March 13, 1956 R. W. BACHI ET AL 2,738,451

SOLENOID WITH HINGED CORE

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Fig. 1.

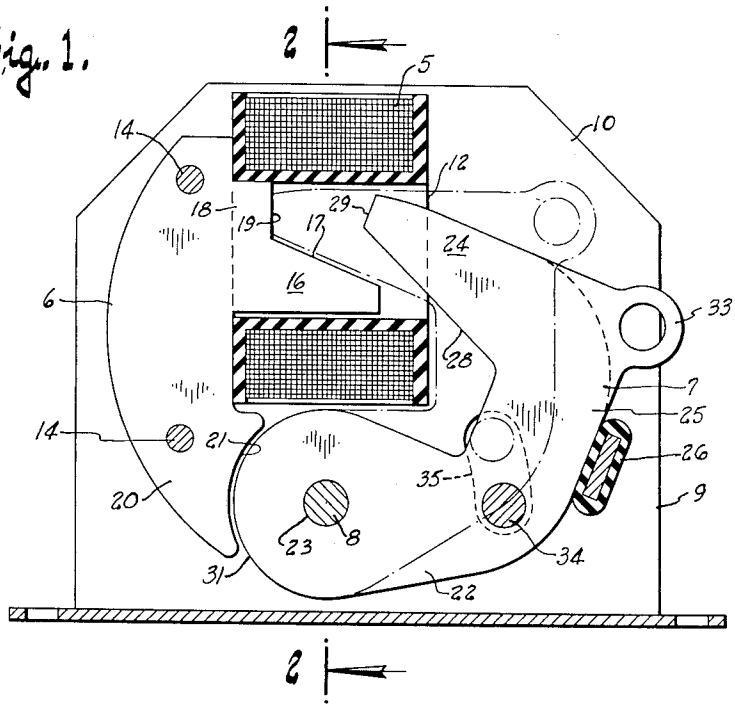
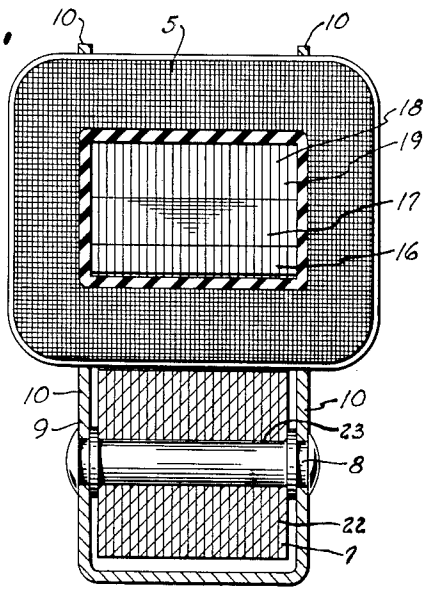


Fig. 2.



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Fig. 3.

