

ELEVATOR DRIVING DEVICE

BACKGROUND OF THE INVENTION

The present invention is directed to an elevator driving arrangement in which a sheave on which the main cable for suspending the cage is wound is driven by an electric motor through a speed reduction mechanism. More specifically, the present invention is directed to a dual motor driving arrangement and the associated control circuitry for simultaneously energizing both motors or a single motor depending upon operating conditions.

In a conventional elevator driving arrangement as illustrated in Figures 1 and 2, an elevator cage 2 is adapted to be moved up and down a shaft 1 by means of a cable 3 which is wound about a sheave 8 with the opposite end of the cable being entrained over the guide sheave 7 for connection to a counter weight 4. The sheave 8 is mounted on the output shaft 8a of a gear reduction mechanism 12, the input shaft of which is operatively connected to an electric motor 13. The entire mechanism is mounted on a machinery platform 6 located in an equipment room 5 located directly above the elevator shaft 1. The motor is controlled by means of a control unit 17 which is operatively connected to the call buttons in a cage and at each floor.

The details of the driving arrangement are shown in Figure 2 wherein the gear reduction mechanism 12 is shown in cross section. A flywheel 15 and a tachometer for detecting the speed of the motor 13 are mounted on one end of the motor shaft while the other end of the motor shaft is operatively associated with the brake 14 for braking the drive shaft of the motor 13. The drive shaft of the motor 13 is operatively coupled to a high speed drive shaft 11 which is rotatably supported within the gear reduction unit 12. The high speed shaft 11 carries a worm which is in operative engagement with an intermediate gear 10 which in turn is coupled to a gear on the low speed output shaft 9 of the gear reduction unit 12. The low speed output shaft is coupled directly to the shaft 8a upon which the sheave 8 is mounted.

When the motor 13 is deenergized and the brake 14 applied the shafts of the speed reduction unit will also be stopped to prevent the rotation of the sheave 8 and movement of the cage 2 which is suspended by the main cable. When a motor 13 is energized by the control unit 17, the brake 14 is released to allow the motor to turn. In this case, the speed of the motor is detected by the tachometer 16 and fed back to the control unit 17 so that the motor 13 is rotated at a predetermined speed. A high speed shaft 11 of the speed reduction unit 12 is driven

by the motor 13 to thereby rotate the sheave 8 through the gearing of the speed reduction unit 12 to cause movement of the cage up or down depending upon the direction of rotation of the motor 13.

5 A similar elevator drive mechanism utilizing a single electric motor and a single speed reduction unit for driving the sheave upon which the elevator cable is wound is disclosed in co-pending U.S. Patent Application Serial Number 259,609, filed May 1, 1981 and assigned to
10 the same assignee as the present application. In the co-pending application, the arrangement of the sheave, gear reduction unit and electric motor has been modified with respect to the arrangement shown in Figures 1 and 2 of the present application to provide a more compact arrangement.
15 which can more readily be enclosed in a small equipment room at the top of the elevator shaft while still providing easy access to the individual components for servicing.

 In the arrangement disclosed in Figures 1 and
20 2 of the present application, and in the arrangement disclosed in the above-identified co-pending application, the use of a single motor and single gear reduction unit under the control of a single control unit limits the operation of the elevator with respect to speed and
25 torque. When it is desired to design an elevator drive

mechanism for a cage having a higher load capacity, it is necessary to provide a heavy duty speed reduction unit having stronger gears and shafts and if it is desired to vary the speed of the cage, it is necessary to provide a speed reduction unit having a different gear reduction ratio and possibly vary the design of the motor. When the motor is designed differently, for example with a different number of poles, it also becomes necessary to modify the control unit. Thus, it is necessary to provide a variety of different electric motors, different control units, and different speed reduction units so that elevator drive systems can be designed to accomodate different speeds and load capacities. Since a large number of different types of parts are required, it is difficult to achieve savings which would ordinarily be achieved with the mass production of identical components which could be utilized in a larger number of different capacity systems.

SUMMARY OF THE INVENTION

The present invention provides a new and improved elevator driving device which overcomes all of the above-mentioned difficulties associated with the design of elevator drive systems of different capacities and speeds.

