DESCRIPTION

TITLE: SYSTEM FOR THE TWO-DIMENSIONAL MOVEMENT OF A BIN IN A MODULAR STORAGE STRUCTURE

TECHNICAL FIELD

The object of the present disclosure relates to the field of automated storage systems. More specifically, the present disclosure relates to the drive and guide devices for the displacements of storage elements within a robotic modular structure.

STATE OF THE ART

With the growth of industrial needs and online commerce (or "e-commerce," by the customary terminology), requiring flexible, fine, and responsive logistics, the development and adoption of automated goods storage and retrieval solutions are becoming crucial for many stakeholders.

For example, it is possible to use transport technologies such as stacker cranes, carousels, robotic fleets, or even the implementation of autonomous and mobile robots. However, these technologies do not necessarily provide a compact storage solution adaptable to all types of spaces, including the most confined ones, while maintaining a high distribution rate.

French patent no. 1907047 presents a compact storage and displacement solution, adaptable to various storage environments, and with a high distribution pace. The system described in the aforementioned patent comprises a modular structure and bins configured to be moved within the modular structure. The displacement of the bins within the modular structure is enabled by a displacement system comprising disengageable actuators that equip the modular structure and interact with complementary recesses present on the bins.

However, the drive device described is complex, fragile and limited in terms of acceptable load. In addition, it induces mounting and maintenance challenges.

US patent 7941243B2 proposes a system for moving a bin within a grid. The bin comprises an upper grooved wall and another lower grooved wall that mesh respectively with pinions fixed to the grid and configured to move the bin along two perpendicular directions. However, this system requires bins with very specific and complex walls and generates recurring tolerance problems due to the simultaneous contact between pinions and the upper grooved

wall, and between pinions and the other lower grooved wall, regardless of the direction of displacement of the bin.

Therefore, there is a need for simplification and improvement of the systems for moving a bin within a modular structure.

GENERAL DISCLOSURE

One of the objectives of the present disclosure is for example to propose a system for moving a bin within a compact modular structure, enabling rapid and reliable displacement in two perpendicular directions.

To this end, according to one aspect of the present disclosure, a system for moving a bin within a modular storage structure is proposed, comprising a frame forming a plurality of adjacent modules, the displacement system comprising:

- a longitudinal rack positioned on the bin and configured to move the bin within the modular structure along a first direction, and a transverse rack positioned on the bin and configured to move the bin within the modular structure along a second direction, perpendicular to the first direction; and
- a longitudinal pinion and a transverse pinion positioned on the frame of each module, the longitudinal pinion being configured to mesh with the longitudinal rack and the transverse pinion being configured to mesh with the transverse rack.

The longitudinal rack and the transverse rack respectively comprise teeth spaced by an interval and having a width, the width of the teeth of the longitudinal rack being smaller than or equal to the interval between the teeth of the transverse rack and the width of the teeth of the transverse rack being smaller than or equal to the interval between the teeth of the longitudinal rack.

This displacement system thus allows for a bidirectional displacement of a bin within a modular storage structure. It offers reduced complexity and bulk. Indeed, the system is simplified by positioning the two racks on the bottom of the bin. In addition, the system eliminates the need for disengagement and prevents a blocking of the bin thanks to the spacing between the intersecting teeth of the racks. The system is further simplified by the implementation of bins, called passive bins, which can be moved solely by the action of the pinions fixed to the frame of the modular structure and therefore without integrated motorization in each bin and without disengagement of the bin.

Advantageously, but optionally, the disclosed method comprises the at least one of the following characteristics, either alone or in any combination:

- the longitudinal pinion comprises successive teeth each spaced by an interval greater than the thickness of the teeth of the longitudinal rack, so as to allow the teeth of the longitudinal rack to translate through the interval of the longitudinal pinion when the transverse rack meshes with the transverse pinion, and
the transverse pinion comprises successive teeth each spaced by an interval greater than the thickness of the teeth of the transverse rack, so as to allow the teeth of the transverse rack to translate through the interval of the transverse pinion when the longitudinal rack meshes with the longitudinal pinion;

- the interval between the teeth of the longitudinal rack is greater than the width of the teeth of the transverse pinion, and the interval between the teeth of the transverse rack is greater than the width of the teeth of the longitudinal pinion, so as to allow the longitudinal pinion to intersect the transverse rack when it meshes with the longitudinal rack, and allow the transverse pinion to intersect the longitudinal rack when it meshes with the transverse rack;

- the longitudinal rack and the transverse rack are positioned on the bin transversely, relative to each other, and intersect so as to balance the loads on the bin;

- the system comprises two distinct and parallel longitudinal racks, and two distinct and parallel transverse racks, each of the two longitudinal racks and of the two transverse racks meshing respectively with two longitudinal pinions and two transverse pinions;

- the system comprises ball joints to support the bin on the frame; the ball joints allowing a displacement of the bin along the first direction and along the second direction;

- the system comprises longitudinal rails fixed to the frame in order to guide the ball joints supporting the bin along the first direction and transverse rails fixed to the frame in order to guide the ball joints supporting the bin along the second direction, each longitudinal rail showing an intersection with each transverse rail;

- each longitudinal pinion is positioned on the frame along a transverse rail and each transverse pinion is positioned on the frame along a longitudinal rail, a single first motor driving in rotation each longitudinal pinion positioned along the same transverse rail, and a

single second motor driving in rotation each transverse pinion positioned along the same longitudinal rail;

- each ball joint comprises a guide skirt configured to hold the ball joint in one of the longitudinal rails or in one of the transverse rails;

- each of the longitudinal rack and of the transverse rack comprises, respectively at its two ends, a guide tooth whose width is respectively greater than the width of the teeth of the longitudinal rack and of the transverse rack, the guide tooth of the longitudinal rack being configured to guide the bin along the second direction by sliding within the interval of the longitudinal pinion, and the guide tooth of the transverse rack being configured to guide the bin along the first direction by sliding within the interval of the transverse pinion.

