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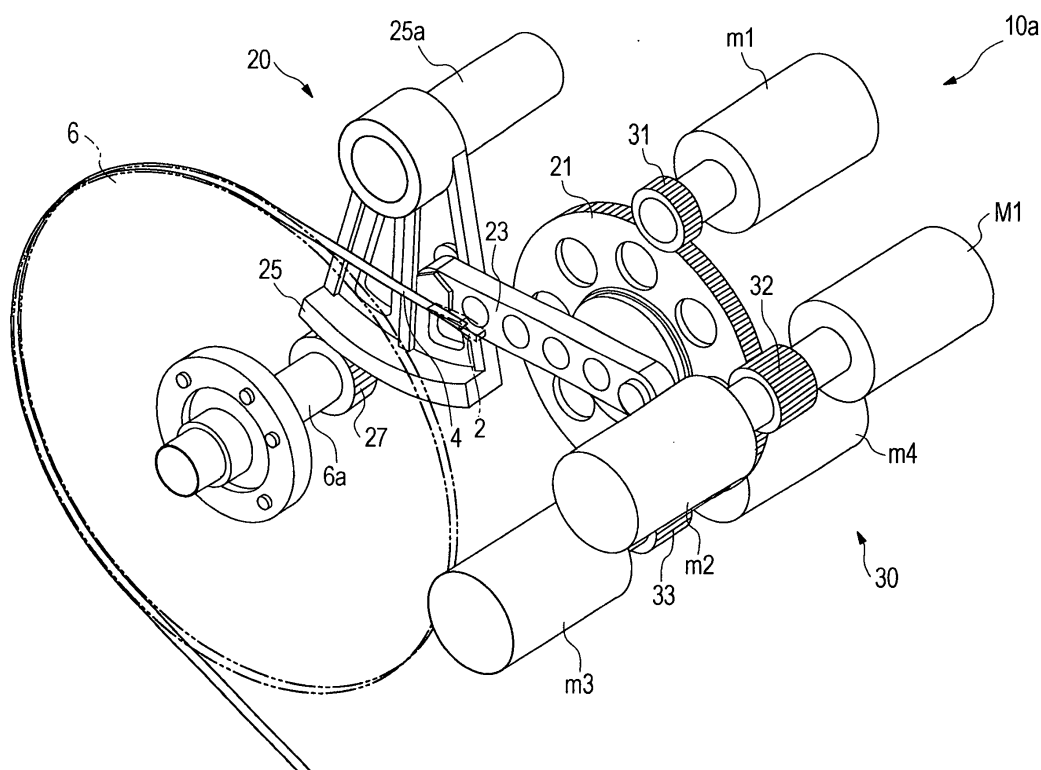
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(54) **Rapier driving device in rapier loom**

(57) In a rapier driving device (10a, 10b) in a rapier loom (1), which includes designated driving means (30) by which a driving wheel (6, 7) for reciprocating a rapier

head (2, 3) is driven independently of a main driving motor of the loom (1), the driving means (30) includes a plurality of driving motors (M1, m1, m2, m3, m4).

**FIG. 2**



## Description

### BACKGROUND OF THE INVENTION

#### 1. Field of the Invention

**[0001]** The present invention relates to driving devices (rapier driving devices) for rapier heads in rapier looms. In particular, the present invention relates to a rapier driving device in a rapier loom, which includes designated driving means by which a driving wheel for reciprocating a rapier head is driven independently of a main driving motor of the loom.

#### 2. Description of the Related Art

**[0002]** Japanese Unexamined Patent Application Publication No. 7-316952 (referred to as "JP 7-316952 A" hereinafter) discloses an example of a rapier driving device in a rapier loom of the above-referenced type. In this rapier driving device, a single servomotor is provided in correspondence with driving wheels (rapier wheels), which are linked to a feeding-side rapier head and a receiving-side rapier head via rapier bands. The single servomotor rotates the rapier wheels in a reciprocating motion so as to reciprocate the rapier heads.

