

ELEVATOR APPARATUS

The present invention relates to an elevator system equipped with a traction drive having a reduction gear unit having rotary gears with parallel axes.

5 A conventional elevator system is described with reference to Figures 1 to 3 of the accompanying drawings, in which:

Figure 1 is a diagrammatic view of a conventional elevator system;

10 Figure 2 is a new, partly in section, view of a traction drive of the system; and

Figure 3 shows characteristic curves representing operation of the system.

Referring to Figures 1 and 2, a conventional
15 elevator system will be described.

In Figures 1 and 2, the reference numeral (1)

designates an elevator shaft; (2) designates a machine room placed above the shaft; (3) designates a reduction gear unit having as main parts rotary gears, e.g. helical gears, with parallel axes as shown in Figure 2, which unit is fixed relative to a floor of the machine room. Referring to Figure 2, the reduction gear unit comprises a fixed housing (3a); an input shaft (3b) mounted in the fixed housing (3a); an intermediate shaft (3c) mounted in the fixed housing (3a) parallel to the input shaft (3b); an output shaft (3d) mounted in the fixed housing (3a) parallel to the intermediate shaft (3c); a first, helical, gear (3f) gear mounted on the input shaft (3b); a second gear (3g) mounted on the intermediate shaft (3c) and meshed with the first gear; a third, helical, gear (3h) mounted on the intermediate shaft (3c); and a fourth gear (3i) mounted on the output shaft (3d) and meshed with the third gear, thereby providing a gear train (3e).

The reference numeral (4) designates a traction sheave which is mounted on one end of the output shaft (3d) of the reduction gear unit (3) for rotation therewith; (5) designates a traction motor connected to one end of the input shaft (3b)

of the reduction gear unit (3) for driving the same; (6) designates a main rope, at the ends of which a car (7) and a counterweight (8) are suspended and which is wound on the traction sheave (4); and (9) designates a deflector sheave.

In this elevator system, the traction sheave (4) is driven through the reduction gear unit (3e) by the traction motor (5), whereby the main rope (6) raises or lowers the car (7). The reduction gear unit (3) having the parallel gears (3f) to (3i) offers superior transmission efficiency relative to conventional worm gear units whereby energy may effectively be saved.

However, vibration of the reduction gear unit. (3e), represented by the curve (b) in Figure 3, occurs during acceleration and deceleration of the car (7) whose velocity is represented by the curve (a) in Figure 3. Such vibration is caused by backlash in the train including the parallel gears (3f) to (3i) of the reduction gear unit (3e) and is transmitted through the traction sheave (4) and the main rope (6) to the car (7), which is unpleasant for passengers.

Moreover, when the weight of the car (7) and its load balances the weight of the counterweight (8), lost motion between the gears results in the vibration of the car (7) increasing.

5 The present invention alleviates these problems and saves energy by employing rotary gears with parallel axes, thereby obtaining superior transmission efficiency in relation to the conventional worm gear unit, and by employing friction generating
10 means to damp vibration resulting from backlash.

 According to the invention, there is provided an elevator system comprising an elevator car, a counterweight, a main cable supporting the elevator car and the counterweight, a traction sheave about
15 which the main cable is wound, a reduction gear unit having an output shaft on which the traction sheave is mounted, and a traction motor for rotating an input shaft of the reduction gear unit whereby to rotate the output shaft and the
20 traction sheave, the reduction gear unit comprising a gear train having rotary gears with parallel axes, and the reduction gear unit further comprising friction generating means for damping vibration resulting from backlash from the gear train.

The invention is described further, by way of example, with reference to Figures 4 to 8 of the accompanying drawings, in which:

Figure 4 is a side view partly in section of one form of traction drive employed in the elevator system of the present invention;

Figure 5 is a circuit diagram of the main electrical parts of the elevator system;

Figure 6 shows characteristic curves representing the operation of the elevator system of the present invention; and

Figures 7 and 8 are side views partly in section of other forms of traction drive employed in the elevator system of the present invention.

Referring to Figures 4 and 5, one embodiment of the present invention will be described. Parts identical to or corresponding with parts shown in Figures 1 and 2 are designated by the same reference numerals.

The reference numeral (3j) designates a through-hole formed in the fixed housing (3a) at a position facing one side of the second gear (3g); and (10) designates electromagnetic friction device for applying a frictional force to the rotary parts of the reduction gear unit (3e). The electromagnetic friction device is mounted on the outer surface of the fixed housing (3a) and comprises a casing (10a) containing a coil (10b) and slidably supporting a friction member (10c) comprising one of two pins having a spring therebetween. The pin (10c) projects through the through-hole (3j) towards the side of the second gear (3g), and thus faces one of the rotary parts of the reduction gear unit (3e), while the other pin passes through the coil (10b). The reference numeral (11) designates a control device for generating a command signal during acceleration or deceleration of the car (7), in response to which the coil (10b) of the electromagnetic friction device (10) is energised to push the pin (10c) against the side of the second gear (3g). A power source is represented by (+) and (-).