- the width of the guide teeth of the longitudinal rack is greater than a length of the intersection along the second direction, and the width of the guide teeth of the transverse rack is greater than a length of the intersection along the first direction, in order to allow guiding the bin when one of the ball joints of the bin crosses the intersection.

- the system comprises guide pins fixed to the bin and configured to translate in one of the longitudinal rails or in one of the transverse rails, the guide pin guiding the bin along the first direction or along the second direction when a ball joint is at one of the intersections.

According to another aspect, a bin is proposed, configured to be moved within a modular storage structure and comprising a longitudinal rack configured to move the bin within the modular structure along a first direction and a transverse rack configured to move the bin within the modular structure along a second direction, perpendicular to the first direction, the longitudinal rack and the transverse rack being positioned on the bin, characterized in that the longitudinal rack and the transverse rack respectively comprise teeth spaced by an interval and having a width, the width of the teeth of the longitudinal rack being smaller than or equal to the interval between the teeth of the transverse rack and the width of the teeth of the transverse rack is smaller than or equal to the interval between the teeth of the longitudinal rack.

According to another aspect, an actuation unit for an actuation system as previously described is proposed, the actuation unit comprising:

- a post extending along a main direction,
- a rail fixed along the post and configured to guide ball joints supporting a bin,
- a first pinion positioned on one side of the post relative to the longitudinal direction and a second pinion positioned on another side of the post relative to the main direction, each

pinion being configured to be driven in rotation around the main direction by a motor fixed to the post,

- a control device to synchronously control the respective motor of each of the first pinion and of the second pinion.

According to another aspect, a frame of a modular storage structure is proposed, comprising a plurality of actuation units as previously described, the plurality of actuation units forming a plurality of adjacent modules configured to receive a bin, the frame comprising:

- actuation units whose main direction is oriented along a first direction, configured to mesh with a transverse rack of a bin and to guide ball joints supporting the bin along the first direction, and
- actuation units whose main direction is oriented along a second direction, configured to mesh with a longitudinal rack of a bin and to guide ball joints supporting the bin along the second direction.

According to another aspect, a modular storage structure is proposed, comprising a bin as previously described and a frame as previously described, the bin being configured to be moved within the modules of the frame.

DESCRIPTION OF THE FIGURES

Other characteristics, aims and advantages will become apparent from the following description, which is purely illustrative and not limiting, and should be read in relation to the appended drawings:

Figure 1 illustrates a perspective view of a modular storage structure, according to one possible embodiment of the present disclosure;

Figure 2A illustrates a perspective view of a frame forming three adjacent modules of a modular storage structure and of a bin in one of the three modules, according to one possible embodiment of the present disclosure;

Figure 2B illustrates a perspective view of an actuation unit forming part of a frame of a modular storage structure, according to one possible embodiment of the present disclosure;

Figure 3 illustrates a perspective view of a system for moving a bin within a modular storage structure, according to one possible embodiment of the present disclosure;

Figure 4 illustrates a perspective view of part of the system for moving a bin in a modular storage structure, according to one possible embodiment of the present disclosure;

Figure 5 illustrates part of a displacement system and a guide tooth of the displacement system, according to one possible embodiment of the present disclosure.

Figure 6 illustrates the displacement system, and more specifically a support assembly, according to one possible embodiment of the present disclosure;

Figure 7 illustrates part of the support assembly, according to one possible embodiment of the present disclosure;

Figure 8 illustrates a view in a plane perpendicular to a first direction of the system for moving a bin within a first module, according to one possible embodiment of the present disclosure;

Figure 9 is a flowchart of steps of a method for moving a bin within a modular structure, according to one mode of implementation of the present disclosure.

In all figures, similar elements bear identical references.

DETAILED DESCRIPTION

Modular storage structure

A modular storage structure 1, as illustrated in Figure 1, comprises a frame 10, forming a plurality of adjacent modules 11, and bins 20 configured to be positioned within the modules 11 and to move from module 11 to module 11.

The frame 10 of the modular structure 1 may comprise vertical posts 12 fixed to the floor of a warehouse, and horizontal posts 13 fixed to the vertical posts 12. The vertical posts 12 and the horizontal posts 13 define the plurality of modules 11 of the modular structure 1.

The modules 11, as illustrated in Figure 2A, may be identical in shape and size. The vertical posts 12 are positioned together at regular intervals along a first horizontal direction X and at regular intervals along a second horizontal direction Y, perpendicular to the first horizontal direction X. The horizontal posts 13 are fixed between the vertical posts 12 so as to form floors at regular intervals along a third vertical direction Z. Each horizontal post is fixed between two vertical posts 12 parallel to the first horizontal direction X or to the second horizontal direction Y. The frame 10 can thus present a three-dimensional matrix. By three-dimensional matrix, it is understood that the modules 11 of the modular structure 1 are identical in shape and size and can be adjacent to each other along the first direction X, the second direction Y, and the third direction Z.

Each module 11 comprises four vertical posts 12 and four horizontal posts 13. The four horizontal posts 13 are fixed to the four vertical posts 12 and define a parallelogram. The four horizontal posts 13 comprise two horizontal posts 13x along the first horizontal direction X and two horizontal posts 13y along the second horizontal direction Y. The module 11 is therefore delimited by the four vertical posts 12, the four horizontal posts 13, and by the four horizontal posts 13 of the adjacent module 11 above the module 11 along the third vertical direction Z.

The bin 20 can be a tray or a crate or a box, open or closed, or partially closed. The bin 20 comprises dimensions and a shape, in particular a rectangular parallelepiped shape, that allow it to be moved within each module 11. The bin 20 comprises a bottom 21 parallel to the horizontal posts 13 of the frame 10. The bottom 21 is the lower part of the bin 20 along the third direction Z.