**[0003]** On the other hand, Japanese Unexamined Patent Application Publication No. 11-140745 (referred to as "JP 11-140745 A" hereinafter) discloses an example of a rapier driving device equipped with driving means that is independent of a main driving motor of a loom. In this rapier driving device, a band wheel (driving wheel) for reciprocating a rapier head is driven by the main driving motor of the loom via, for example, a main shaft, and auxiliary electrical driving means is provided for subsidizing the main driving motor to drive the driving wheel.

**[0004]** In other words, in the rapier driving device according to JP 11-140745 A, the auxiliary driving means is provided for preventing a weaving operation from being adversely affected by over-fluctuation in the rotation of the main shaft. Such over-fluctuation is caused by unevenness in a driving torque that unavoidably occurs when the main driving motor of the loom drives the driving wheel. Therefore, the auxiliary driving means is intended to equalize the driving torque.

**[0005]** On the other hand, the rapier driving device according to JP 7-316952 A, which drives the driving wheels with a single driving motor, has the following problems.

1. If the driving force (driving torque) of the driving motor is small, the rapier operation cannot follow the operations of other devices in the loom. Therefore, in a rapier driving device having a single driving motor as a driving source, a driving motor with a large capacity is required in order to attain a sufficient driving force. This results in a size increase of the driving motor, thus leading to an increase in the overall size of the driving device.

2. Furthermore, in comparison with a driving motor having a small capacity, an allowable maximum speed of a driving motor with a large capacity is low. Therefore, the use of a driving motor with a large capacity limits the speed of rotation and thus becomes an impediment to achieving high-speed looms.

**[0006]** On the other hand, although the rapier driving device according to JP 11-140745 A is provided with auxiliary electrical driving means, the main driving motor of the loom still serves as the main driving source of the rapier driving device. In such a rapier driving device whose main driving source is the main driving motor of the loom, the rapier movement pattern is dependent on the rotation of the main driving motor and on a mechanical configuration of a drive transmission mechanism between the main driving motor and the driving wheel. This is problematic in that the flexibility in the rapier movement pattern is limited.

**[0007]** In JP 11-140745 A, the auxiliary driving means is provided so as to subsidize the main driving source for the driving torque. However, the auxiliary driving means is intended to solve the problems that occur when the main driving motor of the loom is used as the driving source of the rapier driving device, which implies that the rapier driving device has a structure that is based on the assumption that the device is used in a rapier loom that applies the main driving motor of the loom as a driving source. In other words, JP 11-140745 A specifies that the auxiliary driving means is necessary only when the rapier driving device is driven by the main driving motor which functions also as a driving source for other devices in the loom. This means that if the rapier driving device is driven by a designated driving motor that is independent of the main driving motor, the auxiliary driving means is not necessary.

### SUMMARY OF THE INVENTION

**[0008]** It is an object of the present invention to provide a driving device in a rapier loom, which is not large in size and can attain a sufficient driving torque while being compatible with high-speed looms.

**[0009]** The present invention provides a rapier driving device in a rapier loom, which includes designated driving means by which a driving wheel for reciprocating a rapier head is driven independently of a main driving motor of the loom. The rapier driving device is characterized in that the driving means includes a plurality of driving motors.

**[0010]** Furthermore, in the rapier driving device according to the present invention, an even number of the plurality of driving motors included in the driving means may form one or more pairs, the driving motors of each pair being disposed facing each other while axis lines thereof are aligned with each other, the driving motors of each pair having output shafts that are linked to each

other.

**[0011]** Furthermore, the driving motors included in the driving means may be linked to a common driving gear via gears attached to output shafts of the driving motors, the common driving gear being linked to the driving wheel. Furthermore, the driving motors may be arranged around the common driving gear in a manner such that a layout angle between two of the driving motors disposed at two positions around the driving gear is not equal to an angle determined by multiplying a pitch angle of gear teeth of the driving gear by an integer.

