This invention relates in general to solenoids, and more particularly to alternating current solenoids, and still more particularly to solenoids of laminated structure. Solenoid manufacturers continually endeavor to develop solenoids having improved operating characteristics, including rugged construction resulting in longer life, good seal pull characteristics, quieter operation, and better pull curve characteristics.

It is therefore an object of this invention to provide a solenoid incorporating the above improvements and others.

A further object of this invention is in the provision of a solenoid having a frame and plunger structure that keeps the inductance from dropping off during closing of the plunger relative to the frame.

A still further object of this invention resides in the provision of a solenoid having a frame and plunger structure whereby the plunger includes a seating bar that is completely enclosed by the frame when the plunger is in seated position.

Other objects, features and advantages of the invention will be apparent from the following detailed disclosure, taken in conjunction with the accompanying sheets of drawings, wherein like reference numerals refer to like parts, in which:

FIG. 1 is a perspective view of a solenoid embodying the invention.

FIG. 2 is a top plan view of the solenoid of FIG. 1 looking into the open end of the frame with the plunger removed; and

FIG. 3 is an elevational view of the solenoid of FIGS. 1 and 2, with some parts removed for purposes of clarity and illustrating the plunger in seated position.

To illustrate the invention, the drawings show the solenoid of the present invention as including generally a coil 16 having a plurality of turns carried on an insulating spool or bobbin 17 and a pair of terminal lugs 18 for connection to electrical power.

A plunger 19 having an elongated stem 20 is reciprocably received within the opening or hollow of the coil 16. The plunger is constructed from a plurality of laminae of magnetically permeable material.

A magnetically permeable, generally, C-shaped frame 21, also constructed from a plurality of laminae of magnetically permeable material, embraces the coil 16. The opposite outer laminae of the frame 21 is provided with integral upper and lower laterally extending coil retaining flanges 22 and 23 between which the coil 16 is positioned. A pair of plunger slides 24 face each other and extend through the hollow or center opening of the coil 16, and are suitably held in position relative to the frame for slidably receiving the plunger 19. Plunger stopout and anti-residual springs may be provided between the upper flanges 22 and the upper end of the coil 16 for purposes of limiting the outward travel of the plunger relative to the frame and to counteract the residual magnetism of the solenoid when the plunger is in seated position.

The frame 21 includes parallel spaced legs 25 and 26 straddling the coil 16 and being integrally connected together at their lower ends by the bight 27. At the upper ends of the legs, inwardly projecting arms 28 and 29 extend perpendicularly to the legs 25 and 26, respectively, and are integral therewith. The inner ends of the arms terminate to define faces 30 and 31 which extend parallel to the legs 25 and 26. An opening is defined between the faces 30 and 31 for reciprocably receiving the stem 20 of the plunger. The arms 28 and 29 terminate in beveled faces 32 and 33 and are provided with seating faces 34 and 35 extending perpendicular to the legs 25 and 26. Thus, the beveled faces 32 and 33 connect the seating faces 34 and 35 with the faces 30 and 31, respectively.

Shading coils 36 and 37 are embedded in the seating faces 34 and 35 of the arms 28 and 29, respectively. Each coil is constructed of a conductive material and formed in the shape of a rectangular loop having opposite sides 38 and 39 extending transverse to the frame laminate and embedded in the arms 28 and 29. The sides 38 and 39 are interconnected at opposite ends by end portions 40 and 41 that are arranged exteriorly of the frame. Accordingly, the coils 36 and 37 define a shaded area at each side of the frame.

Pull bars 42 are provided on the plunger 19 and suitably apertured for connection to a link or lever to which a tractive force may be applied by the solenoid.

The plunger 19 includes a seating bar 43 which extends transversely to the frame 20 and is provided with seating faces 44 and 45 which mate with seating faces 34 and 35, respectively, of the frame. A second cross bar 46 is provided below the seating bar 43 and of a narrower width and having opposed beveled faces 47 and 48 which coast but do not engage with the beveled faces 32 and 33 of the frame. A slight clearance is provided between the beveled faces of the plunger and the beveled faces of the frame when the plunger is in seated position.

The opposite ends of the plunger seating bar 43 are enveloped in the frame by projections 49 and 50 which extend upwardly from the spaced legs 25 and 26. The projections are integral with the legs. The height of the projections is substantially equal to the height of the seating bar and this construction keeps the inductance from dropping off during closing of the plunger relative to the frame.

Changes may be made in the form, construction and arrangement of the parts without departing from the spirit of the invention or sacrificing any of its advantages, and the right is hereby reserved to make all such changes as fall fairly within the scope of the following claims.