The modular structure 1 can be configured so that each bin 20 can move within the frame 10, and more specifically within the plurality of modules 11, from module 11 to module 11. The modular structure 1 comprises a system 100 for moving a bin 20. The system 100 for moving a bin 20 can be at least partially positioned on part of the frame 10. The frame 10 can therefore be formed by actuation units 130 linked together to form the modules 11 and comprising elements of the displacement system 100, as illustrated in Figure 2B.

Displacement system

Hereafter, first module 111 will refer to the module 11 among the plurality of modules 11 in which a considered bin 20 is positioned. The plurality of modules 11 comprises, for each first module 111, at least an adjacent second module 112 and at least a adjacent third module 113. The second module 112 is adjacent to the first module 111 along the first horizontal direction X, and the third module 113 is adjacent to the first module 111 along the second horizontal direction Y.

The displacement system 100 allows each considered bin 20 of the modular structure 1 to move within the frame 10, from the first module 111 to the second module 112 and/or to the third module 113. In other words, the displacement system 100 is configured to move a bin 20 horizontally within the modular structure 1, that is to say on the same floor of the frame 10.

The displacement system 100 can be connected to a central control unit C by wired cabling along the frame 10. The control unit C is programmed to coordinate the displacements of

the bins 20 according to a given algorithm and activate the displacement system 100 adequately. The control unit C may further comprise a PID controller. The PID controller is a monitoring device used to regulate the displacement of a bin 20 and synchronize the driving of the bin 20 from the first module 111 to the second module 112 or the third module 1**13**.

The displacement system 100, as illustrated in Figure 3, comprises an assembly 200 for translating the bin 20 and an assembly 300 for supporting the bin 20. The translation assembly 200 is configured to drive in movement the bin 20 within the frame 10. The support assembly 300 is configured to support and guide the bin 20 on the frame 10.

Translation assembly

The translation assembly 200 comprises:

- at least a first rack 210 fixed to the bin 20 and configured to allow the displacement of the bin 20 along the first direction X,
- at least a second rack 220 fixed to the bin 20 and configured to allow the displacement of the bin 20 along the second direction Y,
- at least a first pinion 230 positioned on the frame 10 in each module 11 and configured to mesh with the first rack 210 of the bin 20,
- at least a second pinion 240 positioned on the frame 10 in each module 11 and configured to mesh with the second rack 220 of the bin 20,

The translation assembly 200 thus uses the rack and pinion system. The rack and pinion system transmits power efficiently, minimizing energy losses due to friction. The transmission is direct, meaning that the energy is transferred more effectively compared to a friction system, where the transmission mainly depends on the friction force between the contacting surfaces. The rack and pinion system is configured to withstand high loads, making it a robust choice for applications requiring the displacement of heavy loads. The teeth of the pinions distribute the load evenly, minimizing high-pressure points. In addition, the rack and pinion system shows a dynamic response, meaning it can start, stop, and change direction more quickly and precisely than some friction systems.

Racks

The first rack 210 is configured to allow the displacement of the bin 20 between the first module 111 and the second module 112. For this purpose, the first rack 210 is directed along the first direction X and is called longitudinal rack 210.

The second rack 220 is configured to allow the displacement of the bin 20 between the first module 111 and the third module 113. For this purpose, the second rack 220 is oriented along the second direction Y. The second rack 220 is positioned transversely to the longitudinal rack 210 and is called transverse rack 220.

The longitudinal rack 210 and the transverse rack 220 are respectively positioned at the bottom 21 of the bin 20. In addition, the longitudinal rack 210 and the transverse rack 220 are positioned on the bin 20 in the same horizontal plane parallel to the horizontal posts 13 of the frame 10. Thus, the longitudinal rack 210 and the transverse rack 220 intersect on the bottom 21 of the bin 20. The longitudinal rack 210 and the transverse rack 220 have respectively a length adapted to the dimensions of the bin 20 along the first direction X and the second direction Y.

As illustrated in Figure 4, the longitudinal rack 210 comprises a plurality of successive teeth 211, each spaced by the same first interval 212. The transverse rack 220 comprises a plurality of successive teeth 221, each spaced by the same second interval 222. An interval between two successive teeth of a rack is the distance between the two successive teeth measured at the pitch line of the rack.

The teeth 211 of the longitudinal rack 210 have the same first width 213. The teeth 221 of the transverse rack 220 have the same second width 223. A tooth width of a rack is the dimension of the tooth in the direction orthogonal to the direction of the rack.

The teeth 211 of the longitudinal rack 210 have the same first thickness 215. The teeth 221 of the transverse rack 220 have the same second thickness 225. A tooth thickness of a rack is the dimension from the tooth to the pitch line of the rack.

The first width 213 of the teeth 211 of the longitudinal rack 210 is smaller than or equal to the second interval 222 between the teeth 221 of the transverse rack 220, and the second width 223 of the teeth 221 of the transverse rack 220 is smaller than or equal to the first interval 212 between the teeth 211 of the longitudinal rack 210. Thus, the longitudinal rack 210 and the transverse rack 220 can have an intersection 216 free of teeth 211 of the longitudinal rack and teeth 221 of the transverse rack 220. This allows the longitudinal rack 210 and the transverse rack 220 to intersect without preventing a meshing of the longitudinal pinion 230 with the longitudinal rack 210 and of the transverse pinion 240 with the transverse rack 220 at the intersection 216 between the longitudinal rack 210 and the transverse rack 220.

Thus, the intersection 216 between the longitudinal rack 210 and the transverse rack 220 does not obstruct the displacement of the bin 20.

The first interval 212 between the teeth 211 of the longitudinal rack 210 can be equal to the second interval 222 between the teeth 221 of the transverse rack 220. The first width 213 of the teeth 211 of the longitudinal rack 210 can be equal to the second width 223 of the teeth 221 of the transverse rack 220. The first thickness 215 of the teeth 211 of the longitudinal rack 210 can be equal to the second thickness 225 of the teeth 221 of the transverse rack 220. Thus, the mounting of the translation assembly 200 is facilitated and the displacements of the bin 20 are simplified.

