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Manaugh

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[54] **VERTICAL TRANSPORTATION AND ELEVATOR SYSTEM**

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[52] **U.S. Cl.** ..... **187/25;** 187/1 R

[51] **Int. Cl.** **B66b 11/04**

[58] **Field of Search** 187/25, 24, 17, 1; 151/57, 151/67

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[57] **ABSTRACT**

An elevator and vertical transportation system is provided in which a vertical screw member is used in conjunction with an essentially friction-free nut, as the vertical driving means for an elevator cab, the screw member being mounted so as always to be in tension during such use, rather than in compression and subject to compressive bending. The essentially friction-free nut is driven, for example, by means of an electric motor mounted on the cab so that the nut and the elevator cab may be moved up and down with respect to the suspended vertical screw. It is apparent, however, that the vertical screw, rather than the nut may be rotatably driven so as to achieve the desired vertical movement of the elevator cab.

7 Claims, 7 Drawing Figures

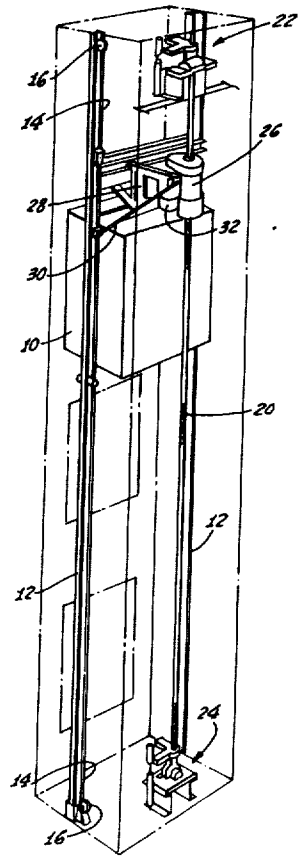


Fig. 1

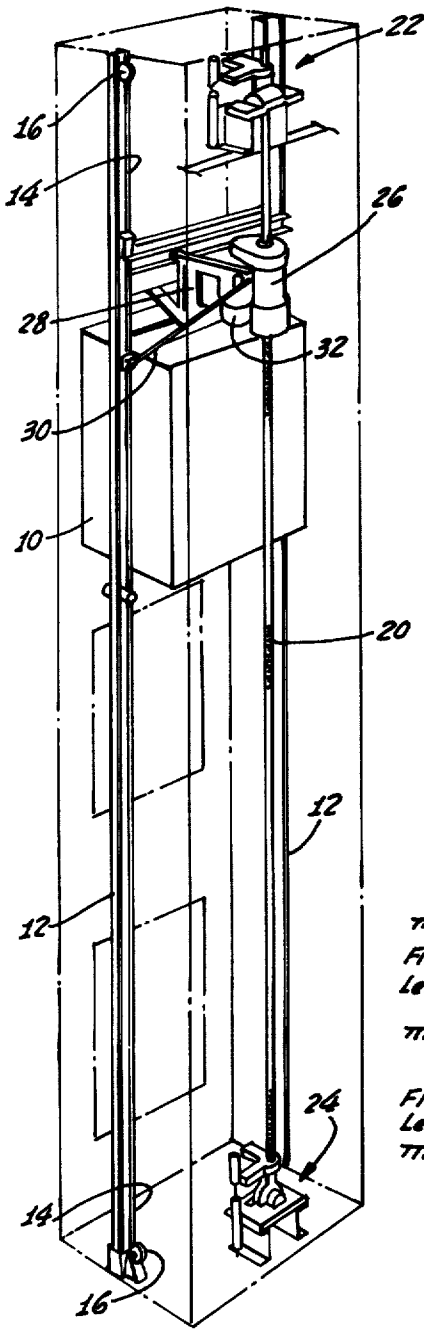


Fig. 2

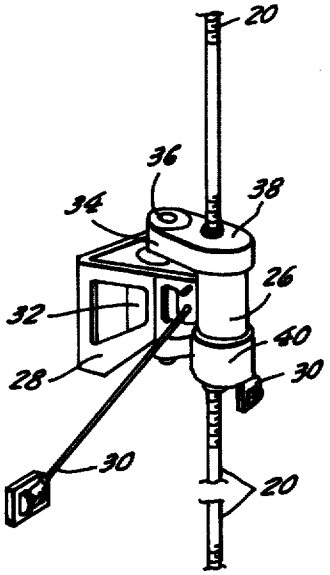
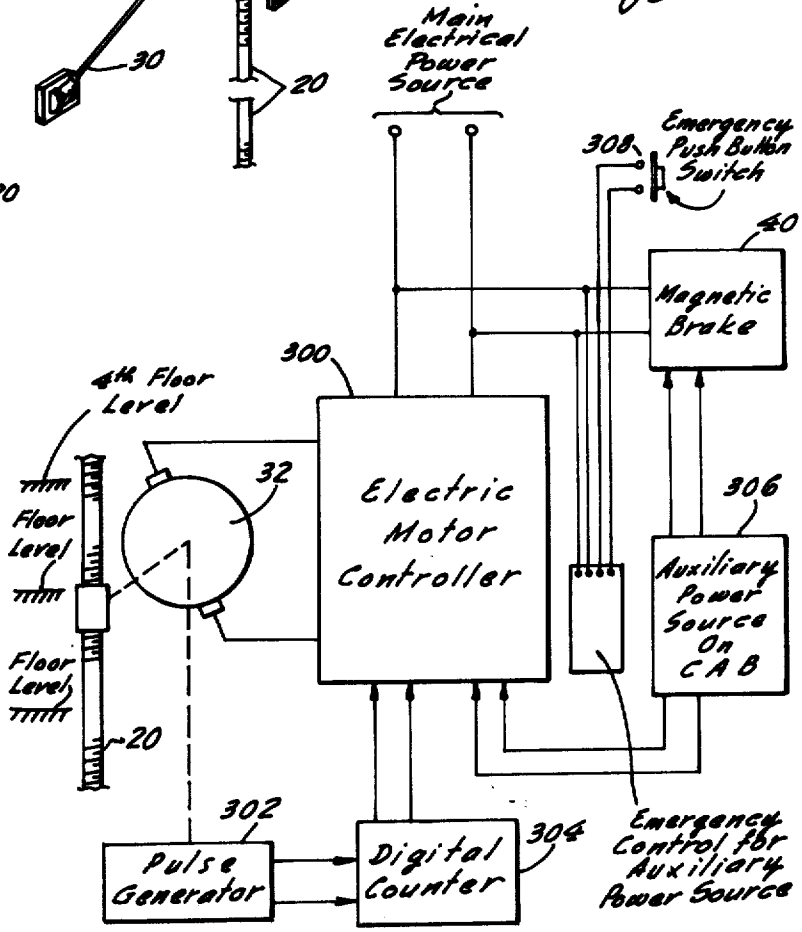


