

TECHNICAL FIELD

The present invention relates to a mechanism for reciprocatingly driving a reciprocatingly movable body, and elevator apparatus comprising a mechanism for reciprocatingly driving a cage which is reciprocatingly movably disposed in a path of reciprocating movement.

BACKGROUND ART

For use in such elevator apparatus, a lift drive mechanism is already known which comprises, as shown in FIG. 24, a plurality of ropes 3 reeved around a plurality of sheaves, such as a traction sheave 9 rotatingly driven by a drive motor 91 and direction changing sheaves 4, 43 attached to a cage 1 and a counterweight 2, and having fixed opposite ends 31, 32 for moving the cage 1 and the counterweight 2 upward or downward in opposite directions to each other.

With the elevator apparatus described, the cage 1, counterweight 2 and lift drive mechanism described are arranged in a lift path 10, the cage 1 is guided by guide rails 14, 14 for upward or downward movement, and the

controlling the upward and downward movement of the cage 1
5 and stopping of a cage door 11 at a position coinciding with
a floor door 12.

With the conventional elevator apparatus shown in FIGS.
24 and 25, the rope 3 reeved around the traction sheave 9
must move with the rotation of the sheave 9 without slipping
10 relative to the sheave 9 while the traction sheave 9 is being
rotated by the drive motor 91 to move the cage 1 upward or
downward. For this reason, the prior art has encountered
problems such as difficulty in reducing the weight of the
cage 1.

15 To render the rope 3 of the conventional elevator
apparatus reeved around the traction sheave 9 free of
slipping in the case where the rope 3 is subjected to tension
T1 on the slack side thereof and to tension T2 on the
tensioned side thereof as shown in FIG. 26, the relationship
20 of Mathematical Expression 1 (Eytelwein) needs to be
satisfied, assuming that the coefficient of friction between
the traction sheave 9 and the rope 3 is μ and that the angle
of the rope 3 reeved around the sheave 9 is θ .

(Mathematical Expression 1)

in the cage 1, the tension T1 is small, and the rope 3 is
5 likely to slip, failing to satisfy the relationship of
Mathematical Expression 1. For example, suppose the cage 1
itself has weight of 1500 Kg, the loading capacity of the
cage is 1000 Kg, and the weight of the counterweight 2 is the
weight of the cage 1 plus 50% of the loading capacity. The
10 left side member of Expression 1 has the following values
when the weight of load is zero and when the cage is fully
loaded.

(Mathematical Expressions 2)

$$T2/T1 = 2000/1500 = 1.33$$

15 $T2/T1 = 2500/2000 = 1.25$

If the weight of the cage 1 itself is then reduced to
1000 Kg, the values of Mathematical Expressions 2 are as
follows.

(Mathematical Expressions 3)

20 $T2/T1 = 1500/1000 = 1.5$

$$T2/T1 = 2000/1500 = 1.33$$

Thus, a change in the weight of the cage itself or in
the weight of load greatly varies the value of the left side
member (T2/T1) of Expression 1 to be satisfied. This value

It is therefore conventional practice to attach a weight
5 to the cage 1 so as not to permit the rope 3 to slip even
when the cage carries a small number of passengers. This
gives increased weight to the cage 1 itself. The increase in
the weight of the cage 1 itself gives rise to the problem of
making the lift drive mechanism large-sized and heavier.
10 Furthermore, the drive motor 91 serving as the power source
for the lift drive mechanism is given an increased capacity,
consequently resulting in increased power consumption and
also entailing the problem of necessitating space for the
installation of the drive motor 91 which becomes greater in
15 size.

An object of the present invention is to overcome all
the foregoing problems by providing a drive mechanism capable
of reciprocatingly driving a cage or like movable body
without using any traction sheave and an elevator apparatus
20 of the novel reciprocating drive type having the drive
mechanism incorporated therein.

DISCLOSURE OF THE INVENTION

The present invention provides a reciprocatingly movable
body drive mechanism which comprises a tension member in the

specified region of the tension member sideways in contact

5 with the tension member. The drive device presses a straight
region of the tension member in contact with the straight
region. Alternatively, the drive device is in contact with a
circular-arc region of the tension member as reeved around a
sheave for pressing the circular-arc region against the
10 sheave. With the drive mechanism, the drive device drives
the tension member by frictional contact therewith to thereby
reciprocatingly drive the movable body.

For example, the drive device can be provided by a belt
transmission disposed alongside the tension member and
15 revolvingly movable along a tension member extension route, a
pressing mechanism for pressing a belt surface of the belt
transmission into contact with the tension member, and a
drive motor for driving the belt transmission.

