

(12) **EUROPEAN PATENT APPLICATION**

(21) Application number: **84302163.5**

(51) Int. Cl. 4: **B 61 B 12/02**
B 61 B 12/06

(22) Date of filing: **29.03.84**

(30) Priority: **23.06.83 US 507142**

(43) Date of publication of application:
02.01.85 Bulletin 85/1

(84) Designated Contracting States:
AT CH DE FR IT LI SE

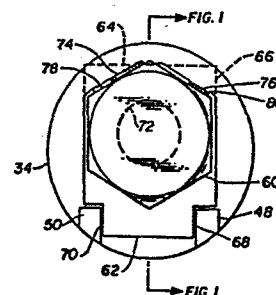
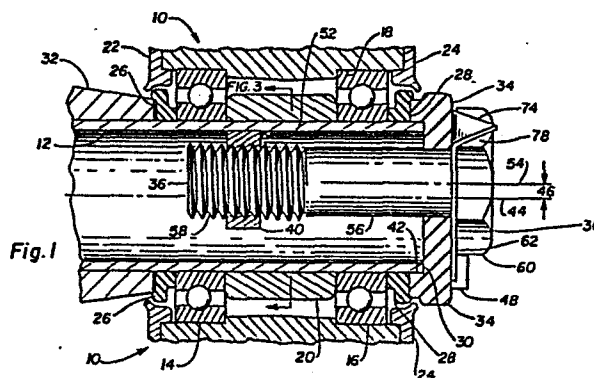
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(54) **Sheave retention apparatus and method.**

(57) The sheave retention apparatus of the present invention includes a cap (34) that fits over the end (30) of an axle (12) to retain a sheave (10) thereon. A bolt (36) fastens the cap to the axle. Cap (34) is disk shaped with a shoulder (42) that fits over end (30) of axle (12). When installed, bolt (36) passes through an off-center hold (38) in the cap and into a corresponding off-center nut (40) welded to the inner wall of the tubular axle. Rotation of cap (34) on axle (12) will bind the cap between the bolt and the axle to prevent unthreading of the bolt. Additionally, to resist unthreading under vibrational influences, a locking plate (62) that is clamped between the hexagonal head (60) of the bolt and the outer surface of the cap. The locking plate has two notched corners (68) and (70) that contact a portion of the cap to prevent rotation of the locking plate with respect to the cap, and has two square corners (64) and (66) that are bent up against the wrench flats of the bolt to prevent the bolt from rotating with respect to the locking plate.



TITLE: SHEAVE RETENTION APPARATUS AND METHOD

This application is a continuation-in-part application based upon prior copending application Serial No. 371,526 filed April 26, 1982, and entitled "Sheave Assembly and Method of Forming the Same."

The present invention relates, in general, to apparatus for retaining a member on an axle or the like, and more particularly, relates to apparatus for retaining a wheel or sheave assembly on an axle, including means to prevent removal of the sheave as a result of rotation and/or vibration.

Aerial tramways, such as chairlifts, gondolas, trams, and ski lifts are driven by an endless or reciprocating wire rope which is supported on a plurality of sheaves that in turn are usually supported from towers or similar structures. Each sheave is usually formed with a disc-like body having a peripheral groove in which the rope is supported. Typically, each sheave includes a hub with one or more ball or cylindrical bearing races. The bearings permit the sheave to freely rotate about a stationary axle.

There are several operational considerations with respect to the method of retaining a sheave or wheel on its axle. Since the main purpose of an aerial tramway is to transport skiers or other passengers, the failure to properly retain sheaves can lead to life threatening situations. Operational reliability is the primary consideration in the evaluation of retention methods. Although gangs of several sheaves are commonly utilized at each tower to minimize risk, the failure to retain a sheave could allow it to jam the other sheaves or to fall and injure skiers or passengers below. Vibrations caused by the sheaves and the wire rope motion tend to loosen commonly available threaded fasteners. The harsh operating environment

1 exposes the sheaves to conditions of water, ice, and
extremely cold temperatures. Replacement of sheaves
under all operating conditions must be accommodated
without endangering the safety of maintenance
5 personnel. In short, the sheaves must be reliably
retained but easily replaceable under the harsh
operating environment typically encountered.

