Nov. 29, 1927. 1,651,306

C. S. WEYANDT

RECIPROCATING ELECTRIC MOTOR

Filed March 5, 1924

Fig. 1

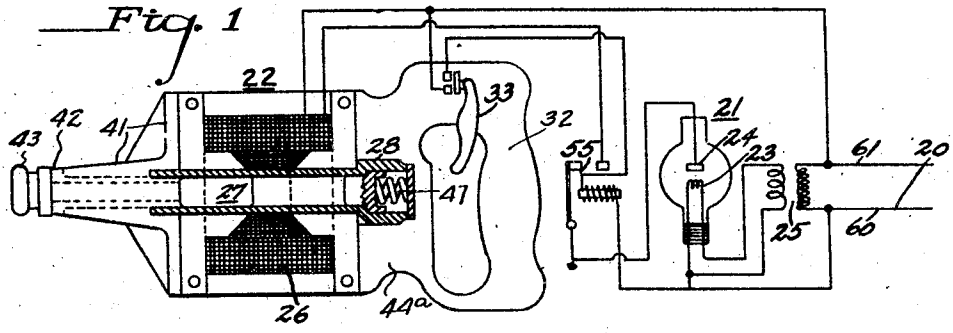


Fig. 2

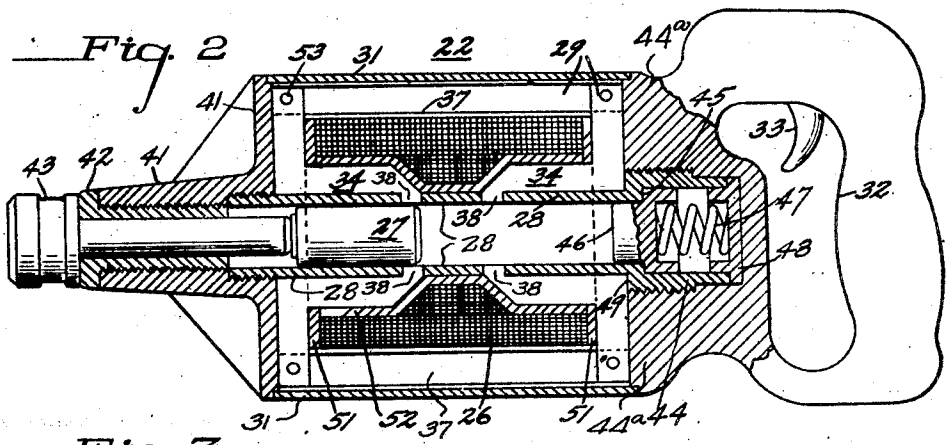


Fig. 3

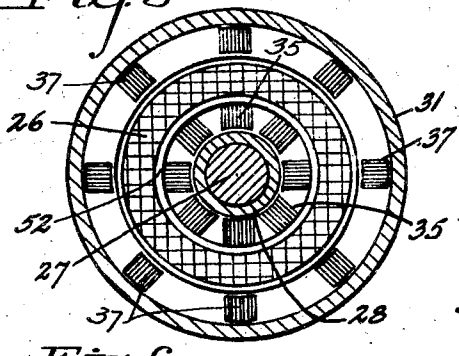


Fig. 4

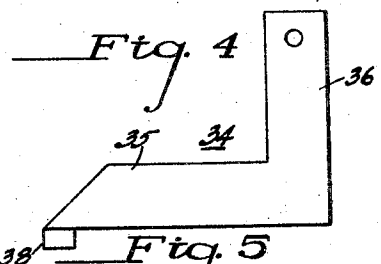


Fig. 5

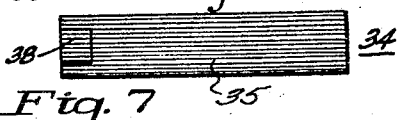


Fig. 6

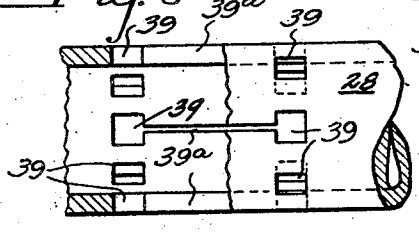
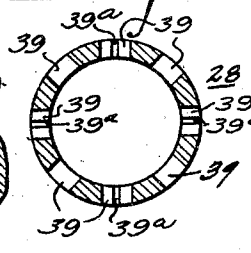


Fig. 7



INVENTOR

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UNITED STATES PATENT OFFICE.

