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Atwater

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[54] **HOISTING MECHANISM FOR AUTOMATIC WAREHOUSING SYSTEM**

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[52] **U.S. Cl.** .....**214/16.4 A**, 187/22

[51] **Int. Cl.** **B65g 47/10**

[58] **Field of Search** .....214/16.4 A; 187/22; 104/196

[56] **References Cited**

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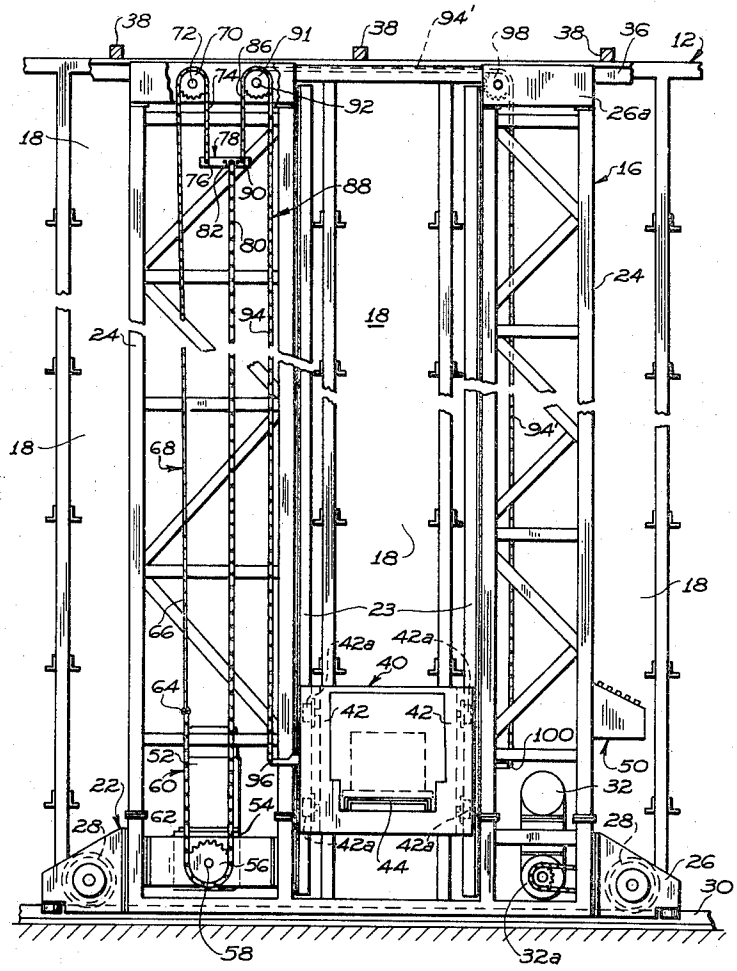
3,402,835	9/1968	Saul	214/16.4 A
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Primary Examiner—Robert G. Sheridan
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[57] **ABSTRACT**

An automatic warehousing system comprising a plurality of load support cubicles for storing loads and a mechanized load carrier comprising a horizontally movable conveyor portion, a vertically movable elevator portion mounted on the conveyor portion and a laterally extensible load handling or extractor portion, mounted on the elevator portion, for inserting loads into and removing loads from selected of the storage cubicles. The lift motor for the elevator portion is mounted adjacent the lower end of the conveyor portion and is coupled to the elevator portion by flexible support means, such as, for instance, roller chain coacting with the lift motor and reeved about idler sprockets mounted on the upper end of the conveyor portion, and then extending downwardly to be anchored to the elevator portion. Automatic tensioning means coacts with the flexible support means for maintaining the flexible support means taut irrespective of the vertical position of the elevator portion with respect to the horizontally movable conveyor portion.

