Oct. 18, 1966 W. H. BRUNS 3,279,762

NOISE ABATING AND TRACTION IMPROVING ELEVATOR SHEAVE

Filed March 11, 1964 2 Sheets-Sheet 1

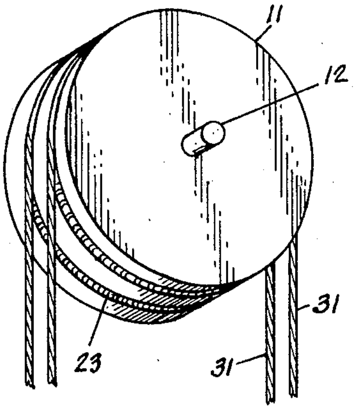

FIG. 1

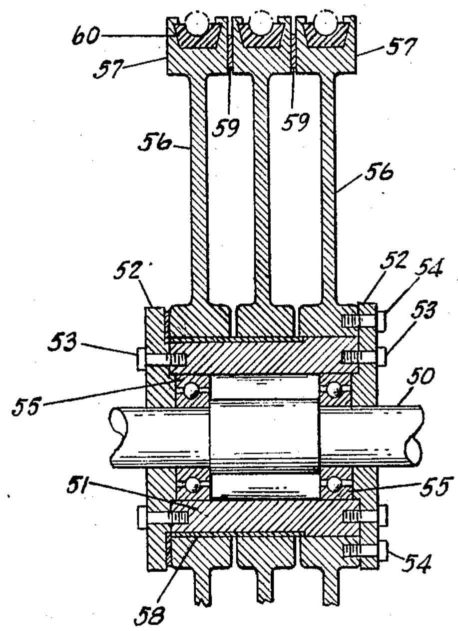

FIG. 2

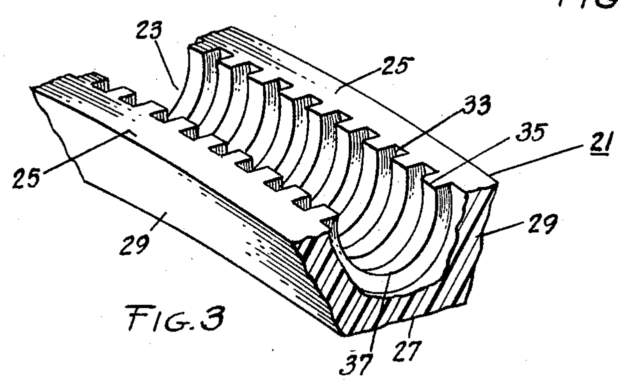

FIG. 3

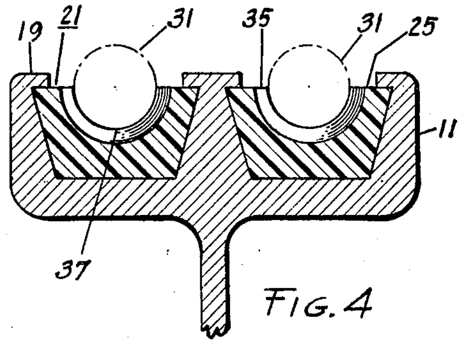

FIG. 4

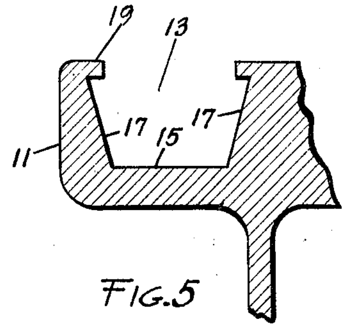

FIG. 5

