ELEVATOR SYSTEM

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ABSTRACT

An elevator system including dispensing means for lubricating the ropes and drive sheave thereof with a lubricant which increases the traction efficiency of the traction machine. The lubricant is a synthetic lubricant selected to substantially increase the coefficient of friction between the drive sheave and ropes, enabling a higher tractive effort per square inch of groove pressure. Different embodiments of the improved elevator system which utilize the higher tractive efforts are disclosed.

10 Claims, 15 Drawing Figures
SINTERED METAL IMPREGNATED WITH SYNTHETIC LUBRICANT

SYNTHETIC GREASE

FIG. 5A

FIG. 5B

FIG. 6A

FIG. 6B

FIG. 7A

FIG. 7B
ELEVATOR SYSTEM

CROSS-REFERENCE TO RELATED APPLICATION

Certain of the apparatus disclosed and described in this application, but not claimed, is claimed in concurrently filed application Ser. No. 269,350, filed July 6, 1972, which is assigned to the same assignee as the present application.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates in general to elevator systems, and more specifically to elevator systems which are deliberately lubricated with a synthetic traction lubricant which increases the traction efficiency, inch rope.

2. Description of the Prior Art

In an elevator system of the traction type, the rating of the traction machine connected to rotate the drive or traction sheave is determined by its traction efficiency. The higher its traction efficiency, the smaller the machine rating required. Traction efficiency may be defined as being responsive to the ratio of the rope and/or sheave life to the required tractive effort.

Adequately lubricating the traction sheave and wires would increase their life, but tractive effort suffers with increased lubrication, lowering the traction efficiency. Thus, the ropes and sheaves are sparingly lubricated.

Further, in order to increase tractive effort, it has been necessary to design the cable grooves of the drive sheave with relatively wide undercuts, such as about 1/5 inch for 1/8 inch rope, in order to pinch the rope and/or an additional wrap around the drive sheave is required.

About the same 0.75 ratio of undercut width to cable diameter would be maintained for larger diameter cables. A wide undercut in the cable groove severely pinches the rope, adversely affecting its useful operating life, and the double wrap doubles the load on the shafts and bearings of the drive sheave, in addition to adversely affecting the operating life of the rope due to the additional bends therein. These structures also limit the operating pressure in the cable grooves, which usually requires that the diameter of the drive sheave be increased and/or a larger number of ropes, resulting in uneconomical low speed machines.

SUMMARY OF THE INVENTION

Briefly, the present invention is a new and improved elevator system in which the ropes and drive sheaves are deliberately lubricated by any suitable dispensing means with a synthetic traction lubricant which increases the coefficient of friction between the ropes and cable grooves of the sheave to at least about 0.145, and preferably to about 0.17. This arrangement results in higher tractive effort for a given pressure.

The deliberate lubrication of the ropes and sheave, during the operation of the elevator system, increases rope life and reduces sheave wear, and enables the width of the undercut in the cable grooves, the sheave diameter, and machine rating, to be reduced. For example, in the prior art the ratio of undercut width to rope diameter required to obtain the desired traction is about 0.75. The present invention enables this ratio to be reduced to about 0.375.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention may be better understood and further advantages and uses thereof more readily apparent, when considered in view of the following detailed description of the exemplary embodiments, taken with the accompanying drawings, in which:

FIG. 1 is a perspective view of an elevator system of the traction type roped 1 to 1, which may use the teachings of the invention;

FIG. 2 is an enlarged cross-sectional view of elevator rope, functionally illustrating automatic lubricating means for adequately maintaining proper lubrication of the rope during operating service;

FIGS. 3A and 3B are fragmentary cross-sectional views of the drive sheave shown in FIG. 1, taken along a line between arrows III—III illustrating undercut cable grooves constructed according to the prior art, and according to the teachings of the invention, respectively;

FIGS. 4A and 4B compare sheave diameters and machine ratings of the prior art with those which are constructed according to the teachings of the invention;

