an arc of slightly more than 180 degrees. A crescent-shaped armature 36 is arranged opposite the web and its end-portions or horns extend over the end-portions of the web and are secured thereto. The ends or horns of said armature are brought quite near together, so that the armature nearly completes a circle. Said armature is positioned on the spider so that the middle or thickest portion of the web 32, comes opposite the gap between the horns of the armature 36. Thus the spider operates as a support and its web 32 as a counterbalance for the armature, enabling it to remain at rest in any position it may occupy. A gear 38 is secured to the shaft 20, and is adapted to serve as a driving-gear for other mechanism not here shown. A plurality of electro-magnets are arranged circumferentially about the shaft 20, and are equidistantly disposed, and supported at one end by the end-plate 23, and at the other end by the case 24, and both ends have sector-shaped heads, ten such magnets being here shown, which are designated by numerals 0, 1, 2, 3, 4, 5, 6, 7, 8, 9. The projecting end-portions 42 of the cores of said magnets are undercut at 43, on a curve corresponding to the outer circular face of the armature 36, to permit the armature to rotate freely in juxtaposition thereto, said end-portions serving as the pole-piece of the magnets.

The crescent-shaped armature 36 is here shown as made quite long so as to enter the fields of all said magnets, and to be influenced by anyone of them that may be energized, and will be moved upon energization of any of said magnets to bring its middle or thickest portion into the field of the energized magnet, thus to rotate the shaft 20, and by reason of the counter-balance 32, the armature, when so moved, will have a tendency to remain in such position when the energized magnet is deenergized.

At the other end of each of said magnets is an auxiliary-armature 44, which is pivoted at 46, and movable toward and from the corresponding end of the core of the magnet, but normally held retracted by a spring 50, connected to a flat ring 50^a arranged in front of and attached by studs 50^b to the plate 22, said end of the core being enlarged to enlarge the field by arranging an iron nut 47 thereon, which latter also serves to hold the parts of the magnet assembled and in engagement with its supporting-plate. Each auxiliary-armature 44 has a tail-piece 48, which extends inward radially toward the shaft 20.

The electric-magnets are here shown as divided into two sets of five each, and the tail-pieces 48 of the auxiliary armatures of one set cooperate with beveled-teeth 52, on a carrier 54, see Fig. 9, which for convenience

has a sleeve bearing on the shaft 20, in a recessed portion of the plate 22, and the tail-pieces 48 of the auxiliary armatures of the other set cooperate with similar beveled-teeth 56 on a carrier 58, see Fig. 10, also for convenience loosely mounted on said shaft 20, in the recessed portion of said plate 22. The teeth 52 and 56 are formed respectively as sectors, each extending a semi-circumference, and said sectors are arranged on their carriers and relative to each other, so that the two sets of teeth together form a circular series, see Fig. 6. The movement of any auxiliary armature 44 into attracted position causes its tail-piece 48 to engage the beveled side of one of the teeth 52 or 56, and thus to impart a slight rotary motion to the carrier 54 or 58, the carrier subsequently returning to normal position upon retraction of the auxiliary armature and a corresponding movement of its tail-piece. The carrier 54 is thus adapted for oscillation on the shaft 20, said shaft serving as a pivot for it.

The carrier 54 has a contact-strip 60 arranged radially on a block 61 of insulating material, which is of sufficient length to engage five contact-fingers 62, 62^a, 62^b, 62^c, 62^d, which are arranged in parallel relation and mounted on a block 63 of insulating material attached to the plate 22, and each of said fingers is connected by a conductor 64, see Fig. 8, to a stationary conducting-strip 65 attached to a block 66 of insulating material, arranged on the end-wall 23, and each of said strips 65 is connected by a conductor 67, with one of the magnet-coils 5, 6, 7, 8, 9, see Fig. 3. Thus it will be observed that the contact-carrier 54, controls the circuits to all of the electro-magnets in the lower half of the series. A spring 69 is connected at one end to the carrier 54, its other end being connected to an ear on the plate 22, and tends normally to hold the contact-strip 60 in engagement with the fingers and to return said strip to such engaging-position upon retraction of the auxiliary-armatures. The carrier 58 has a contact-strip 70, arranged radially on a block 71 of insulating material, which is of sufficient length to engage five contact-fingers 72, 72^a, 72^b, 72^c, 72^d, which are arranged in parallel relation and mounted on a block 74 of insulating material, attached to the plate 22, and each of said fingers is connected by a conductor 76, to a stationary conducting-strip 75, attached to a block 77 of insulating material, arranged on the end-wall 23, and each of said strips 75 is connected by a conductor 78, with one of the magnet-coils 0, 1, 2, 3, 4. Thus it will be observed that the contact-carrier 58 controls the circuits of all of the electro-magnets in the upper half of the series. A spring 79 is connected at one end to the carrier 58, and its other end is connected to an ear 80, which projects inwardly from the