Commonly used methods of retaining wheels on
axles may not be appropriate in this harsh operating
10 environment. One method using an externally threaded
axle and locking nut to retain the sheave would
experience corrosion problems on exposed threads and,
therefore, would not allow easy sheave replacement.
Other methods using adhesives to prevent threaded
15 fasteners from loosening would not operate reliably in
wet or cold weather. Fastener locking using removable
pins would suffer from corrosion and replaceability
problems and high manufacturing expense.

Accordingly, it is an object of the present
20 invention to provide a sheave retention apparatus and
method that is capable of reliably retaining a sheave
on an axle while facilitating removal for replacement.

Another object of the present invention is to
provide a sheave retention apparatus and method capable
25 of reliable operation under conditions of vibration,
rain, ice, and extremely cold temperatures.

A further object of the present invention is
to provide a sheave retention apparatus having threaded
fasteners that are protected from the external
30 environment.

Still another object of the present invention
is to provide a sheave retention apparatus that employs
a locking mechanism that reliably locks a threaded
fastener in place during operation while permitting
35 release of the fastener during sheave replacement.

Still a further object of the present
invention is to provide a reliable method of retaining

1 and replacing a sheave on an axle.

5 The sheave retention apparatus and method of the present invention have other objects and features of advantage which will become apparent from and are set forth in more detail in the accompanying drawing and the following description of the preferred embodiment.

10 The sheave retention apparatus of the present invention includes a cap that fits over the end of an axle to retain a sheave or other member thereon, and a fastener that secures the cap to the axle. The improvement in the sheave retention apparatus of the present invention is comprised, briefly, of the cap being formed for rotation about the longitudinal axis of the axle, the fastener being mounted through a channel or opening in the cap to secure the cap against axial displacement, and one of the cap and axle being formed with a surface which is eccentric to the longitudinal axis of the axle so that rotation of the cap with respect to the axle binds the cap between the fastener and the axle. The cap is advantageously disk shaped and has a shoulder that fits over the end of the axle. Preferably the eccentric surface is provided by an off-center hole in the cap, and a fastening bolt passes through the hole and into a corresponding off-center internal thread within the axle. The internally threaded member can be provided by a nut welded to the inner wall of the tubular axle. Locking means also preferably is provided by employing a locking plate that is clamped between the hexagonal head of the bolt and the outer surface of the cap. The locking plate is formed to prevent relative rotation with respect to the cap and has two square corners that are bent up against the wrench flats of the bolt to prevent the bolt from rotating with respect to the locking plate.

5 The improved method of the present invention,

1 is comprised, briefly, of securing the cap to the axle
by rotating the cap on the axle so as to cause binding
of the cap between the axle and the bolt. At least one
of the cap and the axle must be selected to have an
5 eccentric surface which will cause such binding.

Figure 1 is a side elevational view in cross-section along the axis of an installed sheave retention apparatus constructed according to the present invention.

10 Figure 2 is an end elevational view of the retention apparatus of Figure 1.

Figure 3 is a cross-sectional view of an interior portion of the retention apparatus taken substantially along the plane of line 3-3 in Figure 1.

15 A sheave assembly, generally designated 10, is shown mounted on a tubular axle 12 in Figure 1. Briefly, sheave assembly 10 includes inner and outer ball bearing races 14 and 16 that are pressed into a sheave body 18 and separated by a spacer 20. Sheave 10
20 also includes inner and outer covers 22 and 24 and inner and outer bearing seals 26 and 28, all of which act to exclude dirt and ice from the bearings 14 and 16. One end 30 of axle 12 extends from rocker arm means 32 which attaches the sheave to a tower (not
25 shown). Further details of the design and function of the sheave assembly are contained in my copending application Serial Number 371,526 filed April 26, 1982 and entitled "Sheave Assembly and Method of Forming the Same," which are hereby incorporated by reference.

30 Sheave 10 is mounted on axle 12 by axially sliding the bearings 14 and 16 of the sheave assembly onto the open end 30 of the axle until seal 26 contacts the rocker arm 32. Sheave 10 is axially retained by the rocker arm on the inner side and by a cap means 34
35 on the outer side of the sheave. Cap means 34 is formed for removable mounting on end 30 of axle 12 by fastener means such as a bolt 36.

