April 22, 1952 E. M. SORENG ET AL 2,594,089

SOLENOID WITH PLUNGER

Filed May 29, 1950

2 SHEETS—SHEET 1

Fig. 1.

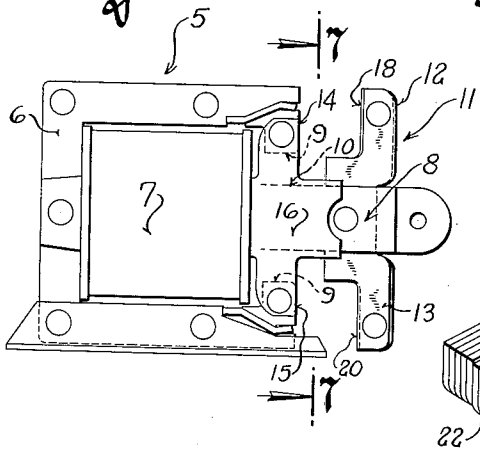


Fig. 2.

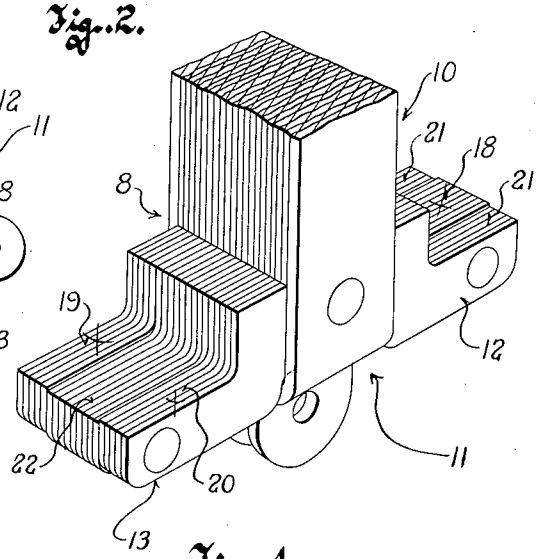


Fig. 3.

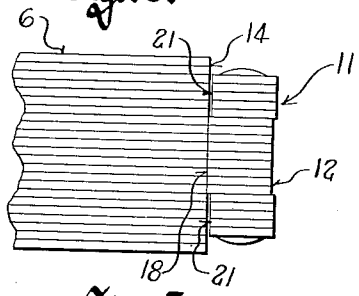


Fig. 4.

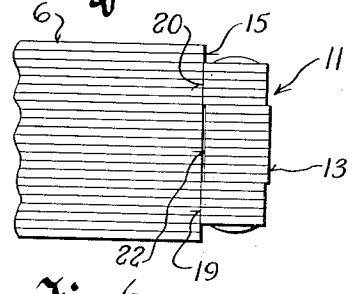


Fig. 5.

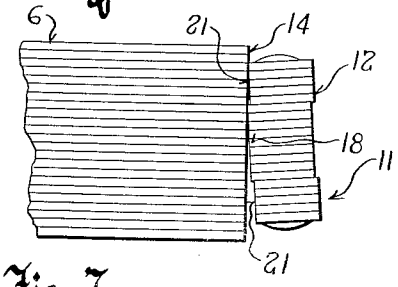


Fig. 6.

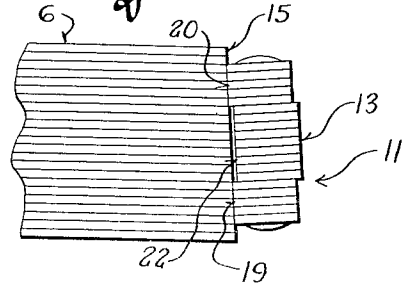
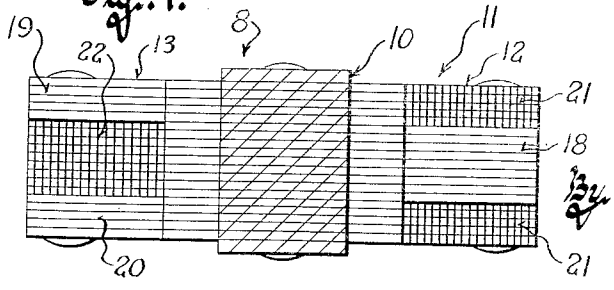


Fig. 7.