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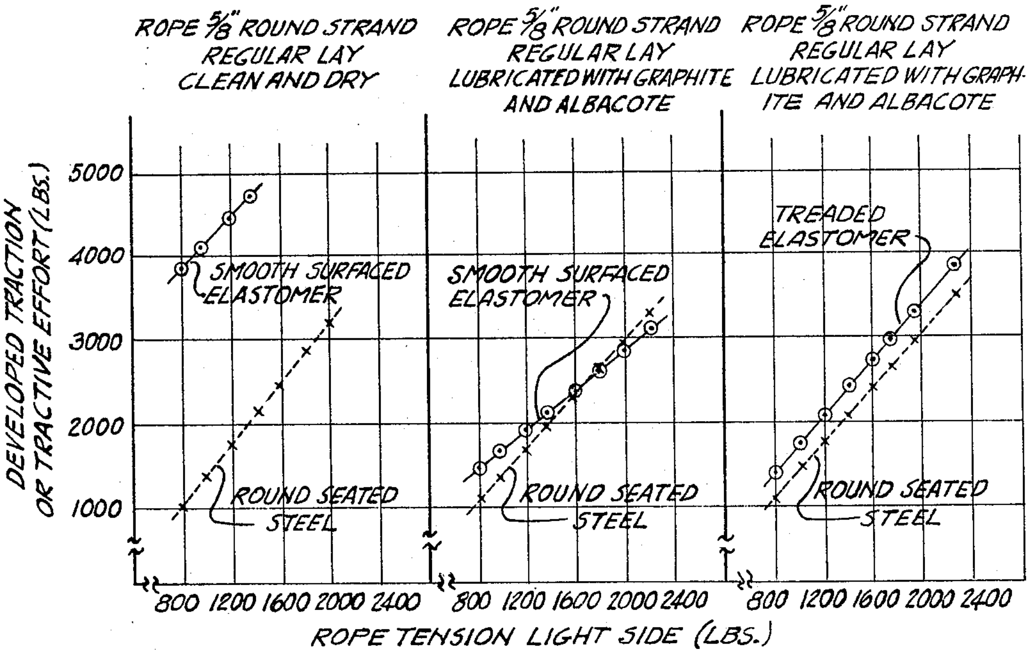

FIG. 6a FIG. 6b FIG. 6c

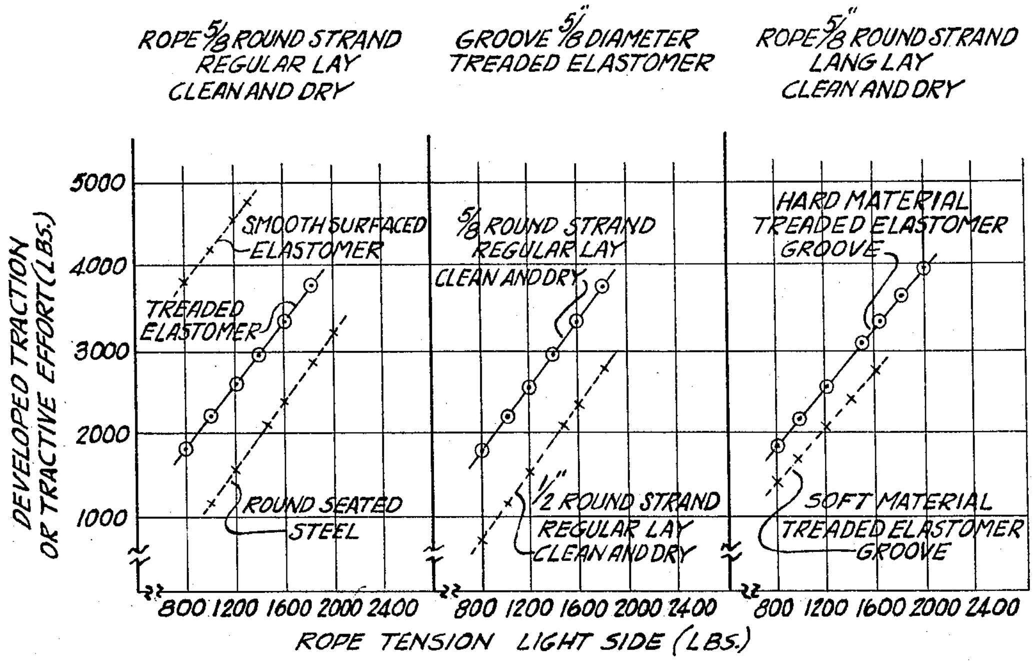

FIG. 7a FIG. 7b FIG. 7c

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NOISE ABATING AND TRACTION IMPROVING ELEVATOR SHEAVE

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This invention relates to elevators and more especially to an arrangement for electric traction machine elevators.