Fig. 5



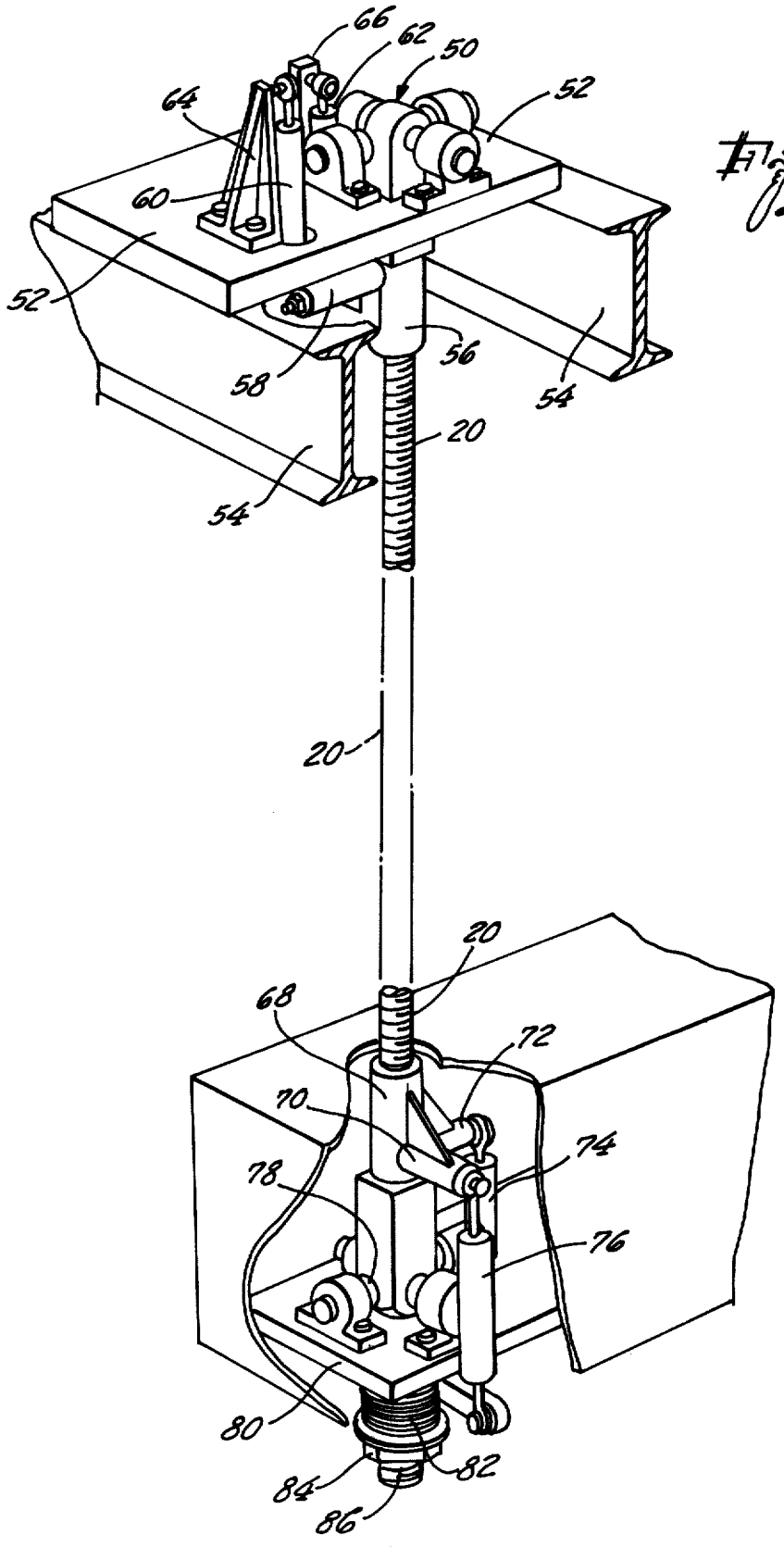


Fig. 2a

Fig. 3

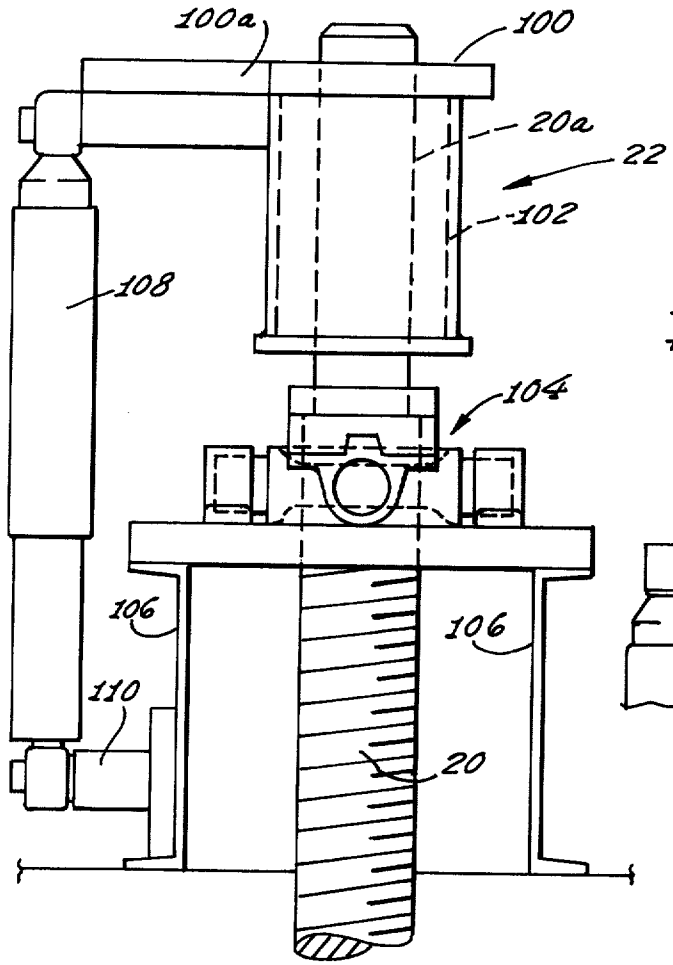


Fig. 4

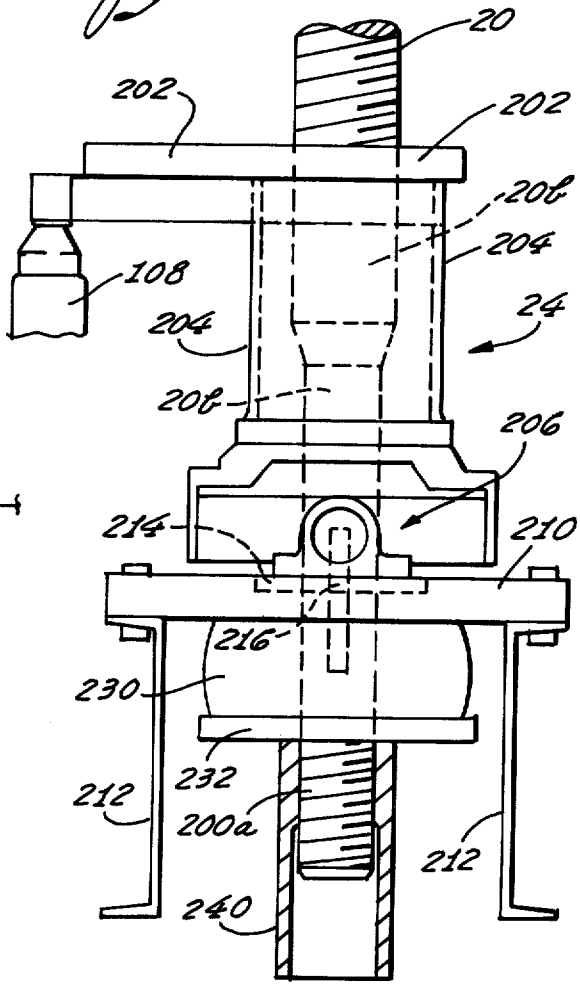
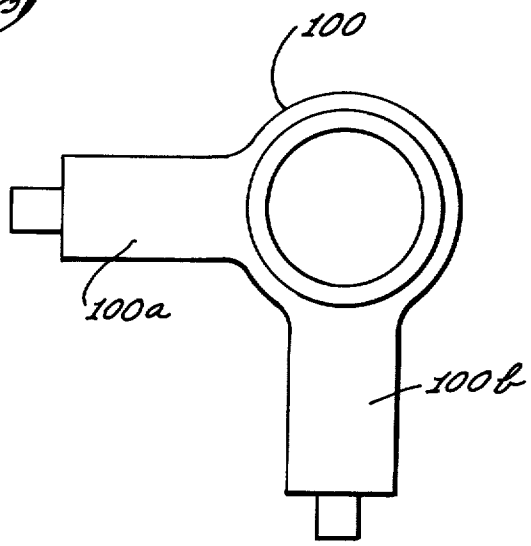


Fig. 4a



VERTICAL TRANSPORTATION AND ELEVATOR SYSTEM

BACKGROUND OF THE INVENTION

More than 75 percent of all types of elevators sold in recent years have been of the oil hydraulic type. This is because of the lower cost economic advantage of this type of elevator over the more expensive electric wire rope traction type, when used in buildings of moderate height, such as office and apartment buildings.

Although the prior art hydraulic oil type of elevator is less expensive than the prior art wire rope traction type, many problems have been encountered with the oil hydraulic elevator. Of these, underground corrosion and galvanic action are the most troublesome. In the prior art oil hydraulic elevator, a hoisting ram is provided which must extend below the ground a distance corresponding to the maximum height of the elevator. The ram is contained within a casing, and oil is pumped down into the casing to create the desired hydraulic pressure so as to raise the ram and the elevator cab which is mounted on the ram. Corrosion of the casing, and scoring and pitting of the ram, result in high maintenance costs, and replacement of either or both is often required in this type of elevator after a relatively short operational lifetime.

