

POLYMER LINEAR GUIDE

BACKGROUND OF THE INVENTION

5 1. Field of the Invention

The present invention relates to linear guides having a slide body and a guide rail. More specifically, the present invention relates to a linear guide in which the slide body, the guide rail, or both are unitarily constructed of polymer, coated, or otherwise provided with a polymer bearing surface.

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2. Description of the Prior Art

Linear motion guides are an important component in the construction of automated and other equipment. The linear motion guide (hereinafter just "linear guide") provides for high precision as a piece of equipment, such as a robotic arm or workpiece, is linearly moved back and forth over a relatively long distance. Since each linear guide has only a single degree of freedom, longitudinally along its guide rail, multiple linear guides may be used in combination to provide additional degrees of freedom for the moving of the equipment.

Generally, linear guides have two primary components, a guide rail (also known as a track and hereinafter referred to as a "rail") and slide body (hereinafter just referred to as a "slider"). The slider and rail are designed so that the slider mounts and moves along the rail without play or backlash. This is achieved by employing a bearing mechanism between the two.

In one variety of prior linear guide, recirculating ball bearings are captured within the slider and contact a bearing race formed in the rail. Such systems are relatively costly to produce and replace. When worn, the construction of the recirculating ball bearing slider is such that, at a minimum, the entire slider must be replaced and, more typically, both the slider and rail. It is not feasible to merely replace the ball bearings because of the wear in the raceways where the bearings contact the slider and the rail.

Another type of linear guide actually eliminates the use of recirculated ball bearings while still providing the necessary low sliding friction between the slider and the rail. In this type of linear guide, a bearing material is permanently bonded to the slider so as to provide a contact interface between the slider and the rail. Polymer materials used to form these bearing surfaces have included nylon, polytetrafluorethylene (PTFE) and numerous others. Such a design is generally considered to be maintenance free in that there is no need for wet lubricants since the polymer chosen typically provides a built-in and permanent lubrication.

Some drawbacks on the above designs are the required separate manufacture of the

slider and bearing portion and the mounting of the bearing material to the slider. Such mounting typically involves the bonding of the polymer, in a predetermined thickness, to areas of the slider so as to engage the rail. The bonding procedure itself is sometimes complex and costly, depending on the specific polymer and slider materials involved. Additionally, concerns may arise regarding a failure of the bond during use and any resulting consequences.

One alternative approach to bonding the polymer to the slider is disclosed in U.S. Patent No. 5,735,610, issued April 7, 1998, the subject matter of which is hereby incorporated by reference. In that patent the slider requires replaceable polymer inserts upon which the slider slides.

In view of the foregoing limitations and shortcomings of the prior art devices, as well as other disadvantages not specifically mentioned above, it should be apparent that there still exists a need in the art for an improved linear guide.

It is therefore a primary object of this invention to fulfill that need by providing a linear guide which eliminates the need for ball bearings or for the bonding of the polymer material to the slider.

Another object of the present invention is to provide a linear guide which eliminates the need for separately manufacturing the slider and the bearing.

A further object of the present invention is to provide a linear guide in which the bearing element and the slider or rail are formed as a unitary component.

SUMMARY OF THE INVENTION

Briefly described, these and other objects are accomplished according to the present invention by providing a linear guide, as with prior linear guides which includes a slider that is slidably mounted to a guide rail. However, in the present invention the slider, and in alternate embodiments the rail, defines the bearing surface which allows the slider and rail to move relative to each other.

The slider of the present invention includes a body having a top, a bottom, opposing sides and opposing ends. Portions of the body define a channel that extends longitudinally through the length of the body, between the opposed ends. The channel has an open side generally in the direction of the bottom of the body and exhibits a cross-sectional shape which allows the rail to be received therein. The rail has opposing ends that define its length, which is greater than the length of the body. The interaction between the cross-sectional shape of the body and the rail is of a low clearance and allows for movement of the body along the rail restricting movement to a single degree of freedom. Lateral or vertical movement of the body relative to the rail is accordingly inhibited.

The slider or rail is made from one of several preferred polymeric materials having a low coefficient of friction, high load capacity and good wear characteristics which facilitates the longitudinal sliding movement of the slider relative to the rail. The present invention encompasses embodiments where the slider is composed of polymer and the rail is a non-polymeric material, where the rail is composed of polymer and the slider is a non-polymeric material, where both the rail and slider are composed of polymer, where the rail has polymer bonded to a non-polymeric core, and where the rail includes replaceable polymer bearing inserts. In embodiments where both the rail and slider are made of polymeric materials, it is preferable that they be made from different polymeric materials.

