

- [54] **HIGH DENSITY MOBILE STORAGE SYSTEM**
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- [63] Continuation of Ser. No. 35,159, May 6, 1970, abandoned.
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[51] Int. Cl. **A47b 53/02**
[58] Field of Search **180/116, 124, 125; 104/162, 163, 173; 312/198, 207; 211/177**

References Cited

UNITED STATES PATENTS

- 3,212,648 10/1965 Baker, Jr. et al. 211/177

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[57] **ABSTRACT**

A high density mobile storage system in which groups of load bearing storage devices such as racks and shelves are provided with selectively energized air bearings which provide a lubricating film of air between a supporting warehouse or like floor and the bearings whereby to reduce the coefficient of friction between the bearings and the floor and permit movement of the storage devices, either singly or in groups from place to place along preferably guided paths with little expenditure of power, either manual or automatic.

3 Claims, 13 Drawing Figures

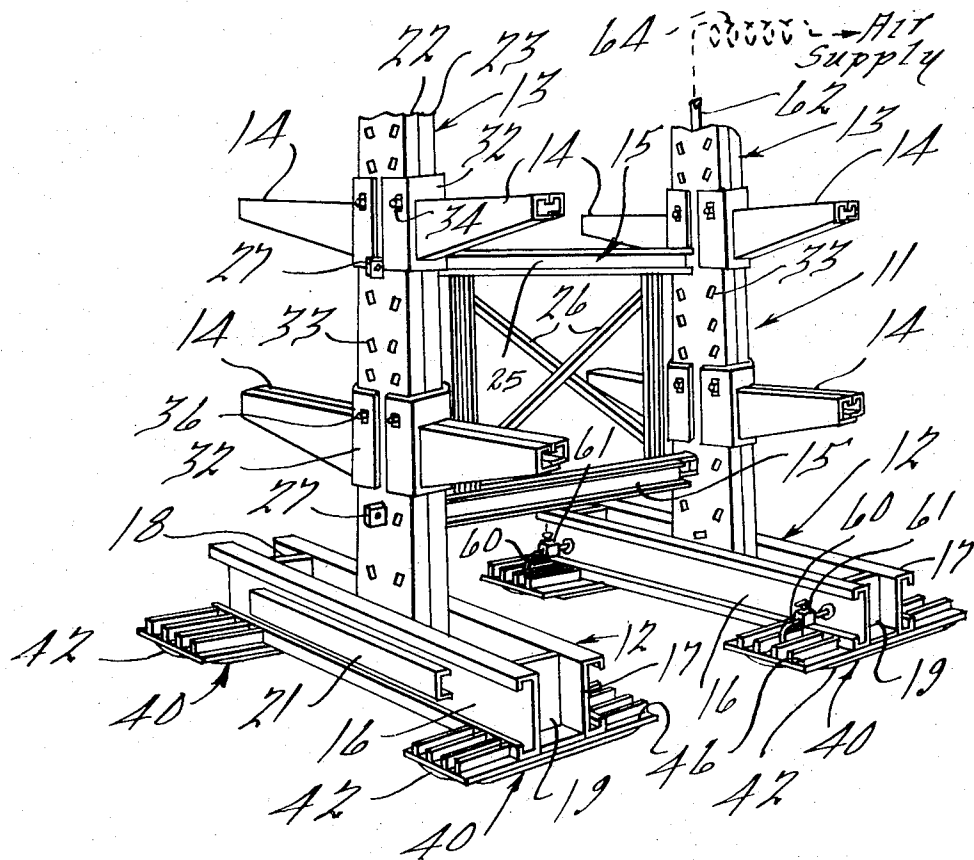


FIG. 1.