The intersection 216 between the longitudinal rack 210 and the transverse rack 220 can be delimited by two successive teeth 211 of the longitudinal rack 210 along the first direction X and by two successive teeth 221 of the transverse rack 220 along the second direction Y.

According to one embodiment, the translation assembly 200 comprises a single longitudinal rack 210 and a single transverse rack 220. The longitudinal rack 210 and the transverse rack 220 can be positioned transversely relative to each other. The longitudinal rack 210 and the transverse rack 220 can be positioned in a cross shape on the bin 20 and intersect respectively in their middle. This allows balancing the loads on the bin 20.

According to another embodiment, as for example illustrated in Figure 3, the translation assembly 200 comprises two longitudinal racks 210 and two transverse racks 220, positioned transversely relative to the longitudinal racks 210. The two longitudinal racks 210 can be positioned so as to balance the forces transmitted by the longitudinal pinion 230 meshing with each of the longitudinal racks 210. To do so, the two longitudinal racks 210 can be positioned symmetrically on the bin 20 relative to the middle of the bin along the second direction Y, and the two longitudinal racks 210 can be positioned symmetrically on the bin 20 relative to the middle of the bin along the first direction X. For example, the two longitudinal racks 210 can each be spaced apart from the middle of the bin 20, along the second direction Y, by one-sixth or one-quarter of the total length of the bin 20 along the second direction Y. And, the two transverse racks 220 can be positioned so as to balance the forces transmitted by the transverse pinion 240 meshing with each of the transverse racks 220. For example, the two transverse racks 220 can each be spaced apart from the middle of the bin 20, along the first direction X, by one-sixth or one-quarter of the total length of the bin 20 along the first direction X. This allows balancing the loads on the bin 20 and preventing any blocking of the bin 20 during the displacement between two modules 11. In

addition, the two longitudinal racks 210 are each positioned on the bin 20 so as to intersect the two transverse racks 220 at a second interval 222, and the two transverse racks 220 are each positioned on the bin 20 so as to intersect the two longitudinal racks 210 at a first interval 212.

According to another embodiment, the translation assembly 200 may comprise more than two longitudinal racks 210 and more than two transverse racks 220.

Pinions

As illustrated in Figure 3, the first pinion 230 is configured to be driven in rotation by a first motor 250 around the second direction Y so as to move the longitudinal rack 210 along the first direction X. Hereafter, the first pinion 230 is called longitudinal pinion 230, because it is configured to drive the longitudinal rack 210. The second pinion 240 is configured to be driven in rotation by a second motor 251 around the first direction X so as to move the transverse rack 220 along the second direction Y. Hereafter, the second pinion 240 is called transverse pinion 240, because it is configured to drive the transverse rack 220. The first motor 250 and the second motor 251 are respectively positioned on the frame 10 of the considered module 11.

As illustrated in Figure 4, the longitudinal pinion 230 comprises successive teeth 231 spaced by the same first interval 232. Each tooth 231 of the longitudinal pinion 230 has the same first width 233. The transverse pinion 240 comprises successive teeth 241 spaced by the same second interval 242. Each tooth 241 of the transverse pinion 240 has the same second width 243. The interval between two successive teeth of a pinion is the dimension of the arc of the pitch circle between the two teeth. The tooth width of a pinion is the dimension of the tooth in the direction of the axis of rotation of the pinion.

The width 233 of the teeth 231 of the longitudinal pinion 230 is smaller than the interval 222 between the teeth 221 of the transverse rack 220, and the width 243 of the teeth 241 of the transverse pinion 240 is smaller than the interval 212 between the teeth 211 of the longitudinal rack 210. This allows:

- the teeth 231 of the longitudinal pinion 230 to intersect the transverse rack 220 without being blocked by the teeth 221 of the transverse rack 220 when the longitudinal pinion 230 meshes with the longitudinal rack 210, and

- the teeth 241 of the transverse pinion 240 to intersect the longitudinal rack 210 without being blocked by the teeth 211 of the longitudinal rack 210 when the transverse pinion 240 meshes with the transverse rack 220.

The first interval 232 between the teeth 231 of the longitudinal pinion 230 is greater than the first thickness 215 of the teeth 211 of the longitudinal rack 210. The second interval 242 between the teeth 241 of the transverse pinion 240 is greater than the second thickness 225 of the teeth 221 of the transverse rack 220. This allows:

- the teeth 211 of the longitudinal rack 210 to translate, along the second direction Y, through the first interval 232 between two teeth 231 of the longitudinal pinion 230, when the transverse rack 220 meshes with the transverse pinion 240 and the bin 20 translates along the second direction Y, and
- the teeth 221 of the transverse rack 220 to translate, along the first direction X, through the second interval 242 between two teeth 241 of the transverse pinion 240 when the longitudinal rack 210 meshes with the longitudinal pinion 230 and the bin 20 translates along the first direction X.

The longitudinal pinion 230 comprises, for pre-selected module and pitch diameter, a number of teeth 231 smaller than the ratio of the pitch diameter to the module. Thus, the first interval 232 between the teeth 231 of the longitudinal pinion 230 is larger than the interval between the teeth of a standard pinion (whose number of teeth is strictly equal to the ratio of the pitch diameter to the chosen module). The transverse pinion 240 comprises, for pre-selected module and pitch diameter, a number of teeth 241 smaller than the ratio of the pitch diameter to the module. Thus, the interval 242 between the teeth 241 of the transverse pinion 240 is larger than the interval between the teeth of a standard pinion (whose number of teeth is strictly equal to the ratio of the pitch diameter to the chosen module). This allows reducing the dimensioning constraints of the displacement system 100.

The longitudinal pinion 230 and the transverse pinion 240 may comprise respectively a number of teeth 231, 241 equal to half the ratio of the pitch diameter to the module, in other words, they comprise respectively every second tooth relative to a standard pinion of the same pitch diameter and module.

