

COVER STRUCTURE OF LINEAR DRIVE DEVICE

Field of the Invention

This invention relates to a cover structure of a linear drive device having a screw mechanism for converting a rotational movement to a linear movement, and more particularly to a cover structure for a linear drive device which can sufficiently prevent lubricant used in a screw area of the device from scattering or dropping and can avoid dust or other unwanted particles from entering and sticking on the screw area in the linear drive device.

Background of the Invention

A linear drive device related to the present invention has a function of motion-direction conversion for converting a rotational motion to a linear motion. A linear drive device is used in a variety of applications such as in an IC test handler for testing semiconductor devices. An IC test handler transfers IC devices to be tested to a test head of an IC test system and establishes mechanical and electrical connections between the IC devices and test contactors in the test head. The IC handler further transfers back the IC devices that have been tested to device trays to sort the IC devices based on the test results.

In such an IC test handler, a linear drive device is used, for example, to bring the test contactors to pins of the IC devices to establish electrical connections therebetween. Because of the high speed and high level functionality of the IC devices, the electrical connection between the IC devices to be tested and the IC test contactors must be perfectly made to fully evaluate the IC devices by the IC test system.

In such a linear drive device, lubricant such as grease is applied to a screw area to decrease wear and friction as well as to prevent heat generation. However, lubricant may scatter or drop because of the high-speed

rotational motion of a screw shaft or other mechanism. This scattering and dropping of the lubricant is not desirable in such a device as IC test handler since it may adversely affect the test performance of the IC devices or other parts or mechanism nearby.

Furthermore, dust or other unwanted objects may come inside of the linear drive device from the surrounding area. Such dust or objects may be deposited and accumulated on the screw area of the linear drive device, which decreases the reliability of the device. Therefore, in a linear drive device, it is provided with a cover or other means to maintain the lubricant within the device as well as to prevent the dust and the like from entering the device.

An example of cover structure for such purposes is explained for a conventional linear drive device shown in Figures 5 and 6. Figure 5 is a perspective exploded view of a conventional example of linear drive device wherein a cover is provided to avoid the scattering or leaking the lubricant from the screw area of the device to the outside area and to prevent the dust from entering and sticking to the screw area of the device.

The example of Figures 5 and 6 is comprised of a main frame cover 80 having end plates 87, a rotation drive mechanism 90 mounted on the end plates 87, a screw shaft 50 connected to the rotation drive mechanism 90, a motion-direction converter 30 connected to the screw shaft 50, an outside transmission block 35 connected to the motion-direction converter 30, and a screw main cover 38.

The screw shaft 50 is a shaft with spiral threads for transmitting a rotational motion from the rotation drive mechanism 90 to the motion-direction converter 30. Both ends of the screw shafts 50 are supported by and connected to, for example, ball bearings 84a, 84b to allow free rotation. The rotation drive mechanism 90 such as a motor is connected to one end of the screw shaft 50. The screw

shaft 50 receives positive or negative rotational forces by the rotation drive mechanism 90. Lubricant, such as grease, is applied to the area formed by the screw shaft 50 and the motion-direction converter 30 to lubricate the motion relative to one another.

The motion-direction converter 30 is a mechanism that converts a rotational motion into a linear motion. A ball nut 31 receives the rotational motion of the screw axis 50. The ball nut 31 is fixed to the motion-direction converter 30. Both sides of the motion-direction converter 30 are supported by a linear guide 82 along the main frame cover 80. Thus, a linear movement is established along the longitudinal direction of the screw shaft 50. As a consequence, the rotational motion provided to the screw shaft 50 is converted to the linear motion of the converter 30. Although not shown, other mechanism such as a guide rail and the like will be provided to accurately guide and position the motion-direction converter 30.

The outside transmission block 35 is connected to the motion-direction converter 30 to transmit the converted linear motion to outside components. For example, a transmission flange 37 may be provided on the outside transmission block 35 to be connected to the outside components to provide the linear motion. Figure 6a shows a cross sectional view in the assembled situation for an A-A line of Figure 5 where the outside transmission block 35 and the motion-direction converter 30 are fixed together.

The screw main cover 38 is attached to the linear drive device by fixing the longitudinal ends thereof to the end plates 87. The main cover 38 is configured so that the linear motion of the outside transmission 37 is not disturbed by the cover 38. The lubricant applied to the screw shaft 50 may scatter because of the high-speed rotation of the screw shaft 50. The lubricant may eventually fall by the gravity even though there is no rotational movements of the screw shaft 50.