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RECIPROCATING ELECTRIC MOTOR.

Application filed March 5, 1924. Serial No. 697,053.

This invention relates to electric motors of the reciprocating type and particularly to motors suitable for use as percussive tools.

The object of my invention is to provide a reciprocating motor suitable for use as an electric hammer, embodying novel features of construction by reason of which a high degree of efficiency is attained, and the structure assembled into a compact unit.

In practicing my invention I dispose an actuating winding around a barrel or cylinder of non-magnetic material or metal within which a core member of magnetizable material is reciprocated by the influence of the winding. In order to reduce the reluctance of the magnetic circuit of the motor, I compose the magnetic circuit of a plurality of sets of laminations of magnetizable material of high permeability such as silicon steel. The laminations are substantially rectangular in shape and extend radially from the barrel almost encircling the winding. The side of the rectangle adjacent the barrel is provided with an air gap. The two portions separated by the gap terminate in tips which are perpendicular to the length of the gap and extend through openings in the barrel to within a few thousandths of an inch from the inner surface of the barrel which is engaged by the moving core. By reason of the magnetic circuit of low reluctance, the leakage flux is reduced to a minimum. Since the tips of the laminations are disposed very close to the core, substantially the entire magnetic flux is concentrated upon the core to actuate it in either direction. With this construction the efficiency of the motor is considerably increased over that heretofore attained.

Figure 1 of the accompanying drawings is a diagrammatic view of an electric hammer system containing an electric hammer constructed in accordance with my invention;

Figure 2 is a longitudinal view partially in section and partially in elevation, of the hammer illustrated in Figure 1;

Figure 3 is a sectional view, taken laterally, of the hammer shown in Figure 2.

Figures 4 and 5 are elevational side and bottom views of the sets of laminations employed in the magnetic circuits of the hammer illustrated in Figure 2.

Figure 6 is a longitudinal view, partially in section and partially in elevation, of the barrel or guide for the core or striking element; and

Figure 7 is a transverse sectional view of the barrel illustrated in Figure 6.

As illustrated in the diagram in Figure 1, energy is derived from an alternating current circuit 20 and transmitted through an electric valve 21, to an electric hammer 22 of the reciprocating motor type.

The electric valve 21 here illustrated is of the electronic type, comprising an electron-emitting element, such as a filament 23, as a cathode, and a plate 24 as an anode. A transformer 25 supplies energy to the filament cathode 23 to render it incandescent and electron-emitting to establish an operative condition in the valve 21 for transmitting current waves of one polarity to the hammer 22.

The hammer 22 comprises, as may be seen in Figures 2 to 7, inc., an operating coil or solenoid 26, a movable core 27 controlled thereby, a barrel or guide 28 of non-magnetic material, such as bronze, for the core 27, coaxially disposed in the coil 26, laminated magnetic circuit conductors 29 for directing the magnetic force developed by the coil 26, a casing 31 enclosing the coil and the laminated magnetic circuit conductors 29, and a handle 32 provided with a trigger switch 33 for controlling the operation of the hammer.

The laminated magnetic circuit conductors 29 comprise two members of L shape 34 having a base portion 35 and a side or radially extending portion 36, and a straight connecting member 37. Some of the L-shape members 34 are provided with tips 38 disposed at the ends of the base portions 35, that are adapted to fit tightly in openings 39 in the barrel.

