Sept. 25, 1956 N. T. ANTON 2,764,703

VIBRATORY TOOLS

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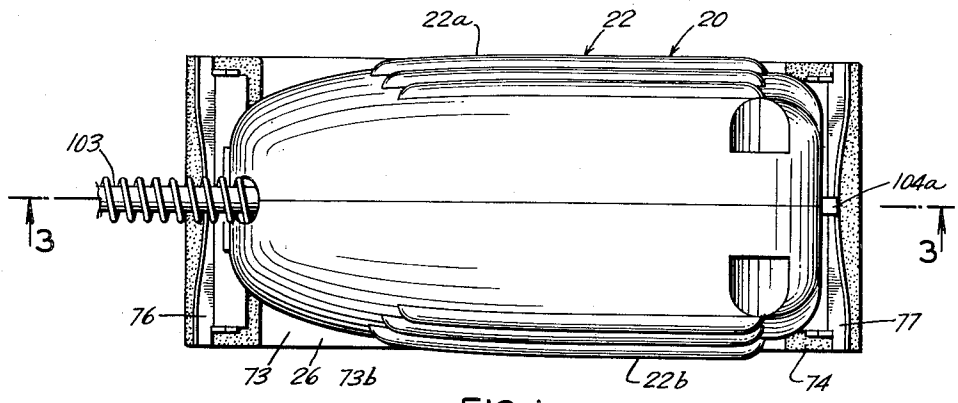


FIG. 1

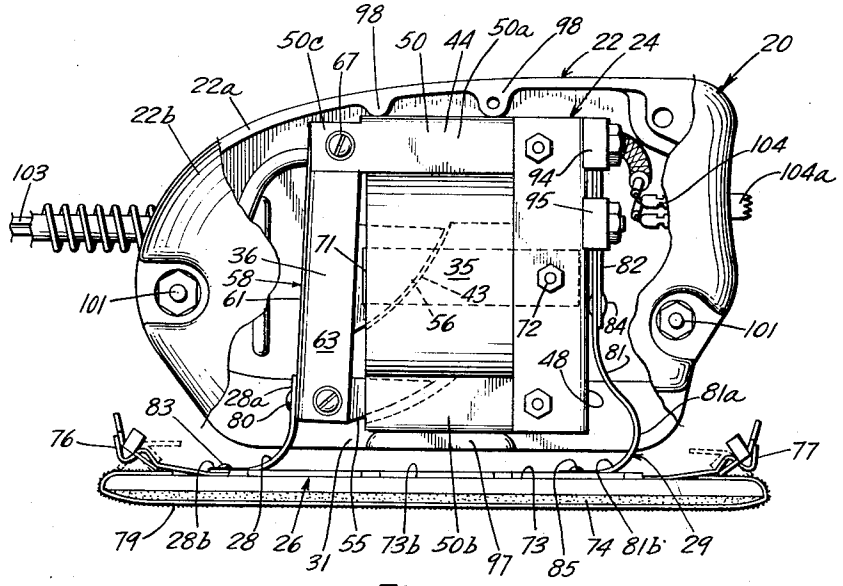


FIG. 2

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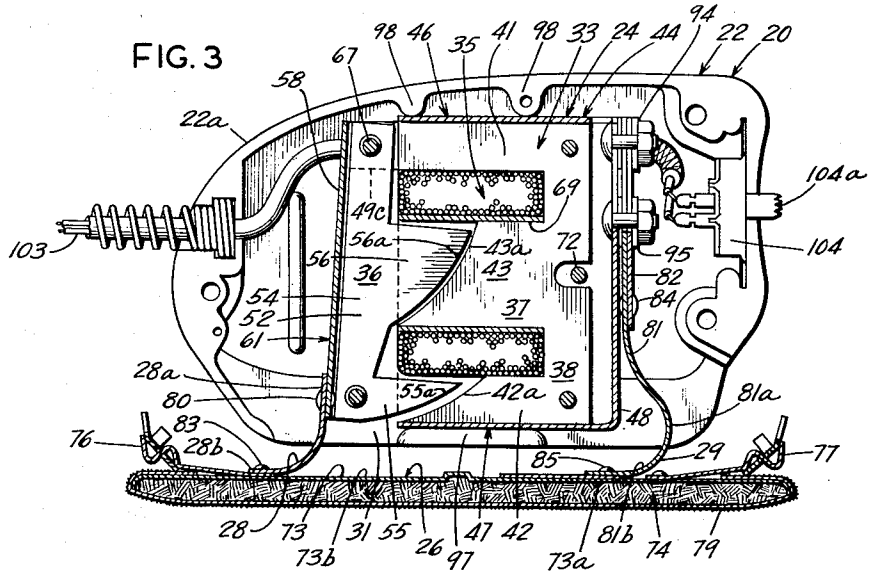
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VIBRATORY TOOLS

