

ELEVATOR DRIVE APPARATUS USING A
TRACTION-TYPE REDUCTION GEAR.

This invention relates to a drive apparatus equipped with a drive mechanism having a traction-type reduction gear, for use in elevator apparatuses and the like.

Drive apparatuses for elevators are frequently equipped with a drive mechanism having a toothed-wheel reduction gear,

with an electric motor connected to the input shaft and a drive sheave connected to the output shaft of the reduction gear and with a hoisting rope for moving an elevator car reeved about the sheave. However, geared reduction devices produce considerable noise and vibrations which are transmitted to the building in which the elevator is provided, resulting in a deterioration of the living and working environment in the building. Further, noise and vibrations are transmitted via the hoisting rope to the elevator car, with the result that the passengers within the elevator car are subjected to an unpleasant sensation.

It is the object of the present invention to provide a drive apparatus which does away with the above-described drawbacks of conventional drive apparatuses, operating silently without vibrations.

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It is a further object of the invention to provide a drive apparatus of great safety. These two objects are accomplished by equipping the drive apparatus with a traction-type reduction gear in combination with an abnormality detection device and a control device. The traction-type reduction gear produces smooth, quiet transmission of power from an electric motor to an elevator drive sheave. The abnormality detection device detects when slippage occurs in the reduction gear, and the control device safely brings the elevator to an emergency stop in the event that slippage occurs.

These and other objects of the present invention will become clear upon reading the following description and studying the accompanying drawings.

Figure 1 is a cross-sectional profile of an elevator apparatus showing one embodiment of a driving apparatus according to the present invention.

Figure 2 is a partial cross-section of the apparatus of Figure 1 as viewed from the right of Figure 1.

Figure 3 is a block diagram showing the connection between the abnormality detection and control portions of the driving apparatus of Figure 1.

Figure 4 is a circuit diagram of an abnormality detection device for use the the embodiment illustrated in Figure 2.

Below, one embodiment of the present invention will be described as used in an elevator apparatus, while referring to Figures 1 through 4.

In the figures, reference numeral 1 indicates an
5 elevator drive mechanism.

2 is a traction-type reduction gear which forms one of the principal parts of the drive mechanism 1.

2a is the housing of the reduction gear 2.

2b is an input shaft rotatably mounted in the
10 housing 2a.

2c is a first roller secured to input shaft 2b which acts as the sun roller of the reduction gear 2.

2d is an output shaft rotatably mounted in the housing 2a.

15 2e represents support plates disposed on one end of the output shaft 2d and located within the housing 2a.

2f represents roller shafts rigidly secured at right angles to support plates 2e, located parallel to and equally separated from the cylindrical surface of the first roller
20 2c.

2g is a frictional body secured inside the housing 2a having a cylindrical inner surface.

2h represents second rollers rotatably attached to roller shafts 2f and pressed against the cylindrical surface of the
25 first roller 2c and the inner cylindrical surface of the frictional body 2g. These second rollers 2h act as planetary rollers and rotate about the sun roller, first roller 2c.

3 is an electric motor which is connected to the input shaft 2b, by means of which the input shaft is rotated.

4 is a drive sheave rigidly connected to the output shaft 2d.

5 is a hoisting rope reeved about the drive sheave 4.

6 is an elevator car suspended from one end of the hoisting rope 5.

7 is a counterweight suspended from the other end of the hoisting rope 5.

8 is a first rotational speed detector of the type well known in the art which measures the rate of revolution of the input shaft 2b and produces an output voltage corresponding to this rate.

9 is a second rotational speed detector also of the type well known in the art which detects the rate of revolution of the output shaft 2d and produces an output voltage corresponding to this rate.

10 is an abnormality detection device which compares the outputs from the first detector 8 and the second detector 9, and 11 is a control device which is activated by the abnormality detection device 10 when the latter determines that the difference between the outputs of first detector 8 and second detector 9 falls outside of a predetermined range.

The operation of the drive apparatus is as follows. When electric motor 3 is activated, it rotates input shaft 2b. This rotation is transmitted to the output shaft 2d

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through the action of the first roller 2c, the frictional body 2g, and the second rollers 2h.

Namely, when first roller 2c is rotated by the input shaft, traction between the various rollers and the frictional body 2g causes the second rollers 2h, which act as planetary rollers, to rotate about first roller 2c, which acts as the sun roller. The rotation of second rollers 2h is transmitted to the output shaft 2d by the shafts 2f and the support plates 2e, and the output shaft is rotated in the same direction as the input shaft but at a slower rate. Thus, the traction-type reduction gear 2 is a reduction gear.

The drive sheave 4 is thereby rotated, and the elevator car 6 and the counterweight 7 are moved by the hoisting rope in mutually opposite directions. The transmission and the change in speed which is carried out by reduction gear 2 consisting of first roller 2c, second roller 2h, etc., is carried out by tractive force, and accordingly an elevator producing little in the way of vibrations and noise is obtained.

The traction-type reduction gear 2 can operate only when there is sufficient tractive force between the various rollers and the frictional body. If friction is reduced by abrasion of the rollers, for example, slippage will occur between the rollers of the reduction gear, and transmission of motive force will become difficult or impossible. In the worst case, this slippage could result in the elevator car sliding freely down the elevator shaft as a result of the output shaft 2d rotating independently of the input shaft 2b.