Therefore, the screw main cover 38 is provided for preventing the lubricant from scattering outside of the linear drive device. The screw main cover 38 is so configured to cover the whole area along the screw shaft 50 of the linear drive device. Therefore, the screw cover 38 is expected to prevent most of the lubricant from leaking through the linear drive device.

However, the cover structure of Figures 5 and 6 cannot cover some portions of the linear drive device. Figure 6b is a cross sectional view in the assembled condition for a B-B line of Figure 5 showing open areas which cannot be covered by the screw main cover 38. The reason of this openings is that linking portions 32a and 32b in Figure 6a are fixed between outside transmission block 35 and the motion-direction converter 30, and openings 85 are unavoidable for allowing the linear motion of the linking portions 32a and 32b along the screw shaft 50.

Consequently, the lubricant may leak from the openings 85, which is inappropriate for a practical use. For example, the lubricant may cause in sufficient electrical connections between the IC device pins and the test contactor when the linear drive device is used in the IC test handler. Further, the dust produced outside of the linear drive device may come in through the openings 85 and deposited on the surface of the screw area in the linear drive device. Therefore, the conventional structure of the linear drive device of Figures 5 and 6 has a problem in that the lubricant or dust decreases reliability of the device itself as well as the surrounding components.

Although not shown, another example of conventional structure for preventing the lubricant from leaking the linear drive device includes a bellow like cover. An ideal result for preventing the leakage of the lubricant is available by a cylindrical cover which can completely seal the housing of the linear drive device as well as freely expand or contract along the movement of linear drive

device. However, a space is necessary at each end of the linear movement for the bellow like cover when the bellow is contracted. Thus, the length of the linear movement will be shortened. If the same length of linear movement has to be maintained, an overall length of the linear drive device has to be increased.

Summary of the Invention

Therefore, it is an object of the present invention to provide a cover structure of a linear drive device which is capable of sufficiently preventing the lubricant from scattering and dropping to the outside of the linear drive device without increasing an outer length of the device.

It is another object of the present invention to provide a cover structure for a linear drive device which is capable of sufficiently preventing the outside dust or other particles from entering the linear drive device to maintain the reliability of the device.

It is a further object of the present invention to provide a cover structure for a linear drive device which is capable of achieving sufficient sealing of the linear drive device during the linear movements without unduly increasing the production cost.

In order to achieve the above objectives, the present invention is provided with one or more covers that cover the openings inevitable for transmitting the linear movement to an outside component.

In a first aspect of the present invention, a cover structure of a linear drive device is comprised of a motion direction converter for receiving a rotational movement of a screw shaft and converting the rotational movement to a linear movement, a frame cover for storing the motion direction converter and the screw shaft, an outside transmission block connected to the motion direction converter for transmitting the linear movement to an outside component, a screw cover attached to the frame cover in a manner between the motion direction converter

and the outside transmission block along the length of the frame cover, and a pair of auxiliary covers each of which is attached to an outside wall of the frame cover for covering openings between the frame cover and the screw cover along the length of the frame cover.

In another aspect of the present invention, the cover structure of a linear drive device is comprised of a motion direction converter for receiving a rotational movement of a screw shaft and converting the rotational movement to a linear movement, a frame cover for storing the motion direction converter and the screw shaft wherein the frame cover has a U-shape in cross section and a bottom of which is attached to a vertical wall of a system for which the linear drive device is used, an outside transmission block connected to the motion direction converter for transmitting the linear movement to an outside component wherein the outside transmission block has a projection at the bottom of the frame cover in substantially parallel with the vertical wall of the system, and a cover attached to an outside wall of the frame cover at its one end along the length of the frame cover wherein the other end of the cover is positioned close proximity to the projection of the outside transmission block at the bottom of the frame cover.

In a further aspect of the present invention, the cover structure for a linear drive device is comprised of a motion direction converter for receiving a rotational movement of a screw shaft and converting the rotational movement to a linear movement, a frame cover for mounting the motion direction converter and the screw shaft thereon and has a linear motion guide along the length of the frame for guiding the motion direction converter wherein a bottom of the frame cover is attached to a vertical wall of a system for which the linear drive device being used, an outside transmission block connected to the motion direction converter for transmitting the linear movement to

an outside component wherein the outside transmission block has a projection at the bottom of the linear drive device in substantially parallel with the vertical wall of the system, a first cover attached to an upper end of the frame cover at its one end along the length of the frame cover, the other end of the cover is positioned close proximity to the projection of the outside transmission block at the bottom of the linear drive device, and a second cover attached to a lower end of the frame cover between a space formed by the motion direction converter and the outside transmission block.