The number of teeth 231 and the width 233 of the teeth 231 of the longitudinal pinion 230 can be respectively equal to the number of teeth 241 and to the width 243 of the teeth 241 of the transverse pinion 240. Thus, the mounting of the translation assembly 200 is facilitated and the displacements of the bin 20 are simplified.

The translation assembly 200 can comprise two longitudinal pinions 230 to drive the longitudinal rack 210 and two transverse pinions 240 to drive the transverse rack 220. The two longitudinal pinions 230 can each be distributed on one of the two horizontal posts 13y along the second horizontal direction Y. The two transverse pinions 240 can each be distributed on one of the two horizontal posts 13x along the first horizontal direction X. Thus, when the bin 20 is positioned at the center of a module, the longitudinal rack 210 can mesh with the two longitudinal pinions 230, and the transverse rack 220 can mesh with the two transverse pinions 240.

The translation assembly 200 may comprise a system for indexing each longitudinal pinion 230 and each transverse pinion 240. The indexing system allows imposing a precise orientation on each longitudinal pinion 230 and each transverse pinion 240 considered. The orientation may comprise a disengaged position and an engaged position. In the engaged position, the longitudinal pinion 230, and respectively the transverse pinion 240, is able to cooperate with the longitudinal rack 210, and respectively with the transverse rack 220, to ensure the driving.

In the embodiment where the translation assembly 200 comprises two longitudinal racks 210 and two transverse racks 220, a single first motor 250 can be positioned on each of the horizontal posts 13y along the second direction Y and a single second motor 251 can be positioned on each of the horizontal posts 13x along the first direction X. Each single first motor 250 drives respectively in rotation the longitudinal pinions 230 positioned on the horizontal post 13y along the second direction Y considered. Each single second motor 251 drives respectively in rotation the transverse pinions 240 positioned on the horizontal post 13x along the first direction X considered. In other words, each longitudinal pinion 230 of each longitudinal rack 210 positioned on the same horizontal post 13y along the second direction Y is driven in rotation by the same first motor 250. And, each transverse pinion 240 of each transverse rack 220, positioned on the same horizontal posts 13x along the first direction X, is driven in rotation by the same second motor 251. In other words, each module comprises a single first motor 250 on each horizontal post 13x along the first direction X and a single second motor 251 on each horizontal post 13y along the second direction Y. This allows mechanically synchronizing the translation of the bin 20 by the two longitudinal racks 210 or transverse racks 220 along the first direction X or the second direction Y. This also allows preventing any blocking of the bin 20 due to over-stresses or deformations of the bin 20.

The translation assembly 200 can also participate in guiding a bin 20, as illustrated in figure 5. The longitudinal rack 210 and the transverse rack 220 each have two ends. Each of the teeth 211 of the longitudinal rack 210 positioned closest to one of the two ends of the longitudinal rack 210 can be a longitudinal guide tooth 214. Each longitudinal guide tooth 214 has a width 217 greater than the first width 213 of the teeth 211 of the longitudinal rack 210, as illustrated in Figure 5. Each of the teeth 231 of the transverse rack 220 positioned closest to one of the two ends of the transverse rack 220 can be a transverse guide tooth 224. Each transverse guide tooth 224 has a width 227 greater than the second width 223 of the teeth 221 of the transverse rack 220.

The longitudinal guide teeth 214 of the longitudinal rack 210 are configured to guide the bin 20 along the second direction Y when the bin 20 moves along the second direction Y. To do so, the longitudinal guide teeth 214 of the longitudinal rack 210 can slide respectively in the first interval 232 between two teeth 231 of a longitudinal pinion 230. And, the transverse guide teeth 224 of the transverse rack 220 are configured to guide the bin 20 along the first direction X when the bin 20 moves along the first direction X. To do so, the transverse guide teeth 224 of the transverse rack 220 can slide respectively in the second interval 242 between the teeth 241 of a transverse pinion 240.

In the embodiment according to which each longitudinal rack 210 and each transverse rack 220 comprises respectively two longitudinal pinions 230 and two transverse pinions 240, the longitudinal guide teeth 214 of the same rack can each be guided by sliding along a tooth 231 of one of the two longitudinal pinions 230. In other words, each of the two longitudinal guide teeth 214 of the longitudinal rack 210 passes between two teeth 231 of one of the two longitudinal pinions 230 and can even be in contact with one of the two teeth 231 in order to be guided along the second direction Y. And, each of the two transverse guide teeth 224 of the transverse rack 220 passes between two teeth 241 of one of the two transverse pinions 240 and can even be in contact with one of the two teeth 241 in order to be guided along the first direction X.

Support assembly

As illustrated in Figure 6, the support assembly 300 may comprise ball joints 310 positioned on the bin 20 and rails 320 fixed to the frame 10 and configured to guide the ball joints 310 on the frame 10.

Rails

The frame 10 comprises rails 320 to support the ball joints 310 of the bin 20. More specifically, the rails 320 are fixed to the four horizontal posts 13 of each module 11.

The rails 320 preferably have a support part 321 and a guide part 322. The support part 321 is advantageously planar and is framed by the guide part 322, which protrudes from the support part 321 along the third direction Z. In other words, each rail 320 forms a channel whose support part 321 forms a bottom 21 and the guide part 322 forms rims. The guide part 322 may have two parts, symmetrical to each other relative to the support part 321, and having respectively a concave shape towards the support part 321. Such rails 320 allow guiding each ball joint 310 along the considered direction.

The rails 320 comprise longitudinal rails 320x fixed to the horizontal posts 13x along the first direction X and configured to guide the ball joints 310 of the bin 20 along the first direction X when the bin 20 moves along the first direction X. The rails 320 comprise transverse rails 320y fixed to the horizontal posts 13y along the second direction Y and configured to guide the ball joints 310 of the bin 20 along the second direction Y when the bin 20 moves along the second direction Y.