The present invention provides a new and

improved elevator drive mechanism which utilizes a plurality of electric motors, each of which is designed for use with an elevator whose cage has a relatively small load capacity, which may be operated simultaneously for driving an elevator cage having a relatively large load capacity thereby allowing the mass production of elevator motors of one size.

The present invention provides a new and improved elevator driving device wherein a plurality of electric motors are operable through speed reduction means to drive a single sheave on which the main cable or suspending cage is wound. Control means are provided for energizing the motors simultaneously to operate the latter in a parallel mode so that controlling the number of electric motors in use provides a motor output which is in agreement with the specification of the elevator. Thus, it is unnecessary to provide a variety of different electric motors or a variety of different elevators, thereby making it possible to produce electric motors for elevators on a large scale with attendant cost savings.

The foregoing and other objects, features, and advantages of the invention will become more apparent from the following more detailed description of the invention as illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a side view, partly in section, of a conventional elevator driving device.

Figure 2 is a sectional view taken along line
5 II-II of Figure 1.

Figure 3 is a top plan view, partly in section of an elevator driving device according to the present invention.

Figure 4 is a schematic circuit diagram showing
10 the control unit according to the present invention.

Figure 5 is a side elevation view, partly in section, showing a modified form of a two motor drive according to the present invention.

Figure 6 is a schematic circuit diagram showing
15 a power converter according to the present invention.

Figure 7 is a detailed circuit diagram showing an operation and direction instruction generating unit and a frequency and phase sequence instruction generating unit from the circuit of Figure 6.

20 Figures 8-13, inclusive, are a number of graphs showing different operating characteristics of the power converter.

DETAILED DESCRIPTION OF THE INVENTION

A first embodiment of the elevator driving
25 device according to the present invention is shown in

Figures 3 and 4 wherein an electric motor 13 and speed reduction unit 12 are provided for driving the sheave 8, similar to that disclosed in the conventional construction of Figure 2. The first electric motor 13 is a three phase induction motor operable under the control of a first control unit 17. A flywheel 15 and tachometer 16 are provided at one end of the motor shaft and a brake mechanism 14 is operably associated with the other end of the motor shaft.

10 An identical electric motor and gear reduction drive unit is provided on the opposite side of the sheave 8 which is a mirror image of the conventional mechanism described above. A second electric motor 23, similar to the first motor 13, is operably coupled to the high speed input shaft 21 of the speed reduction unit 22 and a low speed output shaft 19 is operably driven through the intermediate gears 20. The low speed output shaft 19 is arranged symmetrically with respect to the shaft 9 on the other side of the sheave 8 and both low speed output shafts 9 and 19 are operably coupled to the shaft 8a for supporting the sheave 8. A flywheel 25 is mounted on one end of the motor shaft 23 while a brake mechanism 24 is operably associated with the other end of the motor shaft. A control unit 27 is provided for controlling an electric motor 23 similar to the manner in which the control unit

17 controls the operation of the motor 13. The control circuits 17 and 27 are best seen in Figure 4 wherein an instruction speed generating unit 17a is provided for controlling the operation speed of an elevator cage 2.

5 A first variable-voltage, variable-frequency control unit 17b is provided in which, after three-phase alternating current is converted into direct current, three-phase alternating current is generated again. The variable-voltage, variable-frequency (VVVF) control unit 17b
10 operates to change the frequency and voltage with aid of the difference signal between the output signal of the tachometer 16 and the output signal of the instruction speed generating unit 17a. A second variable-voltage, variable-frequency (VVVF) control unit 27b is similar to
15 the first VVVF control unit 17b and is utilized for the same purpose when applicable.

When the first and second motors 13 and 23 are de-energized, the first and second speed reduction units 12 and 22 are stopped by the first and second brake units
20 14 and 24, respectively, so that the cage will be maintained in a stationary position while being suspended by the main cable 3. When all of the starting conditions have been satisfied the first and second motors 13 and 23
25 are energized by the first and second control units 17 and 27, respectively, while the first and second brake

units 14 and 24 are released, thereby allowing the cage to be driven. The speed of the first motor 13 is detected by the tachometer 16 and is compared with a speed pattern provided by the instruction speed generating unit 17a so
 5 that a comparison signal is produced. With the aid of this comparison signal, the first and second motors 13 and 23 are driven by the first and second VVVF control units 17 and 27, respectively, to run the cage 2 at a predetermined speed.