According to the present invention, the cover structure of the linear drive device is capable of sufficiently preventing the lubricant from scattering and dropping to the outside of the linear drive device without increasing the length of the device. The cover structure of the present invention is capable of sufficiently sealing against the outside dust or other particles to maintain the reliability of the device. Moreover, the cover structure of the present invention can achieve sufficient sealing of the linear drive device during the linear movements without unduly increasing the production cost. Since the bellow type cover in the conventional technology is unnecessary, an effective length of linear movement is not limited by the cover structure of the present invention.

Brief Description of the Drawings

Figure 1a is a cross sectional view of a cover structure and linear drive device of the first embodiment of the present invention taken by an A-A line of Figure 2.

Figure 1b is a cross sectional view of a cover structure and linear drive device of the first embodiment of the present invention taken by a B-B line of Figure 2.

Figure 2 is an exploded perspective view of the first embodiment of the present invention.

Figure 3 is a cross sectional view of a cover structure and linear drive device of the second embodiment

of the present invention wherein the cover is fixed to the side wall of the device.

Figure 4 is a cross sectional view of a cover structure and linear drive device of the third embodiment of the present invention.

Figure 5 is an exploded perspective view of the conventional example of a cover structure and linear drive device.

Figure 6a is a cross sectional view of the conventional example taken by an A-A line of Figure 5.

Figure 6b is a cross sectional view of the conventional example taken by a B-B line of Figure 5.

Detailed Description of the Preferred Embodiments

Figures 1 and 2 show the first embodiment of a cover structure of linear drive device of the present invention. The linear drive device is comprised of a main frame cover 80 having end plates 87, a rotation drive mechanism 90 mounted on the end plates 87, a screw shaft 50 connected to the rotation drive mechanism 90, a motion-direction converter 30 connected to the screw shaft 50, an outside transmission block 35 connected to the motion-direction converter 30, and a screw main cover 38, and covers 10a and 10b. Thus, the covers 10a and 10b are added to the conventional example of Figures 5 and 6.

The covers 10a and 10b are employed to seal the openings 85 shown in Figure 6b formed between the screw main cover 38 and the main frame cover 80. The covers 10a and 10b are attached to corresponding sides of the main frame cover 80 so as not to disturb the linear movement of the outside transmission block 35. Since the openings 85 are intact, the linear motion of the motion-direction converter 30 and the outside transmission block 35 is not affected by the covers 10a and 10b.

As shown in Figures 1 and 2, the covers 10a and 10b are configured to sufficiently cover the whole area of the openings in combination with the screw main cover 38. In

addition, the covers 10a and 10b and the screw main cover 38 are so positioned that gaps 86 formed therebetween (Figure 1b) be as small as possible. As a consequence, the inside mechanism, such as the screw shaft 50, of the linear drive device is fully isolated from the outside components so that the lubricant will not leak out from the device and the outside dust will not come in the device.

In the example above, the motion-direction converter 30 and the outside transmission block 35 are separately provided and fixed together to form a linear movement part of the device. However, those components can be integrally formed as a single component.

As shown in the cross sectional view of Figure 1b, even though the openings are inevitable for the linear movement of the device, the leakage of lubricant and dust to and from the openings are significantly suppressed by the covers 10a and 10b in combination with the screw area main cover 38. Thus, the cover structure of the present invention in Figures 1-2 has a sufficient sealing effect for practical use. The cover structure of the linear drive of the present invention can prevent the scattering or dropping of lubricant from the device or deposition of dust to the screw area. Therefore, the reliability of the linear drive device is increased without decreasing the effective length of linear movement since the billow in the conventional technology is unnecessary.

The second embodiment of the present invention is shown in Figure 3 which is a cross sectional view of a cover structure and linear drive device. The linear drive device is comprised of a main frame cover 80b which is U-shape and has side walls 88, a screw shaft 50, a motion-direction converter 30b, and a cover 10c. Although not shown, the main frame cover 80b has end plates and a rotation drive mechanism 90 as shown in Figures 2 or 5. The linear drive device has an outside transmission block 37b which moves along the side wall 88 at the outside of

the main frame 80b. The outside transmission block 37b is connected to the motion direction converter 30b as shown in Figure 3.