The development of steel framework building construction and the consequent increase in building height which occurred in the early part of this century accompanied the development of the electric traction machine elevator and the subsequent abandonment of drum type machines which necessarily had become larger and more costly with the increased rise of elevator installations. With the adoption of traction machines, a previously unexperienced condition which is now commonly referred to as rope "slip" was introduced to elevator operation. Rope "slip" is the undesirable movement of the ropes in relation to the surface of the drive sheave caused by the failure of the sheave and roping arrangement to develop sufficient traction, or tractive effort, to maintain complete and positive control over the movable loads. Such movement results in lowered efficiency, reduced accuracy of movement, and accelerated rope wear.

To prevent rope "slip," two practical and presently utilized arrangements were devised. One of these employs steel or semi-steel sheaves having undercut metallic rope grooves. This is generally used with single wrap geared traction machines used in medium and low speed installations. The other arrangement employs steel or semi-steel sheaves having round seated metallic rope grooves and is used with double wrap gearless traction machines where the duty load and speed require more traction, or tractive effort, than it is desirable to develop with single wrap geared traction machines.

Nothwithsanding these two arrangements are presently widely employed, they have drawbacks. Metallic-rope grooves cannot deflect any substantial or practicable amount and because of this, rope "creep" occurs causing the rope and rope groove to wear. Rope "creep" is the change in the position or movement of the rope relative to a sheave surface which results from rope stretch caused by the change in the tension in the rope when traveling over a drive sheave while carrying an unbalanced load. This "creep" may also result from one or more of the several grooves on a pulley or sheave having a greater diameter than its companion grooves. This causes the sheave to take or deliver more rope in one groove than in another, with resultant different tensions in the ropes; and where the difference is great enough, with resultant rope "slip."

The rope wear resulting from "creep" occurs because the metal surface of the groove acts abrasively on the wires in the outside layers of the rope's strands. To minimize the effect of this wear on the service life of the rope, the strands of the rope customarily are made with the outside-layer wires having a relatively larger diameter than the rated bearing strength of the strand, or rope, would require. The larger such wires are, the greater the stress they are subjected to during bending over the sheave. Also, it is thought that greater size, and, increased wire stress, causes greater tendency of the wire to break. Thus, to secure the maximum service life from a rope intended for elevator service it is customary to fashion the outside layers of the strand from wire having a larger diameter than that of the inner layers of wire. This difference in diameters is usually the result of a compromise between

large size for increased wear and smaller size for increased bend expectancy.

Other shortcomings are inherent to both the single and double wrap traction arrangements because of the customary practice employed to provide the tractive effort required to maintain complete control over the movable loads. The tractive effort that can be provided by these arrangements is dependent upon the pressures exerted by the ropes in their grooves. These pressures, in turn, are functions of the tensions in the ropes at both sides of the sheave. Generally, the live load and its counterbalancing mass are not heavy enough to produce the tension necessary to provide the required tractive effort and, in order to increase these rope tensions so that the required tractive effort is provided, the weights of the car and its counterweight are made heavier than otherwise would be necessary. As a result of increasing the weights of the car and its counterweight, a sheave shaft must be provided which is of sufficient size to support the added load, and a motor must be provided which is of sufficient size to perform the added work. Ordinarily these provisions increase both the size of the components and the cost of installation.

These aforementioned and various other disadvantages in using metallic ropes in metallic sheave grooves have long been well known in the elevator industry. Nevertheless, this knowledge has not produced a satisfactory solution for these problems.