**[0012]** The term "layout angle" refers to an angle formed between two lines connecting the center of the driving gear with the centers of the output shafts of the two of the driving motors. Furthermore, the phrase "a layout angle between two of the driving motors disposed at two positions around the driving gear is not equal to an angle determined by multiplying a pitch angle of gear teeth of the driving gear by an integer" can also mean that the layout angle is set to an angle determined by multiplying the pitch angle by a numerical value obtained by adding a value less than 1 to an integer.

**[0013]** According to the rapier driving device of the present invention, the driving means is provided with a plurality of small-size driving motors instead of a large-size driving motor with a large capacity. Thus, a sufficient driving torque can be obtained by the driving of the plurality of driving motors. Moreover, by setting the plurality of small-size driving motors at appropriate positions, the overall size of the device is prevented from being increased. Furthermore, the use of the small-size driving motors having a capacity that allows for high-speed rotation contributes to the compatibility with high-speed looms.

**[0014]** Furthermore, as described above, the even number of the plurality of driving motors in the driving means may form one or more pairs. In this case, the driving motors of each pair may be disposed facing each other while the axis lines thereof are aligned with each other, and moreover, the driving motors of each pair may have output shafts that are linked to each other. Consequently, this increases the mechanical supporting rigidity of the driving motors and thus prevents mechanical vibration of the driving motors from occurring. Accordingly, the control operation can be performed stably, thereby achieving a stable rapier movement.

**[0015]** Furthermore, as described above, the plurality of driving motors may be linked to a common driving gear via the gears (motor gears) attached to the output shafts of the driving motors, the common driving gear being linked to the driving wheel. Consequently, this provides a simplified drive transmission mechanism. Moreover, as described above, the driving motors may be arranged around the driving gear in a manner such that the layout angle is not equal to an angle determined by multiplying the pitch angle of the gear teeth of the driving gear by an integer. Accordingly, this minimizes the amplification of vibration, thereby achieving a stable rapier movement.

## BRIEF DESCRIPTION OF THE DRAWINGS

### **[0016]**

Fig. 1 is a schematic side view of a rapier loom to which the present invention is applied;

Fig. 2 is a perspective view showing a relevant portion of a first embodiment of the present invention;

Fig. 3 is a partial cross-sectional view showing a relevant portion of the first embodiment of the present invention; and

Fig. 4 schematically illustrates a relevant portion of the first embodiment of the present invention.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

**[0017]** Embodiments of the present invention will now be described with reference to the drawings.

**[0018]** Figs. 1 to 4 illustrate a first embodiment of the present invention. Fig. 1 schematically shows a rapier loom to which the present invention is applied. In Fig. 1, a rapier loom 1 includes an insert rapier head 2 (which will be referred to as an insert rapier hereinafter) to be inserted into a shed formed by warp threads (not shown) from an initiation side of weft insertion; and a carrier rapier head 3 (which will be referred to as a carrier rapier hereinafter) to be inserted into the warp shed from a terminal side of weft insertion. The insert rapier 2 and the carrier rapier 3 are respectively attached to leading ends of rapier bands 4 and 5. The rapier bands 4, 5 are respectively wound around driving wheels 6, 7 provided for reciprocating the insert rapier 2 and the carrier rapier 3. The driving wheels 6, 7 are rotated in a reciprocating motion respectively by driving devices 10a, 10b that are independent of each other.

**[0019]** In response to the reciprocating rotation of the driving wheel 6, the insert rapier 2 moves back and forth in its front-rear direction while being guided by a plurality of band guides Gr, Gr disposed on a slay S. When moving forward, the insert rapier 2 receives a selected weft thread (not shown) at the initiation side of weft insertion and then enters the warp shed. Subsequently, the insert rapier 2 passes the weft thread over to the carrier rapier 3 at an intermediate position of the warp shed and then recedes from the warp shed. On the other hand, the carrier rapier 3 moves forward to enter the warp shed from the terminal side of weft insertion and receives the weft thread from the insert rapier 2 at the intermediate position of the warp shed. Subsequently, the carrier rapier 3 moves backward together with the weft thread so as to recede from the warp shed. Thus, a series of motions of the insert rapier 2 and the carrier rapier 3 completes one weft insertion cycle in the warp shed.

