

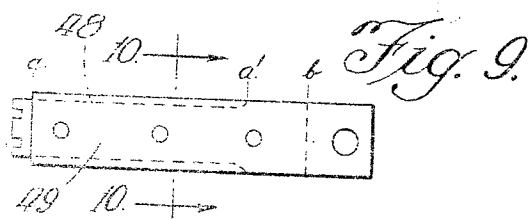
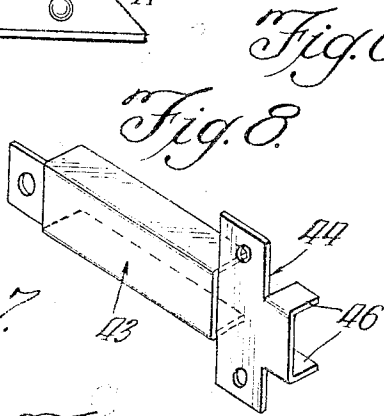
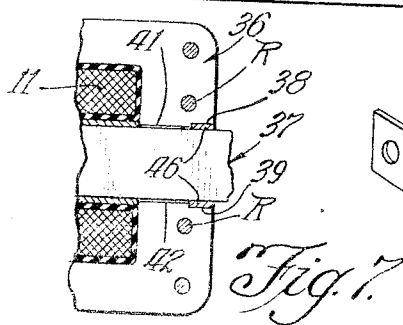
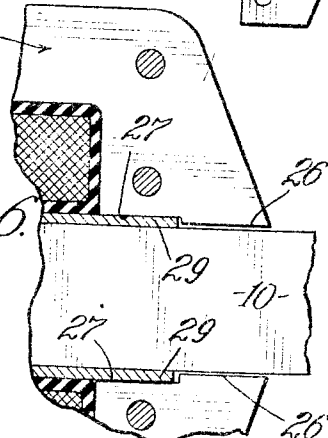
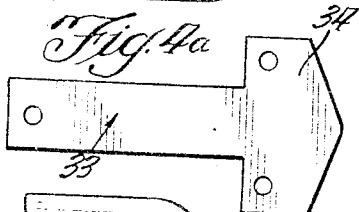
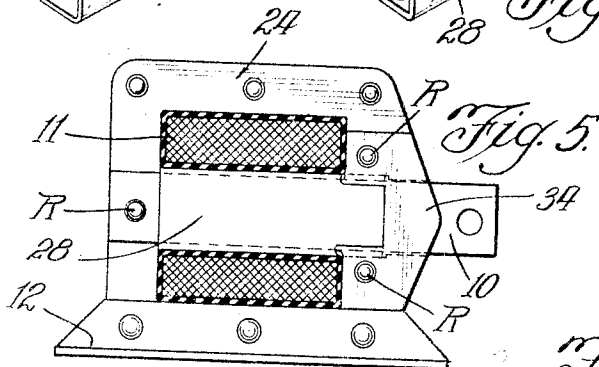
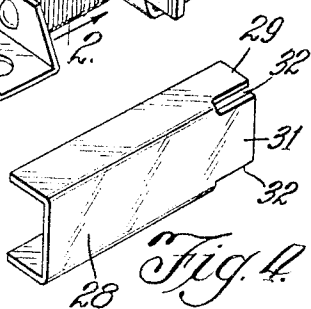
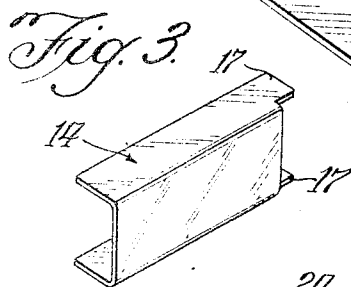
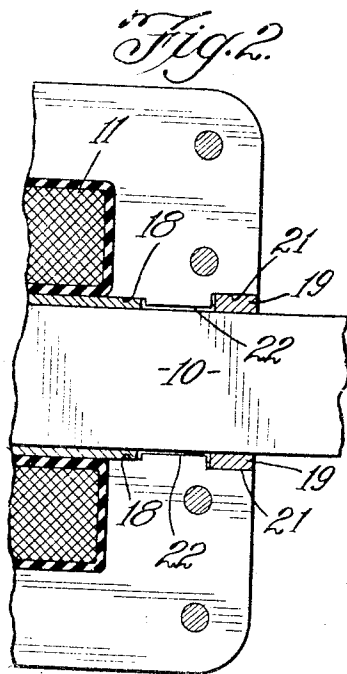
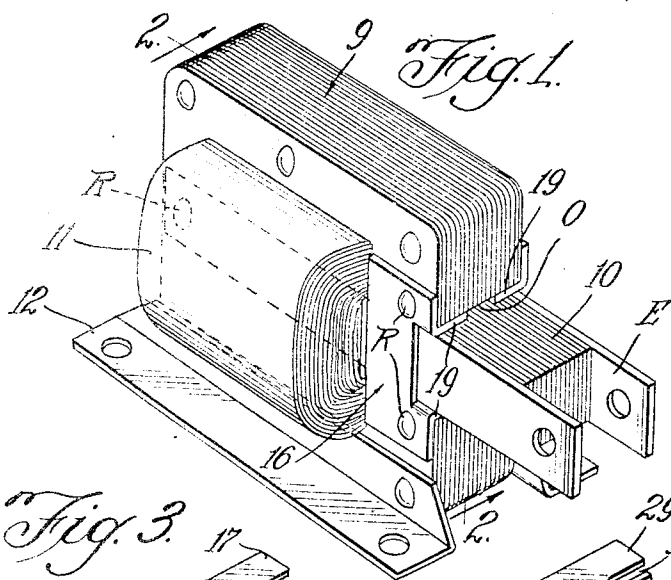
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D. W. DAVIS