10 When the cage 2 reaches a predetermined position, the instruction speed generating unit 17a generates a speed reduction pattern to reduce the speeds of the motors 13 and 23 to thereby decelerate the cage 2. When the cage 2 reaches a stopping point, the first and second
 15 motors 13 and 23 are de-energized and the first and second brake units 14 and 24 are actuated to maintain the cage in the stopped condition.

In the above-described elevator driving device, the cage 2 is driven by two electric motors, namely the
 20 first and second motors 13 and 23. Accordingly, it is unnecessary to provide an electric motor, the output of which is twice that of the first motor 13. The first and second motors 13 and 23 are three-phase induction motors and are controlled by the first and second VVVF control
 25 units 17b and 27b, respectively. Accordingly, if the

upper limit of frequency is changed according to the rated speed of the cage 2, the synchronous speed changes with the frequency whereby the cage 2 can be driven at the rated speed. Therefore, the sheave 8, the first speed
5 reduction unit 12, first motor 13, second speed reduction unit 22 and second motor 23, can be applied to elevators with different rated speeds and they can be manufactured on a large scale.

The main cable 3 is connected to a central
10 portion of the cage 2 and accordingly, the sheave 8 must be arranged in a substantially central position in the shaft 1, thus limiting the layout of the driving mechanism. Therefore, the position of the motor is determined by the necessary location of certain mechanical equipment.
15 Accordingly, if the motor is large in capacity, it is generally large in size so that it might interfere with other equipment or the walls of the mechanical equipment room 5. This interference can be eliminated by the provision of the above-described elevator driving device
20 since the space occupied by the motor is decreased by the employment of two electric motors 13 and 23. By arranging the first and second motors on opposite sides of the sheave 8, the space in the machinery equipment room is more effectively utilized.

25 In the above-described device, the first and

second speed reduction units 12 and 22 are comprised of gears whose axes are in parallel. However, in the embodiment of Figure 5, the speed reduction unit 30 is comprised of a worm gear 31 which is secured to the low speed shaft 9 for rotation therewith and a pair of worms 32 and 35 engaged therewith and driven by motors 33 and 36, respectively, each of which is provided with a brake unit 34 and 37, respectively. In this embodiment the sheave 8 is driven by the low speed shaft 9 and the worm wheel 31 which in turn is driven by the first and second worms 32 and 35 which in turn are driven by the first and second motors 33 and 36. Therefore, in this case it is unnecessary to manufacture separately a large capacity electrical motor since smaller uniform size motors can be used which can be manufactured on a large scale. In the worm gear arrangement of Figure 5 the vibrations are substantially reduced relative to the arrangement in Figure 3 wherein the axes of the gear reduction units are disposed in parallel to each other. The speed reduction units may also be manufactured by utilizing conventional planet rollers (not shown). Such a gear reduction unit could be used with a pair of identical low capacity motors such as used in Figure 5 with a further reduction in vibration.

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In the above-described elevator driving device,

the first and second motors are three-phase induction motors. The device was modified to use these DC motors and DC variable-voltage control units 17 and 27 so that the speeds of the DC motors are changed by controlling
5 the voltages, it would then be possible to utilize the motors and speed reduction units with various elevators having different cage speeds.

In the above-described device, two electric motors are used to drive the elevator. However, when the
10 elevator is substantially under full load the cage 2 is liable to be accelerated during operation in the downward direction since the cage 2 is heavier than the counter-balance weight 4. When the elevator is substantially under no load, the cage 2 is liable to be accelerated
15 during operation in the upward direction. Accordingly, it is unnecessary that the first and second motors 13 and 23 be simultaneously operated and controlled in the same manner. That is, a method may be employed in which, depending upon the state of the load and the direction of
20 the operation of the cage, the second motor 23 is de-energized so as to be turned by inertia while only the first motor 13 is energized. Employment of this method results in the economical use of electric power.

The instruction speed generating unit 17a and
25 the VVVF control unit 17b of Figure 4, will be described.

The control unit 27b is similar to the control unit 17b.

The VVVF control unit 17b is shown in Figure 6 wherein the three-phase AC source R, S, and T, lead from a power transformer TR to diodes 101, 102, and 103 whose cathodes are connected together and diodes 104, 105, and 106, whose anodes are connected together. The cathodes of the diodes 104, 105, and 106, are connected to the anodes of the diodes 101, 102, and 103, thereby forming a rectifier circuit 107 for obtaining a direct current.

