Sept. 17, 1968 G. P. HURST 3,401,924

WIRE ROPE CONNECTOR AND KILN DRIVE STRUCTURE

Filed April 14, 1967 4 Sheets-Sheet 1

FIG. 2

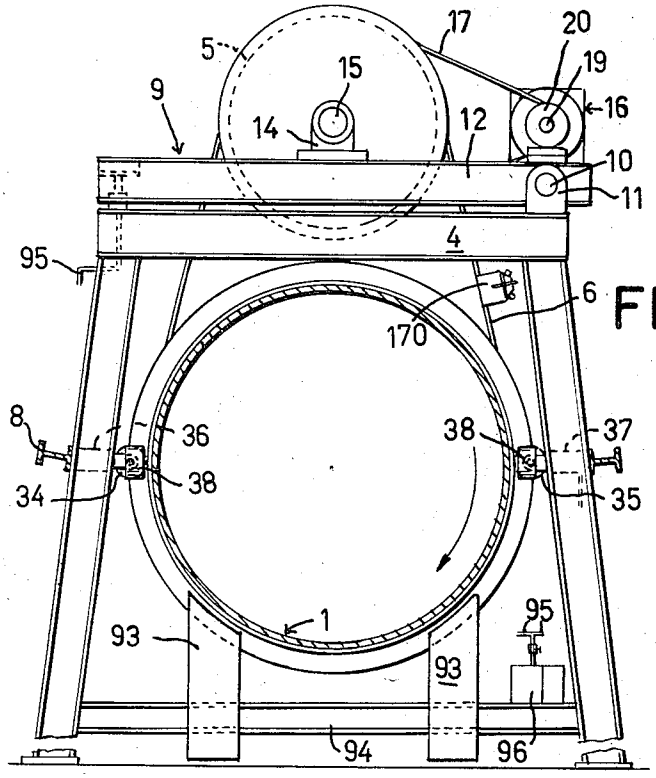


FIG. 3

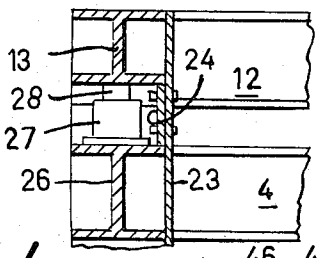


FIG. 4

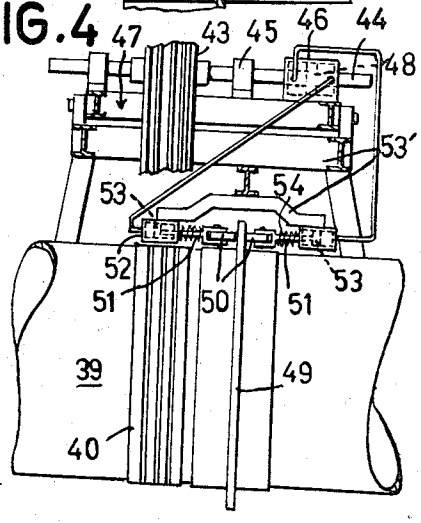
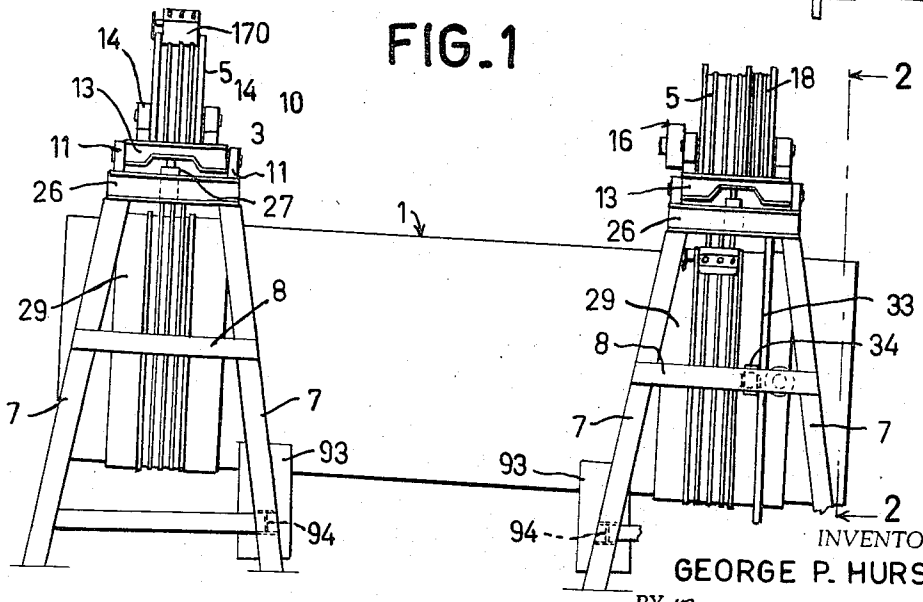