The present invention provides an elevator apparatus
20 which comprises a reciprocatingly movable body
reciprocatingly movably provided in a path of reciprocating
movement, and a mechanism for reciprocatingly driving the
body. The reciprocatingly driving mechanism comprises a
sheave disposed at a predetermined level, a tension member in

region of the tension member sideways. The term

- 5 "reciprocatingly movable body" means a cage having a passenger compartment or cargo compartment, and refers to a concept superior to that of a counterweight as a counterpart of the cage. The term "tension member" refers to a concept superior to that of one or a plurality of ropes or belts.
- 10 The term "reciprocating movement" includes a reciprocating movement in a vertical direction, horizontal direction, oblique direction or direction along a bent or curved path.

Usable as the drive device is a drive device of the first type which drives the tension member by pressing a
15 straight region thereof (hereinafter referred to as the "straight drive type"), or a drive device of the second type which drives the tension member as reeved around at least one sheave disposed along the tension member extension route by pressing a circular-arc region of the tension member against
20 the sheave (hereinafter referred to as the "circular-arc drive type"). Alternatively, the combination of these two types is to be used.

Usable as the drive device of the straight drive type is a device comprising a belt transmission disposed alongside

tension member, and a drive motor for driving the belt
5 transmission. Usable as the drive device of the circular-arc
drive type is a device comprising a belt pressed against the
circular-arc region of the tension member and revolvingly
movable, a plurality of rollers arranged along a path of
revolving movement of the belt, and a drive motor for
10 rotatingly driving at least one of the rollers.

With the elevator apparatus of the invention described,
the belt is driven by the drive motor, whereby the tension
member is driven by frictional contact with the surface of
the belt. As a result, the reciprocatingly movable body is
15 reciprocatingly moved. With the drive device, the tension
member can be prevented from slipping under the condition
expressed by Mathematical Expression 4 given below, wherein
 T_1 is the tension acting on the slack side of the tension
member extending from the drive device toward opposite
20 directions, T_2 is the tension on the tensioned side of the
tension member, μ is the coefficient of friction between the
belt surface of the belt transmission and the tension member,
and N is the pressure exerted by the belt surface on the
tension member.

on the slack side is due to the weight of the reciprocatingly
5 movable body (cage), the tension T_1 is small if the cage
carries a small number of passengers, whereas the
relationship of Mathematical Expression 4 can be satisfied by
increasing the pressure N . The tension member can then be
prevented from slipping.

10 Suppose the cage itself has weight of 1500 Kg, the
loading capacity is 1000 Kg, and the weight of the
counterweight is the weight of the cage itself plus 50% of
the loading capacity as exemplified above. The left side
member of Expression 4 has the following values when the
15 weight of load is zero and when the cage is fully loaded.

(Mathematical Expressions 5)

$$T_2 - T_1 = 2000 - 1500 = 500$$

$$T_2 - T_1 = 2500 - 2000 = 500$$

If the weight of the cage itself is then reduced to 1000
20 Kg, the values of Mathematical Expressions 4 are as follows.

(Mathematical Expressions 6)

$$T_2 - T_1 = 1500 - 1000 = 500$$

$$T_2 - T_1 = 2000 - 1500 = 500$$

Thus, the left side member ($T_2 - T_1$) of Mathematical

slippage of the tension member if the drive device exerts a
5 drive force greater than this value when driving the tension
member in frictional contact therewith.

Without the necessity of altering the tension member
extension route, the drive device may be provided along a
straight region of the tension member extension route when of
10 the straight drive type, or along a circular-arc region of
the tension member as reeved around a sheave when of the
circular-arc drive type. Thus, the drive device is
accommodated and disposed in the path of movement of the
elevator. The drive device can be provided at each of a
15 plurality of locations along the tension member extension
route in accordance with the force ($T_2 - T_1$) required for
driving the tension member.

In the case of a drive device of the straight drive type,
the belt transmission comprises a main belt 6 reeved around a
20 pair of rollers 53, 54, and the pressing mechanism comprises
a subbelt transmission provided by a pair of rollers 64, 65
arranged inside the main belt 6 and a subbelt 62 reeved
around the rollers 64, 65, a plurality of pressing rollers 68
arranged inside the subbelt 62 and spring means for pressing

spring means, whereby the subbelt 62 is pressed against the
5 main belt 6, pressing the surface of the main belt 6 into
contact with the tension member. The subbelt 62 is free to
move revolvingly with the revolving movement of the main belt
6, with rolling friction merely occurring between the subbelt
62 and the pressing rollers 68, so that the pressing
10 mechanism is unlikely to offer resistance to the drive of the
main belt 6. The pressing mechanism is not limited only to
one utilizing the resilient force of springs 57 or the like,
but also usable is, for example, a mechanism utilizing a
magnetic force or a fluid pressure.