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FIG. 3



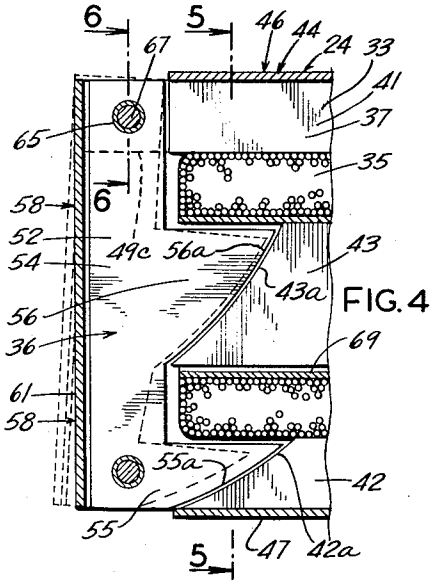


FIG. 4

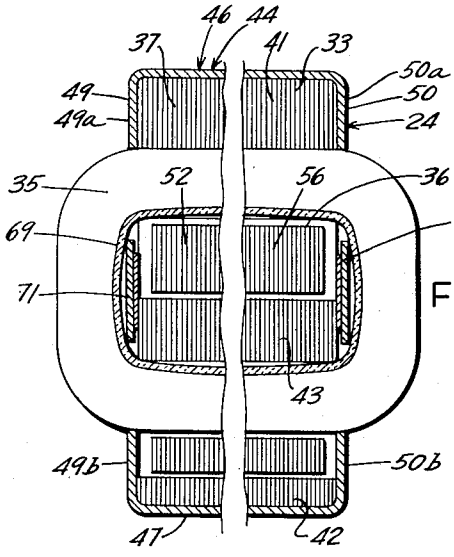


FIG. 5

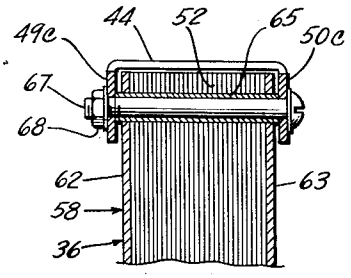


FIG. 6

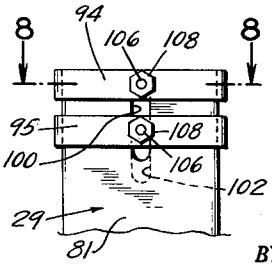


FIG. 7

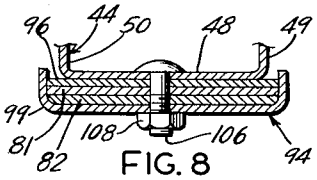


FIG. 8

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VIBRATORY TOOLS

Nicholas T. Anton, Park Ridge, Ill.

Application June 8, 1954, Serial No. 435,327

11 Claims. (Cl. 310—29)

This invention relates to electro-magnetic devices and, more particularly, to electro-magnetic devices which are particularly well adapted for use in vibratory tools such as vibratory sanders and polishers, and the like.

The present invention is an improvement upon the device disclosed in my co-pending application for United States Letters Patent, Serial No. 394,334, filed November 25, 1953, now Patent No. 2,749,676.

The primary object of my invention is to afford a novel electro-magnetic device of the aforementioned type which is constructed, and operates, in a novel and expeditious manner.

Another object of my invention is to enable a sanding shoe, or like tool, to be reciprocated in a substantially straight horizontal movement by a vibratory electro-magnetic device in a novel manner.

A further object of my invention is to minimize the variation in the gap opening between an oscillating armature and the core of an electro-magnetic device in a novel and expeditious manner.

Another object is to afford a novel electro-magnetic device of the aforementioned type wherein the armature enters the windings in a novel manner.

Yet another object of my invention is to afford a novel electro-magnetic device of the aforementioned type which embodies inner and outer legs on the core and armature thereof, and wherein, during operation of the device, the strength of the magnetic attraction is distributed between these legs in a novel and expeditious manner.

Another object of my invention is to enable a work-piece, such as, a shoe, to be reciprocated over a maximum path of travel by an oscillating armature with a minimum of opening and closing of the gap between the armature and its associated core in a novel manner.

A further object of my invention is to afford a novel electro-magnetic device of the aforementioned type which is cool in operation.

Another object of my invention is to improve the operating strength of electro-magnetic devices of the aforementioned type in a novel and expeditious manner.

Other and further objects of the present invention will be apparent from the following description and claims and are illustrated in the accompanying drawings which, by way of illustration, shows a preferred embodiment of the present invention and the principle thereof and what I now consider to be the best mode in which I have contemplated applying that principle. Other embodiments of the inventions embodying the same or equivalent principles may be used and structural changes may be made as desired by those skilled in the art without departing from the present invention and the purview of the appended claims.

In the drawings:

Fig. 1 is a top plan view of a vibratory tool embodying the principles of my invention;

Fig. 2 is a side elevational view of the vibratory tool shown in Fig. 1, with certain portions thereof broken away to show the internal construction thereof;

Fig. 3 is a sectional view taken substantially along the line 3—3 in Fig. 1;

Fig. 4 is a detail sectional view of a portion of the device shown in Fig. 3;

Fig. 5 is a sectional view taken substantially along the line 5—5 in Fig. 4;

Fig. 6 is a detail sectional view taken substantially along the line 6—6 in Fig. 4;

Fig. 7 is a rear elevational view of a portion of the vibratory tool shown in Fig. 3; and

Fig. 8 is a sectional view taken substantially along the line 8—8 in Fig. 7.