It is, therefore, one of the objects of this invention to provide a novel arrangement for electric traction machine elevators which improves the service life of elevator ropes.

It is another object of this invention to provide a novel arrangement for electric traction machine elevators which increases the amount of traction, or tractive effort, that can be developed by such elevators.

It is another object of this invention to provide a novel arrangement for electric traction machine elevators which yields sufficient traction, or tractive effort to be employed with relatively light weight elevator cars.

It is another object of this invention to increase the applicability and use of single wrap traction machines and thereby avoid the expense that accompanies the use of double wrap traction machines.

It is a further object of this invention to quiet the usual noise of operating metal ropes in metal sheave grooves at relatively high linear speeds.

A still further object of the invention is the provision of an arrangement which will encourage the use of a metal rope of the desired capacity in which all strands are of equal optimum size.

In carrying out this invention the elevator ropes as they pass over or around one or more of the sheaves are supported exclusively on a pliable element arranged intermediate the groove surface and the elevator rope.

One of the features of this invention is that the traction, or tractive effort developed between the drive sheave and ropes is controllable according to the configuration and the hardness of the pliable element.

Another feature of this invention is that smaller motors can be employed in elevator installations.

Still another feature of this invention is that smaller sheave shafts can be employed in elevator installations.

Other objects and features of this invention will be evident from the following description and appended claims when read in conjunction with the drawing, in which:

FIGURE 1 is a simplified perspective of elevator ropes supported on a pliable element secured to a driving sheave;

FIGURE 2 is a sectional view of a sheave arranged for relative rotation of the individual groove sections for the purpose of eliminating the effect of unequal groove diameters on multi-groove sheaves.

FIGURE 3 is a perspective view of a portion of a pliable support element;

FIGURE 4 is a cross-sectional view of the elevator ropes, driving sheave rim, and pliable support element shown in FIGURE 1; and,

FIGURE 5 is a cross-sectional view of a portion of the driving sheave rim shown in FIGURE 4; and

FIGURES 6 and 7 are graphs.

Represented in the drawing is an embodiment of the invention which is presently preferred. A driving sheave **11** (FIG. 5) with channels **13** in its rim portion is mounted on shaft **12** (FIG. 1) of the elevator drive motor (not shown). Each channel **13** has a flat bottom surface **15** and two divergent wall surfaces **17** each of which is surmounted at the open end of the channel by a lip **19**. Lining the entire channel **13**, and seated tightly therein so as to prevent movement, is a pliable support element in the form of an elastomer strip, or insert **21** (FIG. 3) having a groove section **23** and shoulder section **25**. Lips **19** abutting shoulder sections **25** of insert **21** serve further to secure the insert in channel **13** and retain it bottomed on surface **15**. Grooves **23** in which elevator ropes **31** are supported are made with alternate voids **33** and treads **35**. The reason for this treading arrangement can best be explained by referring to the several graphs shown in FIGURE 6.

From the graph of FIG. 6*a* it can be seen that a dry, round strand, regular lay rope supported in a smooth surfaced, round seated elastomer groove can develop much better tractive effort over the same range of rope tension than the same rope supported in a round seated steel groove. Furthermore, the elastomer causes far less abrasive wear on the rope than the steel. However, the graph of FIG. 6*b* reveals that the addition of a lubricating mixture of graphite and albacote to the rope causes a more marked decrease in the traction that can be developed with the smooth surfaced elastomer groove than in that which can be developed with the round seated steel groove. From this it would be reasonable to expect that when the lubricant in the core of an elevator rope exuded into a smooth surfaced elastomer groove the traction capable of being developed would be undesirably decreased.