Each of the longitudinal rails 320x has an intersection 324 with each of the transverse rails 320y. The intersection 324 between the longitudinal rail 320x and the transverse rail 320y does not have a guide part 322. The ball joint 310 is therefore not guided by the guide part 322 at the intersection 324 between two rails 320. The longitudinal guide teeth 214 can participate in guiding a bin 20 along the second direction Y when the bin 20 moves along the second direction Y, and the transverse guide teeth 224 of the transverse rack 220 are configured to guide the bin 20 along the first direction X when the bin 20 moves along the first direction X, when one of the ball joints crosses one of the intersections 324. The intersection 324 can have a length 325 along the first direction X smaller than the width 227 of the transverse guide tooth 224 and a length 326 along the second direction Y smaller than the width 217 of the longitudinal guide tooth 214.

Ball Joints

The bin 20 preferably comprises four ball joints 310 in order to evenly distribute the load of the bin 20 and to balance the bin 20 on the frame 10. The ball joints 310 can be positioned at the four corners of the bin 20. The ball joints 310 allow the bin 20 to move along several different horizontal directions without resistance to displacement, unlike wheels that allow only one direction of displacement. Indeed, the ball joints 310 are free in rotation and can therefore be driven in rotation regardless of the horizontal direction of displacement of the

bin 20 on the frame 10. Thus, the ball joints 310 support the bin 20 on the frame 10 and allow the bin 20 to translate along the first direction X and along the second Y direction. The ball joints 310 thus allow eliminating the need for a disengagement system often required with a support assembly 300 comprising wheels.

Each ball joint 310 may comprise a skirt 311. The skirt 311, as illustrated for example in Figure 7, is configured to cooperate with the concave guide part 322 of the rail 320 to ensure a holding of the ball joint 310 in the rail 320 and therefore a proper guiding of the bin 20 in the frame 10. The skirt 311 is fixed to the bin 20 and supports the ball joint 310. The skirt 311 surrounds the ball joint 310 and may have a circular outer edge in order to facilitate its insertion into the concave guide part 322. Once in the rail 320, the skirt 311 is configured to prevent the ball joint 310 from moving in the rail 320 along a direction other than the direction of the considered rail 320.

Guide pin

The support assembly 300 may further comprise guide pins 330. The guide pins 330 are configured to slide in the guide rails 320 and to guide the bin 20 when one or more of the ball joints 310 of the bin 20 pass through an intersection 324 between one of the longitudinal rails 320x and one of the transverse rails 320y. The guide pins 330 thus cooperate with the longitudinal guide teeth 214 and with the transverse guide teeth 224 in guiding the bin 20 when one or more of the ball joints 310 of the bin 20 pass through an intersection 324 between one of the longitudinal rails 320x and one of the transverse rails 320y.

The guide pin 330 is therefore advantageously positioned on the bin 20, between two considered ball joints 310, to be guided by the guide part 322 of a rail 320 along a considered direction of displacement when one of the two ball joints 310 considered is located at one of the intersections 324.

The bin 20 can comprise one guide pin 330 on each side of the bin, namely four guide pins 330.

Each rail 320 has a passage 323, as illustrated in Figure 8, in the guide part 322 to let the guide pin 330 pass. The passage 323 is positioned on the rail 320 so that each guide pin 330 is facing the passage 323 when the bin 20 is positioned at the center of the module 11. This allows the guide pins 330 that do not participate in guiding the bin 20 along the direction of displacement considered, so as not to impede the displacement along this direction by abutting on the guide part 322.

Actuation unit

The actuation unit 130 comprises:

- the horizontal post 13 forming the frame 10. The post extends along a main direction, which can be either the first horizontal direction X or the second horizontal direction Y, depending on the considered actuation unit 130.

- a rail 320 of the displacement system 100. The rail 320 is fixed along the post 13. Depending on whether the post is oriented along the first horizontal direction X or along the second horizontal direction Y, the rail 320 is either a longitudinal rail 320x or a transverse rail 320y.

- a first pinion 230 positioned on one side of the post 13 (in other words on the side of the first module 111), and a second pinion 230 is positioned on another side of the post 13 (in other words on the side of the second module 112 or of the third module 113). Depending on whether the post is oriented along the first horizontal direction X or along the second horizontal direction Y, the first pinion 230 and the second pinion 230 are configured to be driven in rotation around the first direction X or along the second direction Y by a motor 250, 251 fixed to the post 13.

- a control device C, to synchronously control the motor 250, 251 of each of the first pinion 230 and of the second pinion 230. The control device is connected to the central control unit C to allow coordinated displacement of the bin 20 in the frame 10. The control device C of each actuation unit 130 is configured to control the respective motor 250, 251 of each of the first pinion 230 and of the second pinion 230 when a command is received from the control unit C. The control device C of each actuation unit 130 is configured to control the respective motor 250, 251 of each of the first pinion 230 and of the second pinion 230 in a synchronized manner so that a tray passing through the actuation unit 130 can transit by being driven jointly by the first pinion 230 and by the second pinion 230. The control device C thus prevents any malfunction in the translation of the bin 20 between two adjacent modules 11 separated by the considered actuation unit 130.

The arrangement of a plurality of actuation units 130 with each other and with vertical posts 12 allows the formation of the plurality of adjacent modules 11 configured to receive one (or more) bins 20. The frame 10 thus comprises, linked together, in addition to the vertical posts 12:

- actuation units 130 whose main direction is oriented along the first direction X, configured to mesh with a transverse rack 220 of a bin 20 and to guide ball joints 310 supporting the bin 20 along the first direction X, and

- actuation units 130 whose main direction is oriented along the second direction Y, configured to mesh with a longitudinal rack 210 of a bin 20 and to guide ball joints 310 supporting the bin 20 along the second direction Y.

The actuation units 130 can be manufactured and assembled together directly during the mounting of the modular storage structure 1. This allows facilitating the design and mounting of the modular structure.

Method for moving the bin between two adjacent modules

The bin 20 can move between the first module 111 and the second module 112 or the third module 113 under the action of the displacement system 100. The detailed method described below concerns a displacement of the bin 20 from the first module 111 to the second module 112. But a displacement from the first module 111 to the third module 113 is similar in principle.