To illustrate the principles of my invention, an electro-magnetic device in the form of a vibratory sander or polishing tool **20**, comprising the preferred embodiment of my invention, is shown in the drawings. The vibratory tool **20** comprises, in general, a casing **22** enclosing an alternating electro-magnet **24**, which is operable to reciprocate a shoe or block **26** disposed outwardly of the casing **22**, the shoe **26** being mounted on two supporting members **28** and **29** which extend downwardly from the electro-magnet **24** and project outwardly through the open bottom **31**, Figs. 2 and 3, of the casing **22**. To facilitate the description of the construction and operation of my novel device, the right end and the left end of the vibratory tool **20**, as viewed in Figs. 1, 2 and 3, will be considered herein to be the front and rear ends thereof, respectively.

The electro-magnet **24** comprises, in general, a core **33**, a winding **35** and an armature **36**. The core **33** is preferably formed of a plurality of laminations **37**, Fig. 5, and is substantially E-shaped, having a substantially vertically extending elongated base **38** from which two elongated upper and lower end legs **41** and **42** and an elongated intermediate leg **43** project rearwardly in substantially parallel relation to each other, Fig. 3. A housing **44** encloses the laminations **37**, the housing having a top wall **46**, a bottom wall **47**, a front wall **48**, Fig. 3, and two side walls **49** and **50**, Fig. 5. The side walls **49** and **50**, are substantially U-shaped and have upper portions **49***a* and **50***a*, and lower portions **49***b* and **50***b*, respectively, projecting rearwardly along, and in juxtaposition to, the portions of the laminations **37** forming the upper and lower legs **41** and **42**, respectively, of the core **33**. The rearward ends of the bottom portions **49***b* and **50***b* of the side walls **49** and **50** terminate substantially in alignment with the rearward end of the lower leg **42** of the core **33**. However, the upper portions **49***a* and **50***a* of the side walls **49** and **50** have ears **49***c* and **50***c*, respectively, Figs. 2, 3 and 6, which project rearwardly past the rear end of the leg **41** of the core **33**, and afford a supporting bracket on which the armature **36** is pivotally mounted as will be discussed in greater detail hereinafter.

The armature **36**, Figs. 3 and 4, is of a substantially inverted F-shape, and, like the core **33**, comprises a plurality of laminations **52**, Fig. 6, shaped to afford a substantially vertically extending elongated base **54** from the lower end of which a leg **55** projects forwardly and from the central portion of which a leg **56** projects forwardly in substantially parallel relation to the end leg **55**. A housing **58** embodying a rear wall **61** and two side walls **62** and **63**, Figs. 4 and 6, encloses the laminations **52**, the side walls **62** and **63** being complementary in shape to the laminations **52** and being disposed thereon in juxtaposition thereto.

An elongated bearing **65**, Fig. 6, is mounted in and extends through the upper end of the base **54** of the armature **36**, the respective ends of the bearing **65** projecting outwardly past the side walls **62** and **63** of the housing **58**. The armature **36** is pivotally mounted on and carried by the core **33** for swinging movement toward and away from the core **33** by suitable means such as a bolt **67**,

Fig. 6, which extends through the ears 49*c* and 50*c* of the housing 44 and through the bearing 65 in the armature 36. A nut 68 retains the bolt 67 in operative position in the bearing 65. The armature 36 is so disposed in the ears 49*c* and 50*c* that the legs 55 and 56 thereof project forwardly toward the core 33 substantially in longitudinal alignment with the lower leg 42 and the intermediate leg 43 of the core 33, respectively.

The winding 35 comprises a plurality of wires, Fig. 3, wound around a central spool 69, Figs. 3 and 5. The spool 69, is generally rectangular in cross section with the sides thereof bowed out slightly between each pair of adjacent corners, Fig. 5 and the wires of the winding 35 are wrapped around the spool 69 in such a manner as to afford an outer cross sectional shape substantially complementary to the cross-sectional shape of spool 69. Two substantially L-shaped clips 71, Figs. 2 and 5 are mounted on the winding 35 at opposite sides thereof, in position to engage respective opposite sides of the center leg 43 of the core 33, and are secured in such position on the core 33 by suitable means such as a bolt 72. The corners of the spool 69 engage respective corners of the center leg 43 of the core 33, also with a press fit. With this construction, the winding 35 is firmly supported on the leg 43 in a manner to effectively guard against vibration or movement of the winding 35 relative to the core 33 during operation of my novel device, while affording clearance between the portions of the spool 69 disposed between adjacent corners thereof and the respective adjacent outer faces of the center leg 43 of the core 33.

The shoe or block 26 is reciprocated by the electromagnet 24 during the operation of my vibratory tool 20, as will be discussed in greater detail hereinafter, and is operable to carry a sheet of sand-paper or a polishing cloth, or the like, on the bottom face thereof in position to effectively perform sanding or polishing operations. The shoe 26 shown in the drawings comprises, in general, a substantially rectangular-shaped plate 73 having a lower face 73*a* on which a substantially complementary-shaped pad 74 is mounted, and an upper face 73*b* on the opposite ends of which are mounted two clamps 76 and 77, respectively. The clamps 76 and 77 are movable between the open position shown in broken lines in Fig. 2 and the closed position shown in solid lines therein, and when disposed in closed position are operable to clampingly engage opposite end portions of a wiping member 79 such as a sheet of sand-paper, polishing cloth, or the like, to thereby hold the wiping member 79 tightly stretched across the lower face of the pad 74 in operable position.