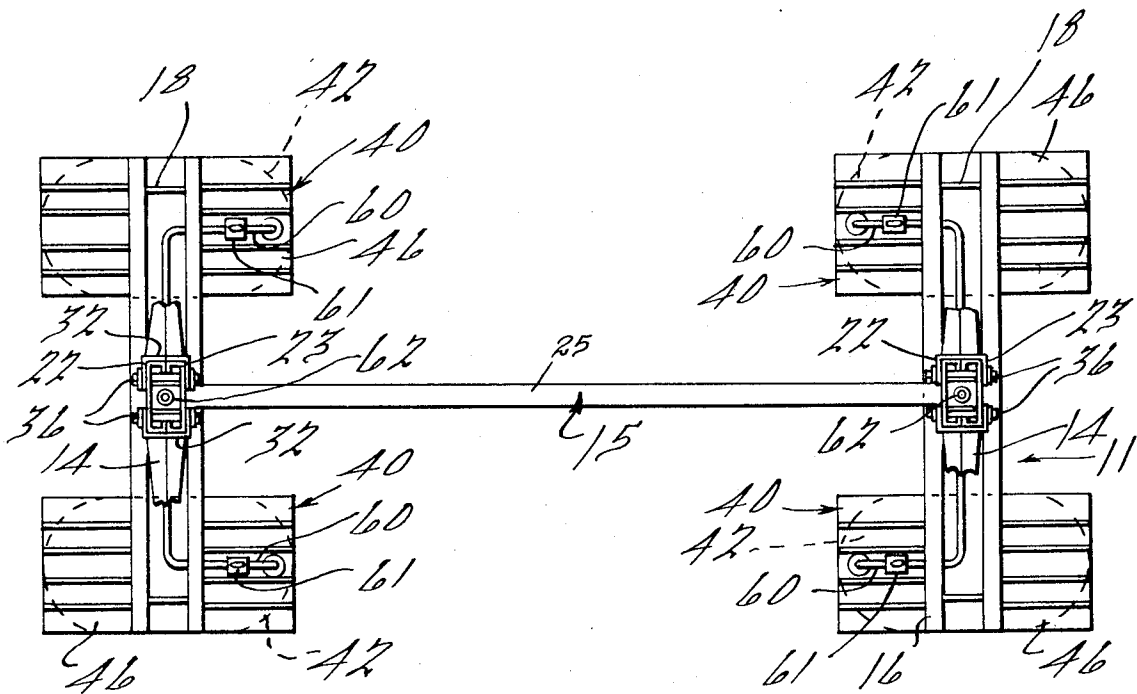
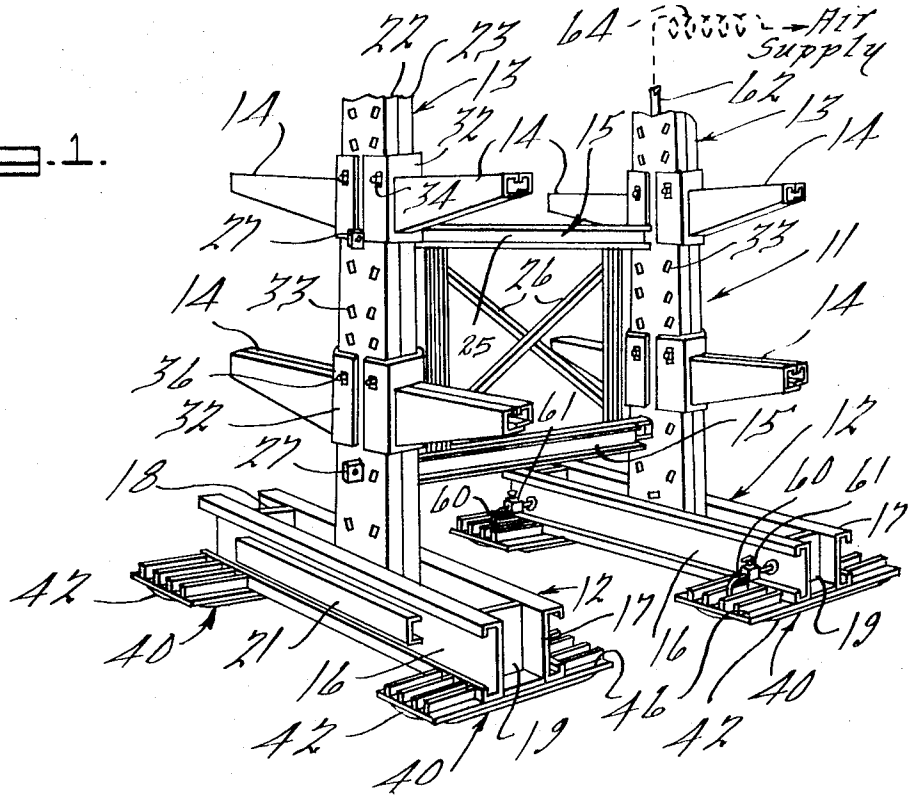


FIG. 2.

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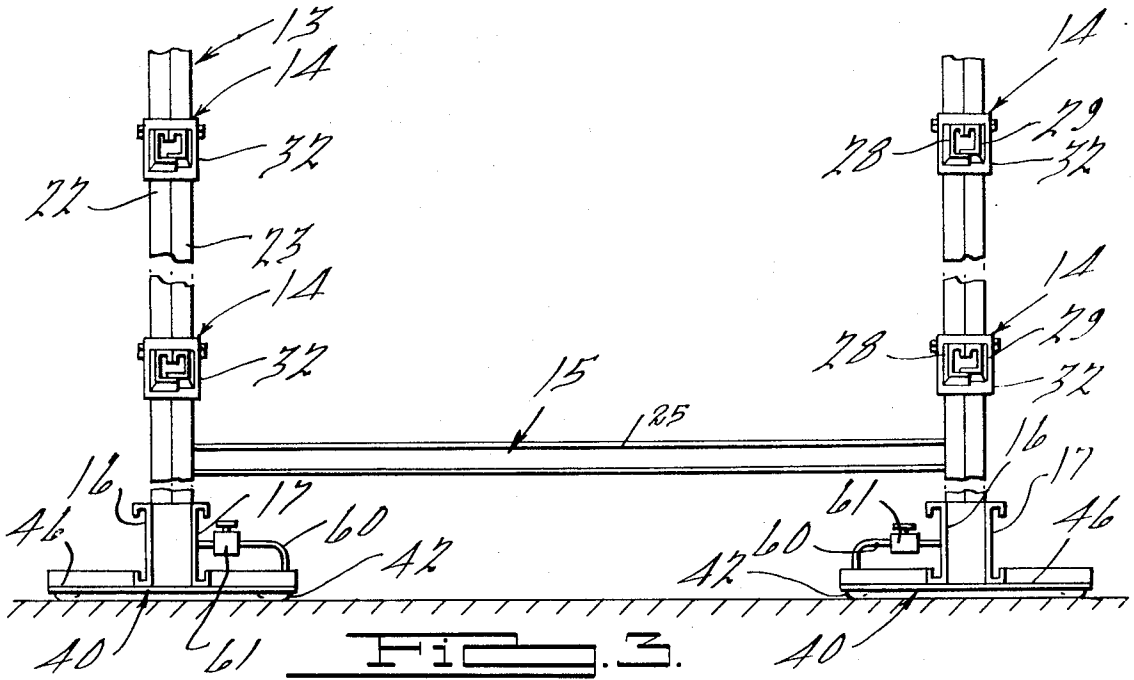