plate 22. This spring tends normally to hold the contact-strip 70, in engagement with the fingers 72, and to return said strip to said engaging-position upon retraction of the auxiliary-armatures.

For the purpose of locking the main-armature 36, when it arrives at a predetermined position and to hold it in such position until again moved, a disk 82 is secured to the shaft 20 which has notches 84 in its periphery equidistantly disposed, and corresponding in number to the number of electro-magnets, and a pawl 88 which is arranged to engage any of said notches. Said pawl 88 is pivoted at 90 and is engaged by a leaf-spring 91, which tends to hold its tooth 86 in engagement with the notches 84, and said pawl has a cam 92, adapted to be engaged by a pin 93, which projects from the carrier 54, and by a pin 94, which projects from the carrier 58. Either of said pins operates to raise the pawl 88, and withdraw the teeth 86, from the notch 84, in which it has been engaged, when the carrier bearing it is given a slight rotary motion by a tail-piece 48, thereby unlocking the shaft 20, so that the armature 36 may be rotated under the influence of any of the electro-magnets.

When a tail-piece 48, by attraction of an auxiliary-armature, is swung outwardly, and engages the teeth 52 or 56, according to which magnet is energized, and slightly rotates the corresponding carrier 54 or 58, the shaft 20, will be unlocked, and will remain unlocked until the tail-piece is swung inwardly by the retraction of the auxiliary-armature upon deenergization of the magnet. Thus the locking of the motor-shaft and main-armature is controlled by the auxiliary-armatures, through the members 54 and 58, and pins borne by said members, and it will be observed that this function of said members is quite independent of their circuit-controlling function.

A pair of pawls 95, 96, are pivotally supported on a plate 99, which is secured to the shaft 20, (see Fig. 11) in a position to dispose the end of the pawls 95 and 96 at the portion of greatest thickness of the armature 36. These pawls are yieldingly held against the stop 97 by a retractive spring 98, connected to both of the pawls. When these pawls, through the rotation of the armature, approach the tail-piece 48 of the auxiliary armature of an energized magnet, (see Fig. 12) pawl 95 (or 96 depending upon the direction of rotation) engages the tail-piece and is thereby swung away from the stop 97, against the tension of the spring 98. The pawl 96 is, meanwhile, held against the stop 97, by the spring and its terminal therefore remains in the path of the member 48. The tail-piece 48 will, therefore, after passing over the pawl 95, engage the pawl 96, and

the armature-shaft will thereby be arrested since the pawl 96 is respectively fixed with respect to the shaft. As soon as the tail-piece 48 engages pawl 96, pawl 95 moves back into normal position, and its terminal engages against the tail-piece to prevent recoil. When the magnet is deenergized and its auxiliary-armature retracts, its tail-piece resumes its normal position and disengages said arresting-pawls 95, 96.

Terminal plates are arranged on the outside of the casing 24, to which the circuit-wires are connected, and, as shown in Figs. 1 and 2, 100 and 101 represent two end terminal plates of the sets, which are mounted respectively on blocks 108, 117, of insulation attached respectively to the two halves of the casing 24, and 102, 103, 104, 105 and 106 other terminal plates attached to the block 108, which are connected respectively to terminal plates 112, 113, 114, 115, 116, attached to the block 117. The terminal plates 100 and 101 are common conductors, that is to say, circuit-wires common to all are connected thereto, and the other terminal plates are connected to the separate magnets.