The shoe 26 is preferably of the type disclosed in my co-pending application for United States Letters Patent, Serial No. 394,334, filed November 25, 1953, now Patent No. 2,749,676 but, the specific structure thereof forms no part of my present invention except insofar as it forms a part of my novel combination, and it will be appreciated by those skilled in the art that other suitable shoes or blocks may be substituted for the shoe 26 without departing from the purview of my present invention.

The supporting members 28 and 29, Figs. 2 and 3, comprise elongated leaf springs mounted on the armature 36 and the core 33, respectively. The supporting member 28 is curved in shape, Fig. 3, being concave rearwardly, and has an upper end portion 28*a* attached to the lower end portion of the rear wall 61 of the housing 53 on the armature 36, by suitable means such as rivets 80, and has a lower end portion 28*b* attached to the upper face of the plate 73 of the shoe 26 at the rear end portion thereof, and inwardly of a clamp 76, by suitable means such as rivets 83.

The supporting member 29, Figs. 2 and 3, comprises an elongated leaf spring 81, and a second leaf spring 82 mounted on the upper end portion of the leaf spring 81 in juxtaposition thereto, and is fixedly secured in such position by suitable means such as rivets 84. The upper end portions of the leaf springs 81 and 82 are adjustably mounted in supporting brackets 94 and 95 mounted on

the front wall 48 of the housing 44 on the core 33, as will be discussed in greater detail presently.

The lower end portion 81*a* of the leaf spring 81 is curved in shape, being concave rearwardly, and has a lower end portion 81*b* connected to the upper face of the plate 73 of the shoe 26 inwardly of the clamp 27, by suitable means such as rivets 85.

The clamps 94 and 95, Figs. 2 and 3, are identical and each includes, Figs. 7 and 8, a backing plate 96 and a front plate 99, and is mounted on the upper end portion of the supporting member 29, with the latter disposed between the plates 96 and 99. A slot 100 is formed in the upper end portion of the two leaf springs 81 and 82, and a similar slot 102 is formed in the upper end portion of the end wall 48 of the housing 44 on the core 33. The supporting member 29 when disposed in operative position, is mounted on the end wall 48 in such position that the slots 100 and 102 are disposed in parallel alignment with each other.

Each of the clamps 94 and 95 includes a bolt 106, Figs. 2, 3, 7 and 8, which extends through the slot 102 in the end wall 48, the backing plate 96, the slot 100 in the supporting member 29, and the front plate 99, Fig. 8. A nut 108 is mounted on the bolt 106 and may be adjusted thereon to effectively clamp the end wall 48, clamping plates 96 and 99, and the upper end portion of the supporting member 29 together to thereby releasably secure the supporting member 29 in operative position on the end wall 48 of the housing 44 of the core 33. It will be seen that with this construction, the position of the supporting member 29 may be readily adjusted relative to the end wall 48, and the position of the clamps 94 and 95 may be readily adjusted relative to the end wall 48 and the supporting member 29.

Thus, for example, I normally prefer to assemble my novel vibratory tool 20 in such a manner that the upper edge of the clamp 94 and the upper edge of the supporting member 29 are disposed in horizontal alignment with the upper edge of the housing 44. However, if desired for the proper adjustment of my novel tool, the supporting member 29 may be readily moved upwardly or downwardly relative to the clamp 94 and the rear wall 48, or the clamp 94 may be readily moved downwardly relative to the supporting member 29 and the rear wall 48, or a combination of both adjustments may be made.

With this ready adjustment of either the supporting member 29, or the clamp 94, or both, relative to the end wall 48, it will be seen that I have afforded effective means for adjusting for variations in manufacturing tolerances for the various parts of my novel tool such as, for example, in the forming of the supporting members 28 and 29, and in the location of mounting holes in the supporting members 28 and 29 and the parts to which they are attached, so as to insure the normal "at rest" positioning of the armature 36 relative to the core 33.

After the supporting member 29 and the clamp 94 have been moved into desired operative position on the end wall 48, the clamp 95 may then be adjusted to properly "tune" the tool 20. This may normally be accomplished by moving the clamp 95 into position wherein the device is tuned to produce maximum throw of the shoe 26 and maximum power, and then moving the clamp 95 into the position wherein, with the tool turned "off", the force necessary to manually hold the shoe 26 in forwardly disposed position equivalent to the aforementioned maximum throw of the shoe 26 is between fifteen and twenty per cent less than was necessary to so hold the shoe 26 when the clamp 95 was disposed in the "tuned" position.

With this construction, the clamp 95 affords ready adjustment of the spring tension and ready tuning of the device, and provides ready compensation for variations which may occur in the thickness, forming, or tempering of the supporting member 29. Also, it affords an effective adjustment for compensating for fatigue in the springs 81 and 82 which may occur with repeated use, the clamp

95 being readily moved downwardly on the supporting member 29 when such fatigue occurs to thereby restore the desired operating characteristics of the supporting member 29.

The casing 22 comprises two elongated substantially cup-shaped sections 22*a* and 22*b* which are substantially mirror images of each other. Each of the sections 22*a* and 22*b*, Figs. 2 and 3, embodies a boss or shelf 97 projecting inwardly from the longitudinal center portion of the bottom edge 31 thereof. Also, each of the sections 22*a* and 22*b* embody bosses 98 which project downwardly from the upper walls thereof. The electromagnet 24 is disposed in the casing 20 and rests on the shelves 97 and is snugly engaged with the bosses 98. With the electromagnet 24 so disposed in the casing 22, the two sections 22*a* and 22*b* may be firmly and releasably secured together by suitable means such as bolts 101 to thereby effectively support the electro-magnet 24 in the casing 22.