The method, whose main steps are schematized by a flowchart in Figure 9, is described for a bin 20 according to the embodiment in which the displacement system 100 comprises two longitudinal racks 210 and two transverse racks 220, as well as two longitudinal pinions 230 for each longitudinal rack 210 and two transverse pinions 240 for each transverse rack 220. But a displacement of a bin 20 with different number of longitudinal racks 210 and number of transverse racks 220, as well as with different number of longitudinal pinions 230 for each longitudinal rack 210 and number of transverse pinions 240 for each transverse rack 220, is also similar in principle.

The bin 20 is initially positioned at the center of the first module 111, as illustrated for example in Figure 2. The guide teeth 214 of each longitudinal rack 210 are each positioned in the interval 232 between two teeth 231 of one of the longitudinal pinions 230, and the guide teeth 224 of each transverse rack 220 are each positioned in the interval 242 between two teeth 241 of one of the transverse pinions 240. The bin 20 can thus possibly be moved along the first direction X and along the second direction Y by actuation of the longitudinal pinions 230 or of the transverse pinions 240.

The control unit C controls (step E1) the second motors 251 of the first module 111 so that the transverse pinions 240 move into a position of guiding the transverse guide teeth 224 of the transverse racks 220. In the guiding position, as illustrated in Figure 8, each of the transverse guide teeth 224 is tangent to one of the teeth 241 of one of the transverse pinions 240. Advantageously, each transverse guide tooth 224 of the transverse racks 220 is tangent to one of the teeth 241 of one of the transverse pinions 240 on the side of the horizontal post along the first direction X to which the considered transverse pinion 240 is fixed. This allows creating a slider on the bin 20 along the first direction X.

The control unit C then controls (step E2) the first motors 250 of the first module 111 so that the longitudinal pinions 230 mesh with the longitudinal racks 210. Advantageously, only the motor 250 actuating the longitudinal pinions 230 of the first module 111, fixed to the horizontal post 13y along the second direction Y adjacent to the second module 112, is actuated.

The control unit C can also control (step E3) the first motor 250 actuating the longitudinal pinions 230 of the second module 112, fixed to the horizontal post along the second direction Y adjacent to the first module 111 in order to collaborate with the longitudinal pinions 230 of the first module 111, which are actuated, to the displacement of the bin 20 and then replace them once the longitudinal racks 210 no longer mesh with the longitudinal pinions 230 of the first module 111. The actuation of the longitudinal pinions 230 of the second module 112 is synchronously made with the actuation of the longitudinal pinions 230 of the first module 111 by the PID controller. The PID controller is configured to maintain a constant speed and minimize the position deviations to allow the bin 20 to move from the first module 111 to the second module 112 without blocking.

The control unit C also controls (step E4) the second motors 251 of the second module 112 so that the transverse pinions 240 move into a position configured to let the transverse guide teeth 224 of the transverse racks 220 pass along the first direction X. In other words, the transverse pinions 240 of the second module 112 are oriented so that the transverse guide teeth 224 of the transverse racks 220 pass respectively in the interval 242 between two of the teeth 241 of the transverse pinions 240 of the second module 112. Thus, the displacement of the bin 20 along the first direction X is not prevented or hindered by the transverse racks 220 and the transverse pinions 240, configured for the displacement along the second direction Y. The transverse pinions 240 of the second module 112 can be actuated to move into the guide position when at least one of the ball joints 310 of the bin 20 crosses one of the intersections 324.

During the displacement of the bin 20 between the first module 111 and the second module 112, the ball joints 310 of the bin 20 move in the rails 320 along the first direction X of the first module 111 and then of the second module 112. During the displacement, each guide pin 330 positioned in the rails 320 along the first direction X cooperate in guiding the bin 20 along the first direction X by sliding in the rails 320 along the first direction X.

CLAIMS

1. A system (100) for moving a bin (20) within a modular storage structure (1) comprising a frame (10) forming a plurality of adjacent modules (11), the displacement system (100) comprising:

- a longitudinal rack (210) positioned on the bin (20) and configured to move the bin (20) within the modular structure (1) along a first direction (X), and a transverse rack (220) positioned on the bin (20) and configured to move the bin (20) within the modular structure (1) along a second direction (Y), perpendicular to the first direction (X); and
- a longitudinal pinion (230) and a transverse pinion (240) positioned on the frame (10) of each module (11), the longitudinal pinion (230) being configured to mesh with the longitudinal rack (210) and the transverse pinion (240) being configured to mesh with the transverse rack (220);

characterized in that the longitudinal rack (210) and the transverse rack (220) respectively comprise teeth (211, 221) spaced by an interval (212, 222) and having a width (213, 223), the width (213) of the teeth (211) of the longitudinal rack (210) being smaller than or equal to the interval (222) between the teeth (221) of the transverse rack (220) and the width (223) of the teeth (221) of the transverse rack (220) being smaller than or equal to the interval (212) between the teeth (211) of the longitudinal rack (210).

2. The displacement system (100) according to claim 1, wherein the longitudinal pinion (230) comprises teeth (231) each successively spaced by an interval (232) greater than the thickness of the teeth (211) of the longitudinal rack (210) so as to allow the teeth (211) of the longitudinal rack (210) to translate through the interval (232) of the longitudinal pinion (230) when the transverse rack (220) meshes with the transverse pinion (240), and the transverse pinion (240) comprises successive teeth (241) each spaced by an interval (242) greater than the thickness of the teeth (221) of the transverse rack (220), so as to allow the teeth (221) of the transverse rack (220) to translate through the interval (242) of the transverse pinion (240) when the longitudinal rack (210) meshes with the longitudinal pinion (230).