The laminations 29 are arranged in sets or groups as illustrated in Figures 3, 4 and 5. The inner laminations of each set comprise those provided with the tips 38 that fit tightly in the barrel. The laminations thus serve the twofold purpose of locking the coil 26 in predetermined position relative to the barrel 28, and of directing and concentrating the magnetic flux at the most effective position to influence the core.

The tips 38 extend through the side of the barrel to within a few thousandths of an inch from the inner surface of the barrel 28, which is engaged by the core in its recipro-

cating movements. The relatively short air gap between the tips of each set of laminations reduces the reluctance of the magnetic circuit to a minimum value and insures a highly efficient magnetic circuit having a relatively small amount of magnetic leakage.

The sets of laminations are disposed radially around the barrel 28 and the coil 26, as illustrated in Fig. 3. The separate air gaps of the respective sets together constitute an air gap of annular shape which is adapted to be bridged or shunted by the core 27 in its reciprocating movements.

The barrel 28 serves as a guide for the core 27 and as a supporting structure for the different elements whereby they may be assembled into a compact unit. The barrel comprises a cylindrical tube of bronze provided with the openings 39 to receive the tips 38 of the laminations. The barrel 28 is preferably provided with slots 39^a extending longitudinally thereof and entirely through the wall of the barrel to interrupt its circumferential continuity between the pole tips 38 spaced longitudinally of each other axially of the barrel or in the direction of movement of the core 27, to reduce the wasteful currents induced in the barrel 28 by fluctuations in the magnetic field at and between the tips 38. Preferably, these slots 39^a extend between apertures 39 in which are received the pole tips 38. The forward end of the barrel is threaded to receive an open end cap 41 provided with a threaded opening within which a tool guide 42 is disposed. The tool guide 42 is provided with an opening within and through which the shank of a tool 43, such as a drill, chisel, rivet set or the like, may be disposed in the path of travel of the core 27. The rear or handle end of the barrel is provided with an enlarged flange-like cylinder 44 that is externally threaded. The end of the barrel at the cylinder 44 constitutes a seat 45, for a spring-cushioned back stop 46. A spring 47 is disposed between the back stop 46 and a cap 48 which together with the cylinder 44 fits into a recess in the end member 44^a threaded on the barrel extension 44, and carrying the handle 32. The member 44^a co-operates with the end surface of the cylinder 44 to secure the cap 48 in position. The outer surface of the base of the cylinder 44 joins the outer surface of the barrel to constitute a shoulder 49 against which and member 44^a the rear laminations 34 are seated.

Although the barrel should be of non-magnetic material, any non-magnetic material will not be satisfactory merely because of its non-magnetic character. A barrel employed in such an application, as a guide for a reciprocating element of steel, such as the core must be, requires, in addition to a non-magnetic characteristic, physical characteristics of hardness, toughness and high tensile strength. The barrel must be hard to resist abrasive action of the core, and must be tough and have a high tensile strength to resist stresses set up by the end plate 41 and the member 44^a in tightly securing all the parts as a unit.

I have found that a bronze barrel having a content of about 60% copper, 39% zinc and from traces to 1% manganese, has the qualities and characteristics essential for a barrel employed as a guide in a reciprocating motor or electric hammer. Such a barrel resists abrasive action of a reciprocating core and permits tightly securing all parts to form a compact unit, as is illustrated in Fig. 2.

The respective dimensions of the tool shank and the core should be such that when one end of the core engages the end of the tool shank, as illustrated in Fig. 2, the other end should be within the path of magnetic influence of the laminations. One end of the core should always be subject to the influence of the magnetic flux at the extreme positions of the core. The backstop 46 should accordingly have such dimensions as to insure that the core will extend into the flux field when the stop is engaged.