By providing the bearing element as outlined above, several of the embodiments of this invention have the slider directly engaging the rail, eliminating the need for a separate bearing carried by the slider or bonded to the slider.

Additional benefits and advantages of the present invention will become apparent to those skilled in the art to which the present invention relates from the subsequent description of the preferred embodiments and the appended claims, taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a linear guide embodying the principles of the present invention;

FIG. 2 is an exploded view of a linear guide according to the principles of the present invention;

FIG. 3 is a sectional view taken substantially along line 3-3 in FIG. 1 illustrating various features of the present invention;

FIGS. 4-7 are a sectional views taken substantially along line 3-3 in FIG. 1 of alternate embodiments of the present invention;

FIGS. 8a-8b are alternate views of an alignment mechanism for the slider of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now in detail to the drawings, there is shown in FIG. 1 a linear guide, generally designated at 10, embodying the principles of the present invention. The linear guide 10 principally includes a guide rail ("rail 12") on which is supported a slide body ("slider 14"). Depending on the specific embodiment of the present invention which is being referred to for discussion, the rail 12 or slider 14 may be constructed out of aluminum, steel, polymer or other suitable material.

The rail 12 is a longitudinal member and includes a top surface 16, a bottom surface 18, and opposing side surfaces 20. Vertical bores 22 are provided in the rail 12, extending from the top surface 16 to the bottom surface 18, to enable the securing of the rail 12 to a suitable base or table by fasteners such as screws (not shown). The bores 22 are provided in a manner which will allow the heads of the fasteners to be counter sunk beneath the top surface 16. In this way, the fasteners will not interfere with movement of the slider 14 along the guide rail 12.

The side surfaces or sides 20 of the rail 12 are profiled such that inclusions 24 are directed generally toward one another inwardly of the rail 12. The inclusions 24 are provided in the shape of trapezoidal indentations into the sides 20. As further discussed below, the inclusions 24 cooperate with protruding portions of the slider 14 to retain the slider 14 on the rail 12 and limit relative movement between the two to an axial or longitudinal direction along the rail 12.

Referring now to FIGS. 2 and 3, the slider 14 is a generally rectangular body which includes a top surface 26, a bottom surface 28, opposed side surfaces 30 and opposed end surfaces 32. The top surface 26 forms a generally planar surface to which at least a portion of the component to be guided by the linear guide 10 is mounted. To facilitate this mounting, mounting bores 34 are vertically provided in the top surface 26 and into the slider 14. Bolts or other fasteners (not shown) can be extended through the slider 14 and through the mounting bores 34 allowing a nut or other engagement mechanism (not shown) to engage the opposing end of the fastener. If desired, the bores 34 may be threaded or provided with threaded inserts (molded or otherwise formed therein) to engage the fastener, without further engagement with the nuts. Cut-outs 36, axially aligned with the mounting bores 34, are formed in the slider 14 to recess the nuts (if utilized) within the exterior dimensions of the slider 14. The cut-outs 36 are illustrated as extending upward from the bottom surface 28 and inward from the side surfaces 30 and end surfaces 32 to locate the cut-outs 36 generally in the four corners of the slider 14. Obviously, alternative locations and configurations, or even complete elimination thereof of the cut-outs 36 could be employed depending on the specific design criteria of the linear guide 10 and its intended application.

Formed longitudinally through the slider 14 and generally being open in the direction of the bottom surface 28, is a channel 38 whose cross-sectional shape generally corresponds to the cross-sectional shape of the rail 12. As seen in FIG. 3, the cross-sectional shape of the channel 38 is closely dimensioned to conform to the cross-sectional shape of the rail 12. Adjacent to the bottom surface 28, the protrusions 40 define a necked-down entrance area into the channel 38 and this cooperates with the channel to inhibit vertical and lateral movement of the slider 14 relative to the rail 12.

While the above discussed shapes of the rail and the channel have been detailed with

some particularity, it will be understood that these shapes can be provided in numerous alternative configurations. All such shapes are therefore considered to be equivalents of the illustrated shape, so long as the above general operating parameters of the linear guide are met.