FIG. 5A is a fragmentary cross-sectional view of a drive sheave illustrating means constructed according to the teachings of the invention for automatically lubricating the drive sheave and rope;

FIG. 5B is a fragmentary cross-sectional view of the drive sheave constructed according to the teachings of the invention, illustrating a continuous automatic lubricating arrangement;

FIG. 6A is a perspective view of a prior art double wrap drive arrangement;

FIG. 6B is a fragmentary cross-sectional view of the drive sheave shown in FIG. 6A, taken along a line between arrows VI—VI;

FIG. 7A is a perspective view of a single wrap drive arrangement which may be used instead of the double wrap arrangement shown in FIG. 6A, when following the teachings of the invention;

FIG. 7B is a fragmentary cross-sectional view of the drive sheave shown in FIG. 7A, taken along a line between arrows VII—VII;

FIG. 8 is a diagrammatic representation of an elevator system roped 2 to 1, which may use the teachings of the invention; and

FIGS. 9A and 9B are fragmentary cross-sectional views of the drive sheave shown in FIG. 8, taken along a line between arrows IX—IX, illustrating cable grooves constructed according to the prior art and according to the teachings of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, and FIG. 1 in particular, there is shown a perspective view of an elevator system of the traction type, which may utilize the teachings of the invention. The elevator system includes a traction machine, which in this embodiment is a geared machine. The traction machine is generally mounted in the penthouse of a structure having a plurality of floors to be served by the elevator system, over a hoistway shown in phantom. Traction machine includes a grooved traction or drive sheave, a geared drive, such as a worm and main gear reduction drive, an electric drive motor, and a brake assembly (not shown). Geared machines are used in
relatively low speed applications, up to about 400 ft./min.

An elevator car 20 is mounted for movement in the hoistway 13 to serve the floors or landings of the associated building or structure. The elevator car 20 is connected to a counterweight 22 by a plurality of ropes or wire cables 24 which pass around the traction sheave 14. A deflection or secondary sheave may be used when necessary to properly space the car and counterweight. The ropes 24 are thus held in frictional engagement with the cable grooves disposed in the periphery of the drive sheave 14 by the weight of the car 20 and counterweight 22.

The elevator system 10 shown in FIG. 1 is roped 1 to 1, i.e., the car moves at the peripheral speed of the traction sheave 14, and the ropes or cables make a half-wrap around the sheave 14, which is also commonly called "single wrap."

FIG. 2 is an enlarged cross-sectional view of one of the ropes 24, illustrating a typical construction thereof which includes a plurality of outer strands 26, such as the six strands illustrated in the figure, or eight strands, with these outer strands being closed around a center portion 28. The center portion 28 may be formed of fiber, as illustrated, or of steel. Each strand includes a center wire, six inner wires, six filler wires, and twelve outer wires. Typical diameters for hoist ropes are 1.2 inch, 9/16 inch, % inch and % inch.

The wires and core of the rope 24 are lubricated, according to the prior art, with a petroleum type lubricant while the wire is being fabricated, as some lubrication of the rope is essential to achieving satisfactory operating life. Ropes with fiber centers have an advantage over ropes with a steel center in that they retain the lubricant over a longer period of time. Extreme care, however, must be taken by the rope manufacturer to lubricate sparingly. Otherwise, trowe effort between the cable and the cable grooves of the drive sheave will be less than that required for adequate traction effort, due to a reduction in the coefficient of friction between the cables and the cable grooves. Therefore, in the prior art, the sheave and cable wear is greater than that which could be achieved with full lubrication, but lubrication is compromised to achieve an adequate tractive effort.