In assembling the hammer the L-shape laminations on the right hand or left hand side are first placed in position, in and around the barrel. Two fibre washers 51 are placed around the barrel on the inside of the laminations. The opposite sets of L-shape laminations are then placed in position. A layer of insulation 52 is wound over the surfaces of the base portions of the L-shape laminations and the portion of the barrel between the tips. The insulation 52 serves to hold the L-shape laminations in position while the operating coil 26 is wound on the barrel, and also serves to hold the fibre washers 51 in position against the sides of the perpendicular or lateral portions 36. After the coil is wound upon the barrel, the straight laminated portions 37 are placed in position and secured to the L-shape portions by suitable means such as rivets 53. The backstop parts are then placed in position and the member 44^a is securely threaded onto the barrel. The casing 31 is placed around the coil, the core 27 is inserted through the front end of the barrel and the front end cap 41 is threaded on to the barrel to clamp the casing and groups of laminations 29 securely between the end cap and the member 44^a. The magnetic field structure comprising the groups of laminations 29, with the coil 26 between the end portions of each group, is accordingly held or clamped between the end members 41 and 44^a threaded upon the barrel 28; and similarly, the housing or casing 31 is held between the members 41 and 44^a. The

tool guide is then placed in position so that the plane of the front surface is a predetermined distance from the front surface of the backstop. When a tool having a shank of predetermined length is inserted through the tool guide, the core will be held in the magnetic path when engaging the tool shank, and proper operation of the core will be ensured.

When operation of the hammer is desired, the trigger switch 33 is closed and connects a relay switch 55 to the circuit 20. The relay switch 55, when closed, connects one terminal of the operating coil of the hammer to the circuit conductor 60 through the electronic valve 21. The other terminal of the coil being already connected to circuit conductor 61, the valve transmits alternate current waves, that is, only current waves of the same polarity, to the operating coil.

The operation of the valve 21 is such that when the filament is negative with respect to the plate, current is transmitted by the valve, but when the filament is positive with respect to the plate or anode, no current traverses the valve. The valve may therefore be regarded as transmitting positive waves or impulses.

Assuming the core 27 to be in the position illustrated in Figs. 1 and 2 when the trigger switch is closed, the first positive alternation or current wave will traverse the valve 21 and energize the operating coil 26 to establish a magnetic flux field across the annular air gap between the laminations 34. The core will be pulled backward toward the backstop 46. When the core reaches the central part of the barrel the positive alternation or current wave diminishes to zero value and the winding then remains unenergized until the next positive alternation begins. During the interval between the positive waves, however, the core continues its travel on its own momentum or inertia, from the central region of the barrel until it engages the backstop 46. At that time the second positive alternation traverses the valve and the operating coil, and the magnetic flux is reestablished across the air gap. The core is then pulled forward to strike the end of the tool shank to deliver a working blow to the tool.

The coil becomes de-energized about the time the core reaches the middle region of the barrel and again the core continues its travel during the interval until the coil is again energized. Such reciprocating action of the core continues in synchronism with the transmitted current waves so long as the trigger switch is held closed. When the trigger switch is opened the magnet switch opens and the valve is disconnected from the operating winding. The hammer thereupon ceases operating.

The principal effective air gap of the reciprocating motor above described is that existing between the inner ends of the laminæ 35, and more particularly between their tips 38, at the left, Fig. 2, and the inner ends of the laminæ 35, and more particularly, their tips 38, at the right, spaced longitudinally of the axis of the barrel 28 and winding 26, from the laminæ and tips at the left. The magnetizable core 27 in its movement across the air gap shortens the gap and eventually bridges it. The air gap is a minimum length when the core 27 is in bridging position. In any event, the core 27 in any stroke passes the position of minimum air gap length, continuing on until it impacts upon the tool or until, in the return stroke, it impacts upon the buffer block 46.

A feature of my construction is the magnetic circuit of the field-producing means comprising magnetizable field core members disposed adjacent the path of movement of the core and pointing towards each other, but falling short of each other, to form an air gap intermediate the ends of the field structure or between the ends of the magnetizing winding such as 26. A further feature resides in such combination provided with magnetizable material disposed outside of the winding and substantially magnetically coupling the aforesaid core members, whereby the reluctance of the magnetic circuit is low.