FIG. 6.

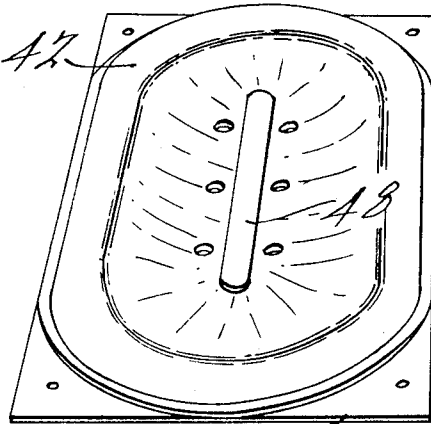
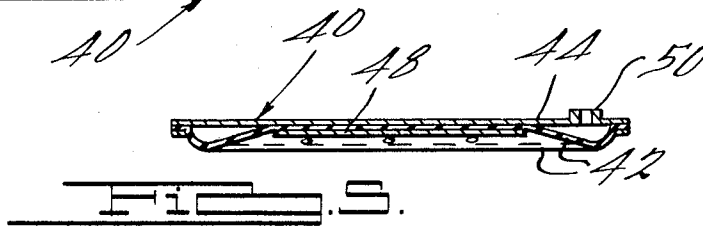
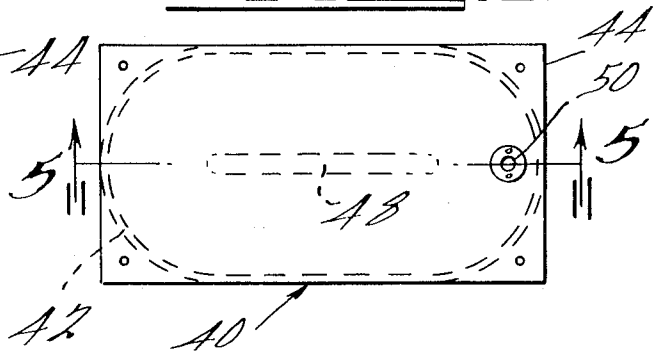
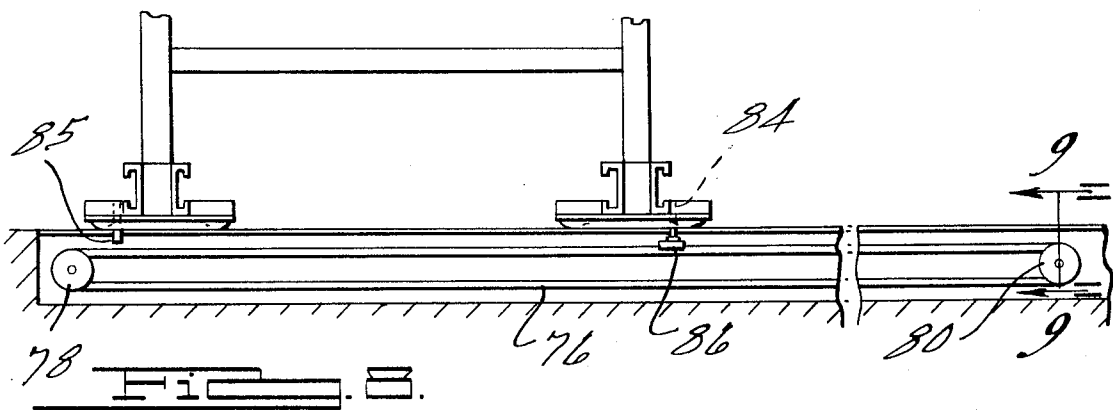
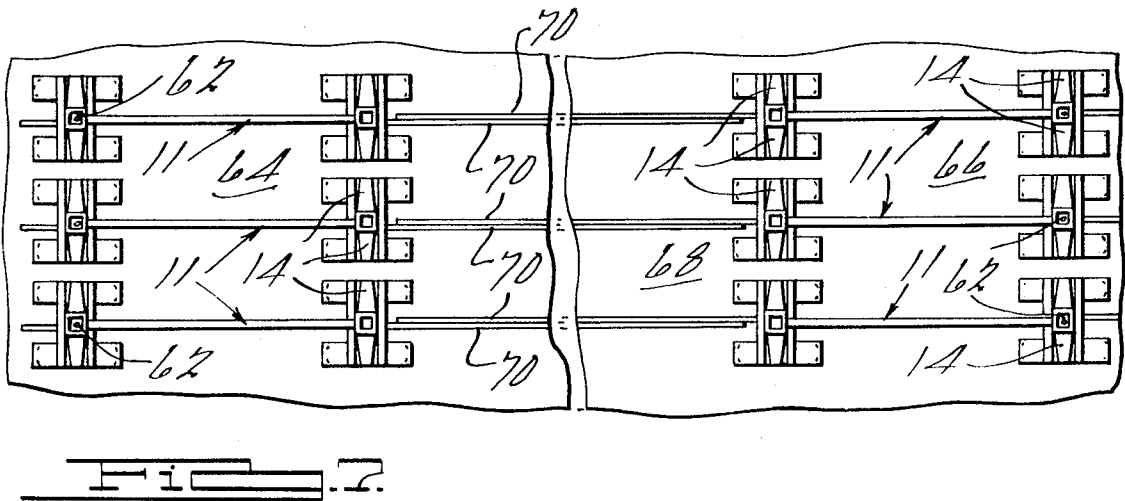
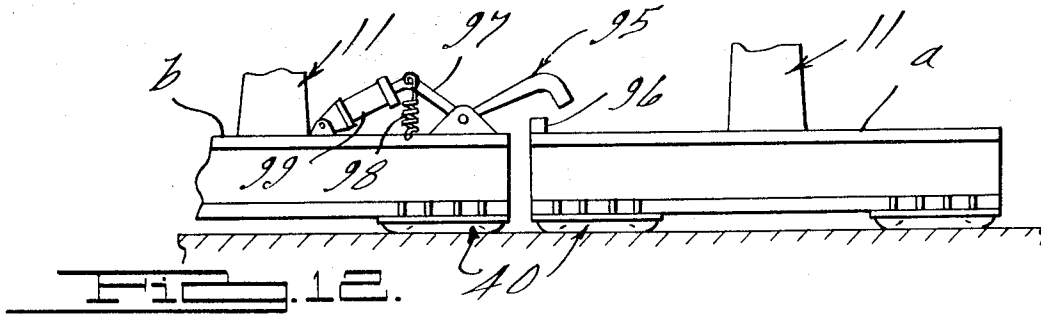