The example of Figure 3 is designed so that the bottom of the U-shaped main frame cover 80b is attached to a side wall 93 of a system for which the linear drive device is used. Thus, the pair of side walls 88 of the main frame cover 80b are placed in a horizontal direction in a manner shown in Figure 3. The outside transmission block 37b is positioned close to the lower side wall 88 and protruded therefrom. The motion-direction converter 30b is supported and guided by linear movement guide 82b of the main frame 80b to secure the movement in the longitudinal direction of the linear drive device.

Preferably, a lubricant storage 81b is provided at the bottom of the inner space of the main frame 80b. Although not shown, at each end of lubricant storage 81b, a wall such as formed by the end plate 87 of Figures 2 and 5 is provided so that the lubricant oil will not flow out. Further, a protrusion 83 is preferably provided on the inner surface of the motion-direction converter 30 in a manner shown in Figure 3. Therefore, the lubricant will be stored in the storage 81b.

The cover 10c has a sufficient length to cover the whole area on the main frame 80b so that the screw shaft 50 will not be exposed to an outside atmosphere. The cover 10c is attached to the main frame in a manner to secure the openings needed for the linear movement of the outside transmission block 37b. At the one end, the cover 10c is fixed to the main frame 80b while the other end can be formed in a manner facing upward to function as another storage of lubricant oil. Preferably, the end of the cover 10c facing upward is inserted in a recess 36 formed on the outside transmission block 37b to more securely seal the lubricant.

As in the foregoing, the openings are secured for

achieving the linear movement of the motion-direction converter 30 and the outside transmission block 37b. At the same time, the cover structure of the present invention can sufficiently prevent the lubricant from leaking from the linear drive device or the unwanted objects from coming through the openings.

The third embodiment of the present invention is shown in Figure 4 which is a cross sectional view of a cover structure and linear drive device. The linear drive device of the third embodiment is comprised of a motion-direction converter 30c on a frame 80, a first cover 10d, a second cover 10e, and an outside transmission block 37c.

Similar to the example of Figure 3, the linear drive device of Figure 4 is designed to be attached on a side wall 93 which is a vertical wall of a system for which the linear drive device is used. At the center of the frame 80, there is provided a guide groove 95 in a longitudinal direction to guide the movement of the motion-direction converter 30c. The motion-direction converter 30 has a projection 82c to be inserted in the guide groove 95 so that the motion-direction converter 30c slides along screw shaft 50 guided by the guide groove 95.

The first cover 10d in this embodiment has one end fixed to the frame 80c and covers the motion-direction converter 30c and the screw shaft 50. The other end of the first cover 10d is positioned at the bottom of the linear drive device close to the outside transmission block 37c. Similar to the example of Figure 3, the other end of the first cover 10d faces upward so that it can function as a storage of lubricant oil. Although not shown, at both ends of the first cover 10d, walls are provided so that the stored oil will not flow out.

The second cover 10e is attached to the frame 80c and has a shape as shown in Figure 4. The end of the second cover 10e is secured in a recess formed on the motion-direction converter 30c so that it can also function as a

lubricant storage. Although not shown, side walls are provided at both ends of the second cover 10e so that the stored oil will not flow out.

In this embodiment, the openings are secured so that the linear movement of the outside transmission block 37c and the motion-direction converter 30c will not be disturbed. At the same time, the cover structure of the present invention can sufficiently prevent the lubricant from leaking from the linear drive device or the unwanted objects from coming through the openings.

As explained above, the present invention is characterized in the following: the openings necessary for the linear movement of the outside transmission block 37 are maintained. The cover structure for the linear drive device is formed so that the screw shaft will not be exposed to external atmosphere by one or more covers. Thus, the sealing of the lubricant oil and the protection from dust or other external contaminants can be attained.

In the above embodiments, the ball nut and screw shaft are used for converting the rotational motion to the linear motion. However, other structured can also be feasible to convert the rotational motion to the linear motion.