15 Stated specifically, an inner periphery of the main belt
6 and an outer periphery of the subbelt 62 have respective
grooved surfaces meshable with each other. This reliably
prevents slippage from occurring between the main belt 6 and
the subbelt 62.

20 Further stated specifically, the belt providing the belt
transmission has a grooved portion extending longitudinally
of the tension member and in contact with the tension member.
This provides an increased frictional force between the belt
and the tension member to produce a greater drive force. An

The drive device of the straight drive type further
5 comprises a second belt transmission positioned as opposed to
the belt transmission (first belt transmission), and the
tension member is held between surfaces of belts of the
respective belt transmissions from opposite sides of the
tension member. The force with which the main belt 6 of the
10 first belt transmission presses the tension member is
supported by the main belt of the second belt transmission,
and the tension member is reliably held between the two belt
surfaces, whereby a greater drive force can be produced.

Incidentally, the belt transmission need not always
15 comprise a striplike belt reeved around a pair of rollers but
can be provided by a chain 7 reeved around a pair of chain
sprockets and a plurality of pressure members 71 arranged on
the chain 7 over the entire periphery thereof. Each of the
pressure members 71 is provided with a recessed face
20 extending longitudinally of the tension member and shaped in
conformity with the cross section of the tension member,
whereby a great frictional force can be produced between the
pressure member 71 and the tension member.

When the pressing mechanism is provided with an

for example, in accordance with the number of passengers.

- 5 The tension member can then be prevented from slipping regardless of the number of passengers. Usable as the adjusting mechanism is, for example, a power transmission utilizing the tension of the tension member as motive power for exerting pressure on the belt surface of the belt
- 10 transmission. The tension of the tension member then varies with the number of passengers, whereby the pressure is made automatically adjustable. Incidentally, the adjusting mechanism is not limited only to a mechanical power transmission such as one using a lever mechanism. Also
- 15 usable is a power transmission comprising a sensor for detecting the tension of the tension member, and a control circuit for adjusting the pressure in response to the detection signal.

On the other hand, an example of drive device of the

20 circular-arc drive type comprises a mechanism for tensioning the belt. This effectively presses the belt into contact with the tension member to produce a great frictional force between the belt and the tension member.

Further stated specifically, the tensioning mechanism

has one end connected to a free end of the frame 130. With
5 this construction, the frame 130 is driven toward the sheave
by the tension of the tension member, and the belt extending
over the rollers is pressed into contact with the circular-
arc region of the tension member as reeved around the sheave.

Consequently, the belt can be given sufficiently great
10 tension at all times. Accordingly, the tensioning mechanism
requires no special power source and consequently becomes
simple in construction.

Alternatively, the tensioning mechanism comprises a
frame 130 supported so as to be movable toward or away from
15 the sheave, the plurality of rollers being rotatably
supported by the frame 130, and a lever mechanism 140 is
provided between a free end of the frame 130 and one end of
the tension member. With this specific construction, the
lever mechanism 140 converts the tension of the tension
20 member to a force for driving the frame 130, with the portion
of the lever mechanism 140 connected to the end of the
tension member serving as a fulcrum and with the portion
thereof opposed to the free end of the frame 130 serving as
the point of application. In this way, the tension of the

away from the sheave, the arm 156 being elastically biased
5 toward a direction away from the sheave, and a plurality of
rollers included among the plurality of rollers and
positioned at opposite ends of the arrangement of rollers are
rotatably supported each at a predetermined level relative to
the sheave, the arm 156 rotatably supporting thereon one or
10 more rollers positioned inwardly of the roller arrangement.
With this specific arrangement, the arm 156 is biased toward
a direction away from the sheave, whereby the inward roller
or rollers are driven away from the sheave to tension the
belt.

15 The elevator apparatus of the invention described above
has a drive device for driving a tension member in frictional
contact therewith. This obviates the need for driving by a
traction sheave, rendering the cage or like reciprocatingly
movable body smaller in weight and consequently permitting
20 use of a compacted lightweight lift drive mechanism.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view showing the basic
construction of an elevator apparatus equipped with a drive
device of the straight drive type.

a path of movement of the elevator apparatus.

5 FIG. 4 is a plan view showing the same arrangement.

FIG. 5 is a plan view showing in detail the construction of the drive device of the straight drive type.

FIG. 6 is a plan view showing the same construction.

FIG. 7 is a front view showing a main belt and a subbelt
10 meshing therewith.

FIG. 8 is a front view showing the construction of another pressing mechanism.

FIG. 9 is a front view showing the construction of another pressing mechanism.

15 FIG. 10 is a perspective view of a belt transmission comprising a chain.

FIG. 11 is a perspective view showing the construction of another drive device of the straight drive type.