Even with carefully controlled lubrication of the ropes and associated sheaves, it has been necessary to severely pinch the ropes and the cable grooves by providing substantially V-shaped grooves with relatively wide undercuts at the bottom thereof. FIG. 3A is a cross-sectional view of sheave 14 taken along a line between arrows III—III in FIG. 1, illustrating a typical prior art cable groove 30 in which a rope 24 is disposed. The rope 24 contacts the relatively flat sides of the substantially V-shaped groove 30, and is wedge or forced downwardly to partially enter undercut 32, which is typically about % inch wide for % inch rope. This 0.75 ratio of undercut width to rope diameter is maintained for larger diameter ropes. As an aid in referring to this ratio, the width of the undercut is referred to as W, and the diameter of the rope is referred to as D. The wedging and pinching action of the groove 30 and undercut 32 on the cable 34 increases the tractive effort, but it has a disadvantage of hastening cable and sheave wear. It has the further disadvantage of limiting the operating pressure in the groove, which thus requires a larger diameter sheave and/or a larger number of ropes. Increasing the traction sheave diameter increases the torque arm and thus a traction machine with a larger rating is required to drive the traction sheave.

The present invention utilizes a synthetic lubricant which substantially increases the coefficient of friction between the rope and grooves of the drive sheave, compared with petroleum lubricants. The coefficient of friction achieved with the synthetic lubricant should be at least about 0.145, and is preferably higher, such as in the range of about 0.145 to about 2.

While the invention is not limited to any specific synthetic lubricant, it has been found that a synthetic hydrocarbon lubricant which includes isopropycyclohexane will provide the specified range of coefficient of friction. Appropriate additives may be used with the isopropycyclohexane, such as an ester. The lower part of the range, about 0.145 to about 0.17 is achieved by utilizing the synthetic lubricant in liquid form, having a viscosity which enables it to be poured below a temperature of 0°F, and the upper part of the range, from about 0.17 to about 0.2 is achieved by adding a thickening agent to the liquid synthetic lubricant, such as one of the soaps commonly added to petroleum lubricants, to provide a grease.

Suitable synthetic lubricants are available commercially in different viscosities from Monsanto Chemical Company which lubricants are sold under the trade name SANTOTRAC. SANTOTRAC synthetic lubricants have been sold for the purpose of increasing the coefficient of traction between two rolling members in rolling contact type drives, i.e., to increase the power transmitted through a rolling contact drive, and also for the purpose of lubricating rolling contact bearings where skidding or sliding contact is a problem. These applications, however, are fundamentally different than the application of lubricating wire hoist rope and the drive sheave of an elevator system, and do not suggest the unexpected advantages obtained by the new and improved combination disclosed in this application.

The hoist ropes 24, according to the invention, are fully lubricated when fabricated with a synthetic lubricant which will provide a coefficient of friction between the ropes and drive sheave of at least 0.145 when held in frictional engagement with the grooves of the drive sheave by the weight of the elevator car and the counterweight means, which in itself will increase the useful operating life of the ropes and sheave compared with the sparingly lubricated ropes and sheaves of the prior art. Thus, without further changing the structure of the drive sheave, this arrangement will provide substantial savings by reducing maintenance costs of the ropes and sheaves.

The combination with the synthetic lubricant further permits new and improved structural changes to be made in elevator systems, which changes cooperate to further reduce rope and sheave wear, as well as reducing sheave diameter, and the rating of the traction drive machine. This new and improved combination allows for the first time an automatic lubrication system to adequately lubricate the ropes and sheaves in service. It allows double wrap arrangements to be replaced by single wrap arrangements. It allows the cable grooves to be restructured to reduce cable and sheave wear.

More specifically, referring to the geared arrangement shown in FIG. 1, the cable groove 20 and under-
cut 32 may be changed to the structure shown in FIG. 3B. The undercut 32 shown in FIG. 3A may be changed to an undercut 32' shown in FIG. 3B, which has a width dimension of only about 3/16 inch for ¼ inch rope, compared with the wide ⅛ inch used in the prior art for ½ inch rope. This new ratio of 0.375 of undercut width W to rope diameter D would be used for larger diameter rope. Further, the relatively straight sides of the V-drive groove 30 of the prior art may be rounded or U-shaped, as illustrated at 30' in FIG. 3B. The groove and undercut construction shown in FIG. 3B thus reduces the severity of the pinching of the cables increasing the useful operating life of both the cables and the sheave.