The oil hydraulic type of elevator is also subject to compressive bending of the hoisting ram, to other structural disadvantages. Moreover, this type of elevator has limited speed capabilities due to the large volume of oil which must be pumped. For the latter reason, the oil hydaulic elevators are seldom used in modern office buildings where speed is an essential requirement. In addition, there is a distinct height limitation for the hydraulic ram elevator due to the aforesaid compressive bending limitations which are manifested in limitations in the length/diameter slenderness ratio of the ram. If the ram is too long, it will buckle and fail. In addition to all the problems outlined above, the oil hydraulic elevator has a tendency towards oil leakage and resulting fire hazard in the surrounding environment.

The elevator and vertical transportation system of the present invention is intended to offer all the advantages of the oil hydraulic elevator over the prior art rope traction elevator insofar as lower installation costs are concerned. Also, the improved elevator of the present invention has low maintenance costs as compared with both the hydraulic type and the prior art traction type of elevator. The elevator of the present invention is capable of moderately high speed operation, and it may be used efficiently in applications in which the prior art elevators are used.

The elevator system of the present invention, as mentioned above, is a screw-nut type, in which an essentially friction-free nut assembly is attached to an elevator cab, and engages a vertical screw member in threaded relationship. Then, either the nut or the screw is rotatably driven by means, for example, of an electric motor. The electric motor may be mounted on the cab, and it may be coupled to the nut assembly by a belt drive, as in the embodiment of the invention to be described. With such an assembly, when the motor is energized for rotation of its drive shaft in one direction or the other, the resulting rotational movement of the nut assembly drives the cab up or down. Geared coupling of the motor to the nut may also be employed. Direct driving of the nut from the motor also may be employed by coupling the nut to a hollow shaft in the motor.

The system to be described also employs a unit brake of a power applied plus fail safe type. When the vertical programming of the height and floor relationship indicates that the floor level has been reached, the power to the motor is cut off and the holding brake automatically sets and holds the established vertical position. This position may be established with a high degree of precision due to the nature of the relationship between the vertical screw and the nut assembly. In the prior art wire cable traction type of elevator, on the other hand, this vertical position is indeterminate due to the inherent stretch of the hoisting wire rope. In the prior art hydraulic elevators, on the other hand, oil leakage through valve and glands cause the final position holding, likewise, to be indeterminate. In the screw elevator of the present invention, the stretch of the screw is measured only in thousandths of inches throughout maximum operational screw length, so that the elevator of the invention may be precisely and accurately controlled to stop exactly at predetermined floor levels. The system transfers the loads of lifting in the screws back into the guide rails of the elevator and hence into the building hatchway structure.

The cab itself in the elevator system of the present invention may be mounted in a usual type of frame presently employed in existing elevator shafts, for example, and the system of the invention also may incorporate all existing safety features, such as overspeed governor safety brakes which operate in conjunction with T-rails in such frames. This means that the existing type of elevator system may be easily and economically converted to the elevator system of the present invention with full compliance of existing safety codes. it will become evident as the description proceeds, however, that the system of the invention has sufficient built-in safety features as to render unnecessary the additional prior art safety mechanisms, such as those mentioned above.

The nut and screw elevator system of the present invention is of the order of 90 percent efficient, as compared with the 20 percent efficiency of most of the prior art systems. The elevator system of the invention, moreover, is capable of rising to heights in excess of 120 feet with complete stability. The speed of the elevator system of the present invention may be of the order of 300 feet per minute, as compared with approximately 100 feet per minute of the prior art hydraulic elevator. The aforesaid features of the nut and screw elevator system of the invention are achieved by suspending the vertical screw in tension, rather than by mounting it in compression. That is, the vertical screw is actually hung from the top of the building hatchway structure, or on an independent structure which carries the load back into the building foundations, and in a manner to be described so that the weight of the cab exerts a tension, rather than a bending compressive force on the screw.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic elevational perspective representation of an elevator and vertical transportation system constructed in accordance with the concepts of the present invention;

FIG. 2 is a fragmentary representation of certain of the operating components of FIG. 1;

FIG. 2A is a perspective representation of the vertical screw member and of universal coupling means for supporting the screw member in tension in the elevator supporting frame structure;

FIG. 3 is a more detailed representation of a slightly different universal coupling assembly which is used to couple the upper end of the vertical screw member of the elevator system of the present invention to the top of the supporting frame structure;

FIG. 4 is a detailed representation of a slightly different universal coupling assembly which is used to couple the lower end of the aforesaid screw to the supporting structure;

FIG. 4A is a plan view of a support bracket used in both the upper and lower coupling assemblies of FIGS. 3 and 4; and

FIG. 5 is a block diagram showing certain electrical controls which may be incorporated into the system.

DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENT

As illustrated, for example, in FIGS. 1 and 2, the elevator system of the present invention includes an elevator cab 10. The cab 10 may, for example, be mounted in a usual type of prior art elevator frame which, for example, includes a pair of vertical T-rails 12. The T-rails are positioned on opposite sides of the elevator frame, and they serve as guides for the elevator cab. A usual counterweight system (not shown) may also be provided. Also, in accordance with existing safety codes, for example, a usual otherwise safety braking mechanism, including wire rope 14 and since 16, may be provided which prevent the cab from falling freely in the elevator shaft.

In the practice of the present invention, the driving mechanism for the elevator cab 10 comprises an elongated vertical screw member 20 which is suspended from the top of the framework by means, for example, of a universal coupling assembly 22 which will be described in some detail in conjunction with FIG. 3. The screw member is also mounted to the lower end of the elevator shaft by means of a further universal coupling assembly 24 which will be described in conjunction with FIG. 4.

As will be described, the vertical screw 20 is mounted within the elevator shaft in a manner such that it is fully under tension at all times during the operation of the elevator system, so as to be immune from compressive loads which would otherwide tend to limit the length of the screw, sicne such compressive loads would tend to cause the screw to buckle and fail.

In the illustrated embodiment, a nut assembly 26 is theadably engaged with the screw 20, and is supported on the cab structure by means, for example, of an appropriate bracket 28 and struts 30. An electric motor 32 (FIG. 2) is mounted within the bracket 28, and the motor is coupled to the rotating nut portion of the nut assembly 26 through a belt 34. The belt 34 may, for example, be of the type known as the "Poly-V" belt. As mentioned above, other types of couplings, such as gear or direct coupling, may be used between the drive motor and the nut assembly. The belt 34 in the illustrated embodiment is coupled between a drive pulley 36 on the drive shaft of the drive motor 32 and a pulley 38. The pulley 38 is coupled to an internal nut element within the nut assembly 26. The nut assembly 26 may be of the type described, for example, in U.S. Pat. No. 3,296,880. A magnetic brake 40 may also be mounted on the nut assembly 26, and the magnetic brake may be power or spring actuated so as to clamp the nut against rotation on the vertical screw 20 whenever power is removed, for example, from the motor 32.

In the embodiment of FIG. 2A, the screw 20 is supported at its upper end by a universal coupling 50 which is mounted on a platform 52, the platform being supported by beams 54 at the top of the building hatchway frame structure. The screw 20 has a upper terminal end bracket 56 which is equipped with at least two radial arms, such as the arm 58, disposed at 90° to one another. A pair of dampeners, 60, 62, are coupled between the radial arms and brackets 64, 66 on the platform 52.

The screw 20 has a lower terminal end bracket 68 which, like the upper end bracket 56, is also equipped with two radial arms 70, 72 disposed at 90° to one another. Further dampeners 74, 76 are coupled between the ends of the arms 70, 72 and brackets at the lower end of the support frame.

The lower terminal end bracket is supported in a universal coupling 78 which is mounted on a platform 80. The screw is tensioned through a loading member, such as a coil spring 82 by means of a nut 84. The nut is threaded on a threaded shaft 86 and holds the screw 20 in tension.

As shown in the slightly different embodiment of FIG. 3, for example, the screw 20 is equipped with an upper terminal end designated 20*a*, which is threaded into the upper end of screw 20 and extends up in coaxially aligned relationship with the screw. The upper terminal end 20*a* is threaded into, or otherwise attached to an upper plate 100 which, in turn, is supported on a tubular member 102, the upper plate 100 being welded or otherwise affixed to the tubular member. The tubular member 102, in turn, is supported on a universal coupling 104 which, in turn, is supported on a pair of upper support brackets 106, the support brackets being secured to the hatchway structure.

The universal couplings referred to herein, may be any appropriate type of universal coupling, such as ball and socket, flexural joints, and the like.