2,311,431

SOLENOID

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SOLENOID

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10 Claims. (Cl. 175—341)

The present invention relates in general to electromagnets and more particularly to the class of such devices commonly referred to as solenoids.

One of the objects of the present invention is to produce a solenoid having by reason of its construction more efficient electrical characteristics.

Another object is to provide a solenoid of the type wherein the plunger slides substantially entirely within the magnetic frame, which has a smooth and reliable operation.

Another object is to provide improved and simplified guideways for the solenoid plunger which are inexpensive both from the stamping and assembly standpoint, and yet are extremely sturdy.

A further object of this invention is to provide improved pole-piece, plunger, and guideway structure of such construction in a solenoid that a reduced air gap in the magnetic circuit is obtained in contrast to the normal condition wherein the air gap is increased by the use of a guideway.

Still another object is to provide improved guideways for the solenoid plunger so as to furnish support for the plunger even in its most extended position.

There are other objects of my invention which, together with the foregoing, will be described with reference to the accompanying drawing illustrating certain embodiments thereof.

While my invention has been shown applied to an alternating current type solenoid, it will be obvious that it will apply equally well to a direct current type.

Referring now to the drawing:

Fig. 1 is a perspective view of one embodiment of my invention arranged to serve as a pull type solenoid;

Fig. 2 is an enlarged fragmentary sectional view of the same, taken along the line 2—2 of Fig. 1, looking in the direction of the arrows;

Fig. 3 is a perspective view of the channel member or guide plate for the solenoid of Figs. 1 and 2;

Fig. 4 is a similar view of a modified form of the guide plate;

Fig. 4a is an elevation or plan of the supporting member for use with the guide plate of Fig. 4;

Fig. 5 is an elevational view of a solenoid incorporating the channel member of Fig. 4 and the corresponding supporting member of Fig. 4a, with the coil cut away to expose the supporting member;

Fig. 6 is an enlarged fragmentary view of the structure of Fig. 5 illustrated similarly to Fig. 2;

Fig. 7 is an enlarged fragmentary sectional view of a solenoid showing the guideway structure at the pole pieces, for another embodiment of my invention;

Fig. 8 is a perspective of the two members for one-half of the guideway for Fig. 7;

Fig. 9 is an elevation of the plunger for the solenoid of Fig. 7; and

Fig. 10 is a sectional view along the line 10—10 of Fig. 9.