The new groove and undercut arrangement of FIG. 3B lifts the restriction on groove pressure, necessary in the prior art arrangement shown in FIG. 3A, enabling the sheave diameter to be reduced substantially. For example, the sheave diameter may be reduced by at least 25 percent when selecting the synthetic lubricant to provide at least a 25 percent increase in the coefficient of friction over the prior art petroleum lubricant used to lubricate elevator rope and sheave arrangements. A 25 percent reduction in the diameter of the drive sheave results in at least a 25 percent reduction in the torque rating of the associated elevator drive machine. These relationships are illustrated in FIGS. 4A and 4B, with FIG. 4A diagrammatically illustrating an elevator machine 40 having a drive 42 rated T and a drive sheave having a diameter D. FIG. 4B illustrates an elevator machine 40' which has the ropes and sheave lubricated according to the teachings of the invention, with a synthetic lubricant selected to provide at least a 25 percent increase in the coefficient of friction between the ropes and sheave, compared with a petroleum lubricant, which would normally provide a coefficient of friction of about 0.133 to 0.137 when sparingly lubricated, and less when lubricated more fully. Thus, to achieve the 25 percent reduction in sheave diameter and torque rating of the drive machine, would require a synthetic lubricant which would provide a coefficient of friction of about 0.17, which the synthetic grease of the type hereinbefore mentioned would easily achieve.

As hereinbefore mentioned, the ropes, including all the strands thereof, may for the first time be adequately lubricated during manufacture of the rope. Further, the adequate lubrication may be automatically maintained during operating service without regard to losing tractive effort due to this inadequate lubrication. FIG. 2 functionally illustrates automatic lubrication dispensing means 50, associated with rope 24, which, for example, may be of the spray, drip or wiper type, with the latter being illustrated by the wick 51. The automatic mechanism may take into account the RPM of the sheave, as well as the weight of the car and sheave, to dispense the synthetic lubricant.

FIGS. 5A and 5B illustrate two additional arrangements for automatically lubricating the ropes and drive sheave during operation. FIG. 5A is a fragmentary, cross-sectional view of a portion of a drive sheave 52.

The drive sheave 52 defines one or more chambers or cavities 54, which chambers are in communication with the cable grooves 56, such as through openings disposed to intercept the narrow undercut 58, when an undercut is utilized. A grease fitting 60 may be used to charge the chamber 54 with the synthetic lubricant during scheduled maintenance of the elevator system. A grease disposed in the chamber 54 may be prevented from being forced out through the openings which communicate with the cable grooves too rapidly, by properly selecting the diameter of the openings; by disposing screens over the openings with the mesh being selected to properly meter the transfer of lubricant; by a spring-loaded closure member (not shown) which is operated to the open position against the spring bias by the ropes 62 when they contact the cable grooves; or, by any other suitable arrangement.

FIG. 5B is a fragmentary, cross-sectional view of a drive sheave 70, in which at least the metal which surrounds the cable grooves is formed of a sintered metal impregnated with the synthetic lubricant, which will automatically lubricate the rope 72 as the rope 72 presses against the sides of the cable groove. The sintered metal may be in the form of removable inserts, which are replaced when necessary to maintain adequate lubrication of the system and/or due to wear.