FIG. 1



INVENTOR.
GEORGE P. HURST
BY Boyken, Mohler, Foster & Schlemmer

Sept. 17, 1968 G. P. HURST 3,401,924

WIRE ROPE CONNECTOR AND KILN DRIVE STRUCTURE

Filed April 14, 1967 4 Sheets-Sheet 2

FIG. 5

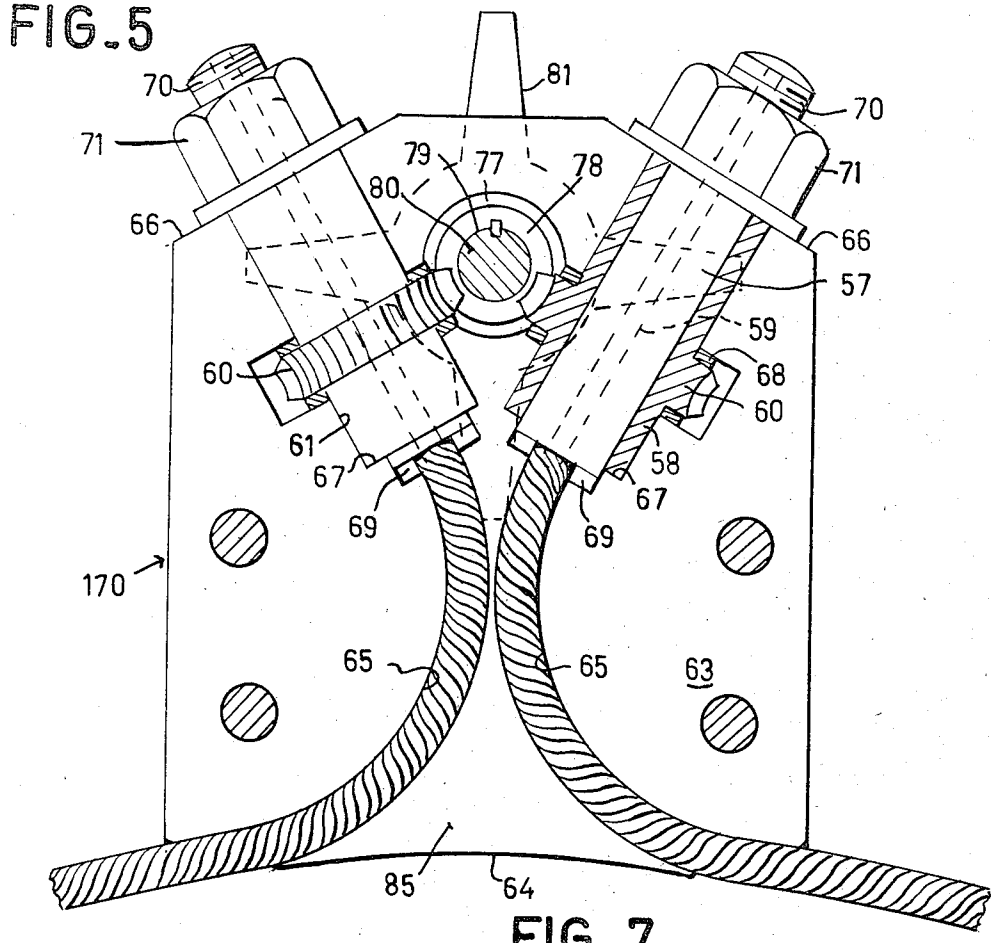


FIG. 7

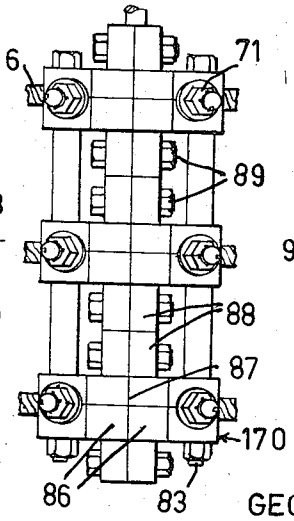


FIG. 8

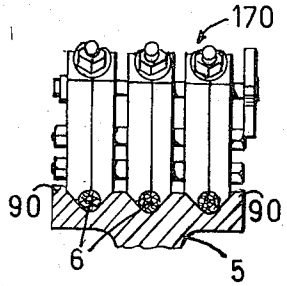
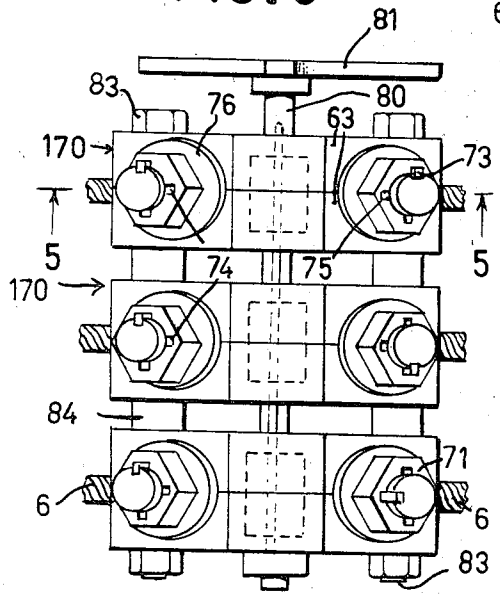


FIG. 6



INVENTOR.
GEORGE P. HURST
BY Boyken, Mohler, Foster & Schlemmer

Sept. 17, 1968 G. P. HURST 3,401,924

WIRE ROPE CONNECTOR AND KILN DRIVE STRUCTURE

Filed April 14, 1967 4 Sheets-Sheet 3

FIG. 9

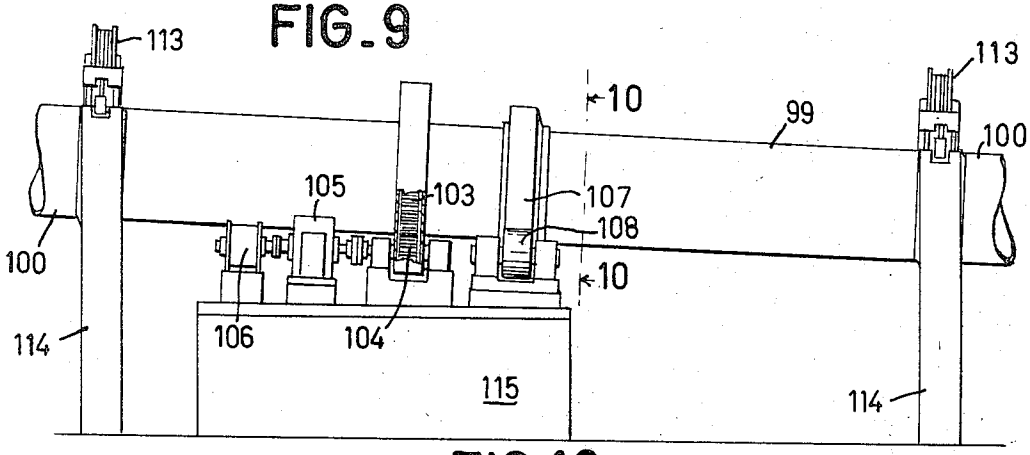


FIG. 12

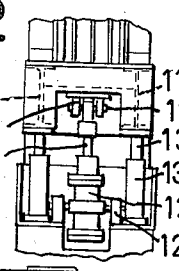


FIG. 10

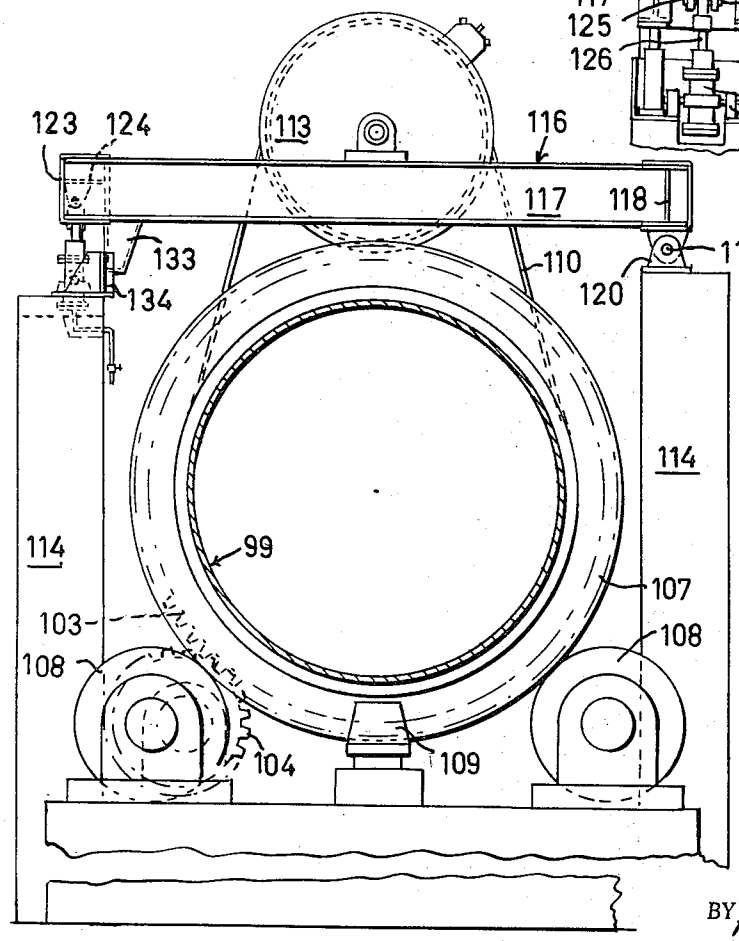
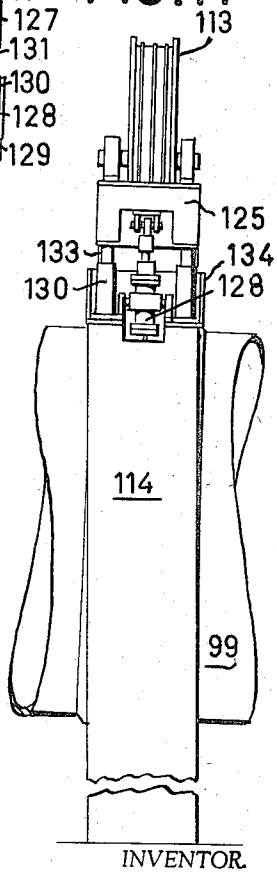