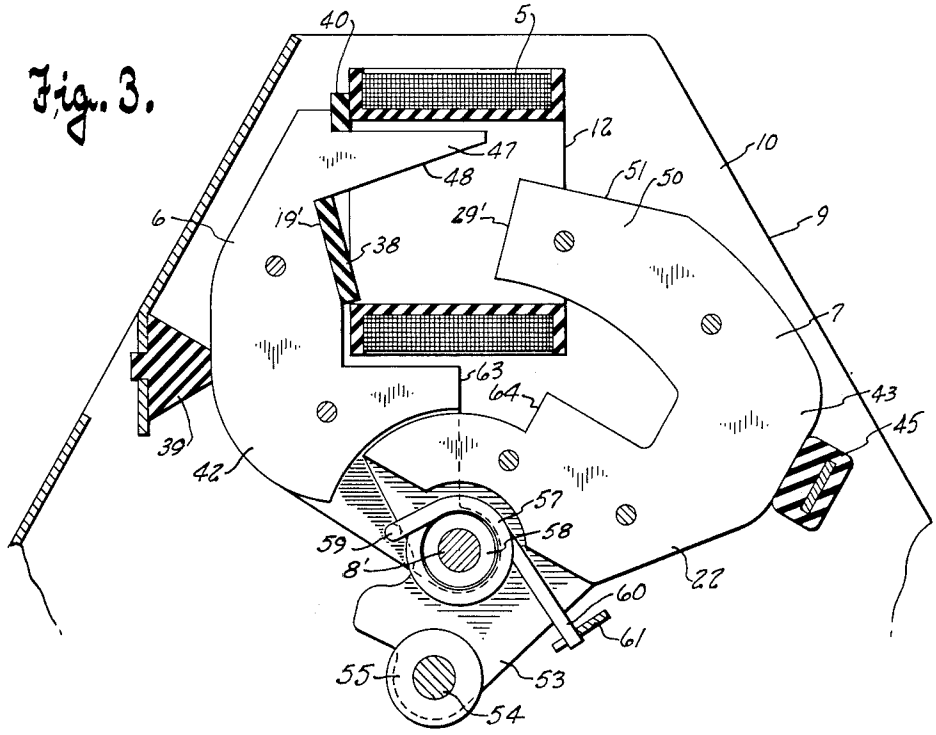
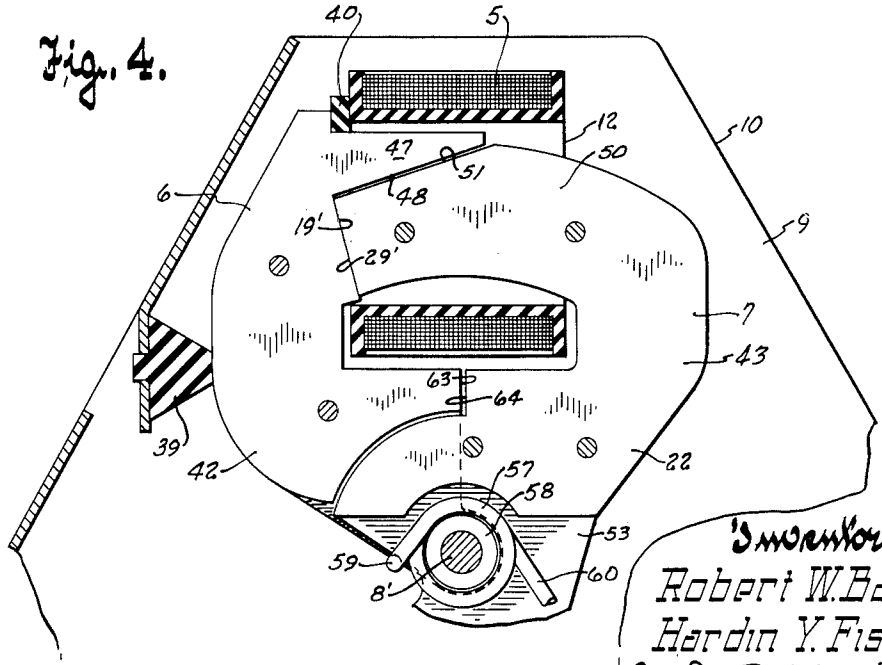


Fig. 4.



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Fig. 5.