A smoothing capacitor 107A is connected to the output in rectifier circuit 107 and the collectors of transistors 108, 109, and 110 are connected to the positive output terminal of the rectifier circuit 107. The collectors of transistors 111, 112, and 113 are connected respectively to the emitters of transistors 108, 109, and 110, while the emitters of transistors 111, 112, and 113 are connected to the negative output terminal of the rectifier circuit 107. Diodes 114-119 are connected in parallel to the transistors 109-113, respectively.

The transistors 108-113 and diodes 114-119 form an inverter circuit for converting direct current into alternating current for applying three-phase alternating current to lines U, V, and W, which are connected respectively to the emitters of transistors 108, 109, and 110.

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The electromagnetic contactors 122a, 122b, and 122c, are connected respectively to the lines U, V, and W, and are also connected to a three-phase induction motor 123 which is coupled through the shaft 123a to a winding sheave 124. Upon closure of the contactors 122a, 122b, and 122c, the induction motor is energized by the variable-frequency, three-phase current to turn the winding sheave to thereby move the cage 125 and the counter-balance weight 126 through the main cable 124A. Control push button units 125a and 128 are located in the elevator cage 125, and on each floor 127, respectively.

The instruction speed generating unit 17a is comprised of an operation and direction instruction generating unit 129 for providing the operation-direction and operation-instruction which are determined by the floor call registered by the push button control unit 128 or 125a. The instruction speed generating unit 17a also includes a frequency and sequence instruction generating unit 130 which receives the output signal of the operation and direction instruction generating unit 129 and is provided with six output terminals which operate individually and which are connected to the bases of the transistors 108-113. In response to the output signal from the operation and direction instruction generating unit 129, the transistors 108-113 are rendered conductive,

thereby applying three-phase alternating current to the lines U, V, and W.

The instruction speed generating unit 117a, which is shown broadly in Figure 6, is shown in greater detail in Figure 7 and includes a DC positive pole, +Vcc, a DC negative pole, -Vcb, start instruction contact means 131 having one terminal connected to the DC positive pole for starting the three-phase induction motor 123 upon being closed, deceleration instruction contact means 132, having one terminal connected to the DC negative pole which is adapted to be closed when the cage reaches a predetermined position prior to reaching the desired floor to provide a deceleration instruction, a resistor 133 having one terminal connected to the other terminal of the start instruction contact means 131, a resistor 134 having one terminal connected to the other terminal of the resistor 133 and the other terminal connected to the other terminal of the deceleration instruction contact means 132, a capacitor 135 having one terminal connected to the other terminal of the resistor 133 and the other terminal grounded, and a diode 136 having its anode grounded while being connected in parallel to a capacitor 135. The start instruction contact means 131, the deceleration instruction contact means 132, resistors 133 and 134, capacitor 135 and diode 136 form a speed instruc-

tion generating circuit for providing a voltage at one end of the capacitor as a speed instruction signal V_p . An upward movement instruction contact means 139 having one terminal connected to a DC positive pole is closed when the cage 125 is moved upwardly and a downward movement instruction contact means 140 having one terminal connected to the other terminal of the upward movement instruction contact means 139 and the other terminal grounded is closed when the cage is moved downwardly. The contact means 139 and 140 form a direction instruction generating circuit 141 which provides an output direction instruction signal V_d . The aforementioned operation direction and speed instruction generating unit 129 is made up of the direction and instruction generating circuit 141 and the speed instructing generating circuit 137.

The circuit of Figure 7 also includes a pulse generator 142 for providing a pulse signal 143a having a number of pulses which correspond to the speed instruction signal V_p applied thereto. A binary adder/subtractor 144 receives the direction instruction signal V_d through terminal U/D and the pulse signal 143a through terminal I. When the upward movement instruction contact means 139 is closed to allow the direction instruction signal V_d to have the potential of the DC positive pole $+V_{cc}$ (hereinafter referred to as "a signal H", when applicable) the

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pulses of the pulse signal 143a are subjected to addition, whereas when the downward movement instruction contact means 140 is closed to allow the signal Vd to have a ground potential (hereinafter referred to as "a signal L",
5 when applicable), the pulses are subjected to subtraction so that the first, second, and third bites of the binary number are applied to signal lines 144a, 144d, and 144c, respectively.