Inventors
Edgar M. Soreng
Hardin Y. Fisher
George H. Johnson
By Dallas Jones
Attorney

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Fig. 8.

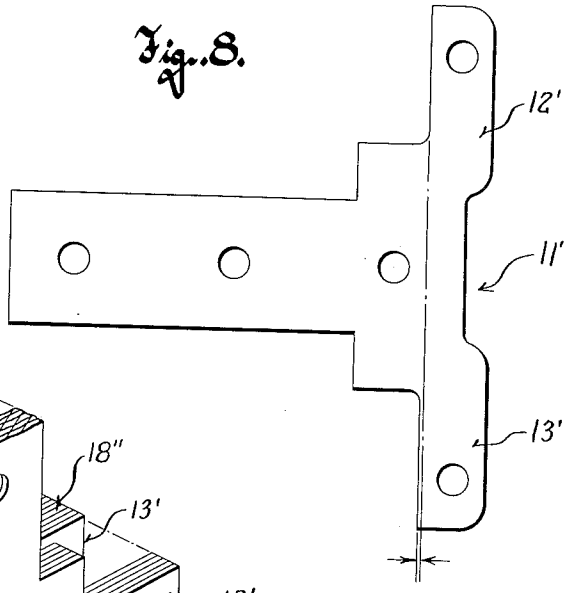


Fig. 9.

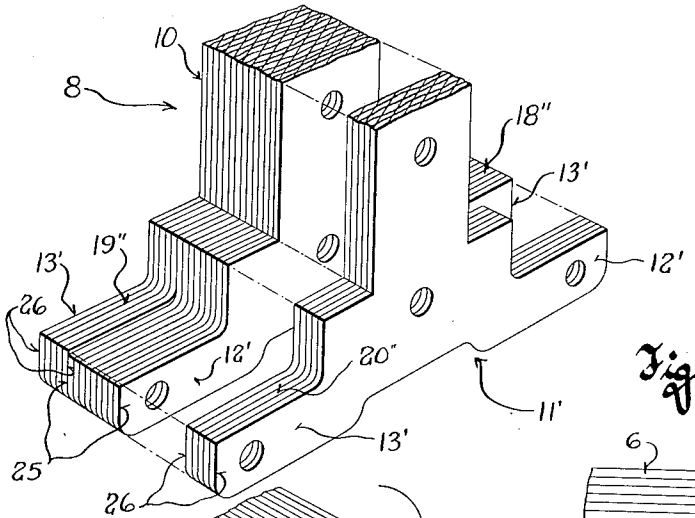
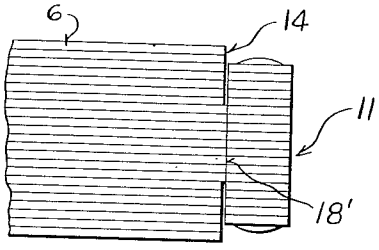


Fig. 10.



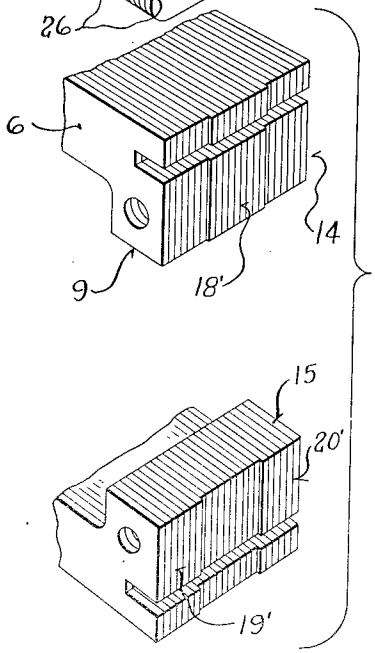


Fig. 11.