The invention is hereby claimed as follows:

1. A laminated solenoid comprising a coil having an axial bore therethrough, a frame embracing the coil and having an opening at one end thereof aligning with said bore, and a plunger having a stem reciprocably received in the opening of said frame and the bore of said coil, said frame including a pair of upstanding parallel spaced leg portions, a bight portion interconnecting the legs together at their lower ends, inwardly extending arm portions at the upper ends of said legs terminating in beveled faces, and upwardly extending projection portions at the upper ends of said leg portions extending above said arm portions, said plunger having a seating bar extending perpendicular to said stem and adapted to seat on said arm portions, and a cross bar beneath said seating bar having opposed beveled faces mating with the beveled faces on said frame, the opposite ends of said seating bar being substantially within the confines of said projection portions.

2. A laminated solenoid comprising a coil having an axial bore therethrough, a generally C-shaped frame embracing the coil and having an opening at one end aligning with the bore of the coil, said frame including a pair of parallel spaced leg portions, a bight portion extending perpendicular to said leg portions and interconnecting adjacent ends thereof, arm portions normal to said leg portions and extending inwardly from the adjacent ends opposite the bight portion, beveled surfaces on the terminal ends of said arm portions, projection portions ex-
tending from the ends of said leg portions opposite said bight portion and beyond said arm portions, and a plunger having an elongated stem portion reciprocally received in said frame opening and said coil bore, a seating bar portion at one end of the stem and normal thereto, said seating bar portion adapted to engage said arm portions and be substantially within the confines of the projection portions when in seated position, said plunger having a cross bar portion adjacent said seating bar portion having beveled terminal ends mating with the beveled surfaces on said arm portions.

3. A laminated solenoid comprising a coil having an axial bore therethrough, a generally C-shaped frame embracing the coil and having an opening at one end aligning with the bore of the coil, said frame including a pair of parallel spaced leg portions, a bight portion extending perpendicular to said leg portions and interconnecting adjacent ends thereof, arm portions normal to said leg portions and extending inwardly from the adjacent ends opposite the bight portion, beveled surfaces on the terminal ends of said arm portions, projection portions extending from the ends of said leg portions opposite said bight portion and beyond said arm portions, and a plunger having an elongated stem portion reciprocally received in said frame opening and said coil bore, a seating bar portion at one end of the stem and normal thereto, said seating bar portion adapted to engage said arm portions and be substantially within the confines of the projection portions when in seated position, said seating bar portion having a thickness substantially equal to said projection portions, said plunger having a cross bar portion adjacent said seating bar portion having beveled terminal ends mating with the beveled surfaces on said arm portions.

4. A laminated solenoid comprising a coil having an axial bore therethrough, a generally C-shaped frame embracing the coil and having an opening at one end aligning with the bore of the coil, said frame including a pair of parallel spaced leg portions, a bight portion extending perpendicular to said leg portions and interconnecting adjacent ends thereof, arm portions normal to said leg portions and extending inwardly from the adjacent ends opposite the bight portion, the terminal ends of said arm portions having surfaces paralleling said leg portions and surfaces angularly positioned thereto, projection portions extending from the ends of said leg portions opposite said bight portion and beyond said arm portions, and a plunger having an elongated stem portion reciprocally received in said frame opening and said coil bore, a seating bar portion at one end of the stem and normal thereto, said seating bar portion adapted to engage said arm portions and be substantially within the confines of the projection portions when in seated position, said plunger having a cross bar portion adjacent said seating bar portion having terminal ends with faces angularly positioned relative to said stem and mating with the angularly positioned surfaces on said leg portions.

5. A laminated solenoid comprising a coil having an axial bore therethrough, a generally C-shaped frame embracing the coil and having an opening at one end aligning with the bore of the coil, said frame including a pair of parallel spaced leg portions, a bight portion extending perpendicular to said leg portions and interconnecting adjacent ends thereof, arm portions normal to said leg portions and extending inwardly from the adjacent ends opposite the bight portion, beveled surfaces on the terminal ends of said arm portions, projection portions extending from the ends of said leg portions opposite said bight portion and beyond said arm portions, and a plunger having an elongated stem portion reciprocally received in said frame opening and said coil bore, a seating bar portion at one end of the stem and normal thereto, said seating bar portion adapted to engage said arm portions and be substantially within the confines of the projection portions when in seated position, said plunger having a cross bar portion adjacent said seating bar portion having beveled terminal ends mating with the beveled surfaces on said arm portions.

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