10 Claims, 5 Drawing Figures



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SHEET 1 OF 3

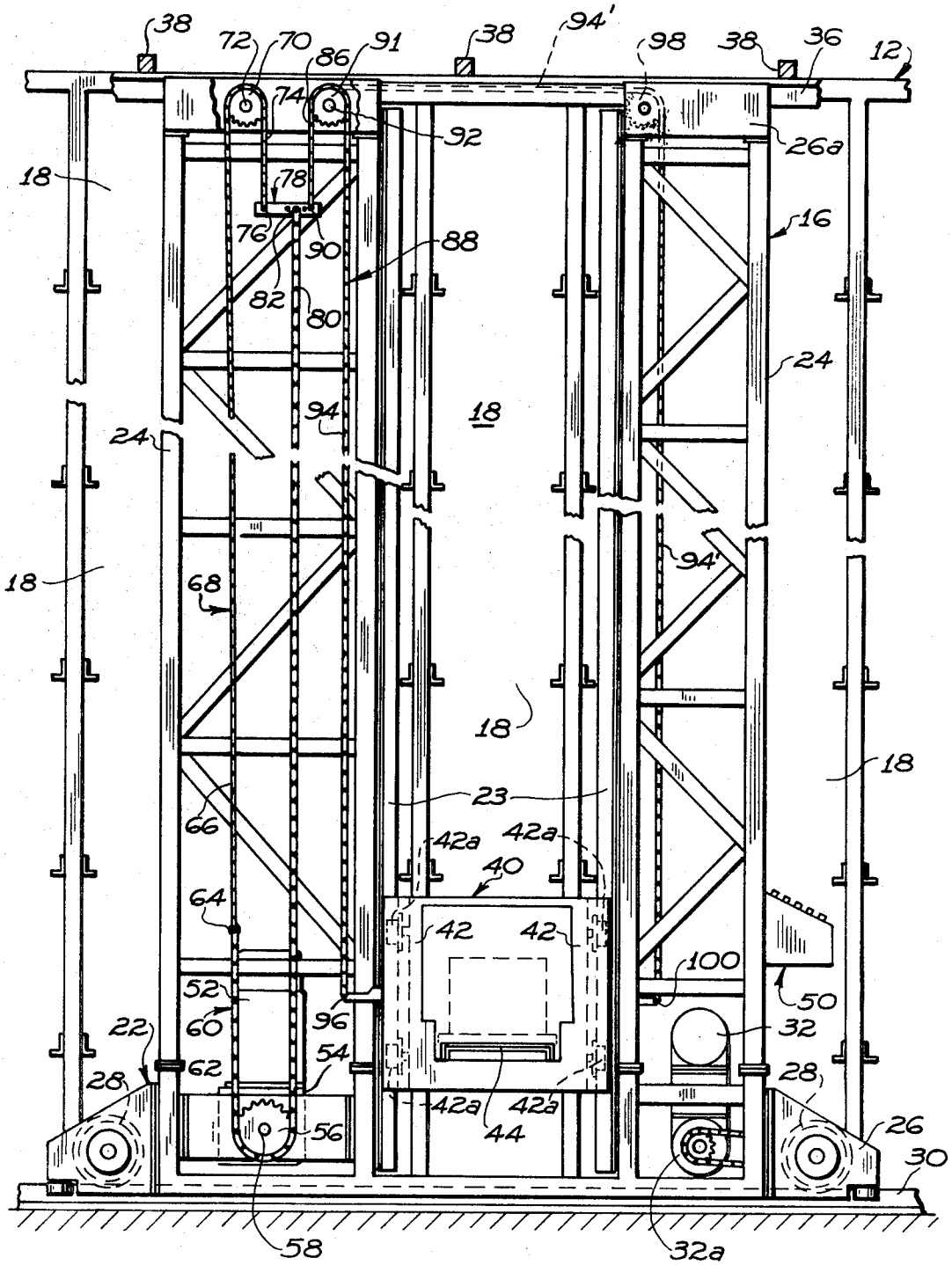


Fig. 1