By means of a magnetic circuit of the character described herein, the reluctance and leakage losses are reduced to a minimum and the entire active flux is concentrated upon the core at the most advantageous position. Moreover, all parts are assembled and securely locked into a compact unit.

My invention comprehends, therefore, a reciprocating motor of novel construction, whereby a relatively high efficiency is obtained, and the process of assembling the elements into a compact unit is simplified. It is contemplated, of course, that changes may be made in the structure or the design of the different elements without varying their cooperative relation or departing from the spirit and scope of this invention as set forth in the appended claims.

Certain of the subject matter herein disclosed, particularly the electric circuit arrangements and the employment of an electric valve or the like for controlling energization of the motor, is not herein claimed, but is claimed in my application Serial No. 697,054, filed March 5, 1924.

This application is a continuation in part of application Serial No. 527,037, filed January 4, 1922, and relating to methods of operating electric tools.

I claim as my invention—

1. An electric hammer of the reciprocat-

ing motor type comprising a winding, a core axially movable therein, a barrel or guide for the core axially disposed relative to the core, and means comprising magnetic conductors for locking the coil in predetermined position relative to the barrel or guide and for concentrating the developed magnetic flux at a predetermined region of the barrel or guide.

2. A reciprocating electric motor comprising an actuating coil, a core responsive thereto, a longitudinally slotted member within which said core travels, and means constituting a magnetic circuit for the coil arranged to present an annular air gap to be bridged by the core in its movement.

3. A reciprocating electric motor comprising an actuating coil, a core responsive thereto, a slotted, hollow member to guide said core, and laminations of substantially C-shape encircling the coil and radially disposed relative to said guide member to present an annular air gap adjacent the path of travel of the core.

4. A reciprocating electric motor comprising an actuating coil, a core responsive thereto, and groups of laminæ spaced from each other circumferentially of said core, comprising laminations having radially extending portions, long extensions within said coil, and inwardly disposed tips on said extensions.

5. A reciprocating electric motor comprising an actuating coil, a core responsive thereto, a barrel of non-magnetic material within the coil and surrounding the core to act as a guide therefor, and means constituting magnetic circuit conductors having their opposed faces tapered to concentrate the magnetic flux of the coil at a predetermined region of the barrel.

6. An electric hammer unit comprising an actuating coil, a movable core or striker element responsive thereto, a barrel or guide surrounding the core, magnetic laminations between which the coil is disposed and locking it in position relative to the barrel, an end cap fixed at the front end of the barrel and provided with a guide to align an inserted tool in the path of the movable core, a cylinder casing enclosing the coil and laminations, and a rear cap comprising a handle fixed at the rear end of the barrel and cooperating with the other end cap to maintain the casing in position.

7. A reciprocating electric motor comprising an actuating winding, a core responsive thereto, and a magnetic circuit for the winding comprising spaced magnetizable members having tapered, opposed faces which form an air gap that is substantially closed by the core during its movement in each direction.

8. A reciprocating electric motor comprising an actuating winding, a core responsive thereto, and a magnetic circuit for the winding comprising pole extensions within said winding having ends tapered toward tips to concentrate the magnetic flux of the winding at a region adjacent the path of travel of said core.

9. An electric hammer of the reciprocating motor type suitable for doing useful work through the medium of a tool or element to be recurringly struck, comprising an actuating winding, a movable core or striker element responsive thereto for striking the tool or element on its forward stroke, a back-stop for the core on its backward stroke, an abutment limiting movement of said back-stop in one direction, a spring normally maintaining said back-stop in engagement with said abutment, and means for concentrating the magnetic field of the winding at a region between the end of the tool and the backstop.