1 Broadly it is known to mount cap means on the
end of an axle by a fastener in order to secure a
member, such as a sheave assembly, to the axle. In the
improved retention apparatus of the present invention,
5 however, the retention of sheave 10 on axle 12 is
accomplished by forming cap means 34 for rotation on
the axle about longitudinal axis 44 of the axle and
forming the cap with a channel, such as hole 38,
through the cap. Fastener 36 is mounted to extend
10 through channel or hole 38 and is formed to
cooperatively engage a portion of axle 12, in this case
a nut 40 welded at 52 to the inside of the tubular
axle.

15 In order to secure the fastening bolt against
unthreading, the retention apparatus is further formed
so that one of cap means 34 and axle 12 will wedge
between axle 12 and fastener 36 to bind the fastener
against removal upon rotation of cap 34 on axle 12.

20 Binding of the cap between the bolt and the
axle can be accomplished in a number of ways. It is
preferable that cap 34 be disk-shaped and larger in
diameter than the axle 12. A shoulder or skirt 42 fits
over end 30 of the axle to provide positioning of the
cap for rotation on the axle. Shoulder 42 also acts to
25 retain sheave 10 on axle 12 by pressing against the
outer surface of outer bearing seal 28. The hole 38,
or channel through the cap, is offset from the axis 44
of the axle by an amount designated by an offset
distance 46.

30 Nut 40 provides internal thread means for
mating with bolt 36 for removably affixing the cap 34
to the axle 12. The nut is affixed to the inner wall
of the tubular axle by a weld 52, as shown in Figure 3.
The axis of the nut is concentric to hole 38 and forms
35 a bolt axis 54 that is parallel to axis 44 but offset
therefrom by the offset distance 46.

1 When cap 34 is rotated, therefore, the offset
46 will cause a gradual binding of the cap against bolt
36. Other structures suitable for producing such
binding would be for shoulder 42 to be inside axle 12.
5 Alternatively, hole 38 can be on axis 44 and a cam
surface (eccentric) provided on either cap 34 or axle
12 or both.

 When the member being retained on axle 12 is
a rotatably mounted member, such as sheave assembly 10,
10 it is advantageous to rotate cap 34 in the direction of
rotation of such member. Thus, rotation of sheave
assembly 10 will tend to maintain the binding force on
bolt 36 and provide a highly effective means of locking
the sheave assembly to the wheel.

15 Since in many application, including aerial
tramways, the axle will experience vibration, it is
preferable to provide means which will prevent the
fastener or bolt from backing out of the nut under the
influence of vibrations if, for some reason, the cap is
20 not binding the bolt against rotation.

 Bolt 36 is generally formed with a shank 56
with external threads 58 at the inner end and a
hexagonal head 60 at the outer end. Positioned between
the hexagonal head 60 of the bolt and the outer surface
25 of the cap is a washer element or locking plate 62 that
provides locking means for locking the bolt to the cap.
Locking plate 62 is generally rectangular in shape with
two square corners 64 and 66 and two notched corners 68
and 70 and has a hole 72 therethrough. As installed,
30 the hole 72 in the locking plate lines up with the hole
38 in the cap 34 for the shank 56 of the bolt to be
inserted therethrough. The notched corners 68 and 70
of the locking plate fit between stops 48 and 50
protruding from cap 34 to provide antirotation means to
35 prevent rotation of the locking plate relative to the
cap. To lock the bolt to the locking plate, square
corners 64 and 66 are bent to form tabs 74 and 76 that

1 contact two wrench flats 78 and 80 of the hexagonal
head 60.

5 Although the cap 34 by itself is free to
rotate about axis 44, bolt 36 prevents the cap from
rotating because hole 38 is offset from axis 44. By
locking the bolt to locking plate 62 and to cap 34, the
retention apparatus is completely locked in place. If
the bolt axis 54 were coincident with the axle axis 44,
locking the bolt to the cap would not lock the
10 apparatus because the whole assembly could rotate and
allow the bolt to loosen. However, by offsetting the
two axes, the bolt and the cap act to lock each other
in place.