Lead wires 103, which may be connected to a suitable source of power, extend inwardly through the rear end portion of the casing 22 and are connected through a switch 104 to the windings 35 of the electro-magnet 24. The switch 104 is conveniently mounted on the front end portion of the casing 22 and has a switch actuating member 104*a* projecting outwardly from the casing for ready control of the switch 104 by the operator of the vibratory tool 20.

In my novel vibratory tool 20, the electro-magnet 24 is so constructed that an effective path is afforded for the field of flux through the core 33 and the armature 36; the armature 36 is operable to effect a maximum movement of a work-tool, such as the shoe 26, with a relatively slight opening and closing of the gap between the armature 36 and the core 33; and the magnetic attraction between the core 33 and the armature 36, during inward movement of the armature 36, is such that a pull of relatively great force is applied to the armature. In this novel device, the windings 35 preferably cover the entire center leg 43 of the core 33, extending along the entire length of the leg 43 from the rear edge thereof to the rear edge of the base leg 38 of the core 33.

During operation of the tool 20, the center leg 56 moves into and out of the winding 35, and the legs 56 and 55 on the armature 36 move into and out of alignment with the legs 43 and 42, respectively, on the core 35 in a novel and expeditious manner as will be discussed in greater detail presently.

As is best seen in Figs. 3 and 4, the rear end faces 42*a* and 43*a* of the lower leg 42 and the center leg 43, respectively, of the core 33, and the adjacent front faces 55*a* and 56*a* of the lower leg 55 and the center leg 56, respectively, of the armature 36, are curved in shape, the faces 42*a* and 43*a* being concave rearwardly in shape, and the faces 55*a* and 56*a* being convex forwardly and being preferably complementary in shape to the faces 42*a* and 43*a*, respectively.

In the preferred form of my invention shown in the drawings, the radii of the arcs forming the faces 42*a* and 43*a* are equal in length but have different radial centers, the radial center of the arc 42*a* being disposed on a vertical line which is closer to the pin 67 than is the vertical line on which the radial center of the arc 43*a* is disposed. It will be remembered, of course, that the longitudinal axis of the pin 67 forms the center of rotation of the armature 36.

With this construction, the movement of the lower leg 55 directly away from the leg 42*a* during opening movement of the armature 36 is greater than that of the center leg 56 directly away from the leg 43.

In forming the faces 42*a*, 43*a*, 55*a* and 56*a*, each is preferably of such a shape as would be produced if the armature 36 and the core 33 constituted a single piece of material and the lines 43*a*—56*a*, and 42*a*—55*a* were struck off thereon and the legs 43 and 56, and the legs 42 and 55, were separated along those respective lines. In fact, that is the manner in which I prefer to actually construct the armature 36 and the core 33, namely, to simultaneously stamp one of the laminae 52 and one of the laminae 37 from a single sheet of iron, with the line of separation between the two laminae forming complementary-shaped abutting surfaces therebetween.

In my novel vibratory tool 20, I prefer to dispose the bearing 65 and the pin 67 in such position that when the armature 36, mounted thereby between the ears 49*c* and 50*c*, is disposed in normal fully closed position, as shown in solid lines in Fig. 4, the upper end portion of the armature 36, and the faces 55*a* and 56*a* on the armature 36 are spaced rearwardly from the rear face of the leg 41, and the faces 42*a* and 43*a*, respectively, on the core 33 a distance to insure free swinging movement of the armature 36 relative to the core 33 and to provide clearance for any over-swinging of the armature 36 which may occur during any normal operation of my novel tool 20. In a tool constructed in the manner in which my novel tool 20, shown in the accompanying drawings, is constructed, I prefer that, in normally closed position of the armature 36 as shown in solid lines in Fig. 4, the spacing between the faces 55*a* and 42*a* be less than that between the upper end portion of the armature 36 and the rear face of the leg 41 of the core 33, and that the spacing between the faces 56*a* and 43*a* be less than that between the faces 55*a* and 42*a*. Thus, for example, in a vibratory tool of the character of the tool 20, wherein the legs 41 and 42 of the core 33 and the leg 55 of the armature 36 are seven-sixteenths of an inch in vertical width, the legs 43 of the core 33 and the leg 56 of the armature 36 are seven-eighths of an inch in vertical width, and the horizontally extending center-lines of the legs 55 and 56 are vertically spaced from the axial center of the bearing 65 distances of two and three-sixteenths inches and one and three-thirty-seconds inches, respectively. I prefer that the aforementioned spacing between the upper end portion of the armature 36 and the rear face of the leg 41 of the core 33, the spacing between the faces 42*a* and 55*a*, and the spacing between the faces 43*a* and 56*a*, be ten-thousandths of an inch, five-thousandths of an inch and twenty-five ten-thousandths of an inch, respectively.

Such spacing is made possible by the novel construction of my novel tool 20 and, particularly, by the construction and arrangement of the armature 36 and the core 33 which will now be discussed in greater detail.