10. A reciprocating electric motor comprising a winding, a core movable thereby between two predetermined points and means constituting a magnetic circuit for the winding and presenting an air gap adjacent the path traversed by the core, a yielding back-stop for the core on its backward stroke, and an abutment to limit the forward movement of said back-stop, the relative dimensions of the core, its path of travel and the air gap being such that one end of the core will lie in the flux field between the air gap limits when at either of its extreme positions in its path of travel.

11. In a reciprocating electric motor, the combination with a winding, a core responsive thereto and a barrel serving as a guide for the core and a support for the winding, of means for precluding relative longitudinal movement between the winding and the barrel comprising members disposed at each end of the winding provided with locking tips or tenons fitting into the barrel.

12. In an electric hammer of the reciprocating motor type, the combination with an actuating winding, a core responsive thereto, and a barrel or guide for the core serving also as a support for the winding, of means for concentrating the magnetic flux developed by the winding comprising magnetic circuit members secured to the barrel by tenons extending into the barrel.

13. In an electric hammer of the reciprocating motor type, the combination with an actuating winding, a core responsive thereto, and a barrel or guide for the core serving as a support for the winding, of means for concentrating the magnetic flux developed by the winding comprising magnetic circuit members embodying tenons of magnetic material extending into the barrel to secure the magnetic members thereto.

14. In a reciprocating motor the combination comprising a solenoid, a solid core

therefor susceptible to its influence, and means for conducting the magnetic flux of the solenoid to a region closely adjacent the path of travel of the core, the flux conducting means being of such character as to present less reluctance to the flux than the core would through a predetermined portion of the flux path.

15. In a reciprocating motor, the combination comprising a solenoid, a hollow conducting member having slots therein to reduce eddy current losses, a solid core reciprocating therein, and laminated magnetic circuit conductors for conducting the solenoid flux to a region within which the flux need traverse only a relatively small portion of the solid core, thereby obviating excessive eddy current losses in the core.

16. A reciprocating motor comprising a solenoid, a movable core responsive thereto, and means comprising magnetizable members having tapered ends terminating in tips for directing the magnetic flux to a region including a portion of the core when disposed at either extremity of its travel.

17. An electric hammer comprising a solenoid, a movable core responsive thereto, a hollow member in which said core reciprocates, a tool having its shank disposed in the path of travel of the core to be struck thereby, a tool guiding member secured to one end of said hollow member, a backstop for the core, means for concentrating the magnetic flux of the solenoid between the tool shank or the backstop and the corresponding impact surface of the core, and a handle for said hammer secured to the other end of said hollow member.

18. An electric hammer comprising a solenoid, a movable core responsive thereto, a hollow member in which said core reciprocates, a tool having its shank disposed in the path of travel of the core to be struck thereby, a yielding backstop for the core movable within an extension of said hollow member, and magnetic circuit members radially disposed about the solenoid for concentrating the solenoid flux to establish an annular magnetic field between the tool shank or the back-stop and the corresponding impact surface of the core.

19. A reciprocating motor comprising a solenoid, a movable core responsive thereto, a barrel between the solenoid and the core serving as a guide for the core and provided at one end thereof with an annular shoulder, and laminated magnetic circuit conductors disposed in groups circumferentially of the barrel and securely seated against the shoulder and locked in such position by tips fitting into the barrel.

20. A reciprocating motor comprising a solenoid, a movable core responsive thereto, a tubular member of non-magnetic material between the solenoid and the core, and magnetic circuit conductor elements for the solenoid comprising elements almost surrounding a section of the solenoid and extending through the tubular member to approximately the inner surface of said member.

21. A reciprocating motor comprising a field-producing winding, a magnetizable core reciprocated thereby, field core members extending outwardly from the path of travel of said core and spaced from each other longitudinally of the path of movement of said core, at least one of said field core members extending longitudinally of the path of said core toward the other field core member to effect an air gap with respect to which said core is movable, and a hollow member in which said core reciprocates having openings therein to position said field core members.