The upper support bracket 100 includes a pair of radial arms, such as the arm illustrated as 100*a*, and a second arm extending 100*b*, for example, at 90° to the arm 100*a*, as shown in FIG. 4A. A dampener 108 of any appropriate type is coupled, for example, between the end of the arm 100*a* and a bracket 110 mounted adjacent the support bracket 106, and welded or otherwise affixed thereto. A similar dampener, not shown, is also coupled between the aforesaid arm of the upper plate 100 to be angularly disposed at 90° to the illustrated dampener 108.

A lower terminal end 20*b* (FIG. 4) is provided for the screw 20, and the lower terminal end is threaded into the lower end of the screw 20 in aligned coaxial relationship therewith. The lower terminal end 20*b* of the screw 20 extends through a bracket 202 which is similar to the bracket 100 of FIGS. 3 and 4A, and which supports a pair of dampeners, such as the dampener 108, in the same relationship as described in conjunction with FIG. 3. The support plate or bracket 202 is welded or otherwise mounted over a tubular member 204 which, in turn, is coupled through a universal cou-

pling **206** to the lower plate **210**. The lower plate **210** is supported on a pair of support brackets **212** which, in turn, are supported on the foundation or frame of the elevator assembly.

The lower terminal end **20***b* extends through a collar **214** in the plate **210** and is keyed to the collar by means, for example, of a key **216** which is mounted in the terminal end member **20***b*. The key **216** prevents rotation of the end terminal member **20***b* of the screw **20** attached thereto, while permitting a measure of linear movement of the shaft during operation of the system. The collar **214** is tack welded, for example, to the plate **210** after the lower terminal end member has been torqued, as will be described, and after a desired orientation of the shaft has been achieved.

A tensioning member **230** is supported under the support plate **210**, and the member **230** may be formed of rubber, urethane, Belleville Spring, or the like. A metal plate **232** is mounted under the resilient member **230**. this metal plate, as is the case with the other metallic components of the assembly, may be composed of steel. The lower extremity **200***a* of the terminal end member **20***b* is threaded, and a tubular nut **240** is threaded onto the extremity, as shown, so as to force the steel plate **232** against the resilient member **230**, and thereby serve to hold the screw **20** and its upper terminal end **20***a* and lower terminal end **20***b* in tension, during all operating conditions of the assembly, as is desired.

When the assembly described above is mounted in place, the screw **20** is held securely in tension under all load conditions, and any angular displacements and vibratory energies of the shaft are quickly absorbed by the dampeners **108** which operate in conjunction with the corresponding universal joints **104** and **206**.

It will be appreciated that when power is applied to the motor **32**, the resulting rotation of the drive shaft of the motor causes the nut element assembly **26** to rotate in one direction or the other, causing the assembly to move up or down the screw **20**, and moving the cab **10** with it. The motor **32** may be energized by means of a controller represented by the block **300** in FIG. **5**. The controller may include the usual controls which cause the motor to be energized, either for upward movement or downward movement of the cab, and to cause the motor to stop automatically at a selected floor. The latter automatic control may be achieved, for example, by magnetically coupling a pulse generator **302** to the motor, and for feeding the electric pulse output from the pulse generator **302** to a digital counter **304**.

Pulse generator-digital counter combinations are known to the art and are marketed, for example, by Disc Instruments, Inc. of Santa Ana, Calif. under the trademark "Rotoswitch" incremental shaft encoders. The pulse generator, as is well known, may generate phase displaced signals, so that the digital counter may be controlled to count up or down, depending upon whether the nut assembly **26** and the associated elevator cab **10** are moving up or down. The digital counter provides an output which indicates exactly the vertical position of the cab at any particular time. This output may be used, for example, in the control circuitry of the controller **300**, so that whenever a floor is selected by, for example, a push button selection in the elevator cab, or at the particular floor, the elevator will move up or down until that floor is reached, as indicated by the output from the digital counter. Then, the cab will stop at a precisely levelled position with respect to the particular floor.

As indicated in FIG. **5**, the magnetic brake **40** associated with the nut assembly **26**, and any other magnetic brakes which may be incorporated into the system as suggested above, are energized normally to an open position by power from the main electric source. Whenever the power fails, or when a switch is actuated to interrupt the power, the magnetic brakes close.