Inventors
Edgar M. Soreng
Hardin Y. Fisher
George D. Johnson

By Dudley Williams Jones
Attorney

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SOLENOID WITH PLUNGER

Edgar M. Soreng, Skokie, Hardin Y. Fisher, Hillside, and George D. Johnson, Bensenville, Ill., assignors to Soreng Manufacturing Corporation, Schiller Park, Ill., a corporation of Illinois

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3 Claims. (Cl. 175—338)

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This invention relates to alternating current solenoids and has more particular reference to the elimination of noise in the operation of an A. C. solenoid equipped with a plunger.

An example of the type of solenoid herein concerned is shown in Patent No. 2,468,052, issued to Hardin Y. Fisher on April 26, 1949. In solenoids of this type the winding is surrounded by a substantially C-shaped iron frame, the opening in which aligns with the interior of the winding; and the stem of a substantially T-shaped plunger passes through the frame opening and is received in the interior of the winding. When the solenoid is energized the stem of the plunger is drawn axially into the winding and the head of the plunger, comprising the cross-bar of the T, bridges the poles at the end of the frame at opposite sides of the opening therein.

When alternating current solenoids of this type are used in circumstances requiring them to remain energized for appreciable periods of time, they very frequently produce a buzzing noise which is extremely annoying. We have learned that most of this noise results from the fact that the plunger head does not seat perfectly flatly against the end of the solenoid frame, with the result that the alternate decrease and increase in flux intensity, that is, the variation in magnetic attraction characteristic of A. C. solenoids, tends to vibrate certain portions of the head against the end of the frame which it engages.

Unless the plunger head seats absolutely flatwise upon the end of the solenoid frame, the inner surface of the head will abut the faces of the poles only at one or two high points, so that there is a tendency for the load connected with the plunger to act as a bias holding the remainder of the inner surface of the head separated from its opposing surface on the end of the frame. This bias is overcome by increased magnetic attraction at times when the alternating current reaches its maximum value, and the remainder of the inner head surface then rocks about these high spots and bangs or slaps into engagement with the pole face. The repetition of this banging or slapping results in the characteristic buzzing sound to the elimination of which this invention is directed.

Even when no positive outward bias force is imposed upon the plunger, the inherent resiliency of the plunger and frame parts may be responsible for the vibration of the plunger head against the end of the solenoid frame in the energized condition of the plunger. It is also possible for buzzing to occur in a solenoid having perfectly

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flat abutting surfaces on the frame and plunger if those surfaces are prevented from making absolutely flat contact with one another because of a slight tilt of the plunger. Such tilt may, of course, result from any of several factors, such as a side component of the load force or a slightly misaligned plunger guide.

While shading coils have long been used as an expedient to minimize the noise in question, they have not proven entirely effective because they cannot completely eliminate the variation in flux intensity consequent to energization of a solenoid by means of an alternating current. If any such variation exists, the possibility of buzzing will also exist so long as the plunger head makes such contact with the poles in the energized position of the plunger that portions of the head may be repeatedly withdrawn from contact with the frame and abruptly and forcibly reengaged therewith in response to the varying forces of bias and magnetic flux. Needless to say, the attainment of absolutely flat surfaces on the frame and plunger would be prohibitively expensive in the manufacture of A. C. solenoids for most practical purposes.

The principal object of this invention resides, therefore, in the provision of an alternating current solenoid wherein the noise which has heretofore usually attended energization of the solenoid is greatly reduced or even eliminated by virtue of a simple and inexpensive improvement in the configuration of the abutting frame and plunger faces.