FIG. 11



INVENTOR.
GEORGE P. HURST
BY Boyken, Mohler, Foster & Schlemmer

Sept. 17, 1968 G. P. HURST 3,401,924

WIRE ROPE CONNECTOR AND KILN DRIVE STRUCTURE

Filed April 14, 1967 4 Sheets-Sheet 4

FIG. 15

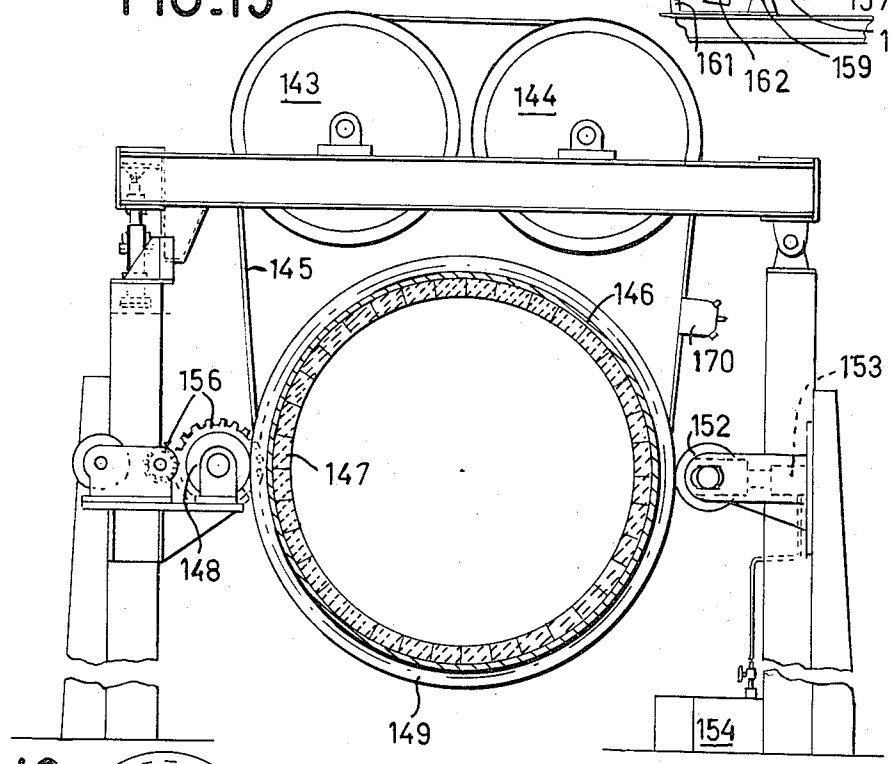


FIG. 17

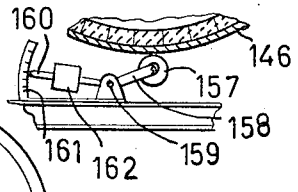


FIG. 18

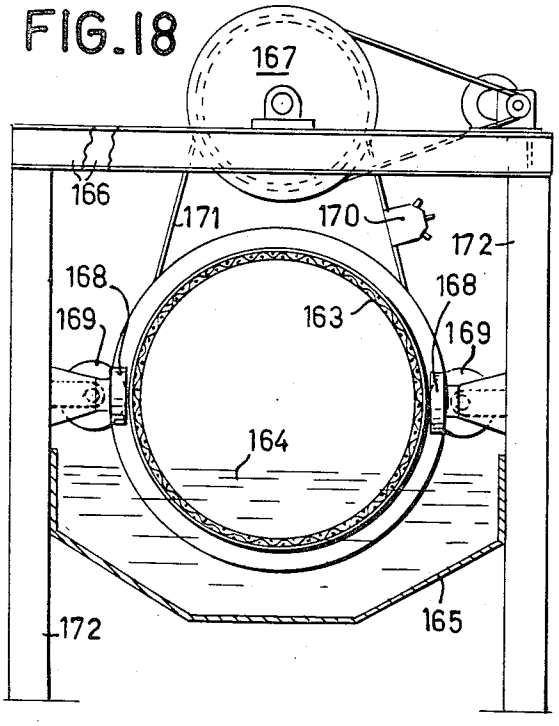


FIG. 16

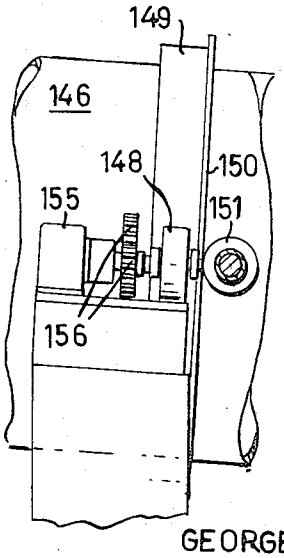


FIG. 13

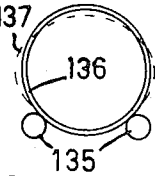
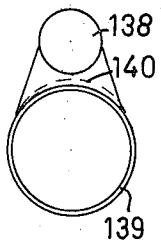


FIG. 14



INVENTOR.
GEORGE P. HURST
BY Boykin, Mohler, Foster & Schlemmer

United States Patent Office 3,401,924
Patented Sept. 17, 1968

3,401,924

WIRE ROPE CONNECTOR AND KILN DRIVE STRUCTURE

George P. Hurst, 719 Northampton Ave., Palo Alto, Calif. 94303

Filed Apr. 14, 1967, Ser. No. 636,233
16 Claims. (Cl. 263—33)

ABSTRACT OF THE DISCLOSURE

A rotary, generally horizontally extending dryer, kiln, trommel, ball mill, or the like, suspended by sets of wire ropes from overhead sheaves for rotation about an axis that is inclined relative to horizontal for passage of material therethrough or for processing material.

Background of invention

In my U.S. Letters Patent No. 3,097,834 of July 16, 1963, an inclined rotary kiln or dryer is shown suspended from sets of wire ropes, and the wire rope connectors shown and described in said patents are similar to those hereinafter described.

