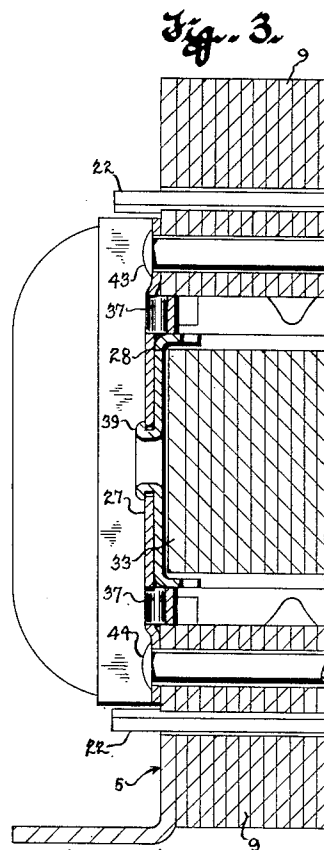
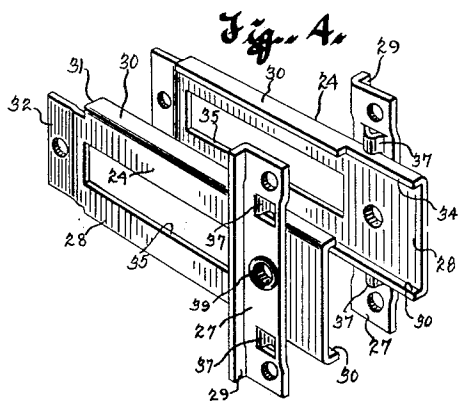
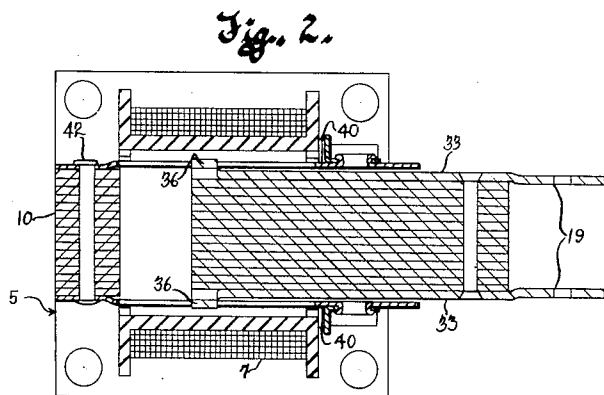
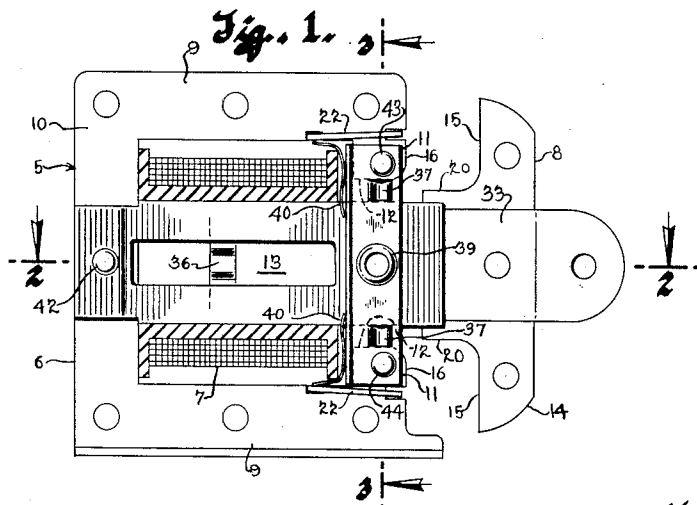


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PLUNGER GUIDE FOR SOLENOIDS

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1

This invention relates to alternating current solenoids and refers more particularly to an improved guide for the plunger of such a solenoid.

Alternating current solenoids of the type here under consideration have a laminated substantially C-shaped frame embracing the coil, which frame comprises a pair of side members at opposite sides of the coil and parallel to its axis, a rear transverse member extending across the rear end of the coil and connecting the side members at their rear ends, and inward extensions at the fronts of the side members extending partway across the front end of the coil to provide pole pieces. The opposing faces of these pole pieces define an air gap which is substantially coaxial with the coil.