**[0020]** Figs. 2 and 3 illustrate the driving devices 10a and 10b for rotating the respective driving wheels 6 and 7 in a reciprocating motion according to the first embodiment. Although only the driving device 10a for driving the insert driving wheel 6 is shown in Figs. 2 and 3, the

driving device 10b for driving the carrier driving wheel 7 has the same configuration as the driving device 10a, and therefore, the description and illustration of the driving device 10b will be omitted here.

**[0021]** In the example shown in the drawings, the driving device 10a includes a drive transmission mechanism 20 and driving means 30. The drive transmission mechanism 20 includes a driving gear 21 linked to the driving means 30; a sector gear 25 linked to the driving gear 21 via a crank lever 23; and a driven gear 27 meshed with the sector gear 25 and attached to a shaft 6a which supports the driving wheel 6 in a relatively non-rotatable fashion.

**[0022]** The drive transmission mechanism 20 is housed inside a casing 12 which is fixedly supported by a side surface of a frame 9 of the rapier loom 1. The casing 12 contains therein an oil bath. The driving gear 21 and the sector gear 25 are supported by a side wall of the casing 12 respectively via shafts 21a and 25a, and are disposed rotatably within the casing 12. The crank lever 23 has its first end attached rotatably to a side surface of the driving gear 21 at an eccentric position with respect to the shaft 21a. Moreover, a second end of the crank lever 23 is attached rotatably to a side surface of the sector gear 25 at an eccentric position with respect to the shaft 25a, the eccentric position being disposed at an end portion of the sector gear 25 that is closer to the driving gear 21.

**[0023]** The driving wheel 6 is supported by the shaft 6a, and the shaft 6a is rotatably supported by a plate-like base bracket 13 which is fixedly supported by the casing 12.

**[0024]** In the drive transmission mechanism 20 having the above-described structure, when the driving gear 21 is rotated, the sector gear 25 rocks back and forth around the shaft 25a. In response to the rocking of the sector gear 25, the shaft 6a is rotated in a reciprocating motion via the driven gear 27, thereby rotating the driving wheel 6 in a reciprocating motion. In this case, the driving gear 21 may be driven unidirectionally or may be driven in forward and reverse directions within a predetermined rotational angle range. Furthermore, the attachment position of the crank lever 23 with respect to the sector gear 25 (i.e. the amount of eccentricity with respect to the shaft 25a) may be adjustable such that the rocking amount of the sector gear 25 can be made adjustable in a case where the driving gear 21 is to be rotated unidirectionally.

**[0025]** As shown in the drawings, the driving means 30 for rotating the driving gear 21 includes a plurality of driving motors. Each of the driving motors is, for example, a servomotor, and in the example shown in the drawings, there are five servomotors M1, m1, m2, m3, m4 provided. The driving motors are not limited to servomotors and may alternatively be other rotary actuators, such as pulse motors and stepping motors.

**[0026]** The driving motors are disposed at their predetermined positions on opposite sides of the casing 12, and are fixedly supported by outer walls of the casing 12.

The driving motors have output shafts that extend through the walls of the casing 12. The output shafts of the driving motors have motor gears 31, 32, 33 attached thereto, which are meshed with the driving gear 21 within the casing 12. In other words, all of the driving motors included in the driving means 30 are linked to a common driving gear 21 via the motor gears 31, 32, 33 attached to the corresponding output shafts of the driving motors.