In actual installations, the balancing of the tension of the individual ropes of a set having their ends connected by a single connector is important, both upon the installation of the apparatus, and periodically during operation thereof.

Heretofore the difficulty of connecting the ends of each rope, while maintaining the advantages of the connectors shown in the aforesaid patent, has been a problem, and inasmuch as all of the exterior or exposed twisted wires of each rope engage the supporting sheaves and tubular dryer, or kiln, many times during a single revolution of the dryer, and always on the same side of the rope, the detrimental wear on the rope is greater than the wear intermittently distributed to all sides of the rope.

The difficulty of connecting the ends of each rope to a connector and having the tension on each rope, under the load of the kiln or dryer, substantially uniform after the connection has been a problem.

While a rope-suspended kiln does not develop the ovality developed where the kiln is supported on rollers, nevertheless there is some ovality, and consequent disintegration of the firebrick, where the sets of ropes extend over single sheaves.

In some instances, in actual practice, the wire rope connectors tend to be cocked at an angle relative to the lengths of the ropes.

Summary

The wire rope connectors of the present invention include means enabling the quick tightening and loosening of the individual ropes so as to uniformly distribute the load among the ropes of each set, while maintaining the benefits of the connector described in my above-noted prior patent, and also means is provided on each connector for intermittently rotating each wire rope to distribute the wear.

By extending the wire ropes divergently upwardly to the overhead sheaves, the ovality developed in a kiln is almost eliminated, and by centrally anchoring an inclined kiln on rollers and suspending the portion of the kiln at opposite sides of the central portion the problem of linear expansion and contraction of a kiln and the resultant detrimental wear on conventional kiln supporting rollers is substantially solved while maintaining the conventional gear-pinion driving arrangement.

By the present invention the rope connectors are constructed to enable assembling portions of the connectors on opposite ends of each rope before extending the ropes around the dryer or kiln, and then bolting the portions together, whereby uniformity in the lengths of the ropes extending between the connectors can be maintained.

Also the present invention provides improved means for more efficiently supporting a kiln or dryer to compensate for distortion and which supporting means also provides for releasing the kiln or dryer for removing and replacing the wire ropes.

Other improvements and advantages will appear in the description and drawings.

Description of drawings

In the drawings, FIG. 1 is a side-elevational view of a single section dryer.

FIG. 2 is a slightly enlarged cross-sectional view taken along line **2—2** of FIG. 1.

FIG. 3 is an enlarged fragmentary cross-sectional view taken generally along line **3—3** of FIG. 1.

FIG. 4 is a fragmentary side-elevational view showing a modification of the supporting structure of FIG. 1, parts of the structural being broken away for clarity.

FIG. 5 is an enlarged cross-sectional view of one of the rope connectors taken along line **5—5** of FIG. 6.

FIG. 6 is a top plan view of the rope connector for a set of ropes.

FIG. 7 is a reduced size top plan view of a connector for a set of ropes similar to the set shown in FIG. 6, but eliminating the means for turning the ropes.

FIG. 8 is a reduced size side-elevational view of the connector of FIG. 7 in position passing over a sheave, the latter being in cross section, as are the wire ropes.

FIG. 9 is a side-elevational view of the central section of a kiln or dryer of a plurality of sections, showing a modified type of driving means and a support in combination with a dryer suspended in inclined position from wire ropes.

FIG. 10 is an enlarged cross-sectional view taken along line **10—10** of FIG. 9.

FIG. 11 is a side-elevational view of the portion of FIG. 9 for suspending the dryer or kiln from the wire ropes, as seen at a right angle from the view in FIGS. 9 and 10.

FIG. 12 is an enlarged fragmentary elevational view of a portion shown in FIG. 11.

FIG. 13 is a semi-schematic view illustrating ovality in a conventional roller-supported kiln.

FIG. 14 is a semi-schematic view illustrating ovality in a single overhead sheave and wire rope support.

FIG. 15 is a cross-sectional view through a kiln showing a structure for substantially eliminating ovality.

FIG. 16 is a fragmentary side-elevational view of the drive means of FIG. 15.

FIG. 17 is a cross-sectional view through an inclined trommel, illustrating the present invention.

FIG. 18 is a vertical cross-sectional view taken through a trommel showing the application of the invention thereto.

In detail, referring to FIG. 1, a horizontally elongated tube generally designated **1** is shown which, in itself, may constitute a dryer (exclusive of burners, feed devices, etc.) or it may constitute one of a plurality of similar aligned and connected sections of a kiln or dryer.

The word "tube" as used herein, includes any generally horizontally disposed rotary tubular member through which material is moved or within which it is processed, such as a kiln, rotary dryer, trommel, etc. and it may include flights or lifters in the case of dryers or mixers, with which this invention is not concerned.

Tube **1** is inclined relative to horizontal for generally downward movement of material therethrough from the upper to the lower end, and in the case of a cement kiln, it includes a liner of firebrick.

Uprights, generally designated **2**, in pairs spaced longitudinally of the tube with the uprights of each pair at opposite sides of the tube provide the legs of an inverted U-shaped frame straddling the tube and a pair of horizontally extending parallel beams **4** in spaced side-by-side relation above the tube connect the upper ends of the uprights **2** and provide the closed upper end of the inverted U-frame.

A sheave **5** is supported on said beams **4**, as will later be described more in detail, and wire ropes **6** connected at their ends to form loops, extend over each sheave and around the tube therebelow for rotatably supporting the latter for rotation.

It should be noted that the supporting frames comprising uprights **2** and beams **4**, are not connected with each other in the direction of the length of the tube, which is important in the case of a kiln, to prevent transfer of heat from one frame to the other through connections between them.

Each upright **2** includes a pair of convergently upwardly extending members **7** (FIG. 1), and horizontally extending vertically spaced side frame members **8** connect corresponding members **7** of each upright.

A horizontal sheave-supporting platform, generally designated **9**, (FIG. 2) is pivotally connected by a hinge pin **10** (FIG. 1, 2) with upstanding ears **11** that are rigid on one of the ends of beams **4**. Said platform itself may comprise a pair of horizontally elongated supports **12** that are connected at the end opposite to pin **10** by a cross piece **13** (FIGS. 1, 3).

The right-hand inverted U-frame, as viewed in FIG. 1, shows an hydraulic motor **16** (FIG. 2) supported thereon, and any suitable drive connection **17** may connect a sprocket **18** (FIG. 1) that is rigid with sheave **5**, with motor **16**, which motor includes a drive shaft **19** (FIG. 2) driven thereby. The chain **17** extends over the sprocket **20** that, in turn, is secured on shaft **19**.

A vertical guide plate **23** (FIG. 3) is adjacent to the end piece **13** and is rigid with the latter. This plate depends to movably fit between the ends of beam **4** that are adjacent thereto so as to cooperate with the hinged end to prevent twisting of the platform **9** relative to the beams **4**, and to thereby hold the platform **9** and sheave **5** so that the axis of rotation of the sheave is parallel with the axis of rotation of the sheave tube **1** as the platform is pivoted about pin **10**.