The plunger is substantially T-shaped, having an elongated stem which passes through the air gap and into the hollow center of the coil, an enlarged head at the front of the stem which seats against the front of the pole pieces, and shoulders directly behind the head which substantially fill the air gap when the plunger is in its attracted or seated position. A solenoid having a plunger of this type is shown, for example, in the patent to H. Y. Fisher, No. 2,468,052, dated April 26, 1949.

The plunger is slidably mounted in a pair of complementary substantially T-shaped plunger guide elements, secured at opposite sides of the frame, which support and guide the plunger for endwise reciprocation. The stem portion of each plunger guide element is secured at its rear to the medial portion of the rear transverse member of the frame, and the cross member or supporting member of each plunger guide element, at the front of its stem portion, is secured to the pole pieces and spans the air gap. The stem portions of the plunger guide elements are channel-shaped, with the flanges of the channels extending inwardly toward one another and embracing the plunger stem, and in addition to serving as a track or slideway for the plunger stem they provide a mounting for the coil.

To reduce the noise created by vibration of the rear face of the plunger head against the frame during energization of the solenoid, a shading ring, comprising a closed loop of electrically conductive material, such as copper, encircles each of the pole pieces. The current induced in the shading rings generates a counterflux which is out of phase with the rapid reversals of field polarity due to the reversals of current sign, and the shading rings thus prevent the small movements of the plunger which would otherwise result from these changes of field flux and which

2

produce vibration or chatter of the plunger head against the frame.

Customarily the two plunger guide elements in which the plunger is mounted are secured to the frame by means of three rivets, one of which passes through the rear ends of the plunger guide stem portions and the medial portion of the rear transverse frame member, and the other two of which pass through the end portions of the plunger guide cross members and through the pole pieces of the frame closely adjacent and parallel to one stretch of the shading rings.

Because the magnetic flux field must be concentrated in the plunger stem, the guide members should be made of nonmagnetic material. Heretofore, as may be seen by reference to the aforesaid patent to H. Y. Fisher, the plunger guide elements have been made as a pair of complementary unitary stampings of either brass or some similar cuprous alloy or nonmagnetic stainless steel. A stainless steel plunger guide is satisfactory in many respects, but it presents poor bearing surfaces for the plunger and sometimes galls. This situation is of course intolerable, since free sliding of the plunger is essential. Brass, on the other hand, makes a good bearing surface and is nonmagnetic, but it is critically scarce and, more important, it is also a good electrical conductor. The use of a unitary brass plunger guide of the previous type therefore created a serious problem because the conductive cross members cooperated with the rivets through the pole pieces to define a closed loop embracing the air gap coaxially with the plunger and in which, because of the low resistance of the cross members, relatively high circulating currents were induced. The proximity to the shading rings of the rivets comprising portions of this closed loop around the air gap resulted in interference between the flux field induced by this closed loop and the localized flux fields of the shading rings, which interference reduced the efficiency of the shading rings in obviating hum and chatter. A more serious consequence of the currents induced in this closed loop around the air gap followed from the fact that such currents caused the coil to draw more current, with the result that the temperature of the coil rose.

Moreover, because the flanges on the plunger guide stem portions did not extend along the entire length of these guides, being interrupted in the neighborhood of the cross member, such a unitary plunger guide had relatively little rigidity.

With these objections to previous types of A. C.

solenoid plunger guides in mind, it is an object of this invention to provide a plunger guide element for a solenoid of the character described which will have a nonmagnetic stem portion providing a good bearing surface for the plunger but which will have a cross member of relatively high resistance material so that circulating currents in the closed loop around the air gap, defined by the cross members and the rivets which hold them, will be minimized, with consequent improvement in both the noise and efficiency characteristics of the solenoid.

Another object of this invention resides in the provision of a plunger guide element which will have a relatively long channel-shaped guiding portion, extending forwardly of the cross member or supporting member of the guide element and having inwardly turned flanges throughout its entire length so as to afford maximum support for the plunger and maximum mechanical strength to resist abuses in handling the solenoid.

Still another object of this invention resides in the provision of a two-piece plunger guide element of the character described wherein the two components may be very accurately located with respect to one another during the assembly of them and may be secured to one another by means of a very simple crimping operation.

A further object of this invention is to provide a plunger guide which may be very accurately and precisely located and secured on the frame of a solenoid even though the holes for the rivets by which it is secured are slightly oversize and are not in exact alignment.