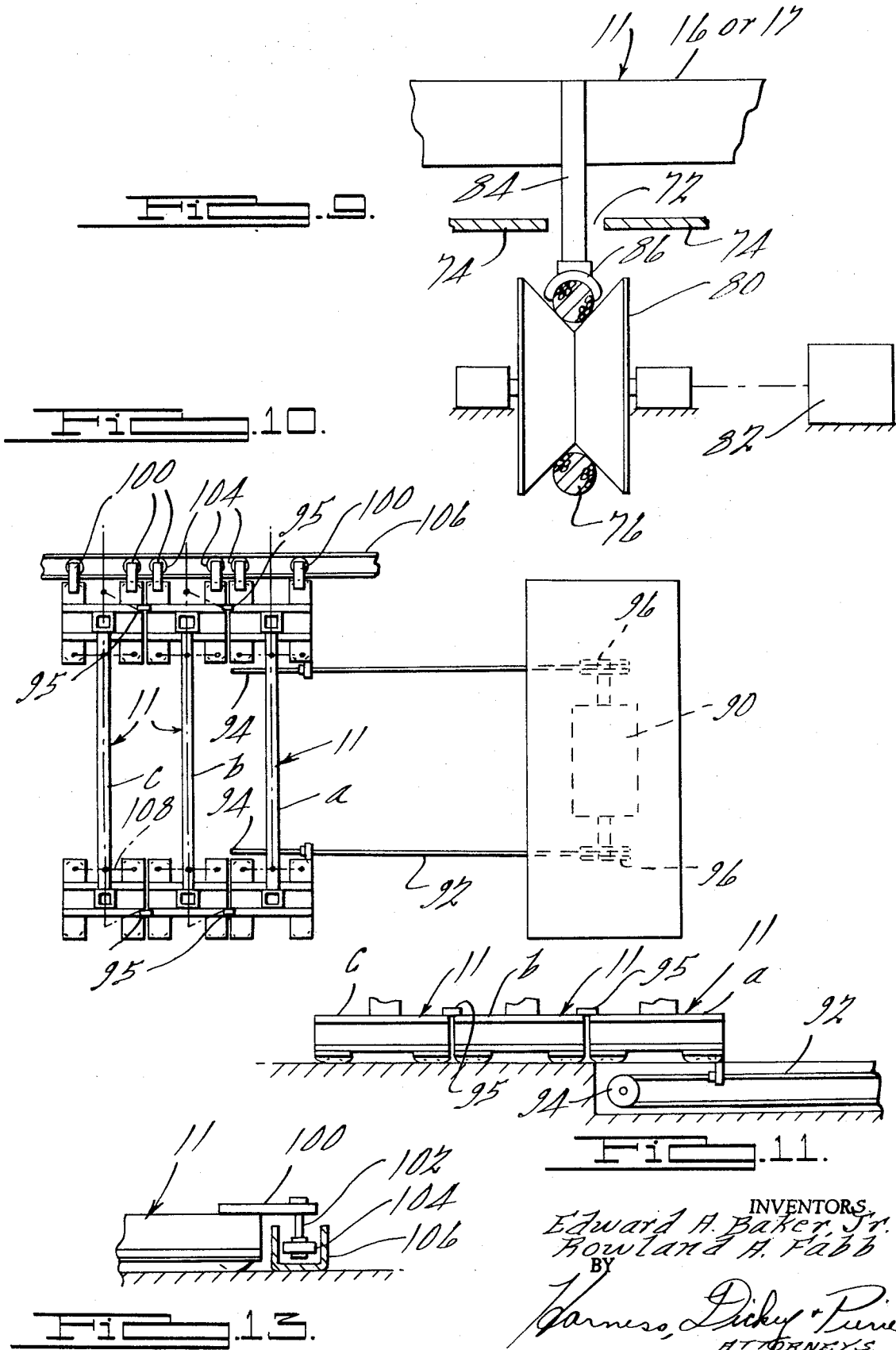
FIG. 4.