15 The method for retaining a member on an axle
of the present invention includes mounting sheave 10 on
axle 12 and pushing it inward until the inner bearing
seal 26 contacts the rocker arm 32. Next, cap 34 is
placed over the outer end 30 of the axle and secured.
In the improved method, however, either cap 34 or axle
20 12 is selected to have an eccentric surface, for
example hole 38, to longitudinal axis 44 of the axle.
Preferably a locking plate 62 is placed on the cap with
the notched corners 68 and 70 fitting between stops 48
and 50 and with hole 72 of the locking plate aligning
25 with hole 38 of the cap prior to securement of the cap
to the axle. Corners 64 and 66 are bent up to form
tabs 74 and 76 to lock the bolt in place. Removal of
the sheave is easily accomplished by reversing the
above listed steps.

30

35

1 CLAIMS:

5 1. A retention apparatus for the removable mounting of a member to axle means or the like, said apparatus including cap means (34) formed for mounting on an end (30) of said axle means (12), and fastener means (36) formed to secure said cap means to said end of said axle means, wherein the improvement in said
10 retainer apparatus comprises:

said cap means (34) being further formed for rotation about the longitudinal axis (44) of said axle means (12) and being formed with a channel (38) extending longitudinally therethrough;

15 said fastener means (36) being mounted to extend through said channel and formed to cooperatively engage said axle means for removable securement of said cap means against axial displacement; and

20 one of said cap means (34) and said axle means (12) being further formed to wedge between said axle means and said fastener means to bind said fastener means against removal upon rotation of said cap means with respect to said axle.

25 2. The retention apparatus as defined in claim 1 wherein,

said fastener means (36) and said axle means (12) are formed for cooperative threaded engagement; and

30 said channel is positioned in said cap means (34) at a location (54) offset with respect to said (44) axis to bind said fastener means (36) against unthreading upon rotation of said cap means (34).

35 3. The retention apparatus as defined in claim 2 wherein,

said fastener means (36) is provided as a

1 bolt having a head portion (60), a shank portion (56)
and a threaded end (58);

said axle means includes a threaded element
(40) formed for mating threaded engagement with said
5 threaded end (58); and

said cap means (34) is formed for binding
against said shank portion (56).

4. The retention apparatus as defined in
10 claim 3 wherein,

said axle means (12) includes an axially
extending bore dimensioned to receive said bolt (36)
and positioned in substantial alignment with said
channel (38) upon mounting of said cap means (34) on
15 said axle;

said threaded end (58) is provided as an
external thread on said bolt; and

said threaded element (40) is provided as an
internal thread.

20

5. The retention apparatus as defined in
claim 4, and

locking means (62) formed for selective
locking and release of said head portion (60) against
25 relative rotation with respect to said cap means (34).

6. The retention apparatus as defined in
claim 5 wherein,

said locking means (62) is provided as a
30 washer element mounted between said head portion (60)
and said cap means (34) and formed with a peripheral
edge portion (64, 66, 68, 70) which can be selectively
engaged with a surface on said head portion (78, 80)
and a surface (48, 50) on said cap means to prevent
35 relative rotation thereof.

7. The retention apparatus as defined in

1 claim 1, and

locking means (62) formed for selective
locking and release of said cap means (34) and said
fastener means (36) against relative rotation.

5

8. Apparatus for removably retaining a
sheave assembly (10) on an axle including a cap (34)
removably affixed to one end (30) of the axle (12) by a
threaded fastener (36), wherein the improvement in said
10 apparatus is comprised of:

thread means (40) secured to said axle and
formed for mating with said threaded fastener;

said cap having a perforation (38)
therethrough;

15

said threaded fastener (36) disposed through
said perforation and threadably engaged with said
thread means (40) and retaining said cap against said
end (30) of said axle (12); and

20

at least one of said axle (12) and said cap
(34) being further formed to produce binding of said
cap between said axle and said fastener (36) upon
rotation of said cap about the longitudinal axis (44)
of said axle (16).

25

9. Apparatus as defined in claim 8 wherein,
said cap (34) and said axle (12) are formed
with complementary bearing surfaces extending along
said longitudinal axis (44) of said axle (12) and
formed for guided rotation of said cap with respect to
30 said axle; and

at least one of said surfaces and said
perforation (38) is relatively displaced with respect
to said axis (44) to produce said binding.