FIG. 12 includes diagrams showing exemplary arrangements
20 of devices in elevator apparatus each comprising a drive device of the straight drive type.

FIG. 13 includes diagrams showing examples of other arrangements.

FIG. 14 is a diagram showing another exemplary

FIG. 16 is a perspective view of another drive device of
5 the circular-arc drive type.

FIG. 17 is a perspective view showing the construction
of rear side of the drive device.

FIG. 18 is a perspective view of another drive device of
the circular-arc drive type.

10 FIG. 19 is a front view of another drive device of the
circular-arc drive type.

FIG. 20 is a front view of another drive device of the
circular-arc drive type.

15 FIG. 21 is a front view of another drive device of the
circular-arc drive type.

FIG. 22 is a front view of another drive device of the
circular-arc drive type.

FIG. 23 is a perspective view of another drive device of
the circular-arc drive type.

20 FIG. 24 is a perspective view of a conventional elevator
apparatus.

FIG. 25 is a plan view showing an arrangement inside a
path of movement of the conventional elevator apparatus.

FIG. 26 is a diagram for illustrating forces acting on a

detail with reference to the drawings. First, a description
5 will be given of an elevator apparatus wherein a drive device
of the straight drive type is used as a drive device for
driving ropes, serving as tension members, by frictional
contact therewith, i.e., by pressing a straight region of
each rope. Subsequently, a description will be given of an
10 elevator apparatus wherein a drive device of the circular-arc
drive type is used for driving ropes as reeved around a
sheave by pressing a circular-arc region of each rope against
the sheave.

Apparatus Comprising Drive Device of Straight Drive Type

15 FIG. 1 shows the basic construction of an elevator
apparatus of the invention wherein a drive device of the
straight drive type is used. As illustrated, a rope 3
extends as reeved around a plurality of sheaves, such as a
sheave 42 provided at a specified position within a path of
20 movement of the elevator and sheaves 4, 43 attached to a cage
1 and a counterweight 2. A drive device 5 for driving the
cage 1 upward or downward is provided along the route of the
rope 3, and rope ends 31, 32 are fixed in position.

FIGS. 3 and 4 show an arrangement inside a path 10 of

1 is guided by guide rails 14, 14 for upward or downward
5 movement, and the counterweight 2 is guided by guide rails 15,
15 for upward or downward movement.

The drive device 5 has connected thereto an
unillustrated control circuit for controlling the upward and
downward movement of the cage 1 and stopping of a cage door
10 11 at a position coinciding with a floor door 12. Although
only one rope 3 is shown in FIGS. 1 and 3 for the sake of
simplicity, a plurality of ropes extend along the same route
in actuality. The ropes are not shown in FIG. 4.

FIG. 2 shows the construction of the drive device 5, and
15 FIGS. 5 and 6 show the construction of the drive device 5 in
greater detail. With reference to FIG. 2, the drive device 5
comprises a pair of drive-side belt drive mechanism Ma and
driven-side belt drive mechanism Mb which are arranged inside
a housing 51. The belt drive mechanism Ma on the drive side
20 comprises a main belt transmission comprising a pair of
rollers 53, 54 arranged along the ropes 3 and a main belt 6
reeved around these rollers, a drive motor 52 for rotatingly
driving the roller 53 of the main belt transmission, a
subbelt transmission comprising a pair of rollers 64, 65

On the other hand, the belt drive mechanism Mb on the
5 driven side comprises a main belt transmission comprising a
pair of rollers 55, 56 arranged along the ropes 3 and a main
belt 61 reeved around these rollers, a subbelt transmission
comprising a pair of rollers 66, 67 arranged inside the main
belt 61 and a subbelt 63 reeved around the rollers 66, 67,
10 and a plurality of support rollers 69 arranged inside the
subbelt 63. In each of the two belt drive mechanisms Ma, Mb,
the outer peripheral surface of the subbelt 62 or 63 on the
rope side is in intimate contact with the inner peripheral
surface of the main belt 6 or 61 on the rope side.

15 With reference to FIGS. 5 and 6, the rollers 53 to 56
and 64 to 67 providing the two belt drive mechanisms Ma, Mb
and the support rollers 69 providing the driven-side belt
drive mechanism Mb are rotatably supported on a fixed frame
50, while the pressing rollers 68 providing the drive-side
20 belt drive mechanism Ma are rotatably supported on a movable
base 60 which is reciprocatingly movably supported by the
fixed frame 50 and are movable toward or away from the
subbelt 62. The fixed frame 50 is provided with a plurality
of springs 57 for biasing the movable base 60 toward the

the ropes 3. Consequently, the pressure N of Mathematical
5 Expression 4 is produced between the belt surface of the main
belt 6 and the ropes 3. Thus, the subbelt transmission
provides a pressing mechanism for the main belt 6.