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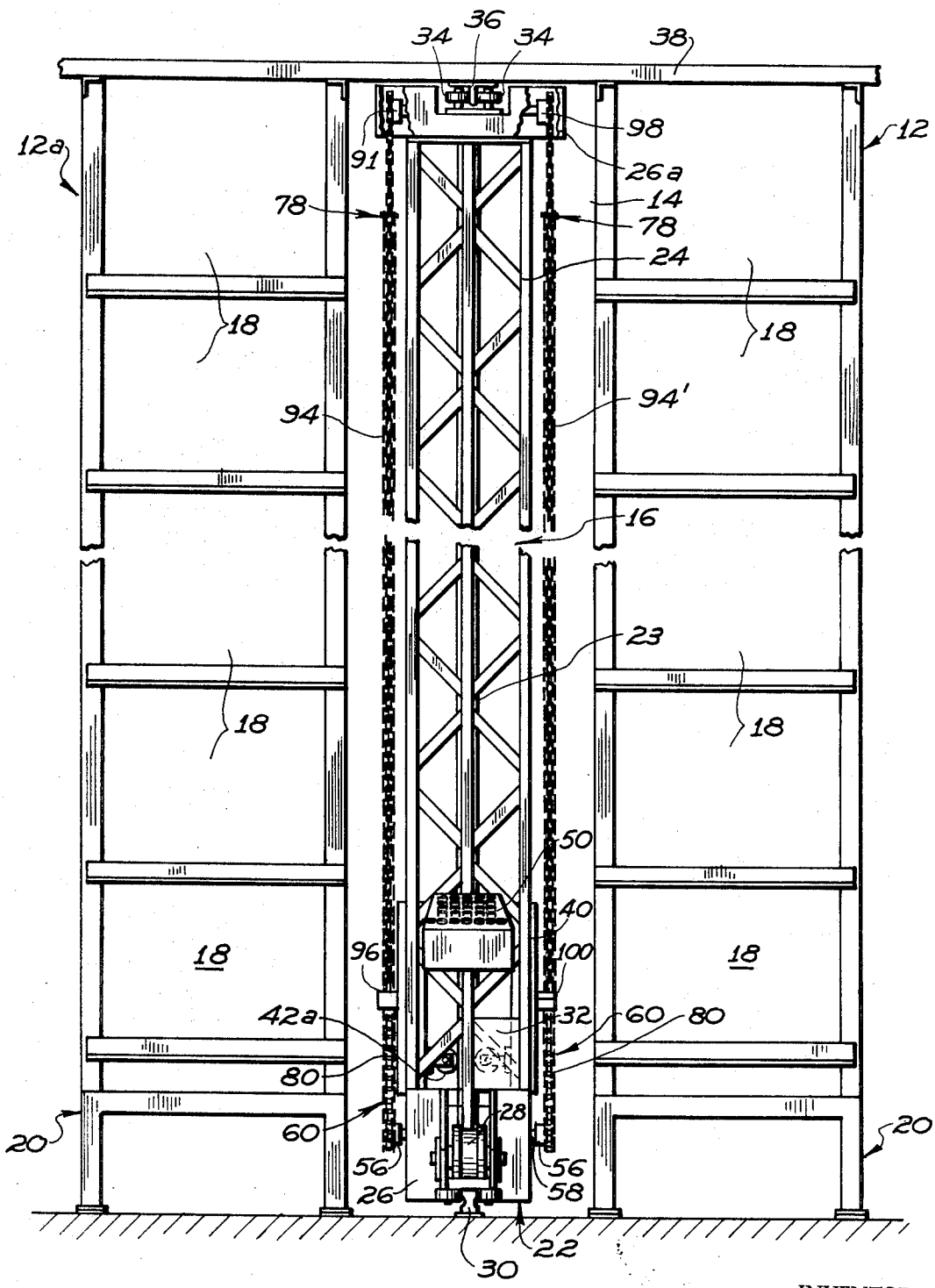


Fig. 2

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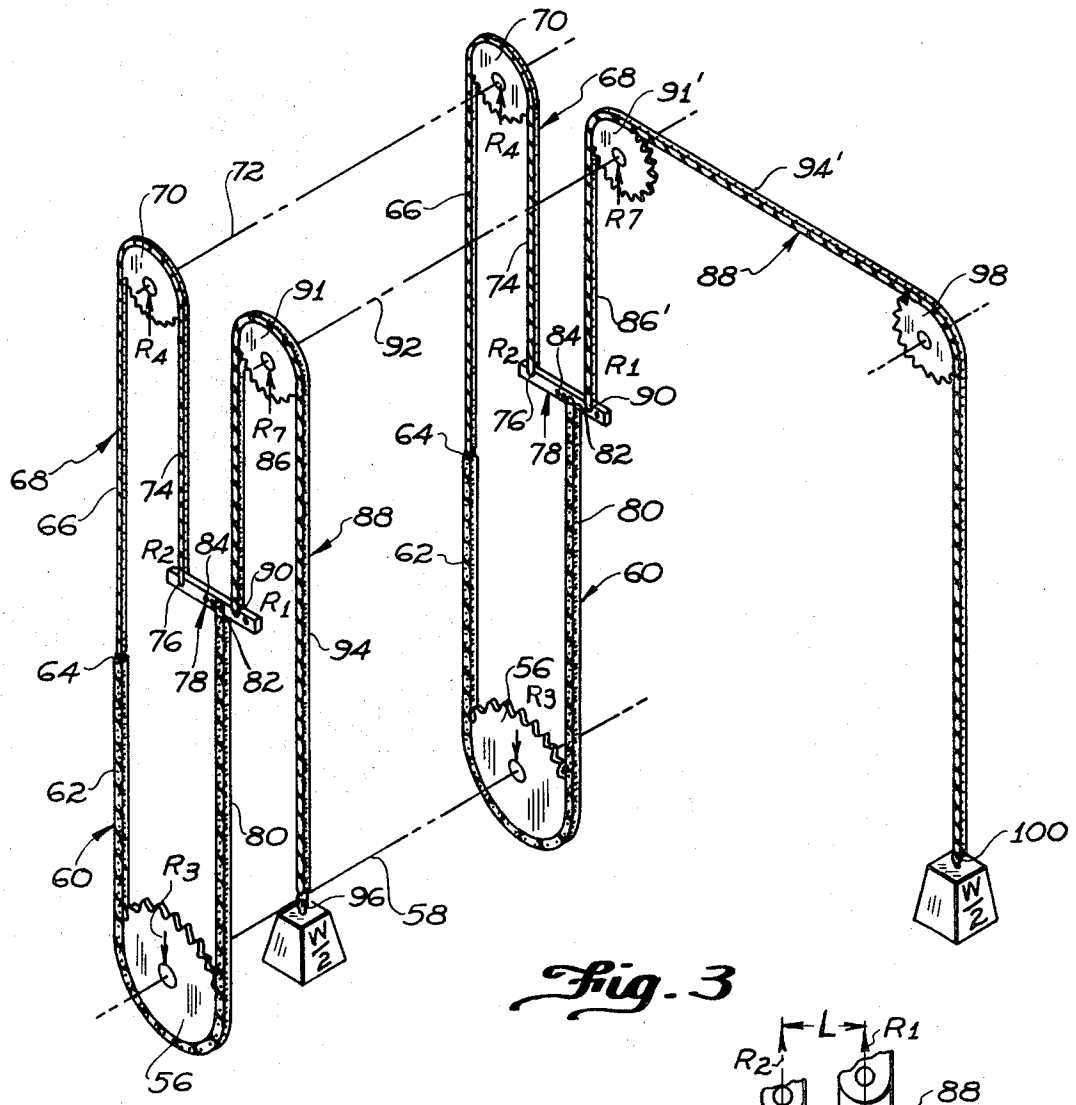