When the linear drive device is used in an IC test handler, ideal electric contacts will be established between the test contactors and the IC device pins since the lubricant leakage from the linear drive device is sufficiently suppressed. Thus, it is possible to fully evaluate the IC devices by in combination with the semiconductor test system. Since the linear drive device is immune to the external dust or other unwanted particles because of the cover structure of the present invention, the IC test handler using the linear drive device can achieve a longer life time as well as higher reliability.

As has been described for each of the embodiments, the cover structure of the linear drive device of the present invention is capable of sufficiently preventing the

lubricant from scattering and dropping to the outside of the linear drive device without increasing the length of the device. The cover structure of the present invention is capable of sufficiently sealing against the outside dust or other particles to maintain the reliability of the device. Moreover, the cover structure of the present invention can achieve sufficient sealing of the linear drive device during the linear movements without unduly increasing the production cost. Since the bellow type cover in the conventional technology is unnecessary, an effective length of linear movement is not limited by the cover structure of the present invention.

WHAT IS CLAIMED IS:

1. A cover structure of a linear drive device for converting a rotational motion to a linear motion, comprising:

a motion direction converter for receiving a rotational movement of a screw shaft and converting the rotational movement to a linear movement;

a frame cover for storing the motion direction converter and the screw shaft;

an outside transmission block connected to the motion direction converter for transmitting the linear movement to an outside component;

a screw cover attached to the frame cover in a manner between the motion direction converter and the outside transmission block along the length of the frame cover; and

a pair of auxiliary covers each of which is attached to an outside wall of the frame cover for covering openings between the frame cover and the screw cover along the length of the frame cover.

2. A cover structure as defined in Claim 1 wherein the outside transmission block has a projection at the center of the outside transmission block to be connected to the outside component, and edges of the pair of auxiliary covers are positioned close proximity to the projection.

3. A cover structure as defined in Claim 2 wherein the edges of the pair of auxiliary covers are downwardly bent in parallel with the corresponding sides of the projection of the outside transmission block.

4. A cover structure as defined in Claim 1 wherein the motion direction converter has a pair of grooves in parallel with the side frame of the frame cover and edges of the screw cover are bent to fit in the grooves of the motion direction converter.

5. A cover structure of a linear drive device for converting a rotational motion to a linear motion,



comprising:

a motion direction converter for receiving a rotational movement of a screw shaft and converting the rotational movement to a linear movement;

a frame cover for storing the motion direction converter and the screw shaft, the frame cover having a U-shape in cross section and a bottom of which being attached to a vertical wall of a system for which the linear drive device being used;

an outside transmission block connected to the motion direction converter for transmitting the linear movement to an outside component, the outside transmission having a projection at the bottom of the frame cover in substantially parallel with the vertical wall of the system; and

a cover attached to an outside wall of the frame cover at its one end along the length of the frame cover, the other end of the cover being positioned close proximity to the projection of the outside transmission block at the bottom of the frame cover.

6. A cover structure as defined in Claim 5 wherein the frame cover forms an upper horizontal wall and a lower horizontal wall when the bottom of the frame cover is connected to the vertical wall of the system, an inner surface of the lower wall being curved to receive lubricant in the linear drive device.

7. A cover structure as defined in Claim 5 wherein the outside transmission block has a groove in parallel with the frame cover and close proximity to the projection, and the other end of the cover faces upward and fits in the groove of the outside transmission block.

8. A cover structure of a linear drive device for converting a rotational motion to a linear motion, comprising:

a motion direction converter for receiving a rotational movement of a screw shaft and converting



the rotational movement to a linear movement;

a frame cover for mounting the motion direction converter and the screw shaft thereon and has a linear motion guide along the length of the frame for guiding the motion direction converter, a bottom of the frame cover being attached to a vertical wall of a system for which the linear drive device being used;

an outside transmission block connected to the motion direction converter for transmitting the linear movement to an outside component, the outside transmission block having a projection at the bottom of the linear drive device in substantially parallel with the vertical wall of the system;

a first cover attached to an upper end of the frame cover at its one end along the length of the frame cover, the other end of the cover being positioned close proximity to the projection of the outside transmission block at the bottom of the linear drive device; and

a second cover attached to a lower end of the frame cover between a space formed by the motion direction converter and the outside transmission block.

9. A cover structure as defined in Claim 8 wherein the other end of the first cover is bent upwardly and positioned close proximity to the projection.

10. A cover structure as defined in Claim 8 wherein the linear motion guide is a groove established on the frame cover and a projection of the motion direction converter fits in the groove to be guided for the linear movement.