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HIGH DENSITY MOBILE STORAGE SYSTEM

This is a continuation, of application Ser. No. 35,159, filed May 6, 1970 now abandoned.

BACKGROUND OF THE INVENTION

Mobile shelving systems are known in which cabinets or the like each carrying a series of vertically spaced shelves, are carried upon rollers or other mechanical casters for movement along guided paths either manually or by mechanically applied power. Ground effect or air flotation systems employing air bearings are also known, but so far as the present applicants are aware have not heretofore been adapted to or applied to storage devices and systems. The present invention achieved such an adaptation or application in a simple, economical and efficient manner and provides a highly desirable high density mobile storage system.

SUMMARY OF THE INVENTION

As aforesaid, the present invention provides a high density mobile storage system in which groups of load bearing storage devices such as racks and shelves are provided with selectively energized air bearings which provide a lubricating film of air between a supporting warehouse or like floor and the bearings whereby to reduce the coefficient of friction between the bearings and the floor and permit movement of the storage devices, either singly or in groups from place to place along preferably guided paths with little expenditure of power, either manual or automatic.

Accordingly, principal objects of the invention are to provide storage equipment such as racks, incorporating air bearings capable of establishing a lubricating film of air between the equipment and its supporting floor, whereby to enable movement of the equipment over the floor with minimum expenditure of power; to provide such equipment capable of supporting both balanced and unbalanced loads; to provide such equipment incorporating a plurality of symmetrically arranged air bearings; to provide high density storage systems, incorporating a plurality of individual powered storage devices arranged for travel along guided paths; and to provide such systems incorporating selectively operable means to interconnect two or more storage devices for simultaneous movement.

Other objects and advantages of the present invention will become apparent from the following detailed description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a cantilever rack embodying the invention;

FIG. 2 is a view in top plan of the structure of FIG. 1;

FIG. 3 is a view in side elevation of the structure of FIG. 1;

FIG. 4 is a view in top plan of one of the air bearings or air casters employed in the structure of FIGS. 1, 2 and 3;

FIG. 5 is a view of vertical section taken along the lines 5—5 of FIG. 4;

FIG. 6 is a view in perspective of the underside of the structure of FIGS. 4 and 5;

FIG. 7 is a view in top plan of a rack system which embodies and is arranged in accordance with the invention;

FIG. 8 is a fragmentary view in side elevation based upon the structure of FIG. 7;

FIG. 9 is a detailed view of a part of the structure shown in FIGS. 7 and 8;

FIG. 10 is a view in top plan of another arrangement of racks which incorporate and are arranged in accordance with the invention;

FIG. 11 is a view and side elevation based upon FIG. 10;

FIG. 12 is a fragmentary view based upon FIGS. 10 and 11; and

FIG. 13 is a detailed view illustrating the guiding mechanism indicated diagrammatically in FIGS. 10 and 11.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Referring first to FIGS. 1 through 3, the storage rack herein illustrated by way of example embodies the construction shown and described in U.S. Pat. No. 3,212,648 granted Oct. 19, 1965 to the present applicant Baker and Lee Z. Hall. This rack, which is preferably formed of steel, is generally indicated at 11 and comprises a pair of bases each of which is generally indicated at 12, a pair of columns each of which is generally indicated at 13 and a plurality of load supporting arms each of which is generally indicated at 14, as well as interconnecting means generally indicated at 15 between columns 13.