As illustrated in Fig. 13, the terminal 100, is connected by a wire 120 to one side of magnet 0, and the other side of said magnet is connected by a wire 121 to the contact-strip 102. One side of the magnets 0 to 4 are connected by wires 122, 123, 124, 125 and 126 to the contact-fingers 71, 72^a, 72^b, 72^c and 72^d, respectively, and one side of magnets 5 to 9 are connected by wires 127, 128, 129, 130, 131, to contact-fingers 62, 62^a, 62^b, 62^c and 62^d, respectively. The other side of magnets 5 to 9 are connected by wires 132, 133, 134, 135 and 136 to magnets 0 to 4, respectively, and the magnets 1 to 4 and 9 are connected by wires 137, 138, 139, 140 and 141 to the terminals 103, 104, 105, 106 and 101, respectively.

The operation of the mechanism is as follows:—

Suppose that the circuit is closed between the terminal-plates 100 and 104, by means of any suitable circuit-closing device connected with a source of current. The current will flow from the terminal 100, through wires 120, 122, finger 72, bar 70, finger 72^b, wire 124, magnet 2, wire 138 to terminal 104, thus energizing the coil 2. The first result of this energization will be to attract the auxiliary-armature 44 of this magnet, and swing outward the tail-piece 48, the latter engaging the teeth 52 and oscillating the carrier 54, through a short arc to cause the pin 93 to engage the locking-pawl cam 92, and move the locking-tooth 86 to disengage the disk 82. The shaft 20, is now unlocked, and the main-armature 36 moves rotarily to bring its thickest portion into the field of magnet 2. In the meantime, as soon as the tail-piece has effected the unlocking of the shaft 20 and the

latter rotated, the former enters the gap between the two arresting-pawls 95, 96, and arrests said shaft; also the rotary motion imparted to the carrier 54 causes the contact-bar 60 to disengage the contact-fingers 62, 62^a, 62^b, 62^c, 62^d, to break the circuit through the lower set of magnets to prevent energization of any of the magnets of said set. When the magnet 2 is deenergized the carrier 54 is returned by the spring 69 and the strip 60 again engages the fingers 62, 62^a, 62^b, 62^c, 62^d, and the disk 82 and shaft 20, together with the main-armature 36 remain locked until another magnet is energized, whereupon its auxiliary-armature operates as above described. In case the shaft 20 was locked by a previous operation of magnet 3, and the thickest part of the armature 36 is in the field of said magnet 3 at the time magnet 2 was energized, it will be observed that the shaft 20 will be rotated backward, such being the shortest rotary movement, to bring the thickest part of the armature into the field of magnet 2; or in case the shaft 20 was locked by a previous operation of magnet 1, at the time magnet 2 was energized, then the shaft 20 will be rotated forward.

In the form of device shown in Fig. 14, there are ten coils similar to those heretofore described but connected to eleven terminal-plates 150 to 160, inclusive. The terminal-plate 150 is connected by a wire 162 to one end of the coil 0, and the other end of said coil is connected to a common return-wire 163, leading to the terminal-plate 160. The terminal-plates 151, 152, 153, 154, 155, 156, 157, 158 and 159 are connected by wires 171, 172, 173, 174, 175, 176, 177, 178, 179 to one side of magnets 1, 2, 3, 4, 5, 6, 7, 8, 9, respectively, and the other side of said magnets is connected to the common return wire 163.

Suppose that magnet 2 is the one to be energized, then the circuit is closed between the terminal-plates 152 and 160, through any suitable circuit-closing device connected with a source of current. The current will flow from the terminal-plate 152, through the wire 172, magnet 2, wire 163 to terminal-plate 160, and the operations of the main and auxiliary armatures and locking-mechanism will be the same as described above, except that the fingers and the contact-strips on the carriers 54 and 58 are omitted.