Fig. 3

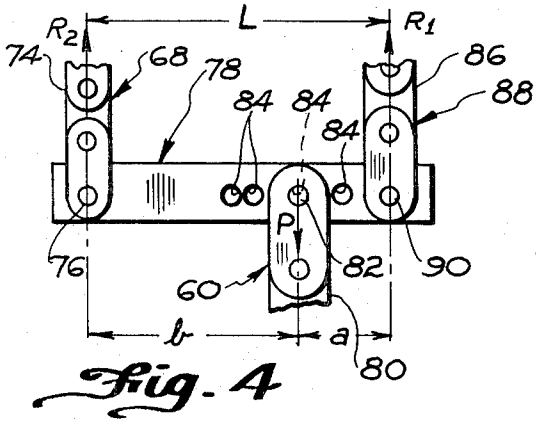


Fig. 4

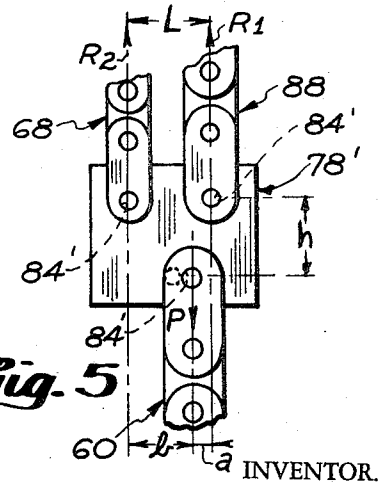


Fig. 5

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HOISTING MECHANISM FOR AUTOMATIC WAREHOUSING SYSTEM

This invention relates in general to automatic warehousing systems and more particularly to a novel means for actuating the vertically movable elevator portion of the system, and for maintaining the flexible support lines coupling the elevator to the hoist motor, in taut condition throughout the range of movement of the elevator on the load carrier mechanism.

BACKGROUND OF THE INVENTION

In many automatic warehousing systems of the type embodying a mechanized floor mounted load carrier, the lift motor for the elevator is mounted on the top of the load carrier mechanism, with the motor being connected to the elevator by chains or other flexible support members coacting with the motor and with the elevator, to move the elevator vertically on the load carrier. As the heights of automatic storage systems increase and as the loads which the systems are adapted to handle become larger and heavier, the inertia loads resulting from starting and stopping heavy masses at the top of the vertically elongated horizontally movable load carrier mechanism, create problems. It is therefore desirable to move the motor means and associated speed reduction mechanism which operates the elevator, from the top of the load carrier down closer to the bottom thereof, so as to decrease these inertia loads. Mounting the power means near the lower portion of the vertically elongated load carrier also enables more convenient access to the hoisting mechanism and facilitates the solution to maintenance problems associated therewith. The present arrangement also eliminates any slack in the lift system and prevents "-sprocket jump."

SUMMARY OF THE INVENTION

The present invention provides an automatic warehousing system wherein the hoist motor and associated speed reduction mechanism for the vertically movable elevator of the vertically elongated load carrier mechanism, is mounted adjacent the lower portion of the load carrier, for convenient access and for decreasing inertia loads on the floor mounted load carrier mechanism. Flexible support means such as for instance strands of roller chain coact with the motor and are reeved about rotatable idler members mounted on the upper portions of the load carrier mechanism and then extend downwardly to be anchored to the elevator portion, for causing vertical movement of the elevator portion upon actuation of the hoist motor. An automatic tensioning arrangement is provided coacting with the flexible support means for insuring that no slack exists in the flexible support means irrespective of the position of the elevator with respect to the vertically elongated conveyor portion of the load carrier, and thus facilitates good engagement of the flexible support means such as for instance roller chain, with the teeth of the hoisting sprocket of the speed reduction mechanism.