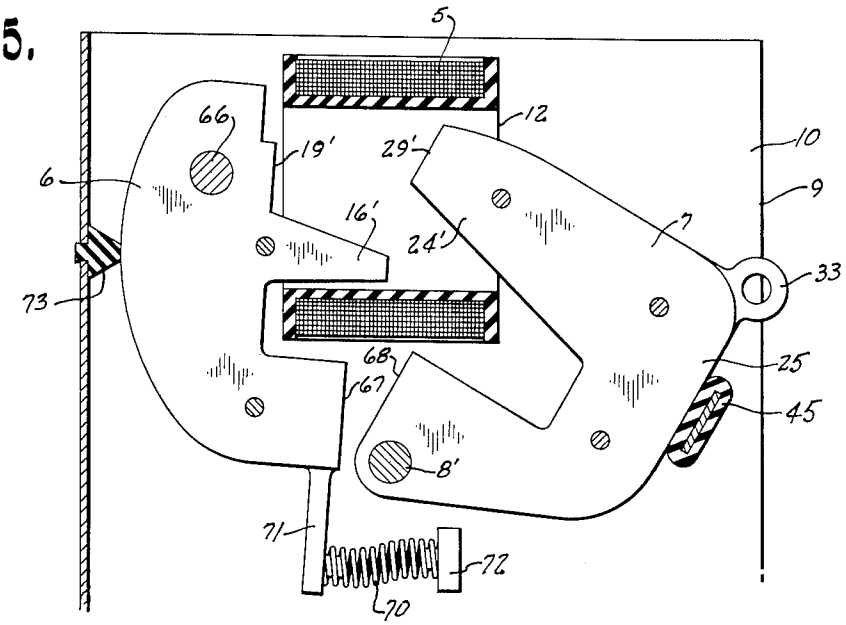
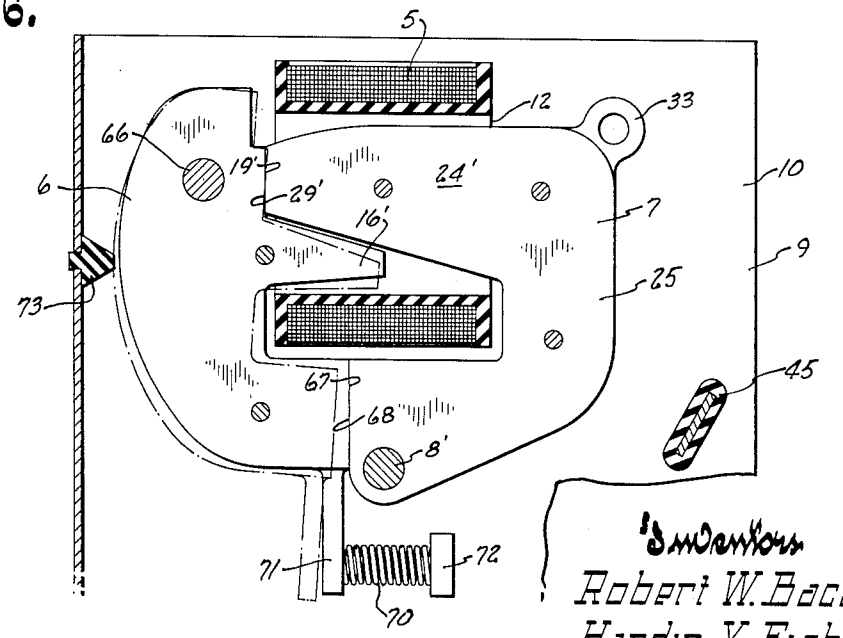


Fig. 6.



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SOLENOID WITH HINGED CORE

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Application May 16, 1952, Serial No. 288,262

2 Claims. (Cl. 317—197)

This invention relates to hinged core solenoids on the order of the alternating current solenoids forming the subject of the copending application of Robert W. Bachi, Serial No. 288,263 filed May 16, 1952, now Patent No. 2,692,965, but has more particular reference to solenoids intended for direct current service.

It has been customary in the past to provide direct current solenoids with a cylindrical armature or plunger slidable endwise through an opening in a magnetically permeable frame and projecting into the hollow interior of a winding embraced by the frame. In most instances it has been necessary to provide cooperating "coned" surfaces on the inner end of the plunger and the frame carried stop engaged thereby in the attracted position of the plunger. The purpose of such coning is to provide the greatest possible area of air gap between the plunger or armature and its stop, in the retracted position of the plunger, and at the same time reduce the effective length and the reluctance of the air gap so as to obtain maximum pull on the plunger in the retracted position thereof.