A plate **24** is removably bolted to plate **23**, and the lower edge of said plate **24** is adapted to extend over and engage a connector **26** connecting the upper ends of the members **7** of each leg of frame **3**. Said connector **26** supports a vertically disposed hydraulic cylinder of a hydraulic jack **27** (FIG. 3), which jack includes vertically reciprocable piston rod **28** that, in turn, is adapted to engage the cross piece **13** thereover. The hydraulic motor **16** is preferably carried on platform **9** over hinge pin **10**; hence its weight is balanced insofar as any weight on rod **10** is concerned. The said plate **24** constitutes a stop member limiting downward movement of the platform **9** about pivot **10**, and it also carries a portion of the load on the platform as will later be explained.

The sheave **5** on each platform **9** is grooved for receiving the wire ropes **6**, and normally a plurality of such ropes is required. Three are shown in the drawings.

The tube **1**, below each sheave **3**, has a band **29** (FIG. 1) secured thereto, each band being formed with annular radially outwardly opening grooves also adapted to receive the wire ropes **6**. In effect, band **29** may be integral with the tube and constitute a thickened portion thereof.

The tube **1**, as already explained, is inclined relative to horizontal, and the platforms **9** are also inclined so that the wire ropes and the grooves in each sheave and in the band **29** will be coplanar. Swinging the platforms **9** will not change the coplanar relationship between the ropes and grooves in which they are received.

In FIG. 1, the right-hand band **29** of the pair thereof,

includes a radially outwardly projecting flange **33**. At one of the sides of this flange and positioned at opposite lateral sides of the tube are rollers **34**, **35** (FIG. 2) carried by brackets **36**, **37** on frame members **8**. The treads of these rollers are in engagement with the band **29** at one side of flange **33** (FIG. 1) and their axes are parallel with the axis of the tube **1**. Rollers **34**, **35** may be spring-urged within brackets **36**, **37**, which brackets are telescopic for yieldable engagement of the rollers with band **29**. If the tube is deformed, one or the other of the rollers **34**, **35** will yield to compensate for the deformity, and also contact will be maintained between the rollers **34**, **35** and tube as the center of gravity of the load may shift laterally.

At the opposite side of flange **33** from the rollers **35**, **36** are rollers **38**, carried by each frame **3** and are supported for rotation about horizontal axes, the treads of the rollers **38** engaging the flange **33** at the downhill side of the latter and are therefore thrust rollers (FIG. 1).

These thrust rollers, and their positions at opposite lateral sides of the flange **33** insures against any likelihood of injury to the rollers or loss of contact with the flange **33** in the event of substantial changes in the height of the tube. The changes in contact between the thrust rollers and the flange **33** will be at points circumferentially of the flange, instead of at points across the width of the flange, as would occur were a thrust roller below the tube.

In a kiln, the tube **39** shown in FIG. 4 is at the hottest end portion of the kiln where the contraction of the tube upon cooling is sufficient to noticeably move the rope receiving band **40** on the tube a substantial distance axially of the tube. In this situation, the sheaves **43** and ropes **40** may be the same as described for FIG. 1 but shaft **44** supporting each sheave is floatingly supported in bearings **45** for movement axially of the bearings, and one end of said shaft extends through an hydraulic cylinder **46** that is stationary on platform **47** that corresponds to platform **9**. Piston **48** in cylinder **46** is intermediate the ends of the cylinder.

A flange **49** similar to flange **33** is adjacent to or may be part of band **40**, and a pair of opposedly positioned rollers **50** rotatably engage opposite sides of the flange **49**, which rollers are carried on coaxial shafts or piston rods **51**, that, in turn, slidably extend through a pair of hydraulic cylinders **52**. Each of the latter corresponds to cylinder **46** and a piston **53** on each rod **51** is positioned within each cylinder **52** intermediate its ends. Cylinders **52** may also be supported stationary on a frame member **53'**, and rods **51** are supported by any suitable means against rotation, while springs **54** around each shaft **50** reacting between each cylinder head and the adjacent outer end of each shaft **51** may function to maintain the rollers **50** in engagement with opposite sides of flange **49**. A closed hydraulic circuit in lines **55** connect with opposite ends of each of the cylinders **46**, **52** whereby any movement of the flange **47** in either opposite direction will effect the same movement of shaft **44** and sheave **43** thereon. By this arrangement, the sheave **43** over each band **40** will automatically remain over the band irrespective of changes in the position of the band axially of the tube **39**.

One of the highly important features in the present invention is the provision of means for equalizing the tension in the wire ropes of each set.

FIGS. 5, 6, 7, 8 clearly show the connector for the ends of each rope in a group thereof. Three ropes are illustrated in each set. Obviously, there may be only two, or more than three. The opposite ends of each rope **6** are rigidly secured within a ferrule **57** that, in turn is connected with a sleeve **58** by a spline **59** on said sleeve that extends into a complementary formed groove in the ferrule. A spiral gear **60** is integral with or rigid on each sleeve **58**, and sleeves **58** on the ends of each wire rope are rotatably held within complementarily formed recesses **61** within the opposed faces of a pair of plates **63**, which recesses receive sleeves **58** and gears **60**.

One of the corresponding edges **64** of each pair of plates is curved, both linearly and in cross section to correspond to the linear and cross-sectional curvature of the groove in sheave **5** in which the wire rope **6** is received, and arcuately extending complementarily formed recesses **65** in plates **63** of each pair extend from the opposite ends of the curved edges **64** toward each other and away from said edges **64** to points adjacent to the center of the pair of plates where they connect with one of the ends of recesses **61**. The latter then extend straight and divergently outwardly relative to each other to the ends of the plates **63** of each pair that are opposite to the edge **64**. The recesses **61** open outwardly of the pair of plates **63** at their ends that are remote from the recesses **65**, and the outer surfaces **66** through which said recesses **61** open are perpendicular to the longitudinal axes of recesses **61**.

Each recess **61** includes one enlarged portion **67** for each spiral gear and for thrust washers **68** at opposite sides of each gear. When the sleeves **58** are in recesses **61**, the sides of said recesses provide bearing surfaces for rotatably holding said sleeves in the same divergently extending relationship as the recesses **61**.

The outer ends of the sleeves **58** may terminate approximately flush with the surfaces **66** and the inner ends of the sleeves may be against shoulders **67** in recesses **61** and the recesses **61** at their junctures with recesses **65** provide a space **69** for axial movement of the ferrule **57**.

The outer end of each ferrule **57** projects outwardly of each sleeve **58** and surfaces **66** and is externally threaded at **70** for threaded engagement with a nut **71**. A groove **73** in the ferrule for spline **59** extends to the outer end of the ferrule, and the nut **70** may be formed with a plurality of keyways **74** (FIG. 6), each of which is adapted to register with the groove **73** in ferrule **57** so that a key **75** in one of the keyways **74** in each nut **70** and in groove **73** will lock the nut **70** against rotation relative to the ferrule. A washer **76** is positioned between each nut **70**, and the adjacent surface **66**.