For this reason, first and second rotational speed detectors 8 and 9, abnormality detection device 10, and control device 11 are provided in this drive apparatus. First detector 8 detects the rate of rotation of the input shaft 2b and produces a corresponding voltage. Second detector 9 likewise produces a voltage corresponding to the rate of rotation of the output shaft 2d. As shown conceptually in Figure 3, these two output voltages are applied to the abnormality detector 10, which compares the voltages. When the difference between the voltages falls outside of a predetermined level, indicating that the input shaft 2b and the output shaft 2d are rotating at disproportionate rates, i.e. that slippage is occurring in the reduction gear 2, the abnormality detection device 10 activates the control device 11. When activated, the control device 11 causes the elevator to make an emergency stop at the nearest floor and issues an alarm.

Figure 4 shows one example of a circuit for an abnormality detection device, consisting of a comparator portion 12, an absolute value production portion 13, and a threshold detection portion 14.

In the figure, V_{T8} is the output voltage of first detector 8, which is proportional to the rotational speed of input shaft 2b and V_{T9} is the output voltage of second detector 9, which is proportional to the rate of rotation of output shaft 2d. V_{T8} and V_{T9} are arranged in the circuit so as to be of opposite polarity. V_{T8} and V_{T9} are applied to the inverting terminal of a first op-amp 15 through resistors R_1 and R_2 . (R_1 through R_{10} are all resistors). The output voltage V_{OUT} of first op-amp

15 is $-R_3(V_{T8}/R_1 + V_{T9}/R_2)$, and R_1 and R_2 are chosen so that V_{OUT} is normally 0.

This is possible because, when there is no slippage in the reduction gear, the rotational speed of input shaft 2b is a constant multiple of the rotational speed of output shaft 2d. If the output V_{T8} of first detector 8 is linearly proportional to the speed of the input shaft 2b and if the output V_{T9} of second detector 9 is linearly proportional to the speed of the output shaft 2d, then V_{T8} will be a constant multiple of V_{T9} as long as no slippage occurs.

Thus, V_{T8}/V_{T9} equals a negative constant, $-N$, which is negative since V_{T8} and V_{T9} are of opposite polarity. R_1 and R_2 are chosen such that

15 $R_1/R_2 = -V_{T8}/V_{T9} = -N$, and accordingly $V_{OUT} = -R_3(V_{T8}/R_1 + V_{T9}/R_2)$ is 0 when there is no slippage.

However, if slippage occurs in the traction-type reduction gear, the relationship between V_{T8} and V_{T9} will change and V_{OUT} will become non-zero. For example, if the input shaft begins to lag due to slippage, the output V_{T9} of the second detector will decrease in magnitude and V_{OUT} will go negative. Alternatively, if the output shaft begins to slip and rotate freely due to the torque applied on it by the drive sheave 4, the output V_{T9} will increase in absolute value, and V_{OUT} will go positive.

25 V_{OUT} is applied to the input terminals of a second op-amp 16 and this second op-amp 16 outputs a positive voltage proportional to the absolute value of V_{OUT} .

The last part of the circuit is a threshold detection portion 14. When the output of the second op-amp 16 exceeds a predetermined value, corresponding to a certain amount of slippage, the Zener diode 17 begins to conduct, driving the transistor 18, which in turn excites a normally unexcited relay coil 19. When excited, the contact of the relay coil 19 (not shown in the figure) turns on the control device 11, and the elevator is thereby controlled.

By appropriately choosing the resistors, the predetermined value of the second op-amp at which the transistor 18 turns on can be set at any desired level, corresponding to a small or a large amount of slippage in the speed change gear.

The control device 11 is not described here in detail, but may be any device of the type well known in the art which when activated can control an elevator drive mechanism so as to make an emergency stop of the elevator car at the nearest floor and issue an alarm.

The above-described drive apparatus of course has the advantage that it is quieter and produces less vibrations than a drive apparatus using a toothed-wheel reduction gear, but it also has the advantage that a traction-type reduction gear is cheaper to manufacture.

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CLAIMS:



1. A drive apparatus for elevators comprising:

a traction-type reduction gear having an input shaft
and an output shaft;

an electric motor connected to said input shaft and
5 disposed so as to rotate the input shaft;

a first detector means for detecting the rate of
rotation of said input shaft and for producing an output
corresponding to said rate of rotation;

a second detector means for detecting the rate of
10 rotation of said output shaft and for producing an
output corresponding to the rate of rotation of said
output shaft;

an abnormality detection device coupled to said
first and second detector means for comparing the
15 outputs of said first and second detector means and for
generating an electrical signal when the difference
between said outputs falls outside a predetermined
range; and

a control means coupled to said abnormality
20 detection device and responsive to the electrical signal
generated by said abnormality detection device for
controlling and stopping said drive apparatus.



2. A drive apparatus as claimed in claim 1, wherein said traction-type reduction gear is of the planetary roller type.

3. A drive apparatus as claimed in claim 2, wherein
5 said traction-type reduction gear comprises:

a housing;

a frictional body having a cylindrical inner surface secured inside said housing;

a first roller rigidly secured to said input shaft
10 and contained within said housing;

a roller shaft rigidly secured to said output shaft;

and

a second roller rotatably mounted on said roller shaft inside said housing between said first roller and
15 said frictional body so as to be in rolling contact with the outer surface of said first roller and the inner cylindrical surface of said frictional body.

4. Elevator drive apparatus, substantially as herein described with reference to the accompanying drawings.