Plungers or armatures for direct current solenoids of the type herein concerned are constrained to back and forth reciprocatory motion in the winding, and for this purpose a tubular non-magnetic armature guide is usually confined inside the winding to slidably receive the armature. Unless the guide is accurately made and carefully aligned with the conical surface of the armature stop, the conical surfaces of the armature and stop will engage eccentrically before the armature reaches its fully attracted position. This condition of contact between the armature and its stop, before final seating of the armature takes place, is also frequently encountered whenever the armature fits too loosely in its guide and the conical surfaces on the armature and stop have relatively long tapers. Under these conditions, efficient operation of the solenoid is impossible as friction between the conical surfaces of the armature and its stop may seriously reduce the pull of the armature on the load connected therewith. The armature may even stick in a partially open position due to excessive friction brought about by the eccentric engagement between the conical surfaces on the armature and stop.

Moreover, if the armature guide does not hold the armature exactly coaxial with its stop, which it cannot do as long as operating clearances for the armature must be provided in the guide, the armature is drawn radially against one side of the guide along the entire length of the armature projecting thereinto. In some cases the friction between the armature and guide which results from such lateral shifting of the armature in extended positions thereof can exceed the pull of the solenoid itself. This tendency of the armature to shift laterally into contact with the side wall of the guide, of course, subjects the armature to unbalanced radial magnetic forces which increase the friction between the side of the armature and its guide proportionately to the amount of unbalance.

It is, therefore, the primary object of this invention to provide a solenoid especially suited for direct current service in which the objections discussed above are eliminated so as to assure maximum tractive effort of the armature in either the extended or attracted position of the same.

In accordance with the foregoing object, it is one of the purposes of this invention to provide a direct current solenoid wherein the armature is mounted to swing about an axis fixed with respect to the winding so as to enable a portion of the armature to move along a very accurate path into the interior of the winding without the need for a guide such as was formerly required for the armature. Consequently, friction tending to oppose attraction of the armature can be held to a minimum by the provision of a good pivot bearing for the armature.

More particularly it is a purpose of this invention to provide a direct current solenoid wherein the benefits of "coning" of the armature and the stator carried stop for the armature are achieved without the necessity of machining conical surfaces on the armature and the stator. According to this invention, this is achieved through the provision of a core including a stator and an armature each comprised of a bank of flat laminae having pole portions thereon projecting into the opposite ends of the winding to occupy laterally adjacent overlapped positions inside the winding in either the retracted or the attracted position of the armature. These pole portions preferably are taperingly reduced toward their extremities to provide flat opposing beveled surfaces on their overlapping sides. Though these beveled surfaces are functional equivalents of the conventional conical surfaces employed in D. C. solenoids in the past, the fact that they are employed in a solenoid having a hinged armature makes it possible for the armature to have a longer work stroke and a higher initial pull than could be obtained in a conventional solenoid with the same coil length.

Due to the provision of the laminated magnetically permeable armature and stator, therefore, it is also possible to have any desired degree of taper on the pole portions without the necessity for machining them. In other words, the tapered pole portions which correspond to the coning of the plunger and stop of the conventional solenoid can be formed by assembling stacks of flat stamped armature and stator laminae each of which has an integral pole portion thereon provided with the same degree of taper along one edge.

A further purpose of this invention is to provide a direct current solenoid which will also operate satisfactorily with alternating current. In this respect it is a more specific object of this invention to provide the solenoid with a magnetically permeable laminated core having a stator and an armature of the type described, both of which are mounted for pivotal motion with respect to the winding and have pole faces formed thereon to engage with one another both inside and outside of the winding in the attracted position of the core parts to afford a completely closed magnetic circuit about the winding. The purpose of the closed magnetic circuit is to insure against chattering of the core parts in their attracted positions and to achieve maximum hold-in power regardless of whether the winding is energized by direct or alternating current. It is to be understood, of course, that the core parts are provided with laterally overlapping pole portions, projecting into opposite ends of the winding and having a taperingly reduced cross section, to assure a high initial pull on the armature. This type of solenoid is disclosed but not specifically claimed in the copending application of Robert W. Bachi and Hardin Y. Fisher, Serial No. 270,924 filed February 11, 1952,

and relating to an electromagnetically operated latch mechanism.