5 As briefly mentioned above, the slider 14 rests directly on the rail 12 and its channel 38 defining surfaces function and operate as a bearing element. Alternatively, the surfaces defining the channel 38 can include a series of protuberances or raised sections not shown, extending partially or fully along the length of the channel 38, which engage the rail 12 and operate as a bearing surface of the slider 14.

10 The slider 14 in the preferred embodiment utilizes a self alignment mechanism 47 which includes spring biased plungers 48, as seen in FIGS. 8a and 8b. The plungers 48 provide for self alignment of the slider 14 relative to the rail 12. A plurality of bores 46 extend laterally through slider 14 so that the plungers 48 (three in the illustrated embodiment) contact the rail 12 at an upper vertical face 49 thereof. Notably, the bores 46 are equidistantly located
15 along the length of the slider 14 for equalizing the loading and self alignment of the slider 14 relative to the rail 12. The contact between the plungers 48 and the rail 12 is adjustably provided by the incorporation of coil springs 50 or other biasing mechanism /member between the plunger 48 and a set screw 52 which is threadably received in the bore 46. The force exerted by the plungers 48 on the rails 12 is varied by progressively advancing or retracting
20 the set screws 52. This change in position varies the force exerted by the plungers 48 upon the rail 12 and allows the position of the slider 14 to self-align relative to the rail 12. In the preferred embodiment three plungers 48 are used to self-align said slider 14 with said rail 12, although a greater or lesser number could be used. The plungers 48 are themselves made of a low friction polymeric material, such as one of the materials described below, since they too contact
25 and slide along the rail 12.

 In another preferred embodiment, the plungers 48 are retained in threaded casings that are threaded into the bores 46. Within the casing is a spring that biases the plunger such that the plunger partially protrudes from a necked down portion of the casing. The opposite end of the casing is closed to retain the spring and include a drive socket or head allowing it to be
30 advanced or retracted in the bore 46. By advancing or retracting the casing relative to the bore 46, or by providing a more or less stiff spring within the casing, the force is exerted by the plungers 48. While the plungers 48 may directly contact the rail 12, they also may all contact a common gib which is itself in contact with the rail 12. The gib is supported by the body 14 or may extend approximately the length of the body 14. As such, the gib may be received in an
35 axial slot formed in the body 14 and is mounted with respect thereto for a limited amount of transverse movement, for example 0.001 inches. Since it contacts the rail 12, the gib is made

of a low friction polymer and, in this embodiment, the plunger 48 may be of a different material, such as steel.

To form the slider 14, the polymer material may be cast or otherwise molded into the desired end shape, may be extruded into the desired end shape, or may be initially formed in any manner and then machined into the desired shape. The bores 34 and 46 mentioned above are machined or molded into the slider 14. If the bores 34 and 46 are threaded, the internal threads are either tapered into a machined bore or internally threaded inserts (of metal or other suitable material), known as heli-coils, are molded in place within the body of the slider 14 or mounted into the bores 34.

The basic operating limits for a linear guide 10 according to the present invention are anticipated to be: load (300-750 lbs./slide body); pressure/velocity level (approximately 7500); and maximum operating temperature (300-500° F) up. Obviously, operating parameters beyond the above listed parameters could be employed upon appropriate design considerations being employed. For example, the load capacity of the linear guide 10 might be increased by the inclusion of reinforcement members (such as rods, mesh, grids or other structures) within the body of the slider 14 during initial formation.

As seen above, in addition to withstanding the anticipated operating parameters, the material from which the slider 14 is formed needs to have a low coefficient of friction, good wear capabilities and not necessarily require wet lubricants. Any suitable material which meets the above criteria therefore constitutes a preferred material of this invention.

Representative materials include, without limitation, thermosetting polymers such as epoxy resins, allyl esters, amino polymers, phenolics, polyesters, polyamides and nylons, cyanoacrylates, polyurethanes, silicones and mixtures thereof; thermoplastic polymers such as polystyrene, polyethylene, polyvinyl chloride, polyethylene terephthalate, and mixtures thereof; materials with characteristics of both of the above varieties of polymers; and plastic lubricants such as polytetrafluoroethylene (PTFE) and filled PTFE. The polymer could also include known self or solid lubricating components. Generally, an acceptable polymer will be any polymer capable of carrying an adequate load while maintaining low friction characteristics.