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

The accompanying drawing illustrates one complete example of the physical embodiment of the invention constructed according to the best mode so far devised for the practical application of the principles thereof, and in which:

Figure 1 is a side elevational view of a solenoid having the plunger guide of this invention installed thereon, a portion of the coil being shown cut away to illustrate detail;

Figure 2 is a sectional view taken along the plane of the line 2—2 in Figure 1;

Figure 3 is an enlarged fragmentary cross sectional view taken along the plane of the line 3—3 in Figure 1; and

Figure 4 is a perspective view of a pair of plunger guide units of this invention shown in approximately their assembled relationship to one another.

Referring now to the accompanying drawing in which like numerals designate like parts throughout the several views, the numeral 5 designates generally an alternating current solenoid having a frame 6 embracing its coil 7 and a plunger 8 mounted for endwise reciprocation into and out of the hollow center of the coil, coaxially therewith.

As is customary, the solenoid frame comprises a stack of identical substantially C-shaped laminations. The shape of the frame may be said to be defined by a pair of side members 9, extending along opposite sides of the coil parallel to its axis, a rear transverse member 10 con-

necting the side members at their rear end portions and extending across the rear end of the coil, and a pair of pole pieces 11 extending toward one another from the front ends of the side members across the front of the coil. The pole pieces have opposed pole faces 12 which define an air gap wherein the plunger is accommodated and which is coaxial with the coil.

The plunger is substantially T-shaped, having a stem portion 13 and an enlarged head 14, the rear face 15 of which abuts against the front faces 16 of the pole pieces in the attracted or rearmost position of the plunger. Immediately behind the head of the plunger is an enlargement 20 of the stem which may be considered as providing shoulders on the stem, and this enlargement fills the air gap in the attracted or seated position of the plunger, there being a substantial space between the pole faces and the plunger stem when the plunger is in its withdrawn position.

Because of the rapid reversals of polarity of the flux field in an alternating current solenoid, the plunger may be partially released during each current cycle and may withdraw slightly from its engagement with the pole faces; then, as the flux again builds up, the plunger reengages the frame with a distinct clicking sound which, because of the frequency of the reversals of the flux field, gives rise to an unpleasant humming or chattering noise. To eliminate or minimize this noise, a shading ring 22, comprising a closed loop of copper or the like, encircles each of the pole pieces. The currents induced in these shading rings by the flux field of the electromagnet generate localized flux fields which restrain the plunger against the above described vibration and thus eliminate or greatly minimize hum and chatter.

The plunger guide of this invention, in which the stem portion of the plunger is slidably mounted and which mounts the coil 7, comprises a pair of identical complementary plunger guide elements 24, each of which consists of a transverse supporting member or cross member 27 and a longitudinal guide member 23, the two component members of each guide element being secured together to form a substantially T-shaped unit.

The cross member or supporting member of each plunger guide element comprises an elongated strip having an outwardly turned flange 29 along one longitudinal edge thereof so that it is L-shaped in cross section. It is preferable to make the cross member of a high resistance nonmagnetic material, such as stainless steel; but a magnetically permeable material may be used if desired without serious disadvantages, although such material should of course have a relatively high electrical resistance.

The guide member 23 is an elongated strip of brass or other nonmagnetic metal which provides a good bearing surface in conjunction with the metal of the plunger. The guide member has a U-shaped or channel-shaped cross section throughout most of its length, the flanges 30 of the channels terminating, as at 31, ahead of the rear end of the member so that its rear end portion 32 is flat to enable it to be secured flatwise to the medial portion of the rear transverse frame member. Since the two guide members are secured at opposite sides of the frame they are laterally spaced apart a distance such as to receive the stem portion of the plunger between them, and their flanges extend toward one

another so as to guidingly embrace the stem portion of the plunger.

The plunger, as is conventional, has elongated substantially rectangular side plates 33 on its sides, preferably slightly thicker than the plunger laminae and having a uniform width throughout their length. These side plates extend some distance forwardly of the plunger head, as at 19, and provide a pull bar by means of which a load may be secured to the plunger in a well-known manner. Behind the supporting members the flanges 30 of the guide members are wide enough to extend across the plunger side plate sufficiently far to embrace most of the outermost plunger laminae; but the front ends of the flanges are cut back or shortened, as at 34, to clear the plunger head and shoulders during seating movement of the plunger.