With the above and other objects in view, which will appear as the description proceeds, this invention resides in the novel construction, combination and arrangement of parts substantially as hereinafter described and more particularly defined by the appended claims, it being understood that such changes in the precise embodiment of the hereindisclosed invention may be made as come within the scope of the claims.

The accompanying drawings illustrate several complete examples of the physical embodiments of the invention constructed according to the best modes so far devised for the practical application of the principles thereof, and in which:

Figure 1 is a view of a solenoid embodying the principles of this invention, and showing the same partly in section and partly in elevation;

Figure 2 is a cross section view taken through Figure 1 along the plane of line 2—2;

Figure 3 is a view similar to Figure 1 but showing a modified embodiment of the solenoid which is suitable for either A. C. or D. C. momentary duty;

Figure 4 is a view similar to Figure 3 showing a further slightly modified form of the solenoid of this invention;

Figure 5 is a view somewhat similar to Figure 4 but showing a still further modified embodiment of the invention; and

Figure 6 is a view similar to Figure 5 but showing the core elements in attracted position.

Referring now more particularly to the accompanying drawings in which like reference characters represent like parts throughout the several views, the numeral 5 designates an annular winding having a magnetically permeable core comprising a stator 6 at one end of the winding and an armature 7 at the opposite end of the winding and pivotally supported on a pin 8, these parts being carried by a substantially U-shaped supporting bracket 9 between the opposite upright legs 10 thereof.

The coil 5 is received in opposite substantially rectangular holes 12 in the legs 10 of the bracket and is secured thereto in any suitable manner (not shown) with the axis of the winding midway between and parallel to the upright legs 10 of the bracket.

The stator 6 comprises a bank of flat identical laminae secured flatwise together as by rivets or other suitable fastening means (not shown), fixedly mounted on the frame between the legs 10 thereof as by rivets 14 passing through the bank of laminae with their ends fixed in the legs of the supporting bracket.

The stator overlies and substantially closes one end of the winding and has a pole portion 16 thereon projecting into the hollow interior of the winding to occupy the lower half thereof. The pole portion is taperingly reduced in cross section toward its extremity which lies near the opposite end of the winding. Though not essential, the pole portion 16 is shown as uniformly reduced in cross section toward its extremity so as to provide a flat beveled surface 17 thereon facing the axis of the winding and disposed at an angle thereto. For the purposes of this invention, however, the surface 17 may have lengthwise curvature.

It is important to note that the pole portion 16 is enlarged at its base, as at 18, to substantially fill the adjacent end of the winding. The enlarged portion 18 is shown as projecting a short distance into the winding from the stator, and it has a flat pole face 19 thereon, adjacent to the base of the pole portion 16, and facing the opposite end of the winding, toward the armature. The pole face 19 is preferably, though not necessarily, normal to the axis of the winding.

The stator is also provided with a lateral extension 20 projecting radially downwardly across the adjacent end of the winding to one side thereof. In the present case this extension is provided with a concave pole face 21 facing the pivot pin 8 and concentric to the axis thereof.

The armature 7 is also comprised of a bank of identical laminae secured flatwise together by any suitable means such as rivets (not shown). The armature has a U-shaped configuration, as viewed in side elevation, and one of the legs 22 thereof is provided with an aperture 23 to snugly but rotatably receive the pivot pin 8 so that the armature is mounted for swinging motion with its other leg 24 arranged to travel inwardly and outwardly of the adjacent end of the winding in an accurately defined path.