A decoder 145 is operated by the output signal
10 of the adder/subtractor 144 in such a manner that a signal H is applied to signal lines 145a-145f, successively, beginning with the signal line 145a and after the signal H is applied to the signal line 145f, the signal line 145a is selected again for receiving the signal H. The input
15 of an OR element 146 is connected to signal line 145a and 145b and the input of OR elements 147-141 are connected to the signal lines 145b and 145c, 145c and 145d, 145d and 145e, 145e and 145f, and 145f and 145a, respectively. The output lines 146a-151a of OR elements 146-151 are
20 connected to the bases of the transistors 108, 113, 109, 111, 110, and 112, respectively.

In the power converter thus constructed three-phase alternate currents from the three phase AC sources R, S, and T are subjected to full-wave rectification in
25 the rectifier circuit 107. Where the smoothing capacitor

107a is not connected to the rectifier circuit 107, the output E_7 of the latter is as shown in Figure 8 which is well known in the art. The output E_7 is smoothed by the capacitor 107a connected to the rectifier circuit 107.

5 On the other hand, the time of occurrence of the peak of the voltage V_{rs} between the three-phase AC sources R and S coincides with that of the peak of the output voltage E_7 as shown in Figure 9. In the case of a line current I_{r7} in the three-phase AC source R, the diodes 101 and
10 105 are rendered conductive with the phase being between $\pi/3$ and $2\pi/3$, the diodes 101 and 106 are rendered conductive with the phase being between $2\pi/3$ and π , the diodes 103 and 104 are rendered conductive with the phase being between $4\pi/3$ and $5\pi/3$, and the diodes 102 and 104
15 are rendered conductive with the phase being between $5\pi/3$ and 2π . That is, the wave form of the line current I_{r7} in the three-phase AC source R is as shown in Figure 9. The same thing can be said with respect to the remaining three-phase AC sources S and T.

20 Assuming the cage 125 is moving upwardly and stopped at a particular floor, the upward movement instruction contact means 139 is closed and the direction instruction signal V_d is applied as the signal H to the adder/subtractor 144. Upon production of the start instruction,
25 the electromagnetic contactors 122a-122c are closed while

the start instruction contact means 131 is closed so that the capacitor 135 is charged through the resistor 133 and the voltage, mainly the speed instruction signal V_p is increased as shown in Figure 10. The pulse generator 142 provides output pulse signals 143a, the number of which corresponds to the speed instruction signal V_p . The pulse signal 143a is subjected to addition in the adder/subtractor 144. More specifically, as shown in Figure 11, when the zero pulse signal 143a is inputted at the time instant t_1 , the signal lines 144a-144c are at the level L. When the first pulse signal 143a is applied, the signal line 144a is at the level H while the signal lines 144b and 144c are at the level L. When the second pulse signal 143a is inputted, the signal line 144b is at the level H and the remaining signal lines are at the level L. When the third pulse signal 143a is inputted, the signal lines 144a and 144b are at the level H and the signal line 144c is at the level L. When the fourth pulse signal 143a is inputted, the signal line 144c is raised to the level H and the remaining signal lines are set to the level L. When the fifth pulse signal 143a is inputted, the signal lines 144a and 144c are at the level H while the signal line 144b is at the level L. When the sixth pulse signal 143a is inputted at the time instant t_2 , all the signal lines 144a-144c are set to the level L. Thus, a senary

counter is formed. When a senary signal is applied to the decoder 145 in synchronism with the pulse signal 143a the signal lines 145a-145f are raised to the level H success-
ively as shown in Figure 12. The signal lines 145a-145f
5 which are raised to the level H successively are connected in pairs to the OR elements 146-151, as shown in Figure 7. Accordingly, a signal H which is twice as long as the signal H provided on each of the signal lines 145a-145f is provided on each of the output lines 146a-151a of the
10 OR elements 146-151 in such a manner that two of the signal lines 146a-151a are at the level H simultaneously as shown in Figure 13. The transistors 108-113 are rendered conductive by the signals H on the signal lines 146a-151a so that three-phase alternating current is
15 applied to the lines U, V, and W to energize the three-phase induction motor 123 to thereby move the cage 125 upwardly. As the speed instruction signal Vp is increased, the interval of the pulse signal 143a is decreased so that the frequency of the three-phase alternating current from
20 the inverter 120 is increased and the three-phase induction motor 123 is accelerated. When the cage 125 reaches the deceleration point in t_3 seconds as shown in Figure 10, the speed reduction instruction contact 132 is closed so that the capacitor 135 is discharged through the
25 resistor 134. Thus, the speed instruction signal Vp is