**[0027]** Furthermore, four (even number) of the five driving motors shown in the drawings are divided into two pairs, which are a pair of the driving motors M1 and m2 and a pair of the driving motors m3 and m4. The driving motors of each pair are disposed facing each other while the axis lines of their output shafts are aligned with each other. In detail, the driving motors M1 and m2 have their output shafts linked to each other via the motor gear 32, and the driving motors m3 and m4 have their output shafts linked to each other via the motor gear 33. Accordingly, each of the motor gears 32 and 33 serves as a common gear between two driving gears.

**[0028]** Referring to Fig. 4, in the first embodiment, the driving motors are arranged in a manner such that the layout angle of adjacent driving motors around the driving gear 21 is not equal to an angle determined by multiplying a pitch angle of the gear teeth of the driving gear 21 by an integer. Specifically, if the number of gear teeth of the driving gear 21 is 60, a pitch angle  $\theta$  of the gear teeth of the driving gear 21 is determined by  $360^\circ / 60 = 6^\circ$ . If the layout angle of the driving motor M1 (m2) with respect to the driving motor m1 is defined as  $\alpha$  and the layout angle of the driving motor m4 (m3) with respect to the driving motor M1 (m2) is defined as  $\beta$ , the driving motors are arranged such that  $\alpha \neq 6n$  and  $\beta \neq 6n$  (n being an integer). In the example shown in Fig. 4,  $\alpha = 84.2^\circ$  and  $\beta = 82.3^\circ$ . Therefore,  $\alpha/\theta \approx 14.03$  and  $\beta/\theta \approx 13.7$ . In this case, the layout angle of the driving motor m4 with respect to the driving motor m1 is also not equal to an angle determined by multiplying the pitch angle by an integer.

**[0029]** In the rapier driving device as described above, the driving means 30 including the plurality of driving motors is used for driving the driving gear 21, which is for rotating the driving wheel 6 in a reciprocating motion. Therefore, the driving motors do not need to have large capacities, which implies that small-size driving motors with small capacities can be used. Accordingly, the driving device is capable of attaining a sufficient driving force while being prevented from size increase. Moreover, in comparison to driving motors with large capacities, the driving motors in the first embodiment can rotate at high speed, which implies that these driving motors can sufficiently comply with high-speed looms.

**[0030]** On the other hand, in a conventional rapier driving device having a single driving motor as a driving source, if the rapier operation becomes uncontrollable due to malfunction of, for example, the driving motor or a control circuit thereof, a rapier may stop in the warp shed, causing a rapier head or band guide to break or a plurality of warp threads to break. In contrast, an addi-

tional advantage of the present invention is that since a plurality of driving motors is provided, even when malfunction occurs in one of the driving motors, a rapier can be successively driven by the remaining driving motors, thus solving the problems existed in the conventional art.

**[0031]** Furthermore, since the driving motors of each pair are disposed facing each other while the output shafts thereof are linked to each other, the supporting rigidity of the driving motors is enhanced, thereby contributing to a stable rapier movement. In contrast, if the supporting rigidity is low, the stability in the control of the driving motors may be impaired as a result of vibration of the driving motors. Because the supporting rigidity is enhanced in the present invention, the vibration of the driving motors is reduced so that the driving motors can be controlled stably, thereby achieving a stable rapier movement.

**[0032]** With regard to the positioning of the driving motors around the driving gear 21, if the layout angles of the driving motors arranged around the driving gear 21 are equal to an angle determined by multiplying the pitch angle of the gear teeth of the driving gear 21 by an integer, the mesh conditions of the motor gears 31, 32, 33 with respect to the driving gear 21 become substantially the same. This may unfavorably cause the waveforms of vibration generated in the mesh sections to be consistent with each other, thus resulting in amplified vibration. In contrast, in the rapier driving device according to the present invention, since the layout angles are not equal to an angle determined by multiplying the pitch angle of the gear teeth of the driving gear 21 by an integer, the mesh conditions of the motor gears 31, 32, 33 with respect to the driving gear 21 are different from each other. Consequently, the conditions of vibration generated in the mesh sections become different from each other, thereby preventing amplification of vibration and also preventing the stability in the control of the driving motors from being impaired. Accordingly, this contributes to a stable rapier movement.