In the retracted position of the armature shown, the bight portion 25 thereof rests against a cushioned stop 26 carried by the supporting bracket while the pole portion provided by the leg 24 of the armature extends part way into the adjacent end of the winding to overlie the extremity of the pole portion 16 of the stator. The leg 24 is also taperingly reduced in cross section toward its extremity to provide a flat beveled surface 28 on the inner side thereof. The surface 28, of course, is disposed at such an angle that it will closely overlie the surface 17 of the stator pole portion 16 in parallel relationship thereto but will not contact the same in the attracted position of the armature. A flat pole face 29 on the extremity of the leg 24 and opposite the pole face 19 on the stator flatwise engages the latter pole face at the end of the attraction stroke of the armature to define the attracted position thereof, as indicated in construction lines in Figure 1.

Thus it will be noted that in the attracted position of the armature, the pole portions 16 and 24 occupy laterally adjacent overlapping positions inside the winding while the pole faces 19 and 29 have flat surface to surface engagement with one another inside the winding and along a plane substantially normal or crosswise of the axis of the winding.

The extremity of the other leg 22 of the armature through which the pivot pin 8 passes is provided with a rounded surface 31 concentric to the axis of the pin 8 and spaced slightly from the concave surface 21 of the stator, so that these curved surfaces provide pole faces at all times defining a small air gap between the core parts. This air gap, of course, eliminates any tendency for residual magnetism in the core elements to interfere with retraction of the armature following de-energization of the winding. The actual retraction of the armature, as is usual, may be effected by the load connected to the armature. The load may be attached to the armature as by opposite apertured ears 33 thereon formed as extensions of the outer side plates of the bank of armature laminations, as shown, and located at any point on the armature distant from the pivot pin 8.

Alternatively, the load may be connected to a pin 34 anchored in the armature and projecting to the exterior of the supporting bracket through a slot 35 in either or both of the legs 10 thereof. Another simple manner of transmitting the tractive effort of the armature to a load would be to fix the pivot pin 8 to the armature and to extend the pin a distance beyond the bracket so as to enable the securement of a lever or the like thereto.

The solenoid shown in Figure 1 and described hereinabove is designed particularly for direct current "hold in" service. For this type of service, existence of a small air gap in the magnetic circuit around the winding, provided by the core elements in the attracted position of the armature, does not appreciably detract from the magnetic force holding the armature seated. It will also be observed that, compared to the axial length of the winding, the armature has a relatively long attraction stroke and that it will have especially good "pull in" characteristics in its retracted position due to the close proximity of the pole portions of the armature and stator. Moreover though the beveled surfaces 17 and 28 on the pole portions of the armature and stator are the equivalent of

the coned surfaces on the plunger and stop in the conventional direct current solenoid, these surfaces do not need to be machined but can be produced on the core laminations at any desired bevel or angle in a stamping operation to reduce the cost of the manufacture.

Obviously, a direct current solenoid like that shown in Figure 1 can also be used for momentary duty without any difference in operation, but for momentary energization it may be desirable to secure a cushioning pad to one of the pole faces 19 or 29 to achieve more quiet operation. The solenoid illustrated in Figure 3 is like that shown and described but not specifically claimed in the copending application of Robert W. Bachi and Hardin Y. Fisher, Serial No. 270,924 filed February 11, 1952; and differs from the Figure 1 solenoid chiefly in that both the armature and stator are mounted on a pivot pin 8'.

This solenoid is used primarily for the control of a door latch of the type used on refrigerators and the like and is intended for momentary energization by either an alternating or direct current source. For this reason the pole face 19' of the stator is provided with a cushioning pad 38 of rubber or the like to be engaged by the pole face 29' of the armature as the latter approaches its attracted position to cushion the impact of the armature against the stator.

A large bumper 39 of rubber or the like is mounted on a portion of the supporting bracket to engage the outer side of the stator, and this bumper serves the double purpose of holding the stator against the adjacent end of the winding and in cooperation with the pad 38 absorbs the impact of the armature. A third rubber pad 40 is preferably interposed between a portion of the stator and the adjacent end of the winding so that the latter will be protected against damage which might result from any recoil of the stator, such as in bouncing off its bumper 39.