To insure proper movement of the armature 36 relative to the core 33, the radial center of any point on either of the arcs 42*a* and 43*a* is disposed either on the line intersecting that point and the point where the center of rotation of the armature 36 would be if the armature 36 were disposed in juxtaposition to the rear end of the core 33, without the initial gap therebetween, or is disposed rearwardly from that line. Also, in all instances, the radial line of the longitudinal center point of each of the arcs 42*a* and 43*a* in tools embodying my invention are disposed below the horizontally extending diameter of the circle of which the arc 42*a* and 43*a* forms a part, and the arc 42*a* or 43*a* terminates at its upper and lower ends at or forwardly of the respective upper and lower tangential horizontal line of the circle of which the respective arc 42*a* or 43*a* forms a part, and on the same side of the center of rotation of the armature.

With such construction, the faces 55*a* and 56*a*, during operative movement outwardly from the core 33, in all instances tend to swing, at least partially, along parallel to the faces 42*a* and 43*a*, respectively, instead of moving directly away from the latter. It will be seen that, by having the radial centers of the arcs 42*a* and 43*a* coincide exactly with the center of rotation of the armature 36, the faces 52*a* and 53*a* may be caused to travel along paths exactly parallel to the faces 42*a* and 43*a*. However, it will be remembered that in my preferred construction, the radial centers of both the faces 52*a* and 53*a*

are disposed rearwardly of the line running from the most forward point on that arc 52*a* or 53*a* to the center of rotation of the armature 36, and the radial center of the arc 42*a* is disposed a lesser horizontal distance rearwardly of the center of rotation of the armature 36 than is the radial center of the arc 43*a*. Thus, for example, with the core 33 and armature 36 constructed with the dimensions heretofore set forth, a highly practical arrangement of the arcs 42*a* and 43*a* is one wherein the radii of the arcs 42*a* and 43*a* are each 2.419 inches in length with the arcs 42*a* and 43*a* so disposed in the legs 42 and 43 of the core 33 that when the core 36 is disposed in such position relative to the core 33 that the upper end portion of the armature 36 is disposed in abutting engagement with the rear face of the leg 41, and the faces 55*a* and 56*a* are disposed in abutting engagement with the faces 42*a* and 43*a*, respectively, the radial center of the arc 43*a* is disposed .376 inch above and 1.243 inches rearwardly of the longitudinal axis of the bearing 65, and the radial center of the arc 42*a* is disposed .112 inch below and .537 inch rearwardly of the longitudinal axis of the bearing 65.

With this construction, when the top of the shoe 26 is disposed 2.89 inches below the longitudinal axis of the bearing 65 in my novel vibratory tool 20, the armature 36 is effective to move the shoe 26 horizontally a distance of one-eighth of an inch with only approximately .024 inch of movement of the face 55*a* directly toward and away from the face 42*a*. During such swinging movement of the armature 36 the face 56*a* moves approximately .019 inch in a direction directly toward and away from the face 43*a*. Hence, it will be seen that with my novel invention, the legs 55 and 56 of the armature 36 remain in relatively close proximity to the legs 42 and 43, respectively, of the core 33 during a relatively great throw of the shoe 26 even though the shoe 26 is disposed relatively close to the center of the bearing 65. Such construction retains the armature 36 at all times during the oscillation thereof in the area of strong attraction to the core 33 and affords a novel, powerful and compact vibratory tool.

As is best seen in Figs. 3 and 4, the central legs 43 and 56 of the core 33 of the armature 36 are substantially twice the width of the outer legs 41 and 42 of the core 33. This, it will be seen, affords an effective path for the two fields of flux in the upper and lower portions, respectively, of the core 33 and because of the relatively larger size of the central legs 43 and 44 and their closer proximity to each other, when the armature 36 is disposed in open position relative to the core 33, the attraction between the legs 43 and 56 is relatively high.

During movement of the armature 36, in my novel electromagnet 24, the legs 55 and 56 of the armature 36 move inwardly and outwardly relative to the winding 35. In all positions of the armature 36 during operation of the latter, the leg 56 projects into the windings 35 and the leg 55 projects forwardly past the rear edge of the windings 35. Hence, a good path is provided for the magnetic field established in the core 33 and the armature 36 at all times during the operation of my novel tool 20.

In adjusting my novel tool 20, the supporting members 28 and 29 are of such strength, and the supporting member 29 is so adjusted on the brackets 94 and 95, that in the normal closed position of the armature 26, the legs 55 and 56 are disposed in substantially longitudinal alignment with the legs 42 and 43 of the core 33. However, as is best seen in Fig. 5, the upper inner face of the spool 69 of the winding 35 is disposed in spaced relation to the upper face of the leg 56 of the armature 36 and this provides additional clearance, preferably, in the nature of twenty-thousandths of an inch, between the leg 56 and the windings 35 so that slight overswinging of the armature 36 past normal closed position thereof, during operation of my novel device, will not cause the leg 56 to strike the spool 69.

It will be noted that when the armature 36 is disposed in normal closed position, the leg 54 thereof is disposed in substantially vertical position, parallel to the leg 38 of the core 33.

In the operation of my novel device 20, a suitable sanding or polishing sheet 79, or the like, may be mounted on the shoe 26, and, with the lines 103 connected to a suitable source of electric power, the switch actuating member 104*a* may be moved to close the switch 104 and energize the electro-magnet 24. Energization of the electro-magnet 24 is effective to cause the armature 36 to oscillate on the bearing 65 and thereby reciprocate the shoe 26.