When the power source is turned on for the drive motor
52 constituting the drive-side belt drive mechanism Ma of the
10 drive device 5, the main belt 6 starts to move revolvingly,
drawing the ropes 3 toward one direction by a frictional
force between the main belt 6 and the ropes 3. With this
movement, the main belt 61 of the driven-side belt drive
mechanism Mb moves revolvingly. Further with the revolving
15 movement of the two main belts 6, 61, the two subbelts 62, 63
also move revolvingly.

The traction of the ropes 3 in one direction moves the
sheave mechanism shown in FIG. 1, which moves the cage 1 and
the counterweight 2 upward or downward in directions opposite
20 to each other. Produced between the belt surface of the main
belt 6 and the ropes 3 in this process is pressure N
satisfying Mathematical Expression 4 due to the biasing force
of the springs 57, consequently obviating the slippage to be
produced between the main belt 6 and the ropes 3.

shown in FIGS. 3 and 4. This eliminates the need to provide
5 an additional installation space for the device 5. Further
when required, a second drive device 5 can be disposed in
another vacant space as indicated in chain lines in FIG. 1.

When the outer periphery of the subbelt 62 and the inner
periphery of the main belt 6 have respective grooved surfaces
10 meshable with each other as shown in FIG. 7, the main belt 6
and the subbelt 62 can be prevented from slipping on each
other. Usable as the pressing mechanism for the main belt 6
is an arrangement comprising a pressure plate 201 disposed
alongside the main belt 6, and springs 202 for biasing the
15 pressure plate 201 toward the main belt 6 to apply pressure
to the main belt 6 as shown in FIG. 8.

Alternatively usable is a mechanism comprising, as shown
in FIG. 9, a pair of chain sprockets 205, 205, a chain 203
reeved around the sprockets, and slats 204 attached to the
20 chain 203 and arranged over the entire periphery of the chain,
the slats 204 being pressed against the main belt 6 by
unillustrated respective springs. The slats 204 are arranged
in a row for each rope or each of groups of ropes.

It is also possible to use a belt transmission

the entire periphery thereof. Each of the pressure members
5 71 is provided with recessed curved faces 72 extending
longitudinally of the ropes 3 and shaped in conformity with
the cross section of the ropes 3, whereby a great frictional
force can be produced between the pressure member 71 and the
ropes 3.

10 FIG. 11 shows the construction of another elevator
apparatus of the invention. A rope 3 connecting a cage 1 to
a counterweight 2 is reeved around two sheaves 45, 46
rotatably supported on a frame 8. A drive device 5 is
provided along the rope 3 extending between the two sheaves
15 45, 46. The drive device 5 comprises a plurality of pressing
rollers 81, 81, 81, a belt 82 reeved around these rollers 81,
81, 81 and a drive motor 83 for driving one pressing roller
81. The rollers 81, 81, 81 press the belt 82 into contact
with the rope 3.

20 FIGS. 12, (a) to (f) and 13, (a) to (f) show other
examples of arrangements which are altered in the number and
position of drive devices 5, the number and position of
sheaves, rope extension route, etc. FIG. 12, (a) and (b)
show drive devices 5 arranged at a plurality of locations.

other than a rope 3 as the main cable and serving as an
5 auxiliary cable. A drive device 5 is in engagement with the
rope 31.

With reference to FIG. 13, (a), a rope 3 has connected
to opposite ends thereof a cage 1 and a counterweight 2, to
which respective drive devices 5, 5 are attached. Each drive
10 device 5 is in engagement with a rope 31 serving as an
auxiliary cable. FIG. 13, (b) shows counterweights 2, 2
attached to respective opposite ends of a rope 3. FIG. 13,
(c) shows a cage 1 and a counterweight 2 connected to the
respective ends of a rope 3, which is in engagement with a
15 drive device 5. FIG. 13, (d) shows a cage 1 connected to one
end of a rope 3, which is in engagement with a drive device 5.
FIG. 13, (e) shows a pair of sheaves and a drive device 5
which are mounted on the ceiling portion of a cage 1. The
drive device 5 is in engagement with the portion of the rope
20 3 between the two sheaves. FIG. 13, (f) further shows a
drive device 5 in engagement with a rope 3 at the portion
thereof between two sheaves, which are provided inside a path
of movement of the elevator. With the elevator apparatus of
the invention, drive devices 5 can be arranged with great

tension produced on the rope 3 is caused to act on a fulcrum
5 for a lever mechanism 200, and a belt surface of a drive
device 5 is pressed against the rope 3 with a force produced
at the point of application of the lever mechanism 200. With
this elevator apparatus, the tension of the rope 3, i.e., a
pressure corresponding to the weight of the cage 1, can be
10 caused to act on the drive device 5, so that the pressure can
be adjusted automatically in accordance with the number of
passengers in the cage 1. Thus, the slippage between the
rope 3 and the drive device 5 can be prevented regardless of
the number of passengers.