Accordingly, an object of the invention is to provide an automatic warehousing system which includes a novel hoisting arrangement for the vertically movable elevator portion of the system.

A further object of the invention is to provide an automatic warehousing system wherein the hoist motor for actuating the vertically movable elevator portion of the system is located adjacent the lower end of the load carrier mechanism, for decreasing inertia loads on the load carrier and improving the accessibility of the hoisting mechanism for servicing procedures.

A still further object of the invention is to provide a system of the latter type which includes flexible chain coacting with the hoist motor and being reeved about rotatable idler members supported on the upper extremities of the load carrier mechanism and extending downwardly to be anchored to the elevator portion and wherein the flexible lift support elements have automatic tensioning means coacting therewith for maintaining tautness in the flexible lift support members irrespective of the vertical position of the elevator portion on the load carrier mechanism.

A still further object of the invention is to provide a system of the latter described type wherein the automatic chain tensioning mechanism comprises a beam-like arrangement wherein a primary chain reeved about the lift sprocket coacts with the beam and other chains identified as take up chain and lift chain coact with the beam, to apply the force of the lift motor to the elevator portion of the system while maintaining the chain system taut.

Other objects and advantages of the invention will be apparent from the following description taken in conjunction with the accompanying drawings wherein:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevational view of an automatic warehousing system embodying the invention;

FIG. 2 is an end elevational view of the system of FIG. 1;

FIG. 3 is a diagrammatic illustration of the stringing of the hoist mechanism for actuating the elevator portion of the load carrier and including the automatic tensioning mechanism associated therewith;

FIG. 4 is an enlarged fragmentary illustration of one form of the tensioning beam mechanism for the hoist; and

FIG. 5 is a fragmentary illustration of another embodiment of tensioning beam mechanism for use with the hoist.

DISCLOSURE OF PREFERRED EMBODIMENTS

Referring now to the drawings, the warehousing system may comprise a plurality of generally parallel extending laterally spaced storage bay sections (e.g. 12, 12*a*) defining between each pair thereof an aisle or travel zone 14, so as to permit a motorized load carrier indicated generally at 16, to move along the aisle or travel zone and to insert loads into and withdraw loads from the load support means or storage bins 18 formed by the storage bays.

Disposed at one end, of preferably each of the storage bay sections there may be provided at least one pickup and discharge stand 20 which is adapted to receive a load to be handled by the load carrier prior to moving the load into the travel zone by the load carrier, and also adapted for receiving a load from the load carrier after such load has been removed from a selected storage bin by the load carrier and returned thereby to the pickup and discharge stand.

The load carrier **16** may comprise a horizontally movable conveyor portion **22** including generally upright mast structure formed in the embodiment illustrated by a pair of generally vertically extending track members **23**. Each vertical track may be reinforced and rigidified by respective truss structure **24** attached thereto and at their ends to respectively lower carriage **26** and upper end portion **26***a* of the conveyor portion **22**.

The lower carriage **26** may comprise a generally centrally recessed (in side elevation) low slung frame (FIG. **1**) supported on flanged wheels **28** which in turn ride on a guiding rail member **30** extending lengthwise of the travel zone, and mounted in the embodiment illustrated on the floor of the storage area. The lower carriage may be driven by means of a preferably reversible electric motor **32** mounted on the lower carriage and operably coupled, as by means of gear reduction mechanism **32***a*, to at least one of the wheels **28** of the lower carriage, for driving the load carrier along the supporting rail **30**.

Upper end portion **26***a* of the load carrier may include a generally rectangular frame supporting spaced rollers **34** mounted thereon which rollers are adapted to coact in rolling engagement with an upper rail **36** running lengthwise of the aisle or travel zone of the system. Rail **36** may be supported on the storage structure by any suitable means such as for instance, by cross elements **38** which join together opposing storage sections of the storage racks. The rollers **34** guide the upper end of the load carrier in its longitudinal movement lengthwise of the respective aisle or travel zone.

The aforementioned elevator portion **40** of the load carrier may comprise side portions **42** having vertically spaced sets of flanged rollers **42***a* rotatably mounted thereon adapted for rolling coaction with the respective of the aforementioned tracks **23** of the mast structure, for guiding the vertical movement of the elevator with respect to the conveyor portion of the load carrier.

Mounted generally centrally on the elevator may be an extractor portion **44** which is adapted to move laterally of the elevator with a load L supported thereon for depositing the load in a selected storage bin of the associated storage section, or to move laterally of the elevator and pickup a load that is already stored in the associated storage section, and move it back to the desired pickup and discharge station. The extractor **44** preferably provides an extensible table with the table being extensible in either of the opposed directions transverse to the longitudinal direction of movement of the load carrier in the travel zone, so as to locate the extractor within either of the storage sections **12** or **12***a* associated with each travel zone, effective to place the table in position to deposit a load into or remove a load from the selected storage bin in the selected storage section. Suitable power means, such as for instance a reversible electric motor **46** may be provided, operatively coupled to the extractor, for actuating the latter.

