VERTICAL TRANSPORTATION AND ELEVATOR SYSTEM

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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
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 hydraulic 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, it drives the gear shaft and the drive gear, which are coupled to the rack gear, which extends vertically and engages with a rack fixed to the guide rails. The rack provides for vertical movement of the elevator car along the guide rails.
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 otherwise tend to limit the length of the screw, since such compressive loads would tend to cause the screw to buckle and fail.

In the illustrated embodiment, a nut assembly 26 is threadably 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 powered 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 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 20a, which is threaded into the upper end of screw 20 and extends up in coaxially aligned relationship with the screw. The upper terminal end 20a 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 100a, and a second arm extending 100b, for example, at 90° to the arm 100a, as shown in FIG. 4A. A damper 108 of any appropriate type is coupled, for example, between the end of the arm 100a and a bracket 110 mounted adjacent the support bracket 106, and welded or otherwise affixed thereto. A similar damper, not shown, is also coupled between the aforesaid arm of the upper plate 100 to be angularly disposed at 90° to the illustrated damper 108.

A lower terminal end 20b (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 20b 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 damper 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-
The lower terminal end 20b 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 20b. The key 216 prevents rotation of the end terminal member 20b 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 tuck 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 200a of the terminal end member 20b 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 20a and lower terminal end 20b 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 controller 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 maintenance 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 that the following claims be interpreted 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
3,881,575

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 afore-said 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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