More specifically, it is an object of this invention to provide an alternating current solenoid of the type having a substantially T-shaped plunger in which certain of the cooperating opposite poles on the plunger and frame are provided with means defining tripodal projections, one at one side of the plunger axis and two at the other side of the plunger axis, to assure a firm engagement between the plunger head and the adjacent end of the solenoid frame despite irregularities in the opposing surfaces of the poles on the plunger and frame.

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

The accompanying drawings illustrate three

complete examples of the physical embodiments of the invention constructed in accordance with the best modes so far devised for the practical application of the principles thereof, and in which:

Figure 1 is a side elevational view of a solenoid embodying the principles of this invention, showing the tripodal projections as formed on the underside of the plunger head;

Figure 2 is an enlarged perspective view of a portion of the plunger looking at the inner side of the head thereof;

Figures 3 and 4 are enlarged views illustrating the tripodal engagement of the projections on the plunger head with the adjacent end of the solenoid frame;

Figures 5 and 6 are views similar to Figures 3 and 4 but illustrating an exaggerated condition of angularity between the surfaces of the poles of the plunger and the solenoid frame;

Figure 7 is a cross-sectional view of the plunger per se taken along the line 7—7 of Figure 1 and looking at the inner side of its head;

Figure 8 is a side elevational view of one of the plunger lamina used in a modified embodiment of the invention;

Figure 9 is an enlarged fragmentary perspective view of the plunger, looking at the inner side of its head, and illustrating the manner in which groups of laminae are assembled to form the plunger;

Figure 10 is a view similar to Figure 3 but showing the projections at one side of the plunger stem formed on the frame laminae; and

Figure 11 is a fragmentary perspective view of a solenoid frame made from laminae which produce the tripodal projections, with the laminae grouped in assembled relationship.

Referring now more particularly to the accompanying drawings, in which like numerals designate like parts throughout the several views, the numeral 5 generally indicates a solenoid of the type forming the subject matter of Patent No. 2,468,052, issued to Hardin Y. Fisher on April 26, 1949. The solenoid comprises a substantially C-shaped magnetically permeable frame 6 surrounding a coil 7 and having a substantially T-shaped plunger 8. The opening 9 in one end of the frame accommodates the stem 10 of the plunger, and the inner portion of the stem, of course, projects into the hollow interior of the winding 7, being guided for axial reciprocatory motion by the usual guide 16. The frame and the plunger are both preferably of laminated construction, with the plane of the laminae lying crosswise of the turns of the coil.

The plunger 8 is made from a bank of identical T-shaped laminae formed to provide an enlarged head 11 on the outer end of the plunger defining the cross-bar of the T. This head may be said to comprise wings 12 and 13 at opposite sides of the plunger stem axis, facing the poles 14 and 15, respectively, which poles are provided by the end portions of the frame at opposite sides of the opening 9.

Heretofore it has been the practice to provide the poles 14 and 15 of the frame with substantially flat surfaces lying in a common plane normal to the axis of the plunger stem, and to likewise provide the head 11 with similar substantially flat surfaces at its inner side, also lying in a common plane normal to the axis of the plunger stem. When these surfaces of the frame and plunger poles are perfectly flat and lie in common planes, and when the guide 16 for the plunger stem holds the plunger so that its axis

is exactly normal to the pole surfaces of the frame, the ideal condition of flat surface-to-surface engagement between the frame and plunger poles is possible. However, in practice it is next to impossible to provide perfectly flat and uniplanar pole surfaces on both the solenoid frame and the inner side of the head of the plunger. The possibility of other than flatwise engagement between the frame and plunger poles may also arise from variations in the position of the guide which slidingly receives the plunger stem and guides it for endwise reciprocatory motion in the plunger opening 9.

If for any reason the inner side of the plunger head does not seat perfectly flat against the surfaces of the poles adjacent the end of the solenoid frame, the head is caused to vibrate rapidly against the frame in the energized condition of the solenoid and such vibration produces a loud and extremely annoying buzzing sound with which persons skilled in the art are familiar.