3. The displacement system (100) according to any one of claims 1 and 2, wherein the interval (212) between the teeth (211) of the longitudinal rack (210) is greater than the width (243) of the teeth (241) of the transverse pinion (240), and the interval (222) between the teeth (221) of the transverse rack (220) is greater than the width (233) of the teeth (231) of the longitudinal pinion (230), so as to allow the longitudinal pinion (230) to intersect the

transverse rack (220) when it meshes with the longitudinal rack (210), and allow the transverse pinion (240) to intersect the longitudinal rack (210) when it meshes with the transverse rack (220).

4. The displacement system (100) according to any one of claims 1 to 3, wherein the longitudinal rack (210) and the transverse rack (220) are positioned on the bin (20) transversely, relative to each other, and intersect so as to balance the loads on the bin (20).

5. The displacement system (100) according to any one of claims 1 to 4, comprising two distinct and parallel longitudinal racks (210), and two distinct and parallel transverse racks (220), each of the two longitudinal racks (210) and of the two transverse racks (220) meshing respectively with two longitudinal pinions (230) and two transverse pinions (240).

6. The displacement system (100) according to any one of claims 1 to 5, comprising ball joints (310) to support the bin (20) on the frame (10), the ball joints (310) allowing a displacement of the bin (20) along the first direction (X) and along the second direction (Y).

7. The displacement system (100) according to any one of claims 1 to 6, comprising longitudinal rails (320x) fixed to the frame (10) in order to guide ball joints (310) supporting the bin (20) along the first direction (X) and transverse rails (320y) fixed to the frame (10) in order to guide ball joints (310) supporting the bin (20) along the second direction (Y), each longitudinal rail (320x) showing an intersection (324) with each transverse rail (320y).

8. The displacement system (100) according to claim 7, wherein each longitudinal pinion (230) is positioned on the frame (10) along a transverse rail (320y) and each transverse pinion (240) is positioned on the frame (10) along a longitudinal rail (320x), a single first motor (250) driving in rotation each longitudinal pinion (230) positioned along the same transverse rail (320y), and a single second motor (251) driving in rotation each transverse pinion (240) positioned along the same longitudinal rail (320x).

9. The displacement system (100) according to claims 6 and 7, wherein each ball joint (310) comprises a guide skirt (311) configured to hold the ball joint (310) in one of the longitudinal rails (320x) or in one of the transverse rails (320y).

10. The displacement system (100) according to any one of claims 1 to 9, wherein each of the longitudinal rack (210) and of the transverse rack (220) comprises, respectively at its two ends, a guide tooth (214, 224) whose width (217, 227) is respectively greater than the width (213, 223) of the teeth (211, 221) of the longitudinal rack (210) and of the transverse

rack (220), the guide tooth (214) of the longitudinal rack (210) being configured to guide the bin (20) along the second direction (Y) by sliding within the interval (232) of the longitudinal pinion (230), and the guide tooth (224) of the transverse rack (220) being configured to guide the bin (20) along the first direction (X) by sliding within the interval (242) of the transverse pinion (240).

11. The displacement system (100) according to claims 7 and 10, wherein the width (217) of the guide teeth (214) of the longitudinal rack (210) is greater than a length (326) of the intersection (324) along the second direction (Y), and the width (227) of the guide teeth (224) of the transverse rack (220) is greater than a length (325) of the intersection (324) along the first direction (X), in order to allow guiding the bin (20) when one of the ball joints (310) of the bin (20) crosses the intersection (324).

12. The displacement system (100) according to claim 7, comprising guide pins (330) fixed to the bin (20) and configured to translate in one of the longitudinal rails (320x) or in one of the transverse rails (320y), the guide pin (330) guiding the bin (20) along the first direction (X) or along the second direction (Y) when a ball joint (310) is at one of the intersections (324).

13. A bin (20) configured to be moved within a modular storage structure (1) and comprising a longitudinal rack (210) configured to move the bin (20) within the modular structure (1) along a first direction (X) and a transverse rack (220) configured to move the bin (20) within the modular structure (1) along a second direction (Y), perpendicular to the first direction (X), the longitudinal rack (210) and the transverse rack (220) being positioned on the bin (20), characterized in that the longitudinal rack (210) and the transverse rack (220) respectively comprise teeth (211, 221) spaced by an interval (212, 222) and having a width (213, 223), the width (213) of the teeth (211) of the longitudinal rack (210) being smaller than or equal to the interval (222) between the teeth (221) of the transverse rack (220) and the width (223) of the teeth (221) of the transverse rack (220) is smaller than or equal to the interval (212) between the teeth (211) of the longitudinal rack (210).

14. An actuation unit (130) for a displacement system (100) according to claim 1, the actuation unit (130) comprising:

- a post (13) extending along a main direction (X,Y),
- a rail (320) fixed along the post (13) and configured to guide ball joints (310) supporting a bin (20),

- a first pinion (230) positioned on one side of the post (13) relative to the longitudinal direction (X, Y) and a second pinion (230) positioned on another side of the post (13) relative to the main direction (X,Y), each pinion being configured to be driven in rotation about the main direction (X,Y) by a motor (250, 251) fixed to the post (13),
- a control device (C) to synchronously control the respective motor (250, 251) of each of the first pinion (230) and of the second pinion (230).

15. A frame (10) of a modular storage structure (1), comprising a plurality of actuation units (130) according to claim 14, the plurality of actuation units (130) forming a plurality of adjacent modules (11) configured to receive a bin (20), the frame (10) comprising:

- actuation units (130) whose main direction is oriented along a first direction (X), configured to mesh with a transverse rack (220) of a bin (20) and to guide ball joints (310) supporting the bin (20) along the first direction (X), and
- actuation units (130) whose main direction is oriented along a second direction (Y), configured to mesh with a longitudinal rack (210) of a bin (20) and to guide ball joints (310) supporting the bin (20) along the second direction (Y).

16. A modular storage structure (1) comprising a bin (20) according to claim 13 and a frame (10) according to claim 15, the bin (20) being configured to be moved within the modules (11) of the frame (10) under the action of a control unit (C).