Connection is adapted to be made in any indiscriminate manner between any of the contact plates controlling the energization of the individual magnets by the circuit-closing device, and thus only the magnet corresponding to the desired armature position is energized to cause a movement of the armature to a new set position from any former set position. The armature, being at all times in the field of every mag-

net, can, by the indiscriminate and independent energization of any magnet, be moved through the shortest path to the position predetermined by the energized magnet.

I claim:—

1. In an electric-motor, the combination of a shaft rotatable in either direction, a plurality of electro-magnets arranged about said shaft adapted for separate energization, an armature connected with said shaft and arranged in the fields of all said magnets and movable into a predetermined position relative to any of the magnets upon energization thereof, locking-mechanism for said shaft normally arranged in locking engagement therewith, and means controlled by any of the magnets upon energization thereof to operate said locking-mechanism to unlock the shaft and permit rotary movement thereof, said locking-mechanism resuming its locking-position upon deenergization of the energized magnet, substantially as described.

2. In an electric-motor, the combination of a shaft rotatable in either direction, a plurality of electro-magnets arranged about said shaft adapted for separate energization, an armature connected with said shaft and arranged in the fields of all said magnets and movable in either direction through the shortest arc into a predetermined position relative to any of the magnets upon energization thereof, and arresting-means for said shaft controlled by any energized magnet, to suddenly arrest the shaft upon arriving at such predetermined position, and hold it while said magnet is energized, and release it upon deenergization of said magnet, substantially as described.

3. In an electric-motor, the combination of a shaft rotatable in either direction through different predetermined arcs, a plurality of separately energizable electro-magnets arranged in a circle concentric to said shaft, each magnet having a pole-piece, a crescent-shaped armature carried by said shaft and arranged in the fields of all of said magnets, and a counterbalancing-piece for said crescent-shaped armature, which is supported by said shaft, substantially as described.

4. In an electric-motor, the combination of a shaft rotatable in either direction through different predetermined arcs, a plurality of separately energizable electro-magnets arranged in a circle concentric to said shaft, each magnet having a pole-piece, a crescent-shaped armature carried by said shaft and arranged in the fields of all of said magnets, and a crescent-shaped piece of non-magnetic material arranged between the two horns of said armature, which serves as a counterbalance therefor, substantially as described.

70

75

80

85

90

95

100

105

110

115

120

125

130

5. In an electric-motor, the combination of a shaft rotatable in either direction through different predetermined arcs, a plurality of separately energizable electro-magnets arranged in a circle concentric to said shaft, each magnet having a pole-piece, a crescent-shaped armature arranged in the fields of all of said magnets, and a spider secured to the shaft and bearing said armature having a crescent-shaped counterbalancing-piece extended over the end-portions of the horns of said armature, substantially as described.

6. In an electric-motor, the combination of a shaft rotatable in either direction through different predetermined arcs, a plurality of electro-magnets arranged in a circle concentric to said shaft and separately energizable, an armature carried by said shaft and arranged in the fields of all of said magnets, and adapted upon energization of any magnet to move in either direction through the shortest arc to a predetermined position relative to the energized magnet and to correspondingly rotate the shaft, arresting-means controlled by any energized magnet to check rotation of the shaft suddenly upon its arrival at such predetermined position, and hold it while said magnet remains energized, and release it upon deenergization of the magnet, and means arranged to lock said shaft in said predetermined positions with respect to said magnets upon deenergization thereof, substantially as described.

7. In an electric-motor, the combination of a shaft, a series of electro-magnets arranged in a circle concentric to said shaft, a main-armature common to all said magnets which is secured to said shaft and rotatable therewith, locking-mechanism arranged to lock said shaft against rotation, an auxiliary-armature for each magnet, and means arranged for operation by the auxiliary-armature of any magnet to operate said locking-mechanism to unlock said shaft when said magnet is energized and to permit locking of said shaft when said magnet is deenergized, substantially as described.

8. An electric-motor comprising a shaft, a series of electro-magnets arranged circumferentially about the shaft, circuit-connections to said magnets, a main-armature upon said shaft, a notched-member secured to said shaft, a pawl adapted to engage said member to lock said shaft against rotation, an auxiliary-armature for each magnet, and means arranged for operation by the auxiliary-armature of any magnet, when said magnet is energized, for actuating said pawl to unlock said shaft, substantially as described.