The programmed operation of the load handling cycle for the load carrier may be controlled by an electrical control circuit as disclosed, as for instance, in U.S. Pat. No. 3,402,835 of Sanford Saul, issued Sept. 24, 1968 and entitled CONTROL SYSTEM FOR A ZONED AUTOMATIC WAREHOUSE ARRANGEMENT. For example, with the load carrier disposed at a pickup and discharge station in the system adjacent a pickup and discharge stand **20**, the load carrier may be automatically moved into a selected aisle or travel zone and located sequentially opposite two storage bins in either of the storage sections or in the same section. At each storage bin during the control interval, the extractor may be actuated so that a load may be deposited into or withdrawn from the confronting bin. For example, a load may be deposited into the selected bin at the first position and a second load withdrawn from a second bin in the second position, and then conveyed back to the aforementioned pickup and discharge stand; or the handling cycle may conclude after the load handling at the first position in the system. The load carrier may be programmed from a control panel (e.g. **50**) mounted on the load carrier, or it may be programmed from a location remote from the load carrier.

Now in accordance with the present invention, a power unit, such as for instance, a reversible electric motor **52** (FIG. **1**) may be mounted on or adjacent the lower carriage **26** of the conveyor portion of the load carrier and coupled by suitable speed reduction mechanism **54** to laterally disposed sprockets **56** (FIGS. **1** and **3**) secured to a common shaft **58** of the geared speed reduction mechanism **54**.

Each sprocket **56** coacts with a respective primary chain section **60** which is looped about the underside of the respective sprocket **56** for substantially a full 180° thereof, with the left hand run **62** (with reference to FIGS. **1** and **3**) of the primary chain being secured, as at **64** to the left hand run **66** of the takeup chain **68** which is reeved about a respective upper sprocket **70** secured to common shaft **72** rotatably mounted by suitable bearing structure on the upper section **26**a of the conveyor portion of the load carrier. The right hand stretch or run **74** of the respective takeup chain **68** extends downwardly to be secured as at **76** to the automatic tension link or bar **78** (FIGS. **1, 3** and **4**) to which the right hand run or stretch **80** of the primary chain **60** is likewise secured, as at **82**. Automatic tension link **78** in the embodiment illustrated in FIGS. **1 – 4** comprises a generally horizontally elongated bar-like member which has openings **84** formed therein for readily attaching respective of the chain ends thereto.

The left hand run or stretch **86** of the respective lift chain **88** is likewise secured, as at **90**, to an associated end of bar **78** and then loops or passes about the upper portion of sprocket **91** secured to common shaft **92** which is rotatably mounted by suitable bearing means on the upper section of the conveyor portion of the load carrier, and then the right hand (with reference to FIG. **1**) stretch or run **94** of the lift chain extends downwardly to be anchored as at **96** to a corner of the elevator **40** and as best shown in FIG. **1**. As can be best seen in FIG. **3**, the other side of the hoist mechanism is generally similar to the aforedescribed side except that the right hand lift chain run **94'** passes over upper sprocket **91'** and then passes generally horizontally to a further sprocket **98** rotatably mounted on upper conveyor section **26***a*, and then passes downwardly to the underlying corner of the elevator portion of the load carrier to be anchored thereto as at **100**. It will be seen that upon actuation of the motor unit **52**, the elevator is moved vertically in a direction depending upon the direction of actuation of the motor.

Referring now to FIG. 4, which illustrates a colinear arrangement of automatic tension link, it is desirable to make the dimension L of the link as short as possible to facilitate its disposal on or in connection with the load carrier of the warehousing system. The smallest practical dimension for "*a*" depends upon the chain size being used. (i.e. "*a*" minimum equals the chain link plate height plus clearance). One-eight inch may be taken as a practical clearance. The ratio of the dimension "*b*" to dimension "*a*" determines the force division of "*P*" into R2 and R1.

For purposes of analysis to determine where the connection **82** of the primary chain **60** should be optimumly accomplished with respect to the link **78** so as to set up a ratio between the dimensions "*b*" and "*a*," it will be seen that the reaction value "**R2**" is dependent upon the weight of the takeup chain which in turn is dependent upon the height of the load carrier, plus the additional reaction force of the chain's dead weight due to the maximum expected acceleration of the chain. It therefore follows that the dimension "*b*" could vary depending upon the height of the retriever. In other words, the higher the retriever, the shorter "*b*" may become.