In practicing my invention I provide improved guiding and magnetic structure for a solenoid such that smoother and more powerful operation is provided for the solenoid plunger. In the various embodiments of the invention which are illustrated, and will be specifically described, a magnetic frame is provided having pole pieces forming an opening at one side through which the plunger slides in a straight line into and out of the magnetic frame structure itself. Projecting, and corresponding recessed portions are provided in the pole faces at the frame opening so that guideway means for the plunger may be mounted in a secure manner, to provide a straight line, non-magnetic, path for the plunger at all operating positions, and at the same time provide a much smaller air gap at the opening adjacent the plunger path than would normally occur from a structural standpoint, and be practical from a magnetic standpoint. A portion of the guideway structure is supported at one end in the recessed portions of the frame structure at the opening, and includes a pair of oppositely disposed guide plates or channel members straddling a substantially T-shaped supporting member mounted rigidly at one end on the magnetic frame adjacent the opening, and rigidly mounted at the other end on an opposite side of the magnetic frame. The guide or channel members and the pole faces or magnetic frame structure at the opening are each of such shape and cooperate with one another in a manner so as to maintain the plunger on a straight line at all portions of its operating path including the fully extended position. At this position it was difficult in the prior art devices to prevent tipping or misalignment, which caused the plunger of magnetic material to engage the magnetic frame structure and possibly apply magnetic braking to the plunger or actually "freeze" the same. Furthermore, the restricted air gap and guideway structures, as well as the plunger structure itself, act to provide the maximum magnetic force on

the plunger, and hence maximum operating efficiency. At the same time this construction substantially insures against "freezing" and magnetic braking between the plunger and magnetic frame at the restricted air gap.

The solenoid illustrated in Fig. 1, being of the alternating current type, includes a stack 9 of C-shaped laminations, a stack 10 of straight laminations constituting the plunger, both stacks of laminations being suitably fastened together, a coil 11, and a pair of securing angle strips 12. The term C-shaped is not intended to describe an exact form, but rather any suitable form having the necessary opening O on one side formed by the separated pole faces to permit the movement of the plunger therein. The plunger 10 is guided in its entire path of movement by non-magnetic guide means including a pair of cooperating channel-shaped guide members or plates 14 of a suitable non-magnetic material. These channel members have their edges substantially abutting or relatively close to one another, and together form a guideway for the plunger 10 in cooperation with a pair of substantially T-shaped supporting plates or members 16 suitably secured by rivets R or otherwise to the laminated field piece 9. These supporting members 16 fit within the channels of the channel members 14, support them in position, and cooperate with them to form the plunger guideway.

The plunger guide structure fits within the solenoid coil 11, with each channel member 14 having extensions 17 on each side thereof (Fig. 3) extending into corresponding recesses 18 in the laminations forming the opening O in the solenoid. Each of the two mounting plates or brackets 16, in turn, has ears 19 intumed from the plane of the head of each member 16, which extend into corresponding recesses 21 at the outer edge of the opening O. Intermediate the recesses 18 and 21 are projecting portions 22 which extend very close to the path of movement of the plunger 10 so as to decrease the air gap intermediate the plunger and the magnetic frame to a minimum. With the non-magnetic members 14 and 16 serving to guide the plunger in its movement into and out of the frame structure up to the very outside of the frame structure as shown in Fig. 2, exact longitudinal alignment is maintained for the plunger at all times and the magnetic frame structure can approach the plunger at the projections 22 very closely without serious danger of "freezing." As a result, the most efficient application of the magnetic force to the plunger is obtained, to thereby exert a very strong pull on such plunger and consequently on any mechanism secured thereto at the coupling end E as shown in Fig. 1. The extensions 17 on the channel member 14 fit behind the head of the plate 16 and are thus securely locked against removal at that end. The coil 11 surrounding the entire guideway structure maintains the members 14 in suitably fixed positions over the remainder of the length thereof. As may be noted from the consideration of Fig. 2, the material for the members 14 and 16 can be of different thicknesses if desired, and these thicknesses can be suitably accommodated in the frame merely by stamping out the recesses 18 and 21 to the desired depth.