9. An electric-motor comprising a shaft, a series of electro-magnets arranged in two sets, circumferentially about the shaft, circuit-connections for said magnets arranged for separate energization of the magnets and of each set of magnets, a main-armature rotatable with the shaft, an auxiliary-armature for each magnet, and means operable by the auxiliary-armature of any magnet of either set upon attracted movement thereof, for breaking the circuits through the other set of magnets, substantially as described.

10. An electric-motor comprising a shaft, a series of electro-magnets arranged in two sets circumferentially about the shaft, circuit-connections for said magnets arranged for separate energization of the magnets and of each set of magnets, a main-armature rotatable with the shaft, means arranged to lock said shaft against rotation when said magnets are deenergized, an auxiliary-armature for each magnet, and means arranged for operation by the auxiliary-armature of any magnet of either set upon an attracted movement thereof to unlock said shaft when said magnet is energized and to break the circuits through the other set of magnets, substantially as described.

11. In an electric-motor, the combination of a shaft rotatable in either direction through different predetermined arcs, a plurality of electro-magnets arranged in a circle concentric to said shaft and separately energizable, each magnet having a pole-piece with a curved face likewise concentric to the shaft, a crescent-shaped armature carried by said shaft and arranged in the fields of all said magnets, and adapted upon energization of any magnet to move in either direction through the shortest arc to a predetermined position relative to the energized magnet and correspondingly rotate the shaft, and means to arrest rotation of the shaft when it arrives in a predetermined position relative to the energized magnet, substantially as described.

12. In an electric-motor, the combination of a shaft rotatable in either direction through different predetermined arcs, a plurality of electro-magnets arranged in a circle concentric to said shaft and separately energizable, each magnet having a pole-piece with a curved face likewise concentric to the shaft, a crescent-shaped armature carried by said shaft and arranged in the fields of all said magnets, and adapted upon energization of any magnet to move in either direction, through the shortest arc, to a predetermined position relative to the energized magnet and correspondingly rotate the shaft, an auxiliary-armature for each magnet, and means cooperating with said auxiliary-armature to arrest said shaft when it arrives at a predetermined position relative to the energized magnet, substantially as described.

13. In an electric-motor, the combination of a shaft rotatable in either direction

through different predetermined arcs, a plurality of electro-magnets arranged in a circle concentric to said shaft and separately energizable, each magnet having a pole-piece with a curved face likewise concentric to the shaft, a crescent-shaped armature carried by said shaft and arranged in the fields of all said magnets, and adapted upon energization of any magnet to move in either direction through the shortest arc to a predetermined position relative to the energized magnet and correspondingly rotate the shaft, an auxiliary-armature for each magnet, and means carried by the shaft and arranged for coöperation with said auxiliary-armature to arrest said shaft when it arrives at a predetermined position relative to the energized magnet, substantially as described.

14. In an electric-motor, the combination of a shaft rotatable in either direction through different predetermined arcs, a plurality of electro-magnets arranged in a circle concentric to said shaft and separately energizable, each magnet having a pole-piece with a curved face likewise concentric to the shaft, a crescent-shaped armature carried by said shaft and arranged in the fields of all said magnets, and adapted upon energization of any magnet to move in either direction, through the shortest arc to a predetermined position relative to the energized magnet and correspondingly rotate the shaft, an auxiliary-armature for each magnet, a pair of spring-pressed pawls arranged to rotate with the shaft and to engage the auxiliary-armature of any energized magnet to arrest said shaft, substantially as described.

15. In an electric-motor, the combination of a shaft, a series of electro-magnets arranged in a circle concentric to said shaft, a main-armature common to all said magnets which is secured to said shaft and rotatable therewith, locking-mechanism arranged to lock said shaft against rotation, an auxiliary-armature for each magnet, means arranged for operation by the auxiliary-armature of any magnet to operate said locking-mechanism to unlock said shaft when said magnet is energized, and to lock said shaft when said magnet is deenergized, and means coöperating with said auxiliary-armature to arrest said shaft when said main-armature arrives at the predetermined position, substantially as described.