15 As described above, the elevator apparatus of the
invention is equipped with a drive device 5 for exerting a
drive force in accordance with the difference between tension
 T_1 on the slack side of a rope 3 and the tension T_2 on the
tensioned side of the rope. This eliminates the need for the
20 conventional mode of driving by a traction sheave, making it
possible to use a cage 1 or counterweight 2 of reduced weight.

Furthermore the following advantages are also available.

1. Although the drive device is installed conventionally
only in a machine room, an upper portion of a path of

thereof, the rope is less burdened, permitting use of various
5 materials, such as iron or steel, synthetic fibers and
synthetic resins, for the rope.

3. The conventional drive device using a traction sheave
needs to support the weight of the cage and the counterweight
and is therefore large-sized, whereas the drive device of the
10 invention need not support the weight of these components and
can therefore be compacted and reduced in weight.
Furthermore, the drive device can singly be removed or
installed and is easy to replace.

4. The cage 1 and the counterweight 2 which are reduced
15 in weight permit use of a drive motor 52 of smaller capacity,
which results in reduced power consumption.

5. An increase in the pressure to be exerted by the
drive device 5 increases the force for driving the rope 3.
This makes it more likely that the chain or rope to be used
20 as a counterbalance can be dispensed with, hence improved
safety or reliability.

Apparatus Comprising Drive Device of Circular-Arc Drive Type

FIGS. 15 to 22 show examples of elevator apparatus of
the invention wherein a drive device of the circular-arc

100 comprises a belt 102 reeved around four rollers 101, 101,
5 101, 101a arranged along the outer periphery of the sheave 42,
and a motor 103 coupled to the roller 101a among the rollers.

About one-half of the circumferential length of the belt 102
is curved in a circular-arc form along the outer periphery of
the sheave 42, pressing circular-arc regions of ropes 3 as
10 reeved around the sheave 42 against the sheave 42. When the
belt 102 is revolvingly moved by driving the motor 103, the
ropes 3 are driven by a frictional force acting between the
belt 102 and the ropes 3.

FIG. 16 shows a drive device 100 having a motor 104
15 serving as a drive source and installed in a hollow space
formed in the center of a sheave 42. A drive pulley 105 is
mounted on the output shaft of the motor 104, and the
rotation of the drive pulley 105 is transmitted to a driven
pulley 106 by a belt 107 as seen in FIG. 17. A roller 101a
20 shown in FIG. 16 is connected to the driven pulley 106. The
rotation of the motor 104 is transmitted to the roller 101a
via the drive pulley 105, belt 107 and driven pulley 106,
whereby a belt 102 is rotated revolvingly to drive ropes 3 in
frictional contact therewith.

circumferential length of the belt 111 is curved in a
5 circular-arc form along the outer periphery of a sheave 42,
pressing circular-arc regions of ropes 3 as reeved around the
sheave 42 against the sheave 42. When the belt 111 is
revolvingly moved by driving the motor 112, the ropes 3 are
driven by a frictional force acting between the belt 111 and
10 the ropes 3.

Like the drive device shown in FIG. 18, a drive device
100 shown in FIG. 19 comprises a belt 122 reeved around two
rollers 121, 121. The two rollers 121, 121 are rotatably
supported by a frame 120, which is supported so as to be
15 movable toward or away from a sheave 42. The frame 120 has a
free end carrying a rope socket 124 thereon, with a
compression spring 123 acting therebetween. Joined to the
rope socket 124 is one end of a rope 3 extending around a
sheave 43 for a counterweight 2.

20 Accordingly, the tension of the rope 3 acts on the frame
120 of the drive device 100, driving the two rollers 121, 121
toward the sheave 42. With this movement, the belt 122 is
strongly pressed into contact with a circular-arc region of
the rope 3 as reeved around the sheave 42, thereby giving

between the rope and the belt 122.

- 5 Like the drive device shown in FIG. 15, a drive device 100 shown in FIG. 20 comprises a belt 132 extending around four rollers 131, 131, 131, 131. These rollers 131, 131, 131, 131 are rotatably supported on a frame 130, which is supported so as to be movable toward or away from a sheave 42.
- 10 The frame 130 has a free end, to which a rope socket 124 is attached, with a compression spring 123 acting therebetween. Joined to the rope socket 124 is one end of a rope 3 extending around a sheave 43 for a counterweight 2.