One specific preferred polymer material, having a PV of 7500, an operating temperature range of over 300° F, is an extruded polyamide-imide commercially available from the DSM Polymer Corporation, Reading, Pennsylvania under the tradename of TORLON. The coefficient friction of this material is 0.20, the operating temperature range of this material is over 500° F (making the material much stronger at elevated temperatures), the thermal expansion rate of the material is significantly low (allowing for closer tolerances between the parts) and the PV limit (45,000) greatly exceeds the anticipated requirements for most known applications of linear guides 10. Another preferred material is commercially available under the

tradename NYLATRON from the above mentioned company.

As seen in the embodiment of FIG. 3, the rail 12 is made from a suitable materials, such as aluminum or steel, and is coated or otherwise provided with an exterior surface having a low coefficient of friction. One such method of providing the low coefficient surface is via a synergistic coating. Such coatings are advantageous because of their wearability, low friction, anticorrosion and non-sticking characteristics. Such coatings are well known and involve the conversion of the base metal surface into an oxide (ceramic) surface and the disposition or infusion of a polymer (such as a fluoropolymer) into the oxide surface resulting in a new surface with superior performance characteristics.

In an alternate embodiment, seen in FIG. 5, the rail 12 is polymeric and the slider 14 is made of a non-polymeric material such as aluminum or steel. As with the embodiment of FIG. 3, the non-polymeric material is provided with an exterior surface (at least where it contracts the rail) having a low coefficient of friction. Again, such a surface may be provided via a synergistic coating. The rail 12, is constructed of the materials mentioned above in connection with the slider 14 of the embodiment seen in FIG. 3 and can be manufactured by any of the aforesaid methods.

Referring now to FIG. 4, the slider 14 and rail 12 are both shown as being composed of polymeric materials. In the preferred embodiment the slider 14 and the rail 12 are made of different polymeric materials. The dissimilarity in polymeric materials between the slider 14 and rail 12 decreases the friction between the slider 14 and rail 12, as the slider 14 traverses the rail 12.

In the embodiment seen in FIG. 6, the rail 12 of the embodiment therein has bonded to it a corresponding covering 60 of suitable polymeric material. The covering 60 provides a bearing surface, at least in those areas engaging the slider 14, similar to the bearing surfaces previously discussed. Various methods are known for bonding polymer to aluminum or steel and such methods are employed in this embodiment.

In the embodiment seen in FIG. 7, a non-polymeric rail 12 is provided with longitudinal slots 62 in which removable polymeric inserts 64 are mounted. The polymeric inserts 64 serve as a bearing surface between the slider 14 and rail 12. The polymeric inserts include feet 66 or are otherwise shaped or keyed to matingly engage and be retained in the slots 62. The inserts 64 are easily removed or installed by sliding the inserts 64, specifically the feet 66, in a longitudinal direction along the rail 14 in and out of the correspondingly shaped slots 62. Once the inserts 64 are in place, the ends of the rail 12, which give access to the installation and removal of the inserts 64, receive end caps (not shown) which cover the ends of the slots 62 into which the inserts 64 are inserted. The end caps are shaped to correspond to the profile or cross-sectional shape of the rail 12 and are secured thereto by screws or other suitable

fasteners. In this manner, the inserts 64 are captured and retained in the slots 62 of the rail 12. The inserts 64 are again formed of one of the above mentioned or similar materials and may be formed by any appropriate method, including casting, machining, extruding or other method. Accordingly, the feet 66 similarly cooperating with the slots 62 prevent the lateral dislodgment
5 of the inserts 64 so that a rigid installation of the inserts 64 is possible.

While the above description constitutes the preferred embodiment of the present invention, it will be appreciated that the invention is susceptible to modification, variation and change without departing from the proper scope and fair meaning of the accompanying claims.

CLAIMS

We claim:



1. A linear guide assembly comprising:
 - a slide body having a top, a bottom, opposing sides and opposing ends, portions of said
 - 5 body defining a channel extending longitudinally through said body between said ends, said
 - body having a unitary construction including bearing surfaces within said channel;
 - a guide rail having opposing ends and a cross-sectional shape corresponding to a
 - cross-sectional shape of said channel, said rail having a unitary construction including bearing
 - surfaces thereon, said rail being received in said channel with said bearing surfaces of said
 - 10 body being in surface-to-surface contact with said bearing surfaces of said rail;
 - at least one of said body and said rail being constructed substantially of a polymeric
 - material and said polymeric material defining said bearing surfaces in contact with the other of
 - said body and said rail; and
 - said body and said rail each having portions cooperating with portions of the other to
 - 15 retain said body on said rail and permit longitudinal movement of said body relative to said rail.
2. The linear guide assembly of Claim 1 wherein said at least one of said body and
- said rail is substantially monolithic in its construction of said polymeric material.
- 20 3. The linear guide assembly of Claim 1 wherein said rail is constructed of said
- polymeric material.
4. The linear guide assembly of Claim 1 wherein said body is constructed of said
- polymeric material.
- 25 5. The linear guide assembly of Claim 3 wherein said body is comprised of a
- nonpolymeric material covered by a synergistic coating at least in areas forming said bearing
- surfaces.
- 30 6. The linear guide assembly of Claim 4 wherein said rail is comprised of a
- nonpolymeric material covered by a synergistic coating at least in areas forming said bearing
- surfaces.