Recesses **67** for spiral gears **60** open into a central recess **77** within which is a worm gear **78** in mesh with the teeth of the spiral gears **60**. Coaxial openings **79** open into the complementarily formed recesses **77** for a shaft **80** and the sides of said openings may provide bearing surfaces for said shaft.

A star wheel **81** is secured on one end of shaft **80** for rotating the latter, and for thereby rotating the worm **78** to rotate the spiral gears **60**, and consequently the wire rope **6**, the two gears **60** moving in unison to apply equal torque in the same direction to the ends of the rope so as not to apply a winding or unwinding tension on the strands of the rope.

FIG. 6 shows a plurality of pairs of plates **63** bolted together by bolts **83** as a unit with spacers **84** between the adjacent pairs of plates so that the wire ropes **6** will be in the same planes as the grooves in the sheave and in the band **29** on tube **1**. Between the openings formed by recesses **65** at the end of the edge **64** of each pair of plates is a bridge piece **85** that will smoothly engage the sheave upon rotation of the latter as the rope connector moves around the sheave. Inasmuch as the diameter of the tube is much greater than that of the sheave, the problem of moving the connected ends of each rope around the tube free from pounding or other objection is negligible.

It is to be understood that the connector for the wire ropes is sufficiently wide in a direction axially of the tube and sheave, and the sheave is also sufficiently wide, so that each connector will prevent twisting of the wire ropes together.

FIG. 7 shows a modification of the connector of FIGS. 5, 6, in that the plates **86** that correspond to plates **63** are split along a line **87**, and flanges **88** are formed along line **87** that project oppositely outwardly from each pair of plates. Bolts **89** connect the flanges. In many instances the structure of FIG. 7 is preferable to the structure shown in FIGS. 5, 6 for the reason that the ends of the wire ropes **6** may be separately clamped on the halves at opposite sides of the line of split **87** and thereafter the bolts **88** may clamp each assembly together to hold the worm **78** and shaft **80** in position extending across the line of split **87**. Sheaves **5** may be formed with radially outwardly opening grooves **90** (FIG. 8) having divergently outwardly inclined sides while the connector plates **63** have complementarily formed V-surfaces that engage the slanted sides of the grooves **94** as the connectors move around the sheaves, that function to prevent the connectors of each set from cocking to one side or the other during operation of the dryer, whereby the connectors are maintained square with the ropes, thus preventing injury to the latter.

In operation, in installing the wire ropes, the tube **1** may be supported on chocks **93** (FIGS. 1, 2) that straddle cross member **94** and that are slidable toward and away from each other to and from tube supporting positions. These chocks may be manually positioned to support the tubes at a sufficient distance from the sheaves to enable the ropes to be brought around the sheaves and each tube so as to connect the ends by the connectors. The hydraulic jacks **27** may be actuated to elevate the tube for the chocks, said jacks being connected by hydraulic lines **95** (FIG. 2) to a source of liquid **96** under pressure for actuating the jacks. After the connectors connect the ends of the ropes, the tube may be elevated again, and the chocks removed to suspend the tube from the ropes, and thereafter the tension on the ropes may be equalized by rotating the nuts **71**. The nuts may then be locked by keys **73**.

The advantage of using the structure of FIG. 7 for the connectors is that the latter may be secured on the ends of each wire rope in the shop and the bolting together of the connector sections may be done at the site and when the ropes are around each tube and sheave is easier than attempting to insert the ferrules and rope ends in the connector at the site, for the reason that the wire rope is quite stiff and resists bending a small section such as is enclosed within the connector.

In operation, the line pressure to each jack **27** may be such that the jack will take by far the major portion of the load of the tube, or approximately 80 percent, as an example, and the plate **24** may take the balance. This structure is of particular importance in a kiln having a plurality of supports, where a "dog leg" or distortion may occur in one or more tubes as will later appear.

The plate **23** (FIG. 3) fits between the ends of beams **4** to prevent platform **9** from twisting or moving in a manner to move the axis of rotation of the sheave **5** on platform **9** out of parallel with the axis of the tube **1**.

FIG. 9 is a modification of FIG. 2 in that a central section **99** of a longer dryer or kiln is shown with tubular sections **100** connected with the ends of section **99**. In a kiln there may be many more sections.

In existing kilns, or in new installations, it may be desirable to retain the conventional gear-pinion drive, instead of driving one or more of the sheaves, in which case the central section **99** has a gear **103** secured thereon, the teeth of which are in mesh with the teeth of a pinion **104** that, in turn, is connected through a transmission **105** with a motor **106** (FIG. 9) for driving the tube **99** and the rest of the kiln. In FIG. 9 a gear housing is indicated, but is broken away to show the gears.

A tire **107** around section **99**, adjacent to the gear **103**, is supported on conventional rollers **108**, and a thrust roller **109** (FIG. 10) engages the downhill side of the tire **107** to maintain the kiln inclined, while the portions of the kiln extending away from the tire are suspended by wire ropes **110** extending over sheaves **113**. Ropes **110** and sheaves **113** correspond to ropes **6** and sheaves **5**, and the structure of FIG. 4 may be employed on the tube sections at the firing end of the kiln or wherever the expansion is such that the sheaves should move with the tube.

By employing the rollers **108** and **109** for supporting the kiln at a point intermediate its ends and using ropes

and sheaves to suspend the remaining tube sections, including the yieldable hydraulic or other supports for the sheaves, the advantages of the rope suspension are combined with the conventional driving means to effect power economy in operating the kiln, and to lower the high cost of installing and maintaining tube supporting rollers. Furthermore, by the rope suspension the misalignment of the tube sections is readily corrected by tightening or loosening the wire ropes at the connectors, or at the platforms for the sheaves.

In FIGS. 9, 10, concrete posts **114** are in pairs respectively at opposite sides of the tube and take the place of the structural steel uprights **2**. The driving assembly and rollers **108** may be supported on a concrete base **115** between adjacent pairs of said posts.

In this structure the beams **4** may be omitted, and each sheave **113** is supported on a platform generally designated **116** that generally corresponds to platform **9**, having a pair of parallel, spaced horizontally disposed frame members **117** connected at one of their corresponding ends by a frame member **118** (FIG. 10) that, in turn, is pivotally connected by a shaft **119** (FIG. 10) with ears **120** secured on the upper end of one of the posts **114**. This shaft corresponds in function to hinge pin **10**.

The opposite ends of members **117** are connected by an end plate **123** and by a horizontally disposed plate **124** that, in turn, carries a pair of depending ears **125** (FIG. 12) between which the upper end of a piston rod **126** extends, and which upper end is pivotally connected with ears **125** by a pin **127**.

Piston rod **126** extends upwardly from a plunger in a hydraulic cylinder **128**, in the conventional way, the latter being pivotally supported by bearings **129** on the upper ends of posts **114**. This hydraulic cylinder functions for the same purpose as the cylinder **127**, namely; to elevate each platform **116** and sheave **113** and to support the major portion of the weight of the tube when the latter is in use.