In the above elevator system, when the traction motor (5) is operated so as to drive the

car (7) in accordance with the velocity curve (a) in Figure 6, the control device (11) generates the command signal during both acceleration and deceleration of the car (7), and the coil (10b) of the electromagnetic friction device (10) is energised during the periods represented by the curve (c) in Figure 6, current flowing along the path from the positive terminal (+) of the power supply, through the control device (11) and the coil (10b) to the negative terminal (-) in the circuit shown in Figure 5. The friction member (10c) is urged against the second gear (3g) by the energisation of the coil (10b). Because of the friction between the member (10c) and the gear (3g), the vibration caused by the backlash in the gear train including the first to the fourth gears (3f) to (3i) during acceleration or deceleration of the car (7) is damped. Thus, the vibration transmitted to the car (7) during acceleration or deceleration is diminished, rendering the movement more comfortable.

When the car (7) travels at a constant speed, the command signal generated by the control device (11) is absent and the coil (10b) of the electromagnetic friction device (10) is de-energised

whereby the friction between the second gear (3g) and the friction member (10c) is eliminated. Thus, the energy loss caused by the frictional force on the second gear (3g) is avoided when the car
5 (7) travels at a constant speed.

In the above-mentioned embodiment, the control device (11) generates the command signal during the entire acceleration and the entire deceleration of the car (7).

10 However, the problem of vibration caused by backlash in the gear train comprising the first to fourth gears (3f) to (3i) is most pronounced just after starting the car (7) or just before the car (7) stops. The energy loss due to the friction
15 can be reduced by causing the control device (11) to generate the command signal only for short periods at these times to energise the coil (10b) of the electromagnetic friction device (10) briefly and briefly apply the friction member
20 (10c) to the side of the second gear.

The problem of vibration caused by backlash is further aggravated at times when the weight of the

car (7) and its load balances the weight of the counterweight (8). Therefore, energy loss may also be reduced by using a control device (11) which detects the load in the car (7) and which generates the command signal only on occasions when this combination balances the weight of the counterweight (8).

Figure 7 shows parts of another embodiment of the present invention wherein a friction device (10) for imparting a frictional force to one of the rotary parts, namely the second gear (3g), comprises a cylindrical casing (10a) which covers the through-hole (3j) in the wall of the fixed housing (3a); a polyurethane friction member (10c) in the form of a pin which is slidably fitted in the hole (3j) in the fixed housing (3a) with one end arranged to contact a side of the second gear (3g) and the other end extending into the cylinder (10a); an adjusting screw (10d) screwed into a screw hole in an end of the casing (10a) remote from the housing (3a) to project into the casing (10a); and a pressure element (10e) comprising a compressed coil spring connected to the adjusting screw (10d) and the friction member (10c).

In this embodiment the friction member (10c) is mounted in the fixed housing (3a) to exert a desired pressure on the side of the second gear (3g) determined by the pressure element (10e) through adjustment of the adjusting screw (10d). Therefore, vibrations generated by backlash in the train including the first to fourth gears (3f) to (3i) causing vibration of the car (7) etc. are damped by the friction between the friction member (10c) and the side of the second gear (3g). Thus, the total vibration (throbbing) caused by backlash in the reduction gear train (3e) can be reduced. The vibration of the car (7) is thus reduced to give the car a more comfortable ride.

In the above-mentioned embodiments, the friction member (10c) presses on the second gear (3g). The same effect may also be attained by imparting a frictional force to one of the other rotary parts, including the first, third or fourth gears (3f), (3h), (3i) and the input shaft (3b), the middle shaft (3c) or the output shaft (3d) in the reduction gear unit (3).

Figure 8 shows parts of another embodiment

of the present invention, the same references designating identical or corresponding parts to those shown in Figure 4. The reference numeral (10f) -- designates a first friction disc made of metal which
5 is fixed to the input shaft (3b) and has an outer diameter corresponding to that of the pitch circle of the first gear (3f); (10g) designates a second friction disc made of metal which is fixed to the middle shaft (3c) and whose periphery contacts the
10 periphery of the first friction disc (10f); the second friction disc having an outer diameter corresponding to that of the pitch circle of the second gear (3g); (10h) designates a third friction disc made of metal which is fixed to the middle
15 shaft (3c) and has an outer diameter corresponding to that of the pitch circle of the third gear (3h); and (10i) designates a fourth friction disc made of metal which is fixed to the output shaft (3d) and whose periphery contacts the periphery of the
20 third friction disc (10h), the fourth friction disc having an outer diameter corresponding to that of the pitch circle of the fourth gear (3i). The friction generating means (10) are formed by the first to fourth friction discs (10f) to (10i).
25 The reference numeral (12) designated an electro-

magnetic brake which is connected to the fixed housing (3a) to provide a brake for the input shaft (3b).