The elevator applications specifically mentioned to this point have been of the geared machine type, but the synthetic lubricant and its advantages are equally applicable to the higher speed elevator systems which use a gearless drive, i.e., a DC motor, and a source of adjustable direct current voltage. For example, in the gearless systems it is common to utilize a double or full wrap of the hoist ropes in order to obtain the tractive effort required. FIG. 6A is a perspective view of a double wrap gearless system 80, including a grooved traction or drive sheave 82, a grooved secondary sheave 84, and a rope 86 which passes around the drive sheave 82 twice. FIG. 6B is a fragmentary perspective view of the drive sheave 82 shown in FIG. 6A, taken generally along a line which extends between arrows VI—VI. With the double wrap arrangement illustrated, it will be noted that the groove 88 is contoured to fit the rope 86, and an undercut is usually not necessary, as the double wrap arrangement provides the required tractive effort. The double wrap arrangement, however, deleteriously affects rope life, due to the additional bends required in the rope. Further, the double wrap increases the loading on the drive machine, compared with the single wrap, and a larger sheave diameter is usually necessary in order to increase the radius of curvature in the rope as it wraps around the sheave.

FIG. 7A is a perspective view of a gearless elevator system 80' constructed with a synthetic lubricant for the ropes and sheave which increases the coefficient of friction therebetween to at least 0.145. The rope 86' passes over the drive sheave 82' and secondary sheave 84', when the secondary sheave is necessary in order to properly space the counterweight and car, with a single wrap. As illustrated in FIG. 7B, which is a fragmentary cross-sectional view of drive sheave 82' taken generally along a line between arrows VII—VII, a small undercut of 3/16 inch for ½ inch rope, and larger according to the same ratio for larger diameter rope, along with the synthetic lubricant, provides sufficient tractive effort for a gearless system, eliminating the necessity for the double wrap shown in FIG. 6A. Thus, the number of bends in the rope 86' are reduced by one-half, the loading on the drive machine is reduced by one-half, and the diameter of the sheave 82' may be reduced, compared with the diameter of the sheave 82 shown in FIG. 6A.

Gearless machines of the prior art which utilize a single wrap and a relatively wide undercut in the cable groove, whether roped 1 to 1 or 2 to 1, may be im-
proved by using the synthetic lubricant to increase the coefficient of friction between the ropes and sheave. For example, FIG. 8 is a diagrammatic representation of a gearless system 90 roped to 1, having a car 92, a counterweight 94, a drive sheave 96, and a gearless machine 98. In addition to the drive or traction sheave 96, sheaves 98 and 100 are provided on the car 92 and counterweight 94, respectively. The hoist rope 102 is dead-ended in the overhead beams at 104, passed under sheave 98 on the car 92, over the traction sheave 96, under the sheave 100 on the counterweight, and back to the overhead beams where it is dead-ended at 106.

FIG. 9A is a fragmentary, cross-sectional view of the drive sheave 96 shown in FIG. 8, with a groove 108 and undercut 110 constructed according to the teachings of the prior art, having a ratio W/D of about 0.75. The groove 108 is V-shaped with slightly curved sides which wedge the rope downwardly and pinch the rope in the relatively wide undercut. The synthetic lubricant with a coefficient of friction in the range of 0.145 to 0.2 enables the groove 108 and undercut 110 to be constructed as shown in FIG. 9B, which utilizes a groove 108' having a contour which more nearly matches that of the rope 102'. The undercut 110' is reduced in width such that the ratio W/D is about 0.375. The diameter of the drive sheave 96 and rating of the drive 98 may also be reduced, with the reduction, compared with a gearless system of the prior art, depending upon the coefficient of friction of the synthetic lubricant which is selected, with a 25 percent reduction being easily achievable, as hereinbefore described relative to geared systems.

The ropes and sheaves in the gearless embodiments of the invention may be automatically lubricated, as hereinbefore described relative to the geared embodiments of the invention.

The upper limit of about .2 of the coefficient of friction is selected because it enables the advantages of the invention to be utilized without adversely affecting the safety advantage of the traction type elevator system. In other words, a coefficient of friction of about .2 will not cause excessive lifting of the counterweight when the car is driven into its buffer, and the car will not be pulled into the overhead when the counterweight is driven into its buffer.