gradually decreased and finally it becomes zero at the time instant t_4 . Accordingly, the interval of the pulse signal 143a is increased and therefore the frequency of the three-phase alternating current from the inverter 120 is decreased to decelerate the three-phase induction motor 123. At the time instant t_4 , the speed instruction signal V_p becomes zero so that the induction motor 123 is stopped. In the case where the cage 125 is moved downwardly, the pulse signals 143a from the pulse generator 142 are subjected to subtraction in the adder/subtractor 144 and the result of subtraction is applied to the signal lines 144a through 144c. The decoder 145 outputs signals to the signal lines 145a-145f so that the inverter 120 produces the three-pulse alternating current which is opposite in phase rotation to that in the upward movement operation. Accordingly, the three-phase induction motor 123 is turned in the opposite direction to move the cage 125 downwardly to the desired floor.

While the invention has been particularly shown and described with reference to a preferred embodiment thereof, it will be understood by those in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention.

CLAIMS

1. An elevator driving device for use with elevator mechanism having a sheave on which a main cable for suspending a cage is wound comprising a plurality of speed reduction mechanisms which are similar to one another in construction and operation coupled to said sheave, a plurality of electric motors which are similar to one another in construction and operation coupled to said speed reduction mechanisms for driving said sheave through said speed reduction mechanisms respectively, and control means for selectively operating said motors simultaneously in a parallel mode or for operating only a single one of said motors.
2. A device as set forth in Claim 1 wherein said electric motors are three-phase induction motors and said control means includes variable-voltage, variable frequency control units.
3. A device as set forth in Claim 1 wherein said electric motors are DC motors and said control means include variable-voltage control units.
4. A device as set forth in Claim 1 wherein separate control means are provided for each of said electric motors respectively.
5. A device as set forth in Claim 4 further comprising speed detecting means coupled to one of said electric motors for providing speed signals for the operation of said electric motor, said speed signal being utilized to allow said control means to control the operation of said electric motors.



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6. A device as set forth in Claim 1 further comprising a plurality of brake means coupled to said electric motors respectively, said brakes being controlled by said control means in synchronism with the operation control of said electric motors.

7. A device as set forth in Claim 1 wherein said control means operates to energize one of said electric motors and de-energize the remaining electric motors according to the direction of operation of said cage and the state of the load applied to said cage.

8. A device as set forth in Claim 7 wherein when said cage is moved downwardly under a substantially full load or when said cage is moved upwardly under substantially no load, said control means energizes one of said electric motors to move said cage.

9. A device as set forth in Claim 1 wherein said plurality of speed reduction mechanisms and said plurality of electric motors are arranged symmetrically with respect to said sheave.

10. A device as set forth in Claim 6 wherein each of said speed reduction mechanisms are similar in construction and operation, each of said electric motors are of similar construction and operation and each of said plurality of brakes are of the same construction and operation.

11. A device as set forth in Claim 1 wherein each of said speed reduction mechanisms is comprised of a group of gears whose axes are disposed in parallel to each other.



12. A device as set forth in Claim 1 wherein each of
said speed reduction mechanisms is comprised of a worm
coupled to a respective electric motor, a worm gear
operatively engaged in each of said worms and an output
5 shaft coupled to said worm gear to turn said sheave.

13. A device as set forth in Claim 12 wherein said
worms are arranged symmetrically with respect to said
worm gear.

14. An elevator driving device for use with an elevator
10 mechanism having a sheave on which a main cable for
suspending a cage is wound, substantially as
hereinbefore described with reference to Figures 3, 4,
6 and 7 of the accompanying drawings.

15. An elevator driving device for use with an elevator
20 mechanism having a sheave on which a main cable for
suspending a cage is wound, substantially as
hereinbefore described with reference to Figures 5, 6
and 7 of the accompanying drawings.