 Accordingly, the tension of the rope 3 acts on the frame

15 130 of the drive device 100, driving the four rollers 131, 131, 131, 131 toward the sheave 42. With this movement, the belt 132 is strongly pressed into contact with a circular-arc region of the rope 3 as reeved around the sheave 42, thereby giving sufficiently great tension to the belt 132. As a

20 result, a great frictional force is produced between the belt 132 and the rope 3, driving the rope 3 without causing slippage between the rope and the belt 132.

 FIG. 21 shows a drive device 100 corresponding to the drive device shown in FIG. 20, in which a lever mechanism 140

compression spring 123 acting therebetween. One end of the
5 rope 3 is joined to the rope socket 124.

The lever mechanism 140 converts the tension of the rope
3 to a force for driving the frame 130, with the portion of
the lever mechanism 140 connected to the end of the rope 3
serving as a fulcrum and with the portion thereof opposed to
10 the free end of the frame 130 serving as the point of
application. In this way, the tension to be given to the
belt 132 is adjusted to a suitable magnitude.

FIG. 22 shows a drive device 100, wherein a pivotal arm
156 is disposed above a sheave 42. The pivotal arm 156 has a
15 base end supported by a pivot 157 positioned at a specified
level on a beam 150, and a forward end 158 of the pivotal arm
156 biased upward by a spring 159. Four rollers 151, 152,
153, 154 are provided with a belt 155 reeved therearound and
positioned around the sheave 42. Among these rollers, the
20 two rollers 151, 154 at opposite sides are rotatably
supported by the beam 150 and positioned each at a specified
level, and the two inward rollers 152, 153 are rotatably
supported by the pivotal arm 156. With this drive device 100,
the pivotal arm 156 is biased counterclockwise by the spring

42 is attached to a frame 160, and rollers 161, 162, 163 are
5 arranged respectively at three locations, i.e., above and at
opposite sides of the sheave 42. A belt 164 is reeved around
these rollers 161, 162, 163 for pressing ropes 3 as reeved
around the sheave 42 against the sheave 42 by the belt 164.
Coupled to the upper roller 161 is a motor (not shown)
10 mounted on the rear side of the frame 160. The rollers 162,
163 at opposite sides are each mounted so as to be adjustable
in level by a position adjusting mechanism 165. The tension
of the belt 164 is adjustable by varying the level.

The elevator apparatus incorporating the drive device of
15 the circular-arc drive type has the same advantages as the
drive device of the straight drive type, and can be simpler
than the latter in the construction of the drive device.
Since a belt is pressed against the circular-arc region of a
rope as reeved around a sheave of large diameter, it is
20 possible to reduce the magnitude and variation rate of
specific pressure acting between the belt and the rope. When
theoretically calculated, the maximum value of specific
pressure of each of the rope surface and the belt surface is
about 4 MPa in the case of the straight drive type, and the

this serves to preclude the damage to be caused to the belt
5 and the rope to ensure a prolonged life.

Furthermore, the drive device of the circular-arc drive
type, which is simpler in construction than the device of the
straight drive type, is diminished in mechanical losses,
therefore permitting use of a motor of smaller capacity and
10 achieving a reduction in power consumption. When
theoretically calculated, the power transmission efficiency
of the drive device of the straight drive type is about 70%,
and that of the drive device of the circular-arc drive type
is as high as about 95%.

15 Furthermore, the belt constituting the drive device of
the circular-arc drive type is pressed against the circular-
arc region of the rope by virtue of the tension thereof. The
belt can therefore be smaller in thickness than when the belt
is pressed by pressing rollers of small diameter as is the
20 case with the drive device of the straight drive type. Thus,
the rollers for driving the belt can be reduced in diameter
and the drive motor to be used can be of smaller capacity.
The noise to be produced by the drive device of the circular-
arc drive type is much smaller, while the device can be

can be modified variously within the technical scope defined
5 in the appended claims. For example, the belt to be brought
into frictional contact with the rope for driving need not
always have a recessed curved contact face which is circular-
arc in cross section, but a grooved surface of V-shaped cross
section or one of various other cross sections is similarly
10 useful. On the other hand, it is effective that the belt
surface to be in contact with the roller be mirror-finished
so as to ensure an improved degree of intimate contact with
the roller. The belt for driving the rope by frictional
contact therewith can be composed of a plurality of belt
15 pieces divided in a direction orthogonal to the longitudinal
direction of the rope 3 so as to use each of the belt pieces
in contact with one or a plurality of ropes 3.