As explained hereinbefore, the vibration between portions of the plunger head which are not in good flatwise engagement with the opposed faces of the solenoid frame results from the alternate increase and decrease in magnetic attraction produced in an alternating current solenoid and from the tendency of either the load connected with the plunger to bias the same away from the frame or the inherent resiliency of the metal to spring the head portions out of engagement with the adjacent frame portions during the instants of least magnetic attraction.

According to the instant invention these loud buzzing noises in the energized condition of the solenoid are greatly minimized and even eliminated through the provision of means effecting a tripodal engagement between the opposite wings of the plunger head and the pole portions of the solenoid frame adjacent thereto. In Figures 1–9 inclusive these tripodal projections are shown as being formed on the inner side of the head of the plunger, while in Figures 10 and 11 they are shown as being formed on the pole faces of the frame 6.

In the embodiment of the invention shown in Figures 1–7, inclusive, tripodal projections 18, 19 and 20 are formed on the inner side of the head 11 of the plunger and project toward the adjacent poles of the frame to engage them in the seated position of the plunger. All of the projections are substantially bar-like and extend lengthwise of the wings comprising the head of the plunger, parallel to one another and to the laminae from which the plunger is formed.

A single projection 18 extends from the inner side of one wing 12 of the plunger head and is confined to the central zone of the wing 12, its thickness corresponding to approximately one-third that of the head; while two bar-like projections 19 and 20 extend from the inner face of the opposite wing 13, being spaced from one another by a distance equal to the central zone occupied by the projection 18, and each of the projections 19 and 20 likewise has a thickness equal to approximately one-third that of the head. All of the tripodal projections have flat faces opposing their cooperating poles 14 and 15 on the frame.

Stated in another manner, the tripodal projections 18, 19 and 20 may be considered as slight edgewise extensions of the plunger laminae projecting from the inner side of the head of the plunger, with the projection 18 comprising such extensions on a group of adjacent laminae at the

center of the stack and the projections 19 and 20 each comprising similar extensions on two other groups of adjacent laminae disposed at opposite sides of the first named group but with their extensions projecting from the other wing 13 of the plunger head.

The bar-like projections 18, 19 and 20 may be formed on the inner side of the plunger head in any desired manner. One method of forming them is to assemble a bank of identical T-shaped laminae to form a plunger having flat substantially co-planar surfaces at the inner side of its T-head, and then to deform the head in a coining operation in which side portions 21 of the inner face of wing 12 are depressed to leave the bar-like projection 18 between them, and a medial depression 22 is formed in the inner face of the opposite wing 13 to leave the spaced bar-like projections 19 and 20 at opposite sides thereof. Obviously, the faces of the tripodal projections 18, 19 and 20 preferably lie in a common plane normal to the axis of the plunger stem.

In operation of the solenoid, whenever the same is energized to draw the plunger stem into the frame 6 the tripodal projection 18 engages the opposite face 14 of the frame pole while the projections 19 and 20 engage the face 15 which opposes them. The plunger head is thus caused to seat upon the three bars of the tripodal projections, as illustrated in Figures 3 and 4, if the faces of the frame poles 14 and 15 are substantially flat and co-planar.

However, these surfaces of the frame poles are more frequently at an angle to one another and/or to the plunger axis, and sometimes are not even flat, but the tripodal projections on the underside of the plunger head have the unique characteristic of enabling the plunger head to seat properly upon the surface of the frame poles despite irregularities in these surfaces.

Such a non-coplanar condition of the frame pole faces is shown in exaggerated form in Figures 5 and 6 wherein, for illustration, the face of the frame pole 14 is shown flat and exactly normal to the axis of the plunger opening 9 while the face of the frame pole 15, while shown flat, is at a noticeable angle out of normal to the axis of the plunger and consequently at an angle to the surface of the pole 14.