In former constructions it has been necessary to mount the guide members within the solenoid between the field laminations and the plunger so that the air gap was normally slightly greater on each side than the thickness of the guide members. The essential feature of my invention with

respect to the magnetic structure is to support either the channel, or the supporting members in recesses in the field laminations or pole faces, so that the spacing between the plunger and the

magnetic frame over at least a portion of the pole faces may be less than the thickness of the non-magnetic guideway members. In other words, the non-magnetic guideway provides for the plunger moving entirely into the confines of the magnetic frame, and yet provides a restricted air gap between the frame and plunger within the frame structure. This enables the magnetic efficiency of the device to be increased while the guideway is still effective to bring about smooth operation of the plunger and prevent any mechanical contact between the plunger and frame.

In the forms of my invention shown in the various figures, the plunger 10 is usually returned to extended position by a spring (not shown).

A modified embodiment is illustrated in Figs. 4 to 6, inclusive. The magnetic frame 24 is substantially the same as the frame 9 previously described, with an opening at one side through which a plunger 10 moves in and out. As shown in Fig. 6, pole faces at the opening in the magnetic frame have projecting portions 25 at the top and bottom of their outside limits, and recesses 27 at the inside. The opening end of the frame is illustrated as having the laminations beveled somewhat toward the opening, but it is understood that the outside configuration can be the same as that illustrated in Fig. 1. The guideway structure for the plunger 10 comprises a pair of channel members or guide plates 28 with extensions 29 corresponding to the extensions 17 in Fig. 3 and a lip or extension 31 on the base of the channel member. Intermediate each extension 29 and the lip 31 is a slot 32 for receiving the head of a substantially T-shaped supporting member as will be explained. The channel members fit into the frame 24 in a manner similar to the channel member of Fig. 3, with the extensions 29 positioned in the recesses 27, and substantially abutting the projections 25 as shown in Fig. 6. The channel members are retained within the frame structure by means of the coil 11 and supporting or mounting members 33 as illustrated in Fig. 4a. The body of the substantially T-shaped member 33 is inserted within the channel for its corresponding channel member, with the head portion 34 extending into the slots 32 as shown in Fig. 5. Rivets R secure the members 33 to the magnetic frame 24.

In the embodiment illustrated in Figs. 7 to 10, inclusive, the magnetic frame 35 is essentially the same as the frame 9. This embodiment will likewise provide an efficient magnetic circuit, and at the same time a non-magnetic guideway which will prevent the plunger 37 from getting out of longitudinal alignment so as to engage the magnetic frame even in its most extended position. A recess 38 is provided at the outside limits of the upper pole face in the magnetic frame, and a similar recess 39 is provided in the lower pole face. The remaining portions of the upper and lower pole faces indicated by the reference characters 41 and 42 respectively, project beyond the recesses 38 and 39 to lie adjacent the path of movement of the plunger 37 in the same manner as heretofore described.

The guideway structure in combination with the magnetic frame structure comprises a pair of guide units each including a channel member 43 (Fig. 8), and a substantially T-shaped supporting member 44 with the elongated body of

the supporting member fitting within the channel of the member 43. The side flanges, or side portions of the channel member 43 do not extend beyond the base, and the member 43 is retained on the supporting member by the encircling coil 11 as previously explained. Each guide unit is supported at one end at the plunger opening in the frame structure by means of inturned ears 46 at one end of the supporting member 44. The ears are positioned in the corresponding recesses 38 and 39 in the pole faces. The supporting members in the two guideway units are secured to the magnetic frame by rivets R extending through the corresponding openings in the head and tail portions as shown in Figs. 1 and 5.