An auxiliary power source, such as represented by the block **306**, may be mounted within the cab **10**. This auxiliary power source may, for example, take the form of appropriate batteries, which are normally maintained in a charged condition by power from the main electric power source. However, when the power source fails, or when an emergency push button such as the push button **308** is depressed, the auxiliary power source takes over and is applied to the controller **300** and to the magnetic brake **40**. Upon the application of auxiliary power to the brake **40**, the brake **40** is opened and the elevator cab moves down to the next floor level, as indicated by the digital counter **304**. When the aforesaid floor is reached, the auxiliary power is automatically turned off by the controlled **300**, and the magnetic brake **400** clamps shut and stops the elevator at the floor level. The doors of the elevator cab are then opened to permit the passengers to leave the cab.

The invention provides, therefore, an improved elevator system which is predicated on a lead screw and roller nut combination, and which incorporates the concept of mounting the lead screw so that it is stressed in tension at all times during operation of the system, and thereby achieves the results of the present invention.

Specifically, the mounting of the lead screw in a tension mode permits elevator systems of substantial height to be designed and constructed in accordance with the principles of the invention, and provides all the advantages of high speed modern elevator systems, without expensive manitenance costs or other disadvantages encountered by the present day types of elevators.

While a particular embodiment of the invention has been shown and described, modifications may be made, and it is intended in the following claims to cover all such modifications which fall within the spirit and scope of the invention.

what is claimed is:

1. A vertical transportation and elevator system including: a vertical supporting frame having an upper end and a lower end; an elongated screw member; mounting means for suspending the elongated screw member in a vertical position on said supporting frame, said mounting means including an upper support means mounted at the upper end of said supporting frame and affixed to the upper end of said elongated screw member, and a lower support means mounted at the lower end of said supporting frame for receiving the lower end of said screw member, the lower end of said screw member being free to move in a vertical linear direction, said lower support means including a bracket to receive the lower end of said screw member and tensioning means connected to the lower end of said screw member to maintain said screw member in tension between the upper and lower support means for all load

conditions of the system, said tensioning means including a resilient block member mounted coaxially with said screw member and engaging the under side of said bracket, and nut means threaded to the lower end of said screw member and engaging the underside of said resilient block; an assembly including a nut member threadably mounted to said screw member; an elevator cab; means coupling said elevator cab to said nut assembly; and drive means coupled to one of the aforesaid members for imparting relative rotational movement between said nut member and said screw member to cause said cab member to move vertically in a linear direction.

2. The vertical transportation and elevator system defined in claim **1**, in which said nut is rotatable on said screw, and said drive means includes an electric motor mounted on said cab, and mechanical means coupling said motor to said nut so as to enable said motor to impart rotational movement to said nut.

3. The vertical transportation and elevator system defined in claim **2**, and which includes a magnetic brake in said assembly for releasably engaging said nut member.

4. The vertical transporation and elevator system defined in claim **1**, in which said upper support means includes a universal joint assembly mounted at the upper end of said supporting frame.

5. The vertical transportation and elevator system defined in claim **4**, in which said lower support means includes a further universal joint assembly mounted at the lower end of said frame.

6. The vertical transportation and elevator system defined in claim **1**, and which includes a key member intercoupling said lower support means and said screw member for preventing rotation of said screw member but permitting a measure of linear movement of the lower end of said screw member.

7. A vertical transportation and elevator system including: a vertical supporting frame having an upper end and a lower end; an elongated screw member; mounting means for suspending the elongated screw member in a vertical position on said supporting frame, said mounting means including an upper support means mounted at the upper end of said supporting frame and affixed to the upper end of said elongated screw member, said upper support means including a universal joint assembly mounted at the upper end of said supporting frame, and a lower support means mounted at the lower end of said supporting frame for receiving the lower end of said screw member, said lower support means including a further universal joint assembly mounted at the lower end of said frame, the lower end of said screw member being free to move in a vertical linear direction, said lower support means including tensioning means connected to the lower end of said screw member to maintain said screw member in tension between the upper and lower support means for all load conditions of the system; dampeners coupled to said universal joint assembly of said upper support means and to said universal joint assembly of said lower support means; an assembly including a nut member threadably mounted to said screw member; an elevator cab; means coupling said elevator cab to said nut assembly; and drive means coupled to one of the aforesaid members for imparting relative rotational movement between said nut member and said screw member to cause said cab member to move vertically in a linear direction.

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