A core having high tension and high strength can be
incorporated in the belt for driving the rope by frictional
20 contact therewith, and the belt surface layer to be in
contact with the rope can be made from a material having
abrasion resistance. A belt of multilayer structure is
useful which comprises, for example, a layer of chloroprene
rubber, a layer of polyamide woven fabric and a layer of

the two members. The advantage of suppressed wear is then
5 available.

A tension member in the form of a belt can be used in
place of the rope 3 serving as a tension member. Use of a
belt having the same structure as described above especially
leads to the same modulus of longitudinal elasticity (spring
10 constant) between the belts to be in contact with each other,
and to the advantage of reduced slippage and suppressed wear.

The motor for driving the belt need not always be
coupled to the center shaft of the roller as shown in FIG. 2
or 15, but can be housed in the roller for driving the roller
15 from inside. The drive device of only one type, i.e., the
drive device 5 of the straight drive type or the drive device
100 of the circular-arc drive type, can be installed at each
of a plurality of locations, or devices of the both types can
be used in combination.

20 The reciprocatingly movable body drive mechanism of the
invention is not limited only for use in elevator apparatus
of the type movable upward or downward wherein a cage and a
counterweight are arranged at opposite sides as described
above, but can be used also in elevator apparatus of the



3. (Amended) A reciprocatingly movable body drive
5 mechanism comprising a tension member in the form of a rope
or belt for reciprocatingly driving a reciprocatingly movable
body, and a drive device for driving the tension member
longitudinally thereof while pressing a specified region of
the tension member sideways in contact with the tension
10 member, the tension member being reeved around at least one
sheave, and the drive device being in contact with a
circular-arc region of the tension member as reeved around
the sheave for pressing the circular-arc region against the
sheave.

15 4. (Amended) A reciprocatingly movable body drive
mechanism according to claim 3 wherein the drive device
comprises a belt transmission disposed alongside the tension
member and revolvingly movable along a tension member
extension route, a pressing mechanism for pressing a belt
20 surface of the belt transmission into contact with the
tension member, and a drive motor for driving the belt
transmission.

5

8. (Canceled)

9. (Canceled)

10. (Canceled)

11. (Canceled)

12. (Canceled)

16. (Canceled)

20. (Canceled)

5

21. (Canceled)

reciprocatingly driving the body, the elevator apparatus
5 being characterized in that the reciprocatingly driving
mechanism comprises:

a sheave disposed at a predetermined level,
a tension member in the form of a rope or belt and
extending along a path around the sheave, and
10 a drive device for driving the tension member in engagement
therewith by pressing a specified longitudinal region of the
tension member sideways, and
the drive device is provided for the tension member as reeved
around at least one sheave disposed along the tension member
15 extension route to press a circular-arc region of the tension
member against the sheave.

23. An elevator apparatus according to claim 22 wherein
the drive device comprises a belt revolvingly movable while
being pressed against the circular-arc region of the tension
20 member, a plurality of rollers arranged along a path of
revolving movement of the belt, and a drive motor for
rotatingly driving at least one of the rollers.

24. An elevator apparatus according to claim 23 wherein
the belt has a grooved portion extending longitudinally of

arranged side by side in a direction orthogonal to the
5 longitudinal direction of the tension member, and each of the
belt pieces is in contact with one or a plurality of tension
members.

26. An elevator apparatus according to any one of claims
23 to 25 wherein the belt has incorporated therein a core
10 having high tension and high strength.

27. An elevator apparatus according to any one of claims
23 to 26 wherein the belt has a multilayer structure, and a
surface layer in contact with the tension member and made of
a material having abrasion resistance.

15 28. An elevator apparatus according to any one of claims

the tensioning mechanism comprises a frame (130) supported so
5 as to be movable toward or away from the sheave, the
plurality of rollers being rotatably supported by the frame
(130), and the tension member has one end connected to a free
end of the frame (130).

30. An elevator apparatus according to claim 28 wherein
10 the tensioning mechanism comprises a frame (130) supported so
as to be movable toward or away from the sheave, the
plurality of rollers being rotatably supported by the frame
(130), and a lever mechanism (140) is provided between a free
end of the frame (130) and one end of the tension member.

15 31. An elevator apparatus according to claim 28 wherein
the tensioning mechanism comprises an arm (156) supported so
as to be movable toward or away from the sheave, the arm
(156) being elastically biased toward a direction away from
the sheave, and a plurality of rollers included among the
20 plurality of rollers and positioned at opposite ends of the
arrangement of rollers are rotatably supported each at a
predetermined level relative to the sheave, the arm (156)
rotatably supporting thereon one or more rollers positioned
inwardly of the roller arrangement.

33. An elevator apparatus according to any one of claims
5 22 or 32 wherein the drive device is disposed at each of a
plurality of locations along the tension member extension
route.