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7. The linear guide assembly of Claim 1 wherein said polymeric material is selected from the group consisting of:

epoxy resins; allyl esters; amino polymers; phenolics; polyesters; polyamides; polyamide-imides; nylons; cyanoacrylates; polyurethanes; silicones and mixtures thereof; polystyrene; polyethylene; polyvinyl chloride; polyethylene terephthalate and mixtures thereof; polytetrafluoroethylene; and filled polytetrafluoroethylene.

8. The linear guide assembly of Claim 1 further comprising a self-alignment mechanism mounted to said body, said mechanism including a plunger, said plunger being biased into contact with said rail.

9. The linear guide assembly of Claim 8 wherein said body includes a plurality of said self-alignment mechanisms axially and equidistantly spaced along said body.

10. The linear guide assembly of Claim 1 wherein said polymeric material is a first polymeric material, the other of said body and said rail being constructed of a second polymeric material, said second polymeric material being different from said first polymeric material.

11. A linear guide assembly comprising:
a slide body having a top, a bottom, opposing sides and opposing ends, portions of said body defining a channel extending longitudinally through said body and between said ends, said body having a unitary construction and including bearing surfaces within said channel;
a guide rail having opposing ends and a cross-sectional shape corresponding to a cross-sectional shape of said channel to permit said rail to be received in said channel, portions of said rail defining longitudinal slots extending substantially the length of said rail; and
polymeric inserts removably located within said longitudinal slots and forming bearing surfaces, said inserts being axially and transversely retained with said rail and in said slots.

12. The linear guide assembly of Claim 11 wherein said inserts are axially received within said slots.

13. The linear guide assembly of Claim 11 further comprising end caps mounted to said ends of said rail, said end caps assisting in retaining said inserts with said rail.

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14. The linear guide assembly of Claim 13 wherein said inserts include portions which engage and cooperate with said portions defining said slots and prevent lateral dislodgment of said inserts from said rail.

15. The linear guide assembly of Claim 14 wherein said inserts are comprised of a material selected from the group consisting of:

epoxy resins; allyl esters; amino polymers; phenolics; polyesters; polyamides; polyamide-imides; nylons; cyanoacrylates; polyurethanes; silicones and mixtures thereof; polystyrene; polyethylene; polyvinyl chloride; polyethylene terephthalate and mixtures thereof; polytetrafluoroethylene; and filled polytetrafluoroethylene.

16. A linear guide assembly comprising:

a slide body having a top, a bottom, opposing sides and opposing ends, portions of said slide body defining a channel extending longitudinally through said body between said ends, said body having a unitary construction including bearing surfaces within said channel;

a guide rail having a top, opposing sides and ends and a cross-sectional shape corresponding to a cross-sectional shape of said channel, said rail being received in said channel, said rail having a unitary construction and portions thereof forming bearing surfaces in surface-to-surface contact with said bearing surfaces of said body; and

a plurality of self-alignment mechanisms mounted to said body, each of said mechanisms including a polymeric plunger and a biasing member, said biasing member biasing said plunger into contact with said rail, said mechanisms being mounted to said slide body such that at least one of said mechanisms is located on each axial half of said body and such that at least two of said mechanisms are located on one longitudinal half of said body.

17. The linear guide assembly of Claim 16 wherein said mechanisms are mounted in bores formed in said body, said bores being transversely oriented relative to said channel such that said plungers contact one of said sides of said rail.

18. The linear guide assembly of Claim 16 wherein said plungers are formed of polymeric material.

19. The linear guide assembly of Claim 16 wherein said plunger engages said rail adjacent to an interiormost portion of said rail.



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20. The linear guide assembly of Claim 16 wherein one of said mechanisms is located adjacent to each of said ends of said body.

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