The following is a resume of typical hoist capacities and associted chain sizes based upon American Standard Roller Chain Size with maximum recommended chain loads.

Maximum Design Capacity W In Pounds	Chain Size	Maximum Allowable Chain Load In Pounds
2,000	80	2,017
4,000	100	3,429
8,000	140	6,571
12,000	160	8,285

The maximum allowable chain load is defined as a value that is approximately one-seventh of the ultimate tensile chain rating and applicable for chain speeds below 50 feet per minute.

The minimum value for R2, or in other words the value at which chain slack may appear in the takeup chain, assuming an approximate 60 foot tall load carrier, may be determined as follows:

Assuming the maximum acceleration of the vertical carriage **40** is 2.5 feet per second per second, the minimum required value of R2 will be equal to the takeup chain's dead weight plus the force required to accelerate the chain weight at 2.5 feet per second.

The following table shows the minimum required values for R2 for each of the aforementioned roller chain sizes, it being understood that a particular chain size is used in a particular design load capacity of load carrier.

Roller Chain Size No.	Chain Dead Weight (60 ft) In Pounds	Acceleration force in pounds	Minimum R2 In Pounds
80	103	8	111
100	154.8	12	167
140	303	24	327
160	396.7	31	428

"*a*" As A Percentage Of "L"-Minimum Recommended

The minimum expected load on the lift chain **88** must be used when establishing the minimum value for "*a;*" otherwise when the vertical carriage is unloaded, the chain dead weight (in the takeup region) could cause the automatic tensioning link **78** to slip clockwise when the vertical carriage approaches its lower elevations and the greatest dead weight of the takeup chain **68** is tending to pull up at R2.

The minimum expected hoist load represents the minimum vertical carriage dead weight anticipated. This value together with the value "R1" determines the automatic tension link ratios.

The following table establishes a minimum percentage of dimension "L" for the dimension "*a*" for various conventionally used chain sizes.

"*a*" as a Percentage of "L" — Minimum Recommended

Chain Size	No. 80	No. 100	No. 140	No. 160
Chain Link Plate Height (in.)	0.934	1.166	1.634	1.866
Max. Hoist Cap. W (lb.)	2000	4000	8000	12000
Min. Expected Hoist Load (lb.)	667	1334	2667	4000
a (in.)	1.059	1.291	1.759	1.991
R_1 (lb.)	334	667	1334	2000
R_2 (lb.)	111	167	327	428
P (lb.)	445	834	1661	2428
b (in.)	3.19	5.16	7.18	9.30
L (in.)	4.25	6.45	8.93	11.29
a (% of L)	24.9	20	19.7	17.6

"a" As A Percentage of "L" - Maximum Recommended

As "*a*" becomes larger, "R2" increases. As "R2" increases, force "P" increases. While P and R2 are increasing, the torque output at sprocket **56** remains constant. As P and R2 increase, R3 and R4 increase. R3 is the chain pull load on the lift reducer shaft **58**, while R4 is the load on the takeup chain idler shaft **72** and associated bearing.

The high limit of the "*a*" dimension is a function of the prime chain's **60** maximum allowable tensile load; the takeup chain's maximum allowable tensile load; the reducer's rated chain pull at R3; and the shaft and bearing capacity at R4. Chain capacity is the limiting criteria, so that "*a*" maximum is approximately 50 percent of L. As can be seen from the above compilation, the extent of link **78** may run from approximately four inches or slightly thereabove to approximately 12 inches, although this is not necessarily critical and is a matter of preference.

Referring now to FIG. **5**, there is illustrated a link **78'** which, instead of having the openings **84'** arranged linearly, the openings for connection of the primary chain **60** and the takeup chains and lift chain **68** and **88** respectively are disposed in a triangular-like arrangement. This enables a reduction in the dimension L. The smallest practical dimension for "*h*" depends upon the chain size being used. In other words, the "*h*" minimum would equal the chain link plate height plus clearance, with a conventional clearance being approximately ⅛ inch. This type of automatic tension link tends to make the load carrier taller due to the "*h*" dimension requirement of the link. However, as can be readily seen, it is extremely compact in the dimension L and with respect to the load carrier horizontal dimension or length.

The arrangement of warehousing system with the automatic tension linkage mechanism incorporated therewith, provides a lift mechanism for the elevator of

the warehousing system wherein no slack can develop in any part of the chain system, thus eliminating the need for periodic takeup of the idler sprockets. Moreover, there are no pretension adjustments to be made when setting up the load carrier and the wrap around of the primary chain is for a full 180° of the reducer sprocket, with taut chain engagement at all times. As the load on the elevator increases, the tautness of the chain increases, thus preventing any sprocket "jump." This lift system of automatic tension link is a substitute for a cable and drum lift and provides positive sprocket tooth engagement and eliminates the conventional bulk and machining necessary with a reeving drum. In prior art arrangements, there have usually been lift shafts installed at the upper end of the conveyor portion of the load carrier for operating the elevator lift. Since no lift shafts are required in this arrangement at the top of the load carrier, less overhead space is used for the hoisting mechanism. The chain stretch **94'** on the right hand chain system (FIG. **3**), since it is disposed laterally of the upper guide rail, can be above the bottom surface of the upper guide rail of the warehousing system.