35

10. Apparatus as defined in claim 9 wherein,
said surfaces are mating substantially

1 cylindrical surfaces positioned substantially
concentrically with said axis (44), and
said perforation (38) is laterally offset with
respect to said axis (44).

5 11. Apparatus as defined in claim 10
wherein,
said cap (34) is formed with a skirt (42)
which extends around the exterior of said axle (12) and
10 provides the bearing surface on said cap.

12. The apparatus as defined in claim 8, and
locking means (62) formed for locking said
threaded fastener (36) to said cap (34).

15 13. Apparatus as defined in claim 12
wherein,
said threaded fastener (36) includes a shank
portion (56), external threads (58) at one end of said
20 shank portion for engaging said internal thread means
(40), and a head portion (60) at the end opposite said
external threads; and

25 said locking means (62) is operable for
engaging said head portion (60) of said threaded
fastener (36) to prevent rotation of said threaded
fastener with respect to said cap.

14. Apparatus as defined in claim 13
wherein,
30 said head portion (60) of said threaded
fastener (36) is formed with at least one surface (78,
80) against which a torque may be applied to rotate
said threaded fastener; and

35 said locking means (62) includes a locking
plate disposed between said cap (34) and said head
portion (60) of said threaded fastener (36), said
locking plate has at least one tab (74, 76) formed for

1 contacting said surface (78, 80), and said locking
means (62) also includes antirotation means (68, 70)
for preventing rotation of said locking plate with
respect to said cap.

5

15. Apparatus as defined in claim 14
wherein,

said threaded fastener (36) is disposed
through a hole (72) in said locking plate; and
10 said antirotation means includes stop means
(48, 50) formed in said cap (34) and positioned to
contact said locking plate (62) and formed to prevent
rotation thereof.

15 16. Apparatus as defined in claim 15
wherein,

said surface is provided by wrench flats
(78, 80)
formed on said head portion (60);
20 said locking plate (62) is formed with at least
one notch (68, 70) in the periphery thereof; and
said stop means (48, 50) is formed as a
protrusion dimensioned for insertion into said notch
(68, 70) and extending outwardly of said cap (34) into
25 said notch (68, 70) when said plate (62) is mounted
between said cap (34) and said head portion (60).

17. Apparatus as defined in claim 8 wherein,
said axle (12) is tubular in shape with said
30 sheave assembly (10) being retained on the external
surface thereof; and

said internal thread means (40) is a nut
having internal threads, said nut being affixed to the
internal surface of said tubular axle.

35

18. A method of retaining a member on axle
means (12) or the like including the step of securing

1 cap means (34) to the end (30) of said axle means,
wherein the improvement in said method is comprised of:
prior to said securing step, selecting at
least one of cap means and axle means to have an
5 eccentric surface with respect to the longitudinal axis
of said axle means; and

during said securing step:

(i) mounting said cap means (34) to said
axle means (12) for engagement of said eccentric
10 surface with one of said fastener and a remainder of
said cap means and said axle means,

(ii) coupling said cap means (34) to said
axle means (12) by fastener means (36) extending in a
direction along said longitudinal axis and secured to
15 said axle means, and

(iii) after said coupling step, rotating
said cap means (34) about said longitudinal axis to
bind said cap means between said fastener means (36)
and said axle means (34).

20

19. The method of retaining a member on axle
means as defined in claim 18, and the additional steps
of:

25 prior to said mounting step, placing sheave
assembly on one end (30) of said axle means;

during said selecting step, selecting cap
means (34) having an off-center hole (38) therethrough;

during said coupling step, installing a bolt
fastener (36) through said hole (38) and threading said
30 bolt into an off-center threaded hole in said axle
means; and

locking said bolt (36) to said cap means (34)
to prevent rotation of said bolt with respect to said
cap means.

35

20. The method of retaining a member on axle

- 1 means as defined in claim 19, and the step of:
 - installing a locking plate (62) over said cap
 - means (34) before said bolt (36) is installed, said
 - locking plate (62) being formed to engage said cap
 - 5 means (34) in a manner preventing relative rotation;
 - and
 - bending a portion of said locking plate to
 - lock said bolt thereto.