The plunger 37 as shown in Figs. 9 and 10, comprises a stack of laminations 48 having a body portion reduced in width substantially over the entire length thereof as indicated by the reference characters $a-a'$, in contrast to a greater width over the remaining portion as indicated by the reference characters $a'-b$. This is shown in dotted lines in Fig. 9, and is evident in the sectional view in Fig. 10. The guide plates 49, however, are of uniform width over the entire length thereof, and in fact correspond in width to the side plates of the plunger 10 as shown in Fig. 1. These guide plates 49 are of non-magnetic material, while the laminations, of course, are of magnetic material. The plunger rides in the guideway on the guide plates 49. With the magnetic portion of the plunger restricted in width over a greater portion of its length, the air gap at the pole face portions 41 and 42 is enlarged over a portion of the travel of the plunger, and then at the outer end of the plunger with the greater width for the magnetic portion the air gap is restricted to the very minimum possible for good practical operation.

In solenoids difficulty is sometimes encountered due to magnetic braking results from an undesirable attraction between the pole pieces and the plunger during the movement thereof due to a restricted gap. This braking is not serious at the very end of the operating stroke of the plunger, however, so long as actual contact between the magnetic portion of the plunger and the pole faces is prevented. Furthermore, at the end of the operating stroke the largest possible operating force is normally desirable to bring the mechanism being operated by the solenoid into its final desired condition. When the plunger 37, therefore, is in its innermost position, the enlarged portion thereof is between the pole faces so that the air gap is reduced to a minimum. The operating force applied to the plunger is thus at a maximum value. The reduced section of the plunger over the portion of its length indicated between the lines $a-a'$ (Fig. 9), increases the air gap so that the operating force applied to the plunger is of a reduced value over the greater part of its path of movement.

At the same time with the inturned ears 46 positioning the plunger at the outside limit of its path of movement and the sides of the channel member 43 positioning it substantially over the remaining length thereof, the plunger is maintained in linear alignment, and there is no direct contact between the lamination stack 48 of the plunger and the pole faces 41 and 42.

It will be seen that my improved solenoid construction furnishes a smooth supporting guideway for the operation of the plunger which is moved substantially entirely within the magnetic frame structure therefor, and at the same time

permits the peak efficiency of the magnetic circuit to be maintained. The two-piece guideways on each side of the solenoid cooperate together to provide a sturdy and substantially closed channel, which is inexpensive to manufacture, and inexpensive to assemble in the solenoid.

My invention may be variously modified without departing from the spirit and scope thereof as indicated in the appended claims.

I claim:

1. A solenoid including a magnetic frame having an opening at one side thereof for receiving a plunger movable in and out of said frame and having a pair of parallel pole faces within said opening close to said plunger, a plunger guideway comprising a pair of channel-shaped members each having a flange portion and a base portion with each channel member having a slot formed at one end in the angle between the base and flange portions, a supporting member for each channel-shaped member extending beyond said channel-shaped member at one end and secured to the magnetic frame and having a head portion on the other end telescoped with the slot in the corresponding channel member to substantially lock said channel member and corresponding supporting member together, and with the flange portion on each channel member having an extension at one end, and each pole face having a recess therein extending transversely of the pole face and parallel to the corresponding extensions with the pole-face recesses receiving the extensions therein.

2. A solenoid including a magnetic frame and a coil therein with an opening at one side thereof, a plunger movable in said frame through said opening, a plunger guideway comprising a pair of channel-shaped members, each channel member having side portions and a base, said magnetic frame within said opening having recesses thereon to receive a corresponding end of each of said channel side portions, said recesses being of lesser depth than the thickness of said corresponding ends so that said plunger is spaced from the magnetic frame through said opening, a pair of substantially T-shaped supporting members mounted on said frame having a head portion at one end and each supporting member adapted to support one of said channel members thereon, and with the said corresponding end of each of said channel members positioned behind the head portion and in locking engagement with its corresponding T-shaped supporting member to retain the channel member in guideway position when surrounded by the coil.