The treading arrangement of insert **21** practically eliminates this undesirable decrease in tractive effort arising from exuding lubricants. This may be seen from the graph of FIG. 6*c* where the traction developed by a rope lubricated with graphite and albacote on a treaded elastomer groove and the traction developed by the same lubricated rope on a round seated steel groove are both presented. This graph clearly illustrates that a well lubricated rope can develop more traction when supported in a treaded elastomer groove than in a round seated steel groove. Thus any lubricant exuding from elevator ropes **31** does not to any appreciable extent adversely effect the traction that can be developed with the treaded elastomer insert **21**. The reason for this is that any lubricant exuded from ropes **31** is squeezed into voids **33** upon initial rope contact with sheave **11** by the pressure between the ropes and the bearing surfaces **37** of treads **35** and by the squeegee action of the leading edges of treads **35**. This leaves the ropes substantially dry for contact with bearing surfaces **37** throughout the entire arc of contact over sheave **11**. Upon ropes **31** leaving contact with sheave **11** the lubricant is thrown from the uncovered voids by gravity and centrifugal force.

Yet another property of elastomer treads **35** is that when subjected to circumferential and radial forces they deflect along the lines of action of such forces. This ability to deflect circumferentially permits the tension in ropes **31** to change without relative motion between the ropes and bearing surfaces **37**. Hence circumferential deflection reduces rope "creep" and results in decreased rope and sheave groove wear. However, some groove wear does occur and unequal sheave groove diameters do result.

When unequal sheave groove diameters exist on sheaves with metal grooves the ropes in some of the grooves

"slip" during each revolution of the sheave. With treaded elastomer grooves the ability of treads **35** to deflect radially equalizes the diameters of unequally worn grooves and reduces the "slip" due to such grooves accordingly.

The reductions in both "creep" and "slip" accompanying the use of the treaded elastomer groove further decreases the effects of abrasion on the outside wires of elevator ropes. Thus a ⅝ inch rope with .029" diameter outside wires was no more adversely affected by abrasion than was a ⅝ inch rope with .041" diameter outside wires. Consequently, if treaded elastomer grooves are used the size of the outside wires of elevator ropes can be reduced. This results in a further increase in the life of the ropes since smaller wires are less rapidly broken by the cold bending stresses experienced in passing over the drive sheave. Additionally, an unforeseen advantage of using ropes having smaller outside wires with treaded elastomer grooves is that they develop more tractive effort than ropes with larger outside wires.

It can be seen from the graph of FIG. 7*a* that a dry clean rope in a smooth surfaced elastomer groove can develop more tractive effort than one in a treaded elastomer groove and that the same rope in a treaded elastomer groove can develop more tractive effort than one in a round seated steel groove. One reason for this is the exertion on the ropes by the elastomer sheave grooves of side pressures acting perpendicular to the sheave radius and parallel to its axis. The existence of these pressures is demonstrated by the fact that under a condition where such pressures substantially cannot exist, namely, where a one-half inch, round strand, regular lay rope is supported in a five-eighths inch diameter treaded elastomer groove, the tractive effort that can be developed under various rope tensions is much less than under a condition where such pressures can exist, such as, where a five-eighths inch, round strand, regular lay rope is supported in the five-eighths inch diameter treaded groove. These results are plotted on the graph of FIG. 7*b*.

These side pressures are inversely proportional to the amount of deflection the elastomer groove undergoes. Substantiating this are two discovered facts, first, a treaded groove which deflects more than a smooth surfaced groove develops less tractive effort than does the latter groove, and, second, a treated groove or softer material develops less tractive effort than a groove of a harder substance (see the graph of FIG. 7*c* for the curves substantiating this second fact). Consequently, since developed tractive effort is affected by the magnitude of side pressure, the amount of tractive effort capable of being developed by a specific elastomer groove can be pre-determined in accordance with the deflective characteristics of the groove. This is significant because the size of the bearing surface area of the treads, the relationship between the area of the treads and the area of the voids, and the hardness of the material of which the insert is composed, all of which contribute to controlling the amount of tractive effort capable of being developed by a driving sheave are all variable factors.

With the increase in the amount of developed tractive effort resulting from the use of the treaded elastomer groove plus the ability to control the amount of developed tractive effort by choice of material and type of treading the single wrap machine arrangement with a treaded elastomer groove is applicable for many duties for which it is now desirable to use the double wrap arrangement.