When the T-head of a conventional plunger engages against such angularly related surfaces on the frame poles the solenoid will be excessively noisy in its energized condition due to the inability of the head to properly seat upon the frame poles. It is believed that the alternate increase and decrease in magnetic attraction which is characteristic of an alternating current solenoid, and which is not entirely overcome by the effect of the shading coils, produces a rapid vibration of a portion of the head into and out of contact with so much of the surface of one of the frame poles as lies outside of the plane of the remaining surfaces of the poles.

According to this invention, however, the tripodal projections, due to their ability to effect seating of both wings of the plunger head against the frame poles opposite thereto, largely minimize and/or even eliminate such objectionable vibration of the plunger against the end of the frame. Though exaggerated for purposes of clarity, the condition shown in Figures 5 and 6 is believed to illustrate accurately the seating effect achieved through the use of the tripodal projections of this invention. Referring to Figure 6 it will be seen that even though the face

of the frame pole 15 is at an angle to the face of the opposite frame pole 14, the tripodal projections 19 and 20 will nevertheless seat themselves against the pole 15 without so far canting the plunger sidewise as to carry the third projection 18 out of engagement with the other frame pole 14. It is understood, of course, that the plunger guide 16 does not embrace the plunger stem so closely as to preclude the slight tilting motion of the plunger necessary to effect seating of the plunger head in the manner described.

While the tripodal projections have been illustrated and described as being of bar-like configuration, it should be understood that where conditions will permit they may also be formed as circular projections having either a flat or a convex face to achieve the best possible seating action. For most purposes, however, it is desirable to provide for engagement of the projections with the frame poles over as large a surface area as possible, and the bar-like tripodal projections fit this requirement.

The object of this invention, that of effecting firm seating of both wings of the T-shaped head of the plunger against the frame poles, may also be achieved by locating all of the tripodal projections on the frame poles, or even by locating only certain of them upon the frame and the remainder on the plunger. The former condition is shown in Figure 11, where the projection 18' is located on the upper frame pole 14 while the two remaining projections 19' and 20' are formed on the lower frame pole 15.

Instead of forming the bar-like tripodal projections on either the plunger head or the frame by means of a coining operation or its equivalent, it is possible to produce them by the use of a bank of identical plunger or frame laminae having a special shape. Figures 8 and 9 illustrate such laminae and their grouping when the tripodal projections are to be located on the inner side of the plunger 8. Referring to Figure 8, it will be seen that one wing 12' of the head 11' of each plunger lamina has slightly less width, as measured parallel to the plunger axis, than the other wing 13' of the lamina head. This difference in width corresponds to the extent to which the projections will protrude from the inner side of the head and may be between .002" and .005". Stated in another way, the inner edge of one wing 13' is spaced inwardly of the inner edge of the other wing 12', but is parallel thereto.

The plunger in this case is adapted to be formed by a bank of such laminae, all identical with one another but with a central group 25 of laminae rotated 180° on the axis of their stem portions to dispose the central group with its wing portions 12' of lesser width between the wider wings 13' of the other two groups 26 of laminae, to thereby provide the spaced projections 19'' and 20'' adjacent to the opposite faces of one of the wings of the plunger head. Such positioning of the central group of laminae will, of course, dispose the narrower wing portions 12' of the outer group of laminae at each side of the wide wing portions 13' of the central group on the other wing of the plunger head thus to form the third projection 18'' on the head.

If desired, the tripodal projections may be provided on the frame poles, as indicated in Figures 10 and 11, by constructing the frame 6 of identical lamina, stamped to have their legs at one side of the plunger opening slightly wider (as measured parallel to the axis of the opening)

than those at the opposite side of the opening. In this case, also, the tripodal projections will be formed by proper grouping of these identical lamina, involving the reversal of the center group of the bank of laminae comprising the frame.