16. In an electric-motor, the combination of a shaft, a series of electro-magnets arranged in a circle concentric to said shaft, a main-armature fast on said shaft and rotatable therewith, means arranged to lock the shaft normally against rotation, an auxiliary-armature for each magnet having a tail-piece, means coöperating with the tail-piece of any auxiliary-armature to unlock said shaft when the corresponding magnet

is energized, and means coöperating with the tail-piece of said auxiliary-armature and arranged to arrest said shaft when the main-armature arrives at the predetermined position, substantially as described.

17. An electric-motor comprising a shaft, a series of electro-magnets arranged in two sets circumferentially about the shaft, circuit-connections for said magnets arranged for separate energization of the magnets and of each set of magnets, a main-armature common to all said magnets fast on said shaft and rotatable therewith, means arranged to lock said shaft against rotation when said magnets are deenergized, an auxiliary-armature for each magnet, means operable by the auxiliary-armature of any magnet upon attractive movement thereof and arranged to unlock said shaft when said magnet is energized and to break the circuits through the other set of magnets, and means coöperating with said auxiliary-armature and arranged to arrest said shaft when said main-armature arrives at the predetermined position, substantially as described.

18. An electric-motor comprising a shaft, a series of electro-magnets arranged circumferentially about the shaft, circuit-connections to said magnets, a main-armature common to all said magnets secured to said shaft and rotatable therewith, a notched-member secured to said shaft, a pawl adapted to engage said member to lock said shaft against rotation, an auxiliary-armature for each magnet, means arranged for operation by the auxiliary-armature of any magnet when said magnet is energized to actuate said pawl to unlock said shaft, and means rotatable with said shaft adapted to be operated by said auxiliary armature to again lock said shaft when the main-armature assumes any predetermined position, substantially as described.

19. An electric-motor comprising a shaft, a series of electro-magnets arranged circumferentially about the shaft, circuit-connections to said magnets, a main-armature fast on said shaft and rotatable therewith, a notched-member fast on said shaft, a pawl arranged to engage said member to lock said shaft against rotation when said magnets are deenergized, an auxiliary-armature for each magnet, means operable by the auxiliary-armature of any magnet when said magnet is energized to actuate said pawl to unlock said shaft, a pair of spring-pressed pawls arranged to rotate with said shaft and engage the auxiliary-armature of any energized magnet to arrest said shaft when the main-armature arrives at any predetermined position, substantially as described.

20. An electric-motor including a plurality of electro-magnets annularly arranged in sets, circuit-connections arranged for

separate energization of the individual magnets and of each set of magnets, an armature rotatable in the fields of the magnets and responsive to energization of any one of the magnets for assuming a predetermined relation to any one of the magnets, and means responsive to any magnet of either set for breaking the circuit of the other set of magnets, and a locking-mechanism normally maintaining the armature against movement, but releasable by said first means upon the response of said first means to an energized magnet.

21. An electric-motor including a plurality of electro-magnets annularly arranged in sets, circuit-connections arranged for separate energization of the individual magnets and of each set of magnets, an armature rotatable in the fields of the magnets and responsive to energization of any one of the magnets for assuming a predetermined relation to any one of the magnets, and means responsive to any magnet of either set for breaking the circuit of the other set of magnets, and means for immediately returning said first means to closed

circuit position upon the deenergization of an energized magnet.

22. In an electric-motor, a rotatable shaft, a plurality of electro-magnets arranged concentric to the shaft, an armature rotatable with the shaft, and responsive to any one of said magnets, means normally locking the shaft against rotation, a member associated with each magnet and responsive to the energization thereof, and operating when responding to release said locking-means, permitting the shaft to rotate, and means movable with the shaft and co-acting with said member for arresting the shaft when the armature arrives at a predetermined position with respect to the energized magnet, and for holding it while the magnet remains energized, and for releasing it upon energization of the magnet.

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

EDWIN V. HAGMAN.

Witnesses:

B. J. NOYES,
H. B. DAVIS.

Copies of this patent may be obtained for five cents each, by addressing the "Commissioner of Patents, Washington, D. C."