During operation of my novel device 29, as the armature 36 swings rearwardly from the aforementioned fully closed position, the rear face thereof, to which the supporting member 28 is secured, swings around the bearing 65 away from the core 33 and, through the supporting member 28, carries the shoe 26 with it. The main body of the armature 36 moves away from the core 33 but the faces 55*a* and 56*a* of the legs 55 and 56 do not move a corresponding distance away from the legs 42 and 43 of the core 33 but swing somewhat along the faces 42*a* and 43*a* of the core 33 so that even for a maximum rearward movement of the armature 36, as a whole, relative to the core 33 the faces 56*a* and 55*a* are separated from the faces 43*a* and 42*a*, respectively, a substantially lesser amount. Hence, during reversal of the magnetic field in the core 33 of the armature 36, the ends of the legs 43 and 56, and the legs 42 and 55, are disposed relatively close to each other and the attraction between the armature 36 and the core 33 is relatively great. In this manner, I have afforded a novel electro-magnet 24 which is powerful in operation and is especially effective for reciprocating work tools such as, for example, a shoe for use as a sanding or polishing device, or the like.

Such movement of the armature 36 is effective to reciprocate the shoe 26 in a substantially horizontal plane. Such transformation of swinging or arcuate motion into substantially straight-line motion is effected by the novel manner in which the parts of my novel tool are constituted and arranged. Thus, for example, it will be remembered that the armature, when in closed position, is preferably disposed in vertical position so that during the relatively short oscillation of the armature 36, the upward or downward movement of any point thereon is substantially minimized. Also, it will be seen that the novel construction and arrangement of the supporting members 28 and 29 tend to prevent upward or downward movement of the shoe 26 during operative oscillation of the armature 36 as is disclosed in greater detail in my aforementioned co-pending application for United States Letters Patent, Serial No. 394,334.

From the foregoing it will be seen that I have afforded a novel vibratory tool which is effective in operation and wherein the parts thereof are constituted and arranged in a novel and expeditious manner.

Thus, while I have illustrated and described the preferred embodiment of my invention, it is to be understood that this is capable of variation and modification, and I therefore do not wish to be limited to the precise details set forth, but desire to avail myself of such changes and alterations as fall within the purview of the following claims.

I claim:

1. A vibratory tool comprising an electro-magnet including a core, a winding mounted on said core, an armature having an elongated leg, and two other legs projecting from respective portions of said elongated leg in substantially parallel spaced relation to each other and in a direction transverse to the length of said elongated leg, each of said other legs having a convex arcuate-shaped face on one end thereof, said core having two concave arcuate-shaped faces thereon, each of said concave faces being substantially complementary to a respective one of

said convex faces, pivot means pivotally connecting one end of said elongated leg to said core in position wherein each of said convex faces is disposed adjacent to and in oppositely facing direction to a respective one of said concave faces, said armature being pivotable on said pivot means through a path of travel wherein said elongated leg swings toward and away from said core and one of said other legs moves into and out of said winding, the radii of said arcuate-shaped convex and concave faces being so disposed relative to said core that during said pivoting of said armature through said path of travel the distance between said portions of said elongated leg and said core varies more than the distance between said convex faces on said other legs projecting from said respective portions and said respective concave faces, and work means mounted on the other end of said elongated leg and movable thereby upon said pivotal movement of said armature.

2. A vibratory tool comprising an electro-magnet including a susbtantially E-shaped core including two elongated legs, each of said legs having an arcuate-shaped end face, and an armature pivotally mounted relative to said core for oscillation toward and away from said core upon operation of said electro-magnet, said armature having two other elongated legs, each of said other legs having an arcuate-shaped face facing a respective one of said first mentioned faces, said armature being so disposed relative to said core that during said oscillation of said armature said legs on said armature move toward and away from longitudinal alignment with said legs on said core and said faces on said armature move toward and away from aligned oppositely disposed relation to said respective ones of said first mentioned faces in a direction to reduce and enlarge the air gaps therebetween, and work means mounted on said armature for movement thereby during said oscillation of the latter.

3. A vibratory device comprising an electro-magnet including a substantially E-shaped core including two elongated legs, a winding mounted on one of said legs, each of said legs having an arcuate-shaped end face, and an armature pivotally mounted for swinging movement toward and away from said core upon operation of said electro-magnet, said armature having two other elongated legs, each of said other legs having an arcuate-shaped end face substantially complementary in shape to said face on a respective one of said first mentioned legs, each of said other legs projecting toward a respective one of said first mentioned legs with said face on each of said other legs facing said face on said respective first mentioned leg, said armature being so disposed relative to said core that upon said swinging movement of said armature said end faces on said armature move toward and away from aligned oppositely disposed relation to said respective end faces on said core in a direction to reduce and enlarge the air gap therebetween, and said leg on said armature which projects toward said leg of said core on which said winding is mounted moves inwardly and outwardly relative to said winding, and work means mounted on said armature for movement thereby during said swinging movement of the latter.