One of the desirable properties of an elevator drive sheave is that it develop a constant tractive effort throughout its life and the life of its supported ropes. Sheaves having steel grooves provide substantially constant traction as long as the shape of the groove remains substantially constant. On a sheave with a polyurethane insert having a groove **23** which was initially semicircular and had five-eighths of an inch diameter treads the tractive effort developed with a five-eighths of an inch diameter regular lay rope also remained substantially constant throughout the life of the insert after the groove wore into and thereafter maintained a substantially semi-elliptical shape. The treads on this insert were three-sixteenths of an inch along the circumference of the groove and two-sixteenths of an inch high. Adjacent treads were separated by a two-sixteenths of an inch void.

One of the difficulties associated with the use of metal ropes in metal grooves is the increased rope noise that is experienced as the height of the building and the speed of the elevator are increased. A part of this arises from the strands of the rope contacting the groove surface as the rope engages the sheave. The noise so produced is sometimes called rope "patter." This "patter" may occur at a frequency close to the natural frequency of vibration of a length of rope, such as between the drive and secondary sheaves, in which case rope vibration occurs to produce a noise of a somewhat different character, and much more noticeable than it otherwise would be.

In addition to rope "patter" there is a degree of noise introduced into the car by rope "creep" and to a greater degree by rope "slip." This is especially true of those installations using 2 to 1 roping on multiple groove sheaves. As a practical matter of manufacture it is difficult to machine each of several sheave grooves to have the same diameter. If each groove is not of the same diameter it carries a greater or lesser length of rope than its companion groove carries on each revolution. This will result in creating different rope tensions and may result only in causing rope "creep" if the differences are relatively small. If, however, this differences are great enough the difference in tensions will exceed the traction that the rope and groove are capable of creating and the rope will slip in a series or multiple of short lengths. These "slips," in addition to harming the rope, give rise to noise in the car which becomes more noticeable as the linear speed of the ropes increase. The use of the elastomer inserts in the sheave grooves eliminates these objectionable products.

These effects arising from the differences in groove diameters on the idler sheaves of the car and counterweight of 2 to 1 roping systems can also be alleviated by the free running sheave illustrated in FIGURE 2 of the drawing. As is shown there, the sheave shaft **50** supports bearings **55**, which may suitably be of the ball type, which in turn support the sheave hub **51**. This hub supports a plurality of individual sheaves, each having a flange section **56** and a rim section **57** in which a groove **60** is machined. These individual sheaves are each mounted on the hub **51** and secured there by clamping rings **52**, which are bolted to hub **51** by a pair of bolts **53**. The right most sheave is also bolted to the adjacent clamping ring by one or more bolts **54**, such that it turns in unison with the rings and hub. The remaining sheaves are each mounted with a plastic bearing **58** intermediate the hub **51** and the flange section such that each one is free to rotate on the hub. A similar plastic bearing surface **59** is interposed between adjacent rim sections. In this manner each sheave section can adjust its speed of rotation to equal the linear speed of its conjugate rope; the speed of which is a function of the speed of revolution of its drive sheave and the diameter of its driving groove. Because the differences in groove diameters are small, the various individual sheaves will make substantially the same number of revolutions in a full length trip; the differences between them being usually in fractional revolutions. This permits the use of plastic bearings **58, 59** which may be composed from polytetrafluoroethylene which is a fluorocarbon resin commercially available under the trademark Teflon. This may be used alone or in combination with an adulterant to improve its wearing properties. One such product is commercially available under the trademark Rulon.

An additional benefit to be derived from the treaded groove is that the high rope tensions presently used with metal driving sheave grooves for developing sufficient

tractive effort are not required with the treaded elastomer grooves. This permits the use of lighter weight cars which ultimately results in a decrease in the size of the sheave shaft and in the required motive power.