A longitudinal slot 35 in the web of each of the guide members accommodates a lug-like projection 36 on each plunger side plate and the ends of the slot cooperate with this projection to define the limits of travel of the plunger to and from its rearmost or seated position.

Each of the supporting members has a pair of spaced apart lug-like indentations 37 which are struck inwardly to a substantially U-shaped cross section from the body portion of the supporting member and which serve a two-fold purpose. Firstly, these indentations snugly embrace the flanges of the guide member at the front end portions thereof so as to accurately align the guide member with its supporting member during assembly of the two. Secondly, these indentations cooperate with the opposed pole faces 12, fitting snugly between them so as to center the cross member with respect to said pole faces during assembly of the plunger guide elements to the frame. It will thus be seen that the height of these indentations is substantially equal to the width of the shoulder 12, or in other words the indentations extend across the air gap from the flanges on the guide members to the pole faces. Their depth is slightly less than the width of the cut back front portions of the flanges 30, so that they do not interfere with the plunger shoulders as the plunger reciprocates.

The longitudinal plunger guide member and the transverse supporting member are assembled to one another by means of a crimped extrusion 39 comprising material punched out of the web of the guide member near the front thereof, through a hole in the supporting member, and rolled or peened across the outer surface of the supporting member to provide, in effect, a self-rivet. When the plunger guide elements are assembled the flange of the supporting member and the flanges of the guide member extend in opposite directions, and the flange on the supporting member extends along the rear longitudinal edge thereof to provide a supporting surface against which the lower end portion of a coil retaining leaf spring 40 reacts. This spring is of the type described in the patent to E. M. Soreng et al., No. 2,516,603, issued July 25, 1950, to which reference may be made for detailed information. It will be noted that the opposite end portion of this coil retaining spring reacts upwardly against the rear portion of the shading ring and thus retains the shading ring in place, while its central portion biases the coil rearwardly into engagement with the front face of the rear transverse frame member.

The guide members are secured at their rear portions to the medial portion of the rear trans-

verse frame member by means of a rivet 42, and the supporting members are likewise secured by means of rivets 43 and 44 to the pole pieces. Attention is directed to the fact that the rivets 43 and 44 are spaced only a small distance from the shading rings and that they cooperate with the supporting members to define a closed loop around the air gap. However, because the supporting members are made of material having a high electrical resistance, the circulation of induced currents through this loop around the air gap will be a minimum.

Assembly of a solenoid having the plunger support of this invention follows the same procedure as that for solenoids having plunger supports of the previous types except that the components of the supporting elements must first be assembled to one another. However, it will be seen that this step is relatively simple, especially because of the lug-like indentations which hold the guide member centered with respect to the supporting member. It will also be seen that assembly of the plunger supporting elements into the frame is greatly facilitated by the cooperation between these indentations and the pole faces, so that even if the rivet holes in which the rivets 43 and 44 are received are slightly oversize and/or are not perfectly aligned, the plunger supports will nevertheless be accurately disposed with respect to the frame.

From the foregoing description, taken together with the accompanying drawing, it will be readily apparent that this invention provides a plunger support which largely overcomes the heating problems heretofore inherent in such devices and which, moreover, has high mechanical strength, provides good support for the coil retaining spring members, provides a good bearing for the plunger stem, and is virtually self-centering because of the lug-like indentations on the supporting member.

What we claim as our invention is:

1. In a solenoid of the type having an endwise slidable plunger and a substantially C-shaped frame embracing the coil and defining an air gap at the front of the frame to accommodate the stem of the plunger, a plunger guide in which the plunger stem is mounted for endwise sliding reciprocation, comprising: a pair of elongated supporting members secured to opposite sides of the frame at the front thereof and extending across the air gap, said supporting members being of a metal having relatively high electrical resistance to thus minimize circulating currents around the air gap; a pair of channel-shaped elongated guide members embraced by the coil, each of said guide members having a web, the front portion of which is secured to one of the supporting members, overlying the inner surface of the supporting member, said web extending rearwardly from the supporting member and being secured to the rear of the frame, said guide members having flanges along a substantial portion of their length extending inwardly toward one another and embracing the stem of the plunger, said guide members being of a non-magnetic metal different from the metal of the supporting members; and spaced apart indentations on each of the supporting members snugly embracing the flanges at the front portion of the guide member to hold the guide member centered on the supporting member during securement of the members to one another.