In common with the solenoid illustrated in Figure 1, the solenoid of Figure 3 likewise employs a laminated magnetically permeable stator 42 and a laminated magnetically permeable armature 43. Both have their opposite side plates extended and pivotally mounted on the hinge pin 8' so that the armature may swing from the retracted position shown, defined by its engagement with a cushioning stop 45 carried by the supporting bracket, to an attracted position seating against the cushioning pad 38 on the stator.

The stator pole portion 47, in this case, projects into the adjacent end of the winding to occupy a position in the upper half thereof, remote from the hinge pin 8'; and it is taperingly reduced in cross section toward its extremity to provide a flat beveled surface 48 on its underside facing the axis of the winding but disposed at an acute angle thereto. The cooperating pole portion 50 of the armature is disposed slightly closer to the axis of the hinge pin 8' and has its upper surface 51 slabbed off and beveled to "mesh" with that of the stator as it travels beneath the stator pole portion in the attraction stroke of the armature.

Though the stator is also supported for pivotal motion on the hinge pin 8' such pivotal motion thereof is limited by its confinement between the rubber bumpers 39 and 40 to only that slight amount of motion which is required to absorb the impact of the armature thereagainst during seating of the armature.

For controlling a door latch such as that disclosed in the copending application of Robert W. Bachi and Hardin Y. Fisher, Serial No. 270,924 filed February 11, 1952, the opposite side plates of the armature are extended beyond the axis of the hinge pin 8' and provide a lever 53 by which the tractive force of the armature may be applied to the latch mechanism. In the specific case shown the lever 53 carries a pin 54 having a camming roller 55 freely rotatably mounted thereon to control the latch mechanism.

The armature 43 is also biased under substantial force to its retracted position engaged with the cushioned stop 45 by means of a relatively heavy torsion spring 57 encircling the bushing 58 on the hinge pin 8' by which the armature is mounted on the hinge pin. The torsion spring has one end 59 hooked over an adjacent edge of one of the armature side plates, and has its opposite end portion 60 engaged with a stop 61 carried by the supporting bracket. As disclosed in said copending application, Serial No. 270,924, the lever 53, camming roller 55, and the torsion spring may in effect form part of the latch mechanism to be controlled.

Portions of the stator and armature adjacent to the hinge pin 8' also have opposing flat pole faces 63 and 64, respectively, formed thereon each lying in a plane radial and parallel to the axis of the hinge pin and which pole faces may engage one another flatwise or at least be brought very close together as the armature seats to provide a good magnetic circuit around the winding through the core therefore.

The solenoid illustrated in Figure 4 is in most respects similar to that shown in Figure 3 but is designed to permit flat intimate engagement between the pole faces 29' and 18' on the armature and stator, respectively, inside of the winding, while the external pole faces 63 and 64 may come close together without actually engaging one another. In this case, the cushioning pad 38 used with the previous embodiment of the invention is eliminated, and accordingly the solenoid is better suited for "hold in" duty. If the solenoid of Figure 4 is to be used with alternating current, shading rings (not shown) can be imbedded in the pole faces 19' and 63 of the stator. The torsion spring 57 in this case can be considered strong enough to retract the armature against the forces of residual magnetism existing in the core following de-energization of the winding.

The solenoid shown in Figure 5 is substantially identical to that shown in the copending application of Robert W. Bachi, Serial No. 288,263, filed May 16, 1952. The main difference resides in the provision of pole portions 16' and 24' on the stator and armature, respectively, projecting into the opposite ends of the winding similarly to the pole portions on the core parts of the Figure 1 solenoid, to occupy laterally adjacent overlapping positions inside the winding upon energization thereof. Both the stator and the armature are mounted for swinging motion in response to energization of the winding, but while the armature swings about a hinge pin 8' located exteriorly of the winding to one side thereof as in Figure 1 embodiment, the stator is mounted to swing about another pivot pin 66 having its ends received in the opposite legs of the supporting bracket and passing through the bank of stator laminations to mount the same for swinging motion about an axis parallel to that of the hinge pin 8' but closely adjacent to the axis of the winding 5.