It is contemplated that this invention is susceptible to modifications which will make it more suitable for different conditions without departing from the scope thereof. Therefore, it is intended that all matter contained in the above description or shown on the accompanying drawing be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. A multi-groove driving sheave for a traction machine elevator over which a plurality of hoisting ropes pass in tension, comprising, a rim, pliable material forming a plurality of grooves along and around the rim of said sheave, each of said grooves supporting a hoisting rope and preventing said rope from contacting any rigid material while passing over said sheave, treads formed in each of said grooves providing the bearing surfaces for said ropes, and voids intermediate adjacent treads such that the tractive effort capable of being developed by said sheave is a function of the relationship between the bearing surface area of said treads and the area of said voids.

2. A multi-groove driving sheave according to claim **1** in which said rim has formed therein a plurality of channels equal to the number of said hoisting ropes and said pliable material is in the form of an equal number of elastomer inserts, a separate insert lining the entirety of a different one of each of said channels, each said insert having formed therein one of said grooves in which is supported one of said hoisting ropes.

3. A multi-groove driving sheave according to claim **1** in which said pliable materal is polyurethane.

4. A multi-groove driving sheave according to claim **2** in which each of said channels has a bottom surface and two side wall surfaces with a lip atop each side wall surface; each said elastomer insert is fitted tightly within its respective channel and has a bottom surface abutting the bottom surface of its channel and two side surfaces each abutting a different side wall surface of its channel, whereby movement of each said insert with relation to its channel is substantially prevented; each said insert also has two shoulder surfaces, one each abutting one of said channel lips, whereby each said insert is secured in its channel and retained bottomed therein; said grooves are formed in the upper surfaces of said inserts; said treads are formed transversely in each of said grooves; and in which the tractive effort capable of being developed by said sheave is also a function of the deflective characteristics of said insert.

5. A multi-groove driving sheave according to claim **2** in which each of said channels has a bottom surface and two side wall surfaces which are divergent from the bottom surface, each side wall surface having a lip formed atop it; each said elastomer insert is polyurethane and is seated lightly within and substantially entirely fills its respective channel; each said insert has a bottom surface abutting the bottom surface of its channel and two side surfaces, which are divergent from the bottom surface, abutting the two side wall surfaces of its channel, whereby movement of each said insert with relation to its channel is prevented; each said groove is formed in the upper surface of its insert; each said insert has a shoulder on each side of its groove abutting one of its channel's lips whereby each said insert is secured in its channel and retained bottomed therein; said treads formed in said grooves are deflectible under the pressure of the ropes bearing on them to minimize any differences in the diameters of said grooves and to exert side pressures on said ropes; and, in which, the tractive effort capable of being developed by said sheave is also a function of the deflective characteristics of said treads.

6. A multi-groove driving sheave according to claim **2**, in which each said elastomer insert is seated tightly within its respective channel and is substantially immovable in relation thereto; each said channel has a lip atop each of its sides, said lips retaining said inserts in their respective channels; each said groove has a semi-circular cross section; said treads in each said groove are formed transverse the circumference of said sheave; and, in which, the tractive effort capable of being developed increases as the surface area of said treads increases in relation to the area of said voids.

7. A multi-groove driving sheave according to claim 6 in which each said insert is polyurethane.

8. A multi-groove driving sheave according to claim 2 in which each said elastomer insert is seated tightly within its respective channel and is substantially immovable in relation thereto; each said groove has a semi-circular cross-section and supports one of said hoisting ropes as it passes over said sheave; said treads in each said groove are formed transverse the circumference of said sheave; the cross-sectional diameter of each said groove is substantially equal to that of the rope it supports, whereby pressure exerted by said ropes on the treads in said grooves deflects them causing them to exert pressure on

said ropes in a direction substantially perpendicular to the radius of said sheave; said treads also deflecting to minimize any differences between the tensions in said ropes; and, in which, the tractive effort capable of being developed by said sheave increases as the surface area of said treads increases in relation to the area of said voids.

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