2. A substantially T-shaped plunger guide element for a solenoid of the character described,

comprising: an elongated supporting member providing the head of the T; an elongated guide member having a channel-shaped cross section along a substantial portion of its length, with its flanges adapted to guidingly embrace the stem portion of a solenoid plunger, said guide member being secured at its front end to the medial portion of the supporting member, to provide the stem of the T, with the web of the guide member channel flatwise adjacent to the supporting member and with the flanges of the guide member extending away from the supporting member; and spaced apart lug-like indentations in the supporting member snugly embracing the front portion of the guide member to hold the guide member centered on the supporting member during securement of the members to one another.

3. The plunger guide element of claim 2, further characterized by the fact that the supporting member is made of a metal having a relatively high electrical resistance, and the guide member is made of a nonmagnetic metal different from the metal of the supporting member.

4. In a solenoid of the type having a substantially C-shaped frame embracing the coil and including a transverse element extending across the rear end of the coil and an air gap defined by opposing pole faces on pole portions extending toward one another over the front end of the coil, and a plunger endwise slidable toward and from a rearmost seated position and having a stem portion and shoulder portions at the front of the stem portion which substantially fill said air gap in the seated position of the plunger, a plunger guide in which the plunger is slidably mounted, comprising: a pair of elongated supporting members of relatively high resistance metal secured to the pole portions of the frame at opposite sides thereof and each extending across the air gap; a pair of elongated guide members of nonmagnetic material which makes a good bearing with the plunger material, said guide members being embraced by the coil and having rear portions secured to the transverse frame element at opposite sides thereof, each of said guide members extending forwardly from said transverse frame element at least to the supporting member at its side of the frame and having a channel shaped cross section with the flanges thereof projecting inwardly and embracing the plunger stem; a pair of spaced lug-like indentations in each of said supporting members snugly embracing the longitudinal sides of its adjacent guide member to hold the guide member centered with respect to the supporting member, said indentations also being engaged with the pole faces to hold the supporting member centered with respect to the frame prior to securement of the supporting members to the frame; and means securing each guide member to its adjacent supporting member.

5. In a solenoid of the type having a substantially C-shaped frame embracing the coil and including a transverse element extending across the rear end of the coil and a pair of pole pieces extending toward one another over the front end of the coil and cooperating to provide an air gap at the front of the coil defined by opposing pole faces on said pole pieces, and an endwise slidable

plunger having a stem portion and shoulder portions at the front of the stem portion which substantially fill said air gap in the seated position of the plunger, a pair of complementary plunger guide elements in which the plunger is slidably mounted, each comprising: a transverse supporting member secured at its ends to the sides of the pole pieces and spanning the air gap; a longitudinal guide member fixed to and extending rearwardly from the supporting member to the rear transverse frame member and having inwardly extending flanges embracing the plunger stem to slidably support the same; and a pair of lug-like indentations on the supporting member engaged with the pole faces to hold the supporting and guide members centered with respect to the pole faces during assembly of the plunger guide element to the frame.

6. The solenoid of claim 1, further characterized by the fact that each of the supporting members has a laterally outwardly extending flange along one longitudinal edge thereof to afford high mechanical strength; and further characterized by the fact that said indentations on each of the supporting members engage the portions of the C-shaped frame defining the air gap to hold the supporting member centered with respect to the frame.

7. In a solenoid of the type having a substantially C-shaped frame embracing the coil and including a transverse element extending across the rear end of the coil and a pair of pole pieces having surfaces facing one another at the front end of the coil and cooperating to provide an air gap and a plunger slidable endwise in the coil and received between said pole surfaces, a pair of complementary plunger guide elements in which the plunger is slidably mounted, each comprising: a transverse supporting member secured at its ends to the sides of the pole pieces and spanning the air gap; a longitudinal guide member fixed to and extending rearwardly from the supporting member to the rear transverse frame member and having inwardly extending flanges embracing the plunger stem to slidably support the same; and a pair of abutments on the supporting member interposed between the flanges of the guide member and said pole surfaces, said abutments serving to locate the supporting member with respect to the guide member during their securement to one another and to hold the supporting and guide members centered with respect to said pole surfaces during assembly of the plunger guide element to the frame.

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