At opposite sides of each cylinder **128** are screw jacks **130**. These jacks **130** may take the place of the chocks **93**, and they are also adapted to either tension or loosen each set of ropes **110**, as a group, by elevating or lowering platform **116** about shaft **119**. Said jacks are supported on the upper ends of posts **114** and their screws **131** engage the platform **116** below the ends of the frame members **117** thereof that are opposite to the pivotally supported ends.

A box-like guide and positioning element **133** (FIG. 10) is rigid with the platform **116** and is adapted to extend between a pair of guide plates **134** that are rigid with post **114**. This guide element and the guide plates perform the same function as plate **23** and beams **4** in FIG. 3, namely, to prevent misalignment of the axis of the sheave on platform **116** relative to the axis of the tube while permitting vertical movement of the platform **116** about pivot **119**.

In operation, the screw jacks will take say 20 percent of the weight of the tube and contents at each sheave and the balance will be yieldably held by the hydraulic cylinder, the hydraulic system including a conventional surge tank to enable the hydraulic cylinder to carry say 80 percent of the load in the event of a radial distortion in the kiln, such as a "dog leg," during upward movement of distorted portion of the tube as the latter rotates, instead of all the weight being taken by the sheaves at the sets of posts adjacent to the distorted portion.

To replace or install ropes, the screw jacks may be lowered and the hydraulic pressure in the cylinder released until sufficient slack occurs to make a rope replacement, after which the jacks may again elevate the tube and the hydraulic cylinder again actuated to take the desired amount of the load.

FIGS. 13, 14 diagrammatically illustrate the occurrence of ovality in a kiln. In FIG. 13 a pair of conventional tube supporting rollers **135** support the tube **136** for rotation, and the tube will slightly flatten vertically as indicated by broken lines **137**.

Where the kiln is suspended from a single sheave **138** (FIG. 14) the sides will be slightly flattened so the tube **139** will be vertically elongated in cross-sectional contour as indicated by dotted lines **140**.

By employment of two overhead sheaves **143, 144** (FIG. 15) so that the ropes **145** extend slightly divergently upwardly to the outermost lateral sides of the pair of sheaves, the objection of ovality is overcome.

The only difference between the sheave supporting structure in FIG. 15 and that of FIG. 10 is that the horizontally extending platform for the sheaves is longer so two sheaves instead of one can be supported thereon, hence the same numerals will be applied to the corresponding elements, and the detailed description will not be repeated.

In FIG. 15 the tube **146** is shown as being lined with firebrick or the like **147**. The ovality that occurs in the kiln results in breaking or disintegrating of these bricks at their radially inner corners relative to the axis of the tube until they finally fall into the kiln to not only contaminate the material in the kiln, but the kiln must be closed down to repair it. This emphasizes the importance of the double sheaves in installations where the ovalling of the kiln is a problem.

Also, in FIG. 15 there is shown a modification of the driving means for the kiln that differs from driving the sheaves or driving the kiln by a gear and pinion connection.

In FIGS. 15, 16, a friction roller **148** at one side of the kiln is in frictional engagement with a tire **149** on the tube **146**, which tire includes a flange **150** (FIG. 16) that is engaged by thrust rollers **151** at opposite sides of the tube **146** to maintain the inclination of the tube. These thrust rollers correspond to rollers **38** of FIGS. 1, 2 in function, structure and position.

The tube **146** is yieldably held tight against roller **148** by a roller **152** (FIG. 15) that is hydraulically actuated by cylinder **153** that, in turn, is connected by a hydraulic line with a source of hydraulic pressure **154**.

The drive roller **148** is driven by a motor **155** through a gear box and gear-pinion assembly **156** (FIG. 15).

FIG. 17 shows a sag detector that may be mounted at various points below the tube **146** along its length, which detector includes a roller **157** on one end of an arm **158** pivoted at **159** intermediate its length, while the end portion **160** of the arm opposite to roller **157** at its outer end scans a segment **161** having graduations thereon extending above and below a zero graduation.

A weight **162** on portion **160** or any other suitable means maintains the roller **157** in contact with the lowermost side of the tube, the axis of the roller **157** and pivot **159** being substantially parallel with the axis of the tube. Any sagging or distortion of the tube from normal will be indicated at once, and the hydraulic piston may be actuated to elevate the overhead sheaves if the sagging is due to stretch in the ropes, or the ropes may be tightened by actuation of nuts **71** on the connectors.

FIG. 18 illustrates the invention as applied to a trommel, in which the tube **163** is of perforated metal or a screen partially submerged in water **164** in a tank **165**.

A pair of parallel horizontally extending overhead beams **166** support each of the sheaves **167**, there being a sheave at each end of the trommel over which the ropes extend, while thrust rollers **168** maintain the trommel inclined, and side rollers **169** center the trommel on the tank by the same structure and arrangement shown in FIG. 1.

The rope connector **170** on ropes **171** may be the same as in FIGS. 5–8, and this same connector is used in all of the forms of the invention, although it is to be understood that the worm and gear drive to rotate the ropes may be omitted where the wear factor is of minor impor-

tance. However, the provision for individual tensioning or loosening of the ropes is in all connectors.

By the structure of FIG. 18 the many disadvantages of having rollers and the like below the level of the water and where subjected to excessive wear from grit, gravel, etc., are overcome. The replacement cost of wire ropes, including material, is relatively low as compared with replacement of tube supporting rollers, and in any event, the wear on the wire ropes is relatively slight compared to the wear on rollers.

Where trommels are used, the overhead supporting structure may be rigid on posts **172** as seen in FIG. 18, although structure similar to that of FIGS. 2 or 10 may be employed.

I claim:

1. In a combination that includes a horizontally elongated tube for carrying material therein for processing, a plurality of sheaves spaced along and supported over said tube for rotation about an axis substantially parallel with the longitudinal axis of said tube, a plurality of groups of wire ropes in planes substantially perpendicular to said axis respectively extending around said tube and sheaves suspending said tube from said sheaves for rotation of said tube with said sheaves, each of said ropes terminating in opposite end portions offset outwardly relative to said tube and sheaves, the improvement comprising:

(a) a rigid connector connecting said opposite end portions of the ropes of each group;

(b) rope holding means respectively on the end portions of the ropes of each pair and on said connectors for holding said end portions to said connectors, and

(c) rope tensioning means respectively on, and movable relative to, at least one of said rope holding means on each rope adapted to react against the connector for tensioning each rope in each group independently of each other to balance the tension on the ropes of each group, and

(d) means for rotating said sheaves and tube.

2. In the combination as defined in claim **1**:

(e) each connector comprising a plurality of plates in opposed relation, and complementary recesses formed in the opposed sides of the plates of each pair in which the end portions of the ropes of each pair are positioned when the plates of each pair thereof are secured together;

(f) said holding means including a member respectively rigid with the end portions of each rope positioned in the recesses in each pair of opposed plates and said one of said members having a threaded portion projecting from said recess and connector and said tensioning means comprising a nut on said threaded portion adapted to engage and react against the connector upon rotation of said nut in one direction to move said member axially of the end portion of each rope for said tensioning of the latter.