Consequently, the lower depending end or extension of the stator can swing toward the extension or exterior leg of the U-shaped armature to bring a flat pole face 67 on the stator extension into intimate engagement with a cooperating flat pole face 68 on the adjacent leg of the armature in the attracted position of the core parts. In this manner, the pivoted leg of tse armature provides a stop to limit the attraction stroke of the stator, while the pole face 19' of the stator provides a stop substantially interposed between the stator hinge 66 and the pole face 29' on the extremity of the armature pole portion to limit the attraction stroke of the armature and define the attracted position thereof.

Attention is directed to the fact that the engagement of the armature pole portion 24' with the stator takes place inside the winding at a location so related to the position of the hinge pin 66 for the stator that practically no torsional forces are exerted upon the stator in consequence of seating of the armature thereagainst.

Since the armature and stator have pole faces which will intimately engage with one another both inside and outside the winding to provide a completely closed mag-

netic circuit about the winding, it is also a feature of this invention that the effects of residual magnetism may be overcome following de-energization of the winding by a force supplied to one of the two movable elements of the core without in anywise lessening the pull of the armature or creating resistance to swinging motion thereof in its attraction stroke. This may be accomplished by interposing a compression spring 70 between a finger 71 depending from the lower portion of the stator and a stop 72 on the supporting bracket, the spring having a force great enough to separate the pole faces 67 and 68 and break the magnetic circuit about the winding at a point exteriorly thereof following de-energization of the winding. The biasing force of the spring exerted upon the stator, of course, makes it necessary to limit motion of the stator away from the armature and this is accomplished in a simple manner by providing a resilient stop on the supporting bracket adjacent to the outer curved surface of the stator to be engaged thereby under the influence of the biasing spring 70 whenever the winding is in a de-energized condition.

Although the provision of the tapered pole portions 16' and 24' on the stator and armature respectively, ideally adapt the solenoid of Figure 5 for D. C. service, it can also perform especially well with alternating current, in which case shading rings (not shown) may be imbedded in the pole faces 19' and 67 of the stator to improve the "hold in" characteristics of the solenoid.

From the foregoing description taken together with the accompanying drawings it will be readily seen that this invention provides a solenoid featuring simplicity of construction through the elimination of armature guides, and wherein the laminated construction of the armature and stator makes it possible for the first time to achieve "coning" and improved traction characteristics in a D. C. solenoid without the necessity of machining these surfaces; and that though primarily intended for direct current service, this invention provides a solenoid which may be operated by either direct current or alternating current with increased efficiency.

What we claim as our invention is:

1. A solenoid comprising: a supporting bracket; an annular winding carried by the supporting bracket; a laminated magnetically permeable stator mounted on the supporting bracket alongside one end of the winding; a laminated magnetically permeable armature mounted on the supporting bracket alongside the other end of the winding and movable along a defined path toward the stator to an attracted position in response to energization of the winding; elongated cooperating pole portions on the armature and stator formed as extensions of the laminae thereof and projecting lengthwise into the opposite ends of the winding to occupy laterally adjacent overlapping positions inside the winding in the attracted position of the armature; and cooperating abutments on the armature and stator engageable to define the attracted position of the armature, the engaging surfaces of said abutments providing pole faces disposed substantially crosswise of said path along which the armature travels, and said abutments being located on the armature and stator pole portions and engaging one another inside the winding so that magnetic flux is led uninterruptedly through the center of the winding in the attracted position of the armature.

2. The solenoid set forth in claim 1 wherein the laterally adjacent sides of said pole portions on the armature and stator have substantially flat angular surfaces tapering from a larger cross section adjacent to the bases of the pole portions to a smaller cross section at the extremities of the pole portions; and wherein one of said abutments is provided by the extremity of one of said pole portions, and the other abutment being located adjacent to the base of the other pole portion.

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