Each base comprises a pair of channel-shaped members 16 and 17, these members being in back-to-back spaced relation and having out-turned flanges. The backs of the members 16 and 17 are secured to the lower ends of the columns 13 and connecting plates 18 and 19 are provided adjacent the ends of the members 16 and 17. Channel-shaped reinforcing bars 21 may also be provided, these being secured to the web portions of the members 16 and 17. Each column 13 is fabricated of two sections 22 and 23, these sections being symmetrical and of generally channel-shape and the in-turned flanges of which are secured together to form a generally rectangular section. The shapes of the members 22 and 23 are such that each column 13 taper upwardly, being slightly narrower at the top than at the bottom.

Interconnecting means 15 comprises horizontal members 25 and diagonal and vertical members 26, the horizontal members being secured to ears 27 on the facing surfaces of the columns 13, these surfaces and the ones opposite them being those to which bases 12 are secured. It will be realized of course that any number of columns, in addition to the two illustrated, may be secured together in the manner shown, each column having its own base 12 and ears 27 on its opposite sides.

In the embodiment of the invention illustrated, each supporting arm 14 is fabricated of two generally channel-shaped but tapered sections 28 and 29, secured together by welding. These sections are similar in shape but have overlapping lower edges, the section 28 being slightly larger than section 29 for this purpose. The upper portions of the sections 28 and 29 have flush surfaces for load supporting purposes, and overlapping lower portions.

The wider end of each supporting arm 14 is provided with a mounting bracket 32. Each bracket 32 comprises a channel-shaped member, the web portion of which is secured to the wider end of the arm 14 and the

sides of which are adapted to fit around the surface of the column 13. The construction is such that when the web portion of each bracket 32 is flush with the facing surface of the column 13, as seen in FIG. 6, the upper surface of the corresponding arm 14 will be tilted slightly upwardly and inwardly.

In the double-sided rack shown, four rows of apertures 38 are provided in each column 13, the rows being in two pairs with apertures in each pair of rows being horizontally aligned in a direction at right angles to the extent of supports 14 and at any desired vertical spacing. The apertures 33 are of inclined rectangular shape, that is, with their side edges extending downwardly and away from the surface of the column 13 which face the supports 14.

The flanges of the brackets 32 are preferably wide enough to overlap several pairs of aligned apertures 33 when the brackets 32 are placed in the positions shown. The upper flange portions of each bracket have a pair of horizontally aligned apertures 34 which are larger in both directions than the apertures 33 and having side edges inclined at the same angle as the side edges of apertures 33. A pin 36 of rectangular cross-sectional shape is insertable through the apertures 34 and 33 when a pair of apertures 34 on any bracket 32 are aligned with a pair of apertures 33. The cross-sectional shapes of pins 36 are identical and such that they will be slidably receivable by the apertures 33 but without appreciable play after they are inserted. Edges 35 of the apertures 34 on the brackets 32 will engage the surfaces of the pins 36 which face away from the corresponding support 14, as seen in FIG. 2. The arrangement is such that this engagement will cause the load supports 14 to be cammed or wedged toward the columns 13 with the web portion of the bracket 32 being forced into tight frictional engagement with the facing surface of the columns 13 so that a substantial portion of the load on the supports is transmitted to the columns through the web portions of the brackets 32 and all of the load on the supports 14 is not transmitted to the columns through the pins 36. The apertures 34 are positioned high enough on the brackets 32 to counteract the moment forces created on the supports 14 by the load thereon, thus holding the supports firmly in position. The pins 36 are longer than the distance between the aligned apertures 34. In use, any desired number of arms, the supports 14 may be mounted at any desired heights on the columns 13, for supporting bars, rods, tubes, or other industrial material.

In accordance with the present invention, rack 11 is supported upon a group of four symmetrically arranged inflatable air-bearings 40 which are secured to the undersides of the cross beams 12 near the outer ends thereof. When inflated as described below, the air-bearings support the rack upon a lubricating cushion of air and enable it, though heavily loaded, to be moved as desired from place with very little expenditure of force or power. Air bearings 40 may be of any suitable type but are illustrated as having the construction sold under the trade name Airfloat. More particularly, referring to FIGS. 4, 5 and 6 each bearing comprises a flexible diaphragm 42 of oval shape secured throughout its border to a relatively light backing plate 44 which in turn is rigidly secured to the underside of a corresponding reinforced support member 46. Members 46 are in turn secured to the outer ends of the beams 14. Diaphragm 42 may be formed of any suit-

able material such, for example, 0.050 inches thick urethane and may be stitched to the backing plate 44.

Throughout a relatively long narrow portion of its central area, diaphragm 42 is fixedly secured to the underside of the backing plate 44, by means of an elongated narrow bar 48. Thus secured, diaphragm 42 defines an inflatable chamber of what may be called race track form. Air can be admitted to this chamber through the inlet fitting 50 and can be discharged therefrom into the plenum space beneath the air bearing through a series of apertures, six being shown, which extend through the diaphragm and are spaced along and near the bar 48.