22. A reciprocating motor comprising a field-producing winding, a magnetizable core reciprocated thereby, field core members extending outwardly from the path of travel of said core and spaced from each other longitudinally of the path of movement of said core, at least one of said field core members extending longitudinally of the path of said core toward the other field core member to effect an air gap with respect to which said core is movable past the position of minimum air gap length, a hollow member in which said core reciprocates, and yielding back-stop disposed in an extension of said hollow member, a handle for the motor secured to said extension, and a spring positioned between said yielding backstop and said handle.

23. A reciprocating motor comprising a reciprocating magnetizable core, a guide member therefor of non-magnetic metal of a character resisting abrasion by said core and having longitudinally extending slots therethrough, laminated field pole structure on said guide member disposed adjacent the path of movement of said core upon said guide member, and a magnetizing winding surrounding said core and guide member for magnetizing said field pole structure.

24. A reciprocating motor comprising a hollow member having openings therein, a magnetizable core reciprocating within said member, field core structure having pole tip structure extending into said openings, and a core-actuating winding for magnetizing said laminations.

25. A reciprocating motor comprising a hollow member, a magnetizable core reciprocating within said member, circumferentially spaced groups of field laminations maintained in spaced relation to each other longitudinally of the movement of said core member by openings in said member which receive extensions on said laminations, and extending toward each other to form air gaps with respect to which said core is mov-

able, and means for magnetizing said groups of laminations.

26. A reciprocating motor comprising a hollow member, a magnetizable core reciprocating within said member, field core structure having pole tip structure extending through said member adjacent the path of movement of said core, and means for magnetizing the field core structure.

27. A reciprocating motor comprising a hollow conducting member, a magnetizable core reciprocating therein, and field pole members spaced from each other longitudinally of the path of movement of the core to form an air gap with respect to which the core is movable, said member being slotted within the region of the air gap to interrupt its circumferential continuity.

28. A reciprocating motor comprising a hollow conducting member, a magnetizable core reciprocating therein, said member having apertures spacel longitudinally with respect to the path of movement of said core, and field pole members terminating at said apertures to form an air gap with respect to which said core is movable, said member having a slot between said apertures to interrupt its circumferential continuity.

29. A reciprocating motor comprising a hollow member, a magnetizable core reciprocating within said member, circumferentially spaced groups of field laminæ having portions extending outwardly from said member and portions extending along said member, field laminations spaced longitudinally of said member from said last named portions to form a circumferential series of air gaps with respect to which said core is movable, members secured to the ends of said hollow member in abutting relation to said laminations, and means for magnetizing said groups of laminations.

30. A reciprocating motor comprising a hollow member, a core reciprocating therein, end members secured to said member adjacent opposite ends thereof, field pole members disposed between said end members and spaced from each other longitudinally of said hollow member to form an air gap between the ends of said hollow member, and a winding surrounding said hollow member and disposed between said field pole members.

31. A reciprocating motor comprising a hollow member, a core reciprocating therein, end members secured to said member adjacent opposite ends thereof, field pole members disposed between said end members and spaced from each other longitudinally of said hollow member to form an air gap between the ends of said hollow member, a winding surrounding said hollow member and disposed between said field pole members, and a casing enclosing said winding and said field pole members and extending from one of said end members to the other.

32. A reciprocating motor comprising a reciprocating magnetizable core, and means for actuating said core comprising field poles spaced from each other longitudinally of the movement of the core to form an air gap, said poles having faces inclined toward said gap, and a magnetizing winding having a length greater than said air gap, said core having a length to bridge said air gap and moved by the field produced by said winding to a position beyond said bridging position.

33. A reciprocating motor comprising a reciprocating magnetizable core, and means for actuating said core comprising field poles spaced from each other longitudinally of the movement of the core, inwardly directed tips on said poles to form an air gap, said poles having faces inclined toward said tips, and a magnetizing winding longer than said air gap and extending to both sides thereof for moving said core with respect to said air gap past the position of minimum air gap length.

In testimony whereof, I have hereunto subscribed my name this 29th day of February, 1924.

CARL S. WEYANDT.