3. A solenoid having a pair of pole pieces with pole faces thereon spaced apart to form an opening therebetween, guideway means supporting a plunger in said solenoid for longitudinal movement in and out of the solenoid through said opening, and a plunger including a pair of non-magnetic guide plates of uniform width over a length corresponding substantially to the magnetic portion of said plunger, and a magnetic portion for said plunger assembled with said guide plates including a plurality of laminations being of one width over one portion thereof and a greater width over the remaining portion thereof, said plunger moving into said solenoid to a position at which the magnetic portion of greater width is substantially entirely within the opening defined by said pole faces, said guideway means having projecting portions extending into said opening to cover a portion of said pole faces, and with another portion of said pole faces pro-

jecting toward the plunger and being of a thickness less than the thickness of the projecting portions of said guideway means, with said projecting portions of said pole faces and the plunger magnetic portion at the greater width acting to provide a relatively small air gap therebetween, and said projecting portions of said guideway means and non-magnetic guide plates of said plunger acting to prevent contact between the plunger and pole faces.

4. In a solenoid having a magnetic frame including a plurality of one-piece C-shaped laminations secured together to form a C-shaped frame with an opening in one side and a pair of parallel pole faces within said opening and a pre-wound coil within the frame, said parallel pole faces consisting of the ends of the laminations within the opening, the combination with the frame including a plunger movable across said pole faces into and away from the coil, each of said pole faces being close to said plunger but having a recessed portion therein extending transversely thereof, and means for supporting and guiding said plunger including a channelled body portion with wall portions extending toward one another within the coil, and a pair of head portions each straddling the frame opening on the outside and on opposite sides of the frame, and each head portion having inturned ears positioned in the corresponding parallel pole face recessed portions and lying in planes parallel to said wall portions of said channelled body portion, with said plunger sliding on wall portions and inturned ears in a straight-line movement.

5. In a solenoid having magnetic frame means with an opening therein, the combination including a pair of pole faces defining said frame means opening therebetween, a plunger operating in said frame means and adapted to move through said opening across said pole faces, a pair of channel members mounted in said frame with sides thereon extending inwardly within the frame, and a substantially T-shaped supporting member for each channel member, said members all together forming a guideway for said plunger, each supporting member having a body portion extending longitudinally of the corresponding channel member and within the same intermediate the sides thereof and having a head at the outer end with inturned ears thereon spaced from but substantially parallel with said channel member sides, said pole faces having recessed portions extending transversely within said opening and said inturned ears of both supporting members positioned in the recessed portions and extending toward one another within the opening, with said pole faces having projections within said opening adjacent said recesses approaching the path of movement of the plunger but being out of engagement with said plunger, with said plunger moving on channel-member-sides and inturned ears and being guided thereby.

6. A solenoid having a substantially C-shaped magnetic frame with an opening in said frame at one end, means for providing and utilizing a powerful operating force for said solenoid, including the combination with the frame, of a plunger movable in and out of said frame through said opening, guideway means for supporting said plunger for straight-line movement in said frame through said opening, and pole faces on said frame at said opening having a projecting portion extending transversely of each pole face within the opening and corresponding recess por-

tions within the opening adjacent said projecting portions on said pole faces, said guideway means including channel portions at each side within said magnetic frame extending toward one another therein and a head portion at said opening on each side of the magnetic frame having inturned portions positioned in the recesses in the pole faces and parallel with the channel portions, said plunger including a body portion and a pair of side portions on opposite sides thereof of uniform width over the length of said body portion riding on the channel portions and the inturned portions which lie in parallel planes in the path of movement of the plunger, said body portion of said plunger being substantially of same width at one end as the width of the side portions, and being of a width less than the side portions substantially over the remaining portion of the body portion, and with said plunger being positioned in the guideway means when the plunger body portion is in fully attracted position within the magnetic frame so that the greater width portion is between the pole faces.