Air bearing 40 is shown in its deflated condition in FIG. 6 and in its inflated condition in FIG. 5. It will be understood that in the deflated condition, the load upon the supported rack maintains the outer marginal areas of diaphragm 40 in substantially though not perfectly sealed relation to the floor, depending upon the condition of the floor. If air is now introduced into the bearing through the inlet 50, a pressure builds up in the plenum chamber space between the underside of the diaphragm 40 and the supporting floor structure as well as within the body of the diaphragm 40. The pressure thus developed not only inflates the marginal areas of the diaphragm 40 to the inflated condition shown in FIG. 5 but also slightly elevates these marginal areas above the supporting floor and allowing air to escape through the annular gap between the diaphragm and the floor, thereby establishing the lubricating air cushion between the bearing and the floor. As is well known, the load capacity of a single air bearing is the product of the air pressure within it and the area of its "foot print"; i.e., the area of the oval plenum chamber bounded by and beneath the diaphragm 42. Thus, at thirty pounds per square inch air pressure, a bearing having a foot print area of 500 square inches can lift a load of 15,000 pounds. Since the diaphragms 42 are quite flexible, the bearings 40 are compliant and maintain the desired air cushion despite minor irregularities in the supporting floor.

Reverting to FIG. 1, the air inlets associated with the air bearings 40 are connected by means of air lines 16 to a common supply line 62. Preferably, the air supply source is external to the associated rack or racks and, consequently, line 61 is diagrammatically indicated as connected through a coiled length of air line 64 to the indicated air supply. It will be understood that line 62 extends downwardly through the righthand column 13 in FIG. 1, that branches therefrom lead to the individual supply lines 60 which are apparent in this figure and that another branch therefrom extends through the interconnecting member 15 and thence to the supply lines (not shown) for the two cushions 40 associated with the lefthand column 13 in FIG. 1. In the use of racks of the illustrated type unbalanced loads are to be expected. For example, under some conditions only one side of a particular rack may be loaded. In other situations though both sides of the rack are loaded, the individual loads may not be matched. Under some conditions also, rack movement is required when a rack is completely unloaded. It is thus desirable to interpose pressure regulating devices 61 in each individual supply line, preferably immediately in advance of the associated cushion inlet 50, to provide that the inlet pressure at each cushion is proportional to the load upon that particular cushion. In accordance with known practice

of course, the lines leading from source 64 to the individual bearings are suitably sized so that under all conditions the air pressures applied at the inlets of the several regulators 61 are the same.

In further accordance with the present invention, a plurality of racks 11 are arranged in groups which occupy a minimum of space and are powered for movement along guided paths to enable individual ones thereof to be readily loaded and unloaded. Various configurations or groupings are within the scope of the invention, one such grouping being illustrated in FIGS. 7, 8 and 9, and another being illustrated in FIGS. 10 through 13.

Referring particularly to FIGS. 7, 8 and 9, two groups of racks 11 are arranged in bays 64 and 66, at respectively opposite sides of a center aisle 68, it being understood of course that each bay may include any desired number of racks 11. Each rack 11 is provided with an air inlet 62 which as described in connection with FIG. 1 may include a coiled portion leading to an external source of air pressure which may be common to all of the racks in the system. These coiled supply lines of course enable individual racks 11 to be moved from the illustrated normal position to a position entirely within the aisle 68. Aisle 68 may of course be entered from either end by lift trucks or other known loading and unloading devices.

In the broader aspects of the invention any suitable drive means may be utilized to effect and guide the movement between the bay position and the aisle position of the individual racks. As shown, the supporting floor structure is provided with gutters 70 which receive the drive mechanism. Gutters 70 have narrow entry throats 72 defined by structural members 74 which are proportioned and supported to bear the loads imposed thereon by the lift trucks and other loading and unloading devices. Each gutter 70 provides space for an endless drive cable 76 which is trained over sheaves 78 and 80, the latter being connected to a suitable reversible drive motor 82 which may be electrically, hydraulically, pneumatically or otherwise operated. The individual racks are connected to their associated drive cables by means of connecting arms 84, which are rigidly secured at their upper ends to a cross beam 16 or 17 of the associated rack and are secured at their lower ends by means of a suitable fitting 86 to the drive cable 76. The arms 84 cooperate with the structural members 74 to positively guide the corresponding ends of the associated racks. Similar guidance for the other ends of the racks is provided by arms 85 secured to the beams 16 or 17 and which project into the spaces between the members 74.

In operation, it will be understood that the air supply system and the connections of the individual motors 82 may be programmed so that when it is desired to load or unload a particular rack 11 the air supply for that rack is turned on thereby establishing the air cushion therefor and thereafter the associated motor 82 is energized to thereby pull the associated rack into the aisle. During this movement its guide bars 84 and 85 insure that it will follow a linear path. Preferably but not necessarily the air supply is shut off and the associated line 62 is vented during the loading or unloading operation, thereby allowing the rack to settle solidly onto the supporting surface. When it is desired to return the rack to the bay position the air supply is again turned on and the associated motor is energized and drives the rack

back into the bay at which time the air supply is shut off and vented, as before.