From the foregoing description, together with the accompanying drawings, it will be apparent that this invention provides for a tripodal engagement between the plunger and frame poles of an alternating current solenoid whereby the plunger is rendered stable and substantially noiseless under all conditions; and that since the air gap on either side of the tripodal bars is very small in the energized condition of the solenoid, while the total area of this air gap is relatively large, reluctance is not appreciably increased by the structure of the invention.

What we claim as our invention is:

1. In a solenoid of the type adapted to be energized by an alternating current: a laminated frame having at one end thereof a plunger opening and a pair of poles at opposite sides of the axis of said opening in the direction of the frame laminae; a laminated plunger having a stem projecting into the frame through said opening and reciprocable endwise therein, the laminae of the plunger being parallel to the laminae of the frame; wings on the outer end of the plunger laminae providing an enlarged head on the plunger, the inner side of which provides a pair of poles each opposite and cooperable with one of the poles of the frame and movable toward engagement therewith upon travel of the plunger stem into the frame in consequence to energization of the solenoid; and means on certain of said poles defining tripodal projections, one at one of said sides of the axis of the plunger opening and two at the other of said sides of said axis, each of said projections comprising extensions on a group of adjacent laminae projecting toward the pole opposite thereto and having a substantially flat surface engageable therewith upon energization of the solenoid.

2. In a solenoid: a frame having at one end thereof a plunger opening and a pair of poles one at each side of the axis of said opening, said poles having substantially flat faces normal to the axis of said opening; a laminated plunger having a stem portion projecting into the frame through said opening and reciprocable endwise therein, and having an enlarged head on its outer end, the inner side of which head provides a pair of poles each opposite and cooperable with one of the poles of the frame, said head being movable toward engagement with the poles of the frame, to bridge the same across the opening in the frame, upon travel of the plunger stem into the frame in consequence to energization of the solenoid; and said plunger comprising a number of identical laminae, each comprising an elongated stem portion and a pair of head forming wing portions at one end thereof, extending from opposite side edges of the stem portion, in the plane thereof, the inner edge of one of said wing portions being offset inwardly with respect to that of the other but parallel thereto, said laminae being arranged in a central group having all of said one wing portions extending in one direction and a pair of outer groups, one on each side of the inner group, having all of said one wing portions extending in the opposite direction so as to provide bar-like tripodal projections on the inner side of the head, each of which projections is adapted to engage the pole opposite thereto upon energization of the solenoid.

3. In a solenoid: a frame having at one end thereof a plunger opening and a pair of poles flanking said opening, said poles having substantially flat faces lying in a common plane normal to the axis of said plunger opening; and a T-shaped plunger having its stem projecting into the frame through said opening and reciprocable endwise therein, the head of the T-shaped plunger providing a pair of poles each having its face opposite and cooperable with the face of one of the poles on the frame, said plunger head being movable toward engagement with the poles on the frame to place the head in bridging relation therewith across the opening in the frame upon travel of the plunger stem into the frame, said plunger comprising a plurality of similar T-shaped laminae securely held together in stacked relation, each lamina having a stem and a head projecting from opposite side edges of the stem in the plane thereof, the undersides of the heads of all of the laminae collectively defining the two pole faces of the plunger, the undersides of the heads of laminae adjacent to the opposite sides of the plunger and which define and which define part of one of the plunger pole faces and the undersides of the heads of a plurality of adjacent laminae intermediate the opposite sides of the plunger and which define part of the other plunger pole face lying in a common plane substantially normal to the axis of the plunger, and the undersides of the heads of the remaining laminae, which define the balance of both pole faces of the plunger lying inwardly of said plane so that the plunger poles together have three separate contact areas simultaneously engageable with the pole faces of the frame, two of said contact areas defining laterally spaced portions of one of the plunger pole faces and the third contact area defining a medial portion of the other plunger pole face.

EDGAR M. SORENG.
HARDIN Y. FISHER.
GEORGE D. JOHNSON.

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