From the foregoing discussion and accompanying drawings it will be seen that the invention provides a novel lift arrangement for the elevator of the load carrier of a warehousing system, and wherein the lift motor is mounted adjacent the lower end of the horizontally movable portion of the load carrier, and is coupled to the elevator by flexible support means, such as roller chain, coacting with the lift motor and reeved about rotatable idler members mounted adjacent the upper end of the load carrier, and then the flexible support means extends downwardly to be anchored to the elevator portion. An automatic tensioning link system is provided coacting with the flexible support means for maintaining the flexible support means taut irrespective of the position of the elevator portion with respect to the vertically elongated horizontally movable conveyor portion. The arrangement is such that the flexible support means includes an endless loop like section completed by said tensioning link and an open ended section coacting between said endless section at said link and the elevator portion of the load carrier. The connection of the primary drive chain to the automatic tensioning link extends within a range of from approximately a minimum of 17 percent to a maximum of approximately 50 percent of the dimension between the connections of the takeup chain and the lift chain to the automatic tensioning link.

The terms and expressions which have been used are used as terms of description, and not of limitation, and there is no intention in the use of such terms and expressions of excluding any equivalents of any of the features shown, or described, or portions thereof, and it is recognized that various modifications are possible within the scope of the invention claimed.

What is claimed is:

1. In an automatic warehousing system comprising, a plurality of horizontally and vertically disposed load mounting means having open load receiving ends defining a generally vertical plane and there being an elongated travel zone alongside said plane, and a load carrier movable in said travel zone for delivering loads to and retrieving loads from said load mounting means, said load carrier comprising a generally horizontally movable conveyor portion, an elevator portion mounted for vertical movement on said conveyor portion, and an extensible extractor portion mounted for lateral movement on said elevator portion, power means for moving said elevator portion vertically with respect to said conveyor portion, said power means comprising a motor mounted on the lower section of said conveyor portion, flexible support means movably mounted on said conveyor portion and attached to said elevator portion, said flexible support means coacting with said motor whereby energization of said motor causes movement of said flexible support means to cause generally vertical movement of said elevator portion relative to said conveyor portion, and tensioning link means coacting with said flexible support means providing for maintaining a predetermined range of tension in the flexible support means throughout the range of vertical movement of said elevator portion with respect to said conveyor portion, said link means being supported by said flexible support means and being adapted to travel therewith upon said movement of said flexible support means.

2. A system in accordance with claim **1** wherein said flexible support means includes a substantially endless loop-like section coacting with said link means and said motor, and an open ended section coacting between said link means and said elevator potion.

3. A system in accordance with claim **2** including idler means on said conveyor portion coacting with said flexible support means facilitating movement of said flexible support means with respect to said conveyor portion during vertical movement of said elevator portion relative to said conveyor portion.

4. A system in accordance with claim **2** wherein said tensioning link means comprises a rigid bar and said endless section comprises a stretch of said flexible support means extending downwardly from said bar and being connected thereto intermediate its ends, and said endless section and said open section comprise runs of said flexible support means extending upwardly from said bar on opposite sides of the connection of the first mentioned stretch of flexible support means to said bar.

5. A system in accordance with claim **4** wherein the connection of said first mentioned stretch to said bar is disposed within a range of approximately 17 to 50 percent of the distance between the connections of said upwardly extending runs to said bar commencing at the connection of said run of said open section to said bar.

6. A system in accordance with claim **2** wherein said tensioning link means comprises a bar, said endless section including a stretch of flexible roller chain connected to said bar intermediate the ends thereof, and said endless section and said open section comprising other flexible stretches of roller chain connected to said bar on opposite sides of the connection of the first mentioned stretch to said bar, with the distance of the connection of the first mentioned stretch to the bar being no greater than approximately 50 percent of the distance between the connections of said other stretches to said bar commencing at the connection of said stretch of said open section of roller chain to said bar.

7. A system in accordance with claim **4** wherein said bar is of inverted triangular-shaped configuration with

the connection of said first mentioned stretch to said bar being offset downwardly from the connections of said runs to said bar.

8. A system in accordance with claim 4 wherein said connections of said first mentioned stretch and said runs to said bar are disposed generally linearly along said bar substantially in a horizontal plane.

9. A system in accordance with claim 7 including means for changing the location of said connections to said bar.

10. A system in accordance with claim 8 including means on said bar for changing the distance ratio between the locations of said connections to said bar.

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