In this embodiment, the first to fourth
5 friction discs (10f) to (10i) are rotated with the first to fourth gears (3f) to (3i) by the traction motor (5) whereby the first and second friction discs (10f), (10g) rotate in contact with one another and the third and fourth friction discs
10 (10h), (10i) rotate in contact with one another. Therefore, collisions between the teeth of the gears of the reduction gear unit (3e) which are meshed together are controlled by the friction between the friction discs of the friction
15 generating means (10) acting as a buffer. Thus, vibration caused by backlash in the gears of the reduction gear unit (3e) is damped, which in turn reduces the vibration transmitted to the car (7). Thus, the ride of car (7) can be improved.

20 The same effect may be attained by modifying the embodiment shown in Figure 8 such that the first to fourth friction discs (10f) to (10i) are fixed on corresponding sides of the gears (3f) to (3i)

or on corresponding ends of the input shaft (3b), the middle shaft (3c) and the output shaft (3d) projecting out of the reduction gear unit (3).

Another possible modification of the Figure 8 embodiment is that the first to fourth friction discs are made of rubber instead of metal so as to contact one another with elastic deformation. Thus, the friction between the friction discs is increased, enhancing their ability to damp vibration. When the friction discs are made of an elastic material, there is also the advantage that the noise of the friction discs is lower than when they are made of a rigid material.

In accordance with the present invention, the elevator system comprises a reduction unit having rotary parts comprising gears with parallel axes, and further comprises friction generating means for applying a frictional force to the rotary parts of the reduction unit to damp vibration. Energy can be saved by employing a reduction gear unit having gears with parallel axes, such a unit providing superior transmission efficiency relative to conventional reduction gear units including

worm gears; and vibration caused by backlash in the gear train comprising the parallel-axial gears damped by the friction generating means to reduce the vibration of the car and give the elevator

5 car a comfortable ride.



CLAIMS:

1. An elevator system comprising an elevator car, a counterweight, a main cable supporting the elevator car and the counterweight, a traction sheave about which the main cable is wound, a reduction gear unit having an output shaft on which the traction sheave is mounted, and a traction motor for rotating an input shaft of the reduction gear unit whereby to rotate the output shaft and the traction sheave, the reduction gear unit comprising a gear train having rotary gears with parallel axes, and the reduction gear unit further comprising friction generating means for damping vibration resulting from backlash from the gear train.

2. A system according to claim 1 wherein the friction generating means comprise a friction member engageable with one of the rotary gears.

3. A system according to claim 2 wherein the friction generating means comprise an electromagnetic device including the friction member, the electromagnetic device having a



casing which is mounted on the outer surface of
a housing of the reduction gear unit and which
contains an electromagnetic coil, the friction
member being a pin actuatable by the electromagnetic
5 coil to engage one side of said one rotary gear.

4. A system according to claim 3 wherein
the pin is actuatable by the electromagnetic coil
to engage said one rotary gear during acceleration
of the elevator car.

10 5. A system according to claim 3 or 4
wherein the pin is actuatable by the electromagnetic
coil to engage said one rotary gear during
deceleration of the elevator car.

15 6. A system according to claim 3 wherein
the pin is actuatable by the electromagnetic coil
to engage said one rotary gear just after the
elevator car starts to move.

20 7. A system according to claim 3 or 6
wherein the pin is actuatable by the electromagnetic
coil to engage said one rotary gear just before
the elevator car stops moving.

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8. A system according to any of claims 3 to 7 wherein the pin is actuatable by the electromagnetic coil to engage said one rotary gear only on occasions when the weight of the car and its load balances the weight of the counterweight.

9. A system according to claim 2 wherein the friction member comprises a pin resiliently biased into engagement with one side of one of the rotary gears, the friction generating means comprising a cylindrical casing mounted on the outer surface of a housing of the reduction gear unit, an adjusting screw extending into the cylindrical casing through a base wall thereof, and a spring arranged between the adjusting screw and the friction member.

10. A system according to claim 9 wherein the friction member is made of polyurethane.

11. A system according to claim 1 wherein the friction generating means comprise a pair of friction discs each associated with a respective one of a pair of the rotary gears



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which are meshed with one another and each having a diameter corresponding to that of the pitch circle of the associated gear, each friction disc being fixed relative to the associated gear,
5 the friction discs being arranged with their peripheries in contact with one another.

12. A system according to claim 11 wherein the friction discs are made of metal.

13. A system according to claim 11 wherein
10 the friction discs are radially deformable.

14. A system according to claim 13 wherein the friction discs are made of an elastic material.

15. An elevator system substantially as herein particularly described with reference to
15 Figures 4 and 5, Figure 7 or Figure 8 of the accompanying drawings.

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