7. A solenoid including in combination a frame having an opening in one side with a pair of parallel pole faces within said opening, each pole face having a pair of recesses therein parallel to one another and extending transversely of the pole face, a plunger movable over the pole faces, and a guideway for the plunger including a pair of channel members with side flanges thereon serving as a guideway for the plunger on two opposite sides thereof, and a substantially T-shaped supporting member for each channel member, each supporting member having a body portion within its corresponding channel member and the two body portions forming a guideway for the plunger on the other two sides thereof, with each supporting member having a head portion at one end with a pair of inturned ears thereon, with the end portions of the corresponding flanges of the channel members positioned in corresponding two recesses in the pole faces whereby to utilize thereby one recess of each pair in each pole face, and with the inturned ears of the supporting members correspondingly positioned in the two remaining recesses of the four recesses of the pole faces.

8. A solenoid including in combination magnetic frame means having an opening therein and a pair of parallel pole faces within said opening consisting of the ends of the magnetic frame means within the opening, a plunger movable across said pole faces, each of said pole faces being close to the plunger but having a recess therein extending transversely thereof, a plunger guideway including a pair of channel-shaped members, a pair of substantially T-shaped supporting members each having a portion within a corresponding channel-shaped member and having a head portion secured to the frame means at the opening, each head portion having inturned ears positioned in the pole face recesses with each inturned ear having an inside face and an outside face, said plunger riding on the inside faces of said ears, and with the frame means at the non-recessed portion of the pole faces coming closer to said plunger than the outside faces of said ears.

9. A solenoid including in combination a laminated frame having an opening therein, a pair of parallel pole faces within said opening with each pole face comprising the ends of the frame laminations at the opening, guideway means within said solenoid having an outer wall and

a plunger movable in said guideway means and through said opening, with at least a part of each pole face coming closer to the plunger within the opening than the outer wall of the guideway means at the opening by an amount less than the thickness of the guideway means, said plunger having a longitudinally extending body portion including a non-magnetic portion lengthwise thereof upon which said plunger rides in the guideway means with said non-magnetic portion being of substantially the same width over said body portion, and said body portion including a magnetic portion lengthwise thereof of a width over one part which is less than the width of the non-magnetic portion and a width over another part substantially the same as the width of the non-magnetic portion, with said parts and non-magnetic portion being arranged lengthwise of the plunger so that the plunger moves on the guideway means in a substantially straight line relative to the parallel pole faces with the lesser width part providing a gap intermediate the same and each pole face when it is in said opening, and said other part nearly but not completely closing the gaps and lying adjacent the pole faces when the plunger body portion is within the solenoid in a fully attracted position thereof.

10. A solenoid including a substantially C-shaped magnetic frame having a pair of parallel

pole faces within the opening therein, a plunger movable in said frame through said opening, a guideway for said plunger including a pair of substantially T-shaped supporting members arranged on opposite sides of said opening and secured at each end to said frame, a flanged channel member separably supported on each of said substantially T-shaped members intermediate the ends of such T-shaped members, with the flanges of each of said channel members extending inwardly to approach the flanges of the other channel member to form two walls of said guideway and each channel member and corresponding T-shaped member forming a unit with at least one of the members in each unit having a pair of extending portions thereon parallel to said flanges of said unit, and each of said pole faces being close to said plunger but having a recess therein extending transversely of the pole face, parallel to the corresponding flanges, the pole face recess receiving said extending portions, with said extending portions being of greater thickness than the depth of said recesses to provide with the channel members flanges a slidable support of the plunger in a linear path of movement out of contact with said pole faces for all operating positions of said plunger.

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