3. In the combination as defined in claim **1**:

(e) said end portions of each rope being generally in side-by-side relation in each connector, and

(f) each connector being divided into a pair of halves along a plane disposed between the end portions of each rope whereby each half of said connector is secured to one of the end portions of each pair, and means for releasably securing the halves of each connector together.

4. In the combination as defined in claim **1**:

(e) the rope holding means in the end portions of the ropes of each pair being rigid on said end portions and rotatable within each connector, and

(f) means within each connector connected with each of said holding means and accessible from outside each connector for rotating the holding means on each rope relative to the connector to rotate each rope to different positions and for holding each rope in each of such positions.

5. In the combination as defined in claim **1**:

(e) connector aligning means respectively on each sheave extending therearound, and on each connector, movable into engagement with each other upon movement of said connector around said sheaves during rotation of the latter for holding each connector and said end portions of said ropes in alignment with a line parallel with the axis of rotation of said sheaves.

6. In a structure as defined in claim **1**:

(e) rope rotating means on each connector operably connected with the opposite ends of each rope for rotating each rope about its longitudinally extending axis for changing the surfaces of said ropes that are adapted to engage said sheaves during rotation of said sheaves and tube.

7. In the combination as defined in claim **1**:

(e) said plurality of sheaves being in one row extending axially of said tube;

(f) a second row of sheaves corresponding to those in said first row with the sheaves of said second row being alongside the respective sheaves in said one row and rotatable about an axis parallel with the axis of rotation of the sheaves of said one row;

(g) each of said groups of ropes extending from the sheaves of said first row over the sheaves of said second row, and the lengths of said ropes of said groups between the sheaves of said rows and said tube extending approximately vertically past the sides of said tube for extending below the latter.

8. In the combination as defined in claim **7**:

(h) said lengths of said ropes extending from the sheaves of said rows past opposite sides of said tube extending convergently downwardly from the sheaves of said rows to said opposite sides.

9. In a construction as defined in claim **1**:

(e) said wire ropes being in a plurality of groups spaced longitudinally of said tube;

(f) a sheave for each group of ropes;

(g) means supporting the sheave for each group of ropes for movement from an upper position for carrying said tube to a lower position for slacking said ropes and vice versa;

(h) means movable for supporting said tube indedependently of said ropes when said means supporting each sheave is in said lower position to enable replacement of one or more ropes of each group.

10. In a construction as defined in claim **1**:

(e) a pair of rollers respectively at each of the opposite lateral sides of said tube supported in engagement with said opposite sides for rotation about axes parallel with the axis of rotation of said tube;

(f) yieldable means operatively connected with at least one of the rollers of said pair, yieldably urging the latter against said tube in a direction toward the other roller of said pair.

11. In a kiln and the like that includes a horizontally elongated tube, rotatable about its longitudinal axis:

(a) a plurality of pairs of overhead sheaves spaced above said tube at spaced intervals along said tube;

(b) means supporting each pair of said sheaves for rotation about axes parallel to said axis of rotation of said tube with the sheaves of each pair substantially equally spaced at opposite sides of a medial vertical plane in which the axis of said tube is disposed;

(c) a plurality of wire ropes in endless relation extending around said tube and each sheave suspending said tube from said sheaves for said rotation of said tube;

(d) each of said ropes extending over the sheaves of each pair being substantially in the same plane as that in which said sheaves are disposed and the portions of said ropes extending from said sheaves

to said tube being generally vertical for supporting said tube against ovalling during rotation of the latter.

12. In a combination that includes a horizontally elongated tubular kiln, tube, or the like, a plurality of sheaves spaced along and over said kiln for rotation about an axis substantially parallel with the longitudinal axis of said kiln, a plurality of groups of wire ropes disposed in planes substantially perpendicular to said axis respectively extending around said tube and sheaves suspending said tube from said sheaves for rotation of said tube with said sheaves, the improvement comprising:

(a) an overhead support for each sheave and one of said groups of ropes extending over each of said sheaves and rigid means at opposite sides of said kiln for supporting each overhead support above the ground and over said kiln;

(b) movable means on said rigid means in engagement with each overhead support actuatable for elevating and lowering the latter relative to the ground, and

(c) load supporting means on said rigid means for supporting said support stationary at different heights relative to the ground for taking a portion or all of the load of said kiln from said ropes upon actuating said movable means for lowering said overhead support, whereby said load may be divided between said ropes and said load supporting means or said load may be entirely taken by said load supporting means for slacking said ropes to expedite their replacement or installation.

13. In the combination as defined in claim **12**:

(d) said movable means including means yieldable under variations in the load at each sheave, and

(e) said overhead support comprising a member pivotally supported at one end for swinging of the opposite end vertically, and said movable means being in engagement with said opposite end, and said sheave being intermediate said one end and said opposite end of each member;

(f) said load supporting member being engageable with said member at said opposite end for supporting said support at said different heights.

14. In combination with a wire rope having opposite end portions.

(a) a connector for connecting said opposite end portions to provide a substantially endless rope structure adapted to pass over a sheave and to be held in a radially outwardly opening groove in the outer periphery of such sheave;

(b) said connector comprising a body having a pair of passageways therein and said end portions being disposed within said passageways;

(c) one of the ends of said passageways opening generally oppositely outwardly of said body for extension of the part of said rope that is between said end portions in substantially longitudinal alignment in directions longitudinally of said groove when said connector and the part so extending therefrom are at said sheave in a position moving around the latter;

(d) rope-holding means on the terminal ends of said rope for holding said end portions within said passageways and to said connectors;

(e) at least one of said end portions being slidable longitudinally thereof within the passageway in which it is positioned, and

(f) the rope-holding means on said one of said end portions including rope-tensioning means thereon movable relative thereto and to said connection for varying the length of the portion of the rope extending between said end portions whereby said last-mentioned portion may be tensioned or loosened, as desired.

15. In the combination as defined in claim **14**,

(g) said one of said rope-holding means comprising a ferrule rigidly secured to said wire rope, and said rope-tensioning means comprising a nut threaded onto said ferrule and in engagement with said body.

16. In the combination as defined in claim **14**,

(g) a rotary sheave over which said wire rope extends, having an annular radially outwardly opening groove in which said rope is positioned;

(h) a tube below said sheave around which said rope extends from said sheave for suspending said tube from said sheave for rotation of said tube upon rotation of said sheave, said tube having a radially outwardly opening groove in which said rope is positioned;

(i) means for supporting said sheave above the ground for suspending said tube therefrom with the axes of rotation of said sheave and tube parallel and for supporting said rope and the grooves in said sheave and tube in a common plane perpendicular to the axes of rotation of said sheave and tube;

(j) means supporting said sheave for movement axially thereof, and

(k) means responsive to axial movement of said tube at the grooves thereon under variations in temperature thereof operatively connected with said sheave for moving said sheave axially thereof to degrees corresponding to the degrees of said axial movement of said tube in the same direction as said last-mentioned axial movement to maintain said grooves and rope in a common plane upon such variations in temperature and movement of said tube.

References Cited

UNITED STATES PATENTS

3,097,834 7/1963 Hurst ---------- 263—33

JOHN J. CAMBY, *Acting Primary Examiner.*