In the alternative configuration shown in FIGS. 10 through 13, any desired number of racks 11 are arranged closely adjacent to each other in a row. Three only are shown and bear the subdesignations *a*, *b* and *c*. The righthand rack *a* is connected to a reversible power source 90 of any suitable type, which reversibly drives a pair of endless cable 92, each trained over sheaves 94 and 96. The cables may as before be suitably received in gutters having narrow entrance throats and so constructed and supported relative to the floor as to enable travel thereof of loading and unloading devices such as lift trucks.

In this embodiment of the invention the space to the right of rack *a* constitutes a loading and unloading aisle. Thus, it will be evident that the righthand side of rack *a* may be loaded or unloaded without requiring any movement of any of the racks *a*, *b* and *c*. If it is desired to load or unload the left end side of rack *a* or the right end side of rack *b*, the air supply for rack *a* is turned on, thereby establishing the air cushion therefor and then the motor 90 is energized and pulls rack *a* far enough to the right to establish an aisle between racks *a* and *b* which is wide enough to accommodate the lift truck or other loading or unloading device.

In accordance with the present invention, if it is desired to load or unload the lefthand side of rack *b*, or the righthand side of rack *c*, both racks *a* and *b* are pulled to the right, thereby establishing an aisle between racks *b* and *c*. If it is desired to load or unload the lefthand side of rack *c*, racks *a*, *b* and *c* are all interconnected and moved to the right. These movements are accomplished by providing driving connections between each pair of adjacent racks in the row.

Each of these driving connections comprises a pair of hook-like locking members 95 carried by one of two adjacent racks and a pair of keepers 96 carried by the other such rack, over which hooks 95 can engage. Hooks 95 are formed on bell cranks 97 and are urged to the retracted positions by springs 98 and can be moved to the locking positions by air-operated rams 99. In the illustrated arrangement rack *a* carries two of the keepers 96 at its lefthand side. Racks *b* and *c* and any other racks in the row each have a pair of hooks 95 at the righthand side to cooperate with the keepers on the next adjacent rack to the right, and a pair of keepers at the other side to cooperate with the hooks on the next adjacent rack to the left.

In the embodiment now being described guiding is accomplished by providing at one end of each rack 11 a pair of guide rollers 104 which ride in a channel or track 106 which may be affixed to for example, the wall of the associated warehouse or like storage area. Rollers 104 are carried on arms 102 which project downwardly from supports 100, suitably affixed to supports 46 of the associated rack 11.

It will be appreciated that as indicated by the dotted lines 108 in FIG. 10, the air supply lines for the air bearings associated with the individual racks (other than rack *a*) are interconnected with the supply lines for the rams 99 of the corresponding rack. Thus, assuming it is desired to establish an aisle between racks *b* and *c*, and air-bearing supply lines for racks *a* and *b* are energized thereby establishing the air cushions therefor and the rams 99 for rack *b* are also energized. Thereafter, motor 90 is turned on and both racks *a* and

b are drawn to the right. As before, it is preferred to deflate the air-bearings while the unloading and loading occurs and this of course would release all energized hooks 95. Upon completion of the loading or unloading operation the air bearings are again energized, the associated locks are again established and motor 90 is energized to return the racks to the normal position. It will of course be understood that if it is desired to load or unload the lefthand side of rack *c* all three racks *a*, *b* and *c* are interconnected as aforesaid and simultaneously moved to the right. Because of the very low coefficient of friction established by the air bearings little expenditure of power is required in moving a substantial number of loaded racks.

While it will be apparent that the preferred embodiments illustrated herein are well calculated to fulfill the objects above stated, it will be appreciated that the present invention is susceptible to modification, variation and change without departing from the scope of the invention.

What is claimed is:

1. A high density mobile storage system comprising a plurality of individual storage devices each provided with selectively energizable air bearing means which when energized establish a low friction air cushion between the device and a supporting floor, said devices being normally arranged in a row in closely spaced side-by-side relation, means for effecting guided movement of a first of said devices relative to the other devices so as to make said first device accessible for loading or unloading, selectively operable means on a sec-

ond adjacent storage device coupling it to the first storage device, and a fluid pressure source common to said coupling means and the air bearing means on said second storage device, whereby energization of the air bearing means on the two adjacent storage devices will permit them both to move in unison.

2. The combination according to claim 1, said coupling means comprising a locking member movably mounted on said second storage device, and a fluid operated ram connected thereto.

3. A high density mobile storage system comprising a plurality of individual storage devices each provided with selectively energizable air bearing means which when energized establish a low friction air cushion between the devices and a supporting floor, said devices being normally arranged in a row in closely spaced side-by-side relation, means for effecting guided movement in a predetermined direction of any selected device relative to other devices so as to make said selected device accessible for loading or unloading, and guiding means for governing the path of movement of each of said devices, said guiding means being separate and spaced from said air bearings and comprising a plurality of arms carried by said device and spaced from each other in said predetermined direction, said arms extending laterally with respect to said predetermined direction, and a fixed track adjacent said device and extending in said direction, said arms having elements at their outer ends disposed within and guided by said track.

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