The isopropylcyclohexane material hereinbefore mentioned has a characteristic which is desirable in an elevator application, in that tractive effort is reduced when the pressure between the rope and sheave is reduced, such as when the car or counterweight hits its buffer. Further this material has the characteristic of increasing its viscosity with pressure, which is also desirable in an elevator application.

In summary, the use of new and improved lubricated wire ropes in an elevator system, without changing the remainder of the elevator system, would enable large savings to be realized in maintenance of the ropes and sheaves. The new and improved groove and undercut constructions disclosed herein which permit increased groove pressures without deleteriously affecting rope and sheave life, enable large savings to be realized by using smaller, more efficient machines for a given application. The deliberate lubrication of the rope and sheave, to the extent necessary to provide adequate lubrication, not practical in the prior art, increases rope and sheave life even when the sheave groove and undercut arrangement is changed to utilize higher groove pressures. The disclosed arrangements will also facilitate the move to the more economical higher tensile ropes, whose use has heretofore been limited due to excessive sheave wear.

While the disclosed arrangements permit the ratio W/D to be reduced from about 0.75 to about 0.375, it is to be understood that the ratio W/D may be varied somewhat from 0.375 without departing from the teachings of the invention.

1 claim.

1. An elevator system, comprising: an elevator car, counterweight means, a drive sheave having cable grooves, rope means interconnecting said elevator car and counterweight means, said rope means being held in frictional contact with the cable grooves of said drive sheave by the weight of said elevator car and counterweight means, drive means for rotating said drive sheave to move said elevator car and counterweight means, due to friction between the drive sheave and rope means, and lubricating means, said lubricating means lubricating said rope means and the cable grooves of said drive sheave during operation of the elevator system with a synthetic lubricant which provides a coefficient of friction between said rope means and said drive sheave of at least 0.145.

2. The elevator system of claim 1 wherein the lubricating means includes cavities formed in the drive sheave which are in communication with the cable grooves, with the synthetic lubricant being disposed in said cavities.

3. The elevator system of claim 1 wherein the lubricating means includes a sintered metallic structure impregnated with the synthetic lubricant, said sintered metallic structure forming at least a part of the drive sheave such that it contacts the rope means.

4. The elevator system of claim 1 wherein the lubricating means includes a reservoir of synthetic lubricant external to the drive sheave, and means for at least periodically transferring a predetermined amount of the synthetic lubricant from the reservoir to the rope means and cable grooves.

5. An elevator system, comprising: an elevator car, counterweight means, a drive sheave having a cable groove, drive means connected to said drive sheave, rope means interconnecting said elevator car and counterweight means, said rope means being held in frictional contact with the cable groove of said drive sheave by the weight of said elevator car and said counterweight means, and lubricating means for lubricating said rope means with a synthetic lubricant which provides a coefficient of friction between said rope means and said drive sheave of at least 0.145, and including an undercut in the bottom of the cable groove of said drive sheave which extends in the direction of the groove and which has a width dimension selected to provide a ratio between this dimension and the diameter of the rope means of about 0.375.
6. The elevator system of claim 5 wherein the frictional contact of the rope means with the drive sheave is a single wrap.
7. The elevator system of claim 6 wherein the rope means is anchored to both the elevator car and to the counterweight means.
8. The elevator system of claim 6 including first and second sheave means carried by the elevator car and counterweight means, with the rope means interconnecting the elevator car and counterweight means by extending over the drive sheave and under the first and second sheave means.
9. The elevator system of claim 5 wherein the synthetic lubricant provides a coefficient of friction of at least about 0.17 between the rope means and drive sheave and wherein the diameter of the drive sheave is about 25 percent less than would be required for the same traction efficiency when using a lubricant having a coefficient of friction less than about 0.14.
10. The elevator system of claim 5 wherein the synthetic lubricant provides a coefficient of friction of at least about 0.17 between the rope means and drive sheave, and wherein the torque rating of the drive means is about 25 percent less than would be required for the same traction efficiency when using a lubricant having a coefficient of friction less than about 0.14.

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