4. A vibratory device comprising an electro-magnet comprising a substantially E-shaped core having two elongated end legs and an elongated center leg disposed between said end legs, said legs being substantially parallel to each other, a winding mounted on said center leg between said end legs, and an elongated substantially F-shaped armature having an elongated end leg and an elongated other leg substantially parallel to each other, one end portion of said armature being disposed adjacent to one of said end legs of said core, means pivotally mounting said armature for swinging movement around said one end portion toward and away from said core, the other of said end legs on said core and said center leg on said core each having a substantially arcuate-shaped end face, said end leg on said armature and said other leg on said armature each having a substantially arcuate-shaped end face substantially complementary in

shape to said end face on said other end leg and said center leg on said core, respectively, said end face on said end leg on said armature and said end face on said other leg on said armature facing toward said faces on said other end leg and said center leg, respectively, said armature being so disposed relative to said core that upon said swinging movement of said armature said end faces on said armature move perpendicularly toward and away from said faces on said core and toward and away from aligned oppositely disposed relation to said respective end faces on said core, and said other leg on said armature moves inwardly and outwardly relative to said winding, and work means mounted on said armature for movement thereby during said swinging movement of the latter.

5. A vibratory device comprising an electro-magnet comprising a substantially E-shaped core having two elongated end legs and an elongated center leg disposed between said end legs, said legs being substantially parallel to each other, a winding mounted on said center leg between said end legs, and an elongated substantially F-shaped armature having an elongated end leg and an elongated other leg substantially parallel to each other, one end portion of said armature being disposed adjacent to one of said end legs of said core, means pivotally mounting said armature for swinging movement around said one end portion toward and away from said core, the other of said end legs on said core and said center leg on said core each having a substantially arcuate-shaped end face, said end leg on said armature and said other leg on said armature each having a substantially arcuate-shaped end face substantially complementary in shape to said end face on said other end leg and said center leg on said core, respectively, said end face on said end leg on said armature and said end face on said other leg on said armature facing toward said face on said other end leg and said center leg, respectively, said armature being so disposed relative to said core that upon said swinging movement of said armature said end faces on said armature move perpendicularly toward and away from said faces on said core and toward and away from aligned oppositely disposed relation to said respective end faces on said core, and said end leg and said other leg on said armature move toward and away from longitudinal alignment with said other end leg and said center leg, respectively, and said other leg on said armature moves into and out of said winding, and work means mounted on said armature for movement thereby during said swinging movement of the latter.

6. A vibratory device comprising an electro-magnet including a core having two arcuate-shaped faces, and an armature pivotally mounted for swinging movement toward and away from said core upon operation of said electro-magnet, said armature having two other arcuate-shaped faces, each of said other arcuate-shaped faces being substantially complementary in shape to a respective one of said first mentioned faces and being disposed in facing relation thereto, said armature being so disposed relative to said core that the radial center of the arc of one of said first mentioned faces is disposed closer to the center of rotation of said armature than is the radial center of the arc of the other one of said first mentioned faces and during said swinging movement of said armature each of said other faces move perpendicularly toward and away from said respective one of said first mentioned faces, and work means mounted on said armature for movement thereby during said swinging movement of the latter.

7. A vibratory device as defined in claim 6 and in which the radius on which said face on said armature facing said one first mentioned face swings during said swinging movement of said armature is greater than the radius on which said face on said armature facing said other first mentioned face swings.

8. A vibratory device as defined in claim 7 and in which the radii of the arcs of said first mentioned arcuate-shaped faces are substantially equal.

9. A vibratory device as defined in claim 8 and in which the radial center of the arc of said one of said first mentioned faces is disposed below the horizontal line of said center of rotation of said armature, and in which the radial center of the arc of said other of said first mentioned faces is disposed above the horizontal line of said center of rotation of said armature.

10. A vibratory device comprising an electro-magnet comprising a substantially E-shaped core having two elongated end legs and an elongated center leg disposed between said end legs, said legs being substantially parallel to each other, a winding mounted on said center leg between said end legs, and an elongated substantially F-shaped armature having an elongated end leg and an elongated other leg substantially parallel to each other, one end portion of said armature being disposed adjacent to one of said end legs of said core, means pivotally mounting said armature rearwardly of said core for swinging movement around said one end portion toward and away from said core, the other of said end legs on said core and said center leg on said core each having a substantially arcuate-shaped end face, said end leg on said armature and said other leg on said armature each having a substantially arcuate-shaped end face substantially complementary in shape to said end face on said other end leg and said center leg on said core, respectively, said end face on said end leg on said armature and said end face on said other leg on said armature facing toward said face on said other end leg and said center leg, respectively, the arcs of said faces on said core being of such a size and being so disposed therein that the radial center of each of said arcs disposed rearwardly of a straight line extended between any point on said arc and the center of rotation of said armature.

11. A vibratory device comprising an electro-magnet comprising a substantially E-shaped core having two elongated end legs and an elongated center leg disposed between said end legs, said legs being substantially parallel to each other, a winding mounted on said center leg between said end legs, and an elongated substantially F-shaped armature having an elongated end leg and an elongated other leg substantially parallel to each other, one end portion of said armature being disposed adjacent to one of said end legs of said core, means pivotally mounting said armature rearwardly of said core for swinging movement around said one end portion toward and away from said core, the other of said end legs on said core and said center leg on said core each having a substantially arcuate-shaped end face, said end leg on said armature and said other leg on said armature each having a substantially arcuate-shaped end face substantially complementary in shape to said end face on said other end leg and said center leg on said core, respectively, said end face on said end leg on said armature and said end face on said other leg on said armature facing toward said face on said other end leg and said center leg, respectively, the arcs of said faces on said core being of such a size and being so disposed therein that the radial center of each of said arcs is not disposed forwardly of a straight line extended between any point on said arc and the center of rotation of said armature.

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