**[0033]** Although the number of driving motors provided in the driving means 30 according to the first embodiment is five, the present invention is not limited to this number. Alternatively, the number of driving motors provided may be two or more. The number of driving motors may be set in accordance with, for example, the speed of rotation or weaving condition of the loom. Furthermore, the driving motors may be controlled in a manner such that the number of driving motors to be used is adjusted in accordance with, for example, the speed of rotation or weaving condition of the loom.

**[0034]** Furthermore, in the first embodiment as described above, four of the five driving motors are divided into two pairs, and the driving motors of each pair are disposed facing each other while the output shafts thereof are linked to each other. However, the present invention is not limited to this configuration. Alternatively, all of the driving motors may be disposed on the same side as the driving gear 21.

**[0035]** Furthermore, in the first embodiment as described above, with regard to the arrangement between adjacent driving motors, the layout angle of the driving motor M1 with respect to the driving motor m1 and the layout angle of the driving motor m4 (m3) with respect to the driving motor M1 (m2) are not equal to an angle determined by multiplying the pitch angle of the gear teeth of the driving gear 21 by an integer, and moreover, the layout angle ( $\alpha + \beta$ ) of the driving motor m3 with respect to the driving motor m1 is also not equal to an angle determined by multiplying the pitch angle by an integer. Alternatively, in the present invention, in the case where the driving motors are arranged at three or more positions around the driving gear 21, the driving motors may be arranged in a manner such that the layout angles of the driving motors at two of the positions are not equal to an angle determined by multiplying the pitch angle by an integer. However, it is more preferable that the layout angles of a combination of driving motors at any two of the positions be not equal to an angle determined by multiplying the pitch angle by an integer.

**[0036]** Furthermore, the drive transmission mechanism 20 included in the driving device 10a or 10b is not limited to the use of, for example, the crank lever 23 and the sector gear 25. For example, in place of the crank lever 23, a cam may be attached to the shaft 21a of the driving gear 21 and a cam lever may be linked to the sector gear 25 so as to form a cam mechanism. In this case, the rotation of the shaft 21a is converted to a reciprocating rocking motion of the sector gear 25 via the cam mechanism. As a further alternative, the drive transmission mechanism 20 may be omitted. In that case, the driving gear 21 may be attached to the shaft that supports the driving wheel 6 or 7, and the driving motors may be driven in forward and reverse directions so as to rotate the driving wheel 6 or 7 in a reciprocating motion.

**[0037]** The technical scope of the present invention is not limited to the above embodiments, and modifications are permissible within the scope and spirit of the present invention.

## Claims

1. A rapier driving device (10a, 10b) in a rapier loom (1), the device (10a, 10b) including designated driving means (30) by which a driving wheel (6, 7) for reciprocating a rapier head (2, 3) is driven independently of a main driving motor of the loom (1), wherein the rapier driving device (10a, 10b) is **characterized in that** the driving means (30) includes a plurality of driving motors (M1, m1, m2, m3, m4).
2. The rapier driving device (10a, 10b) in the rapier loom (1) according to Claim 1, wherein an even number of the plurality of driving motors (M1, m1, m2, m3, m4) in the driving means (30) forms one or more pairs, the driving motors of each pair being disposed

facing each other while axis lines thereof are aligned with each other, the driving motors of each pair having output shafts that are linked to each other.

3. The rapier driving device (10a, 10b) in the rapier loom (1) according to Claim 1, wherein the driving motors (M1, m1, m2, m3, m4) included in the driving means (30) are linked to a common driving gear (21) via gears (31, 32, 33) attached to output shafts of the driving motors (M1, m1, m2, m3, m4), the common driving gear (21) being linked to the driving wheel (6, 7). 5 10
4. The rapier driving device (10a, 10b) in the rapier loom (1) according to Claim 3, wherein the driving motors (M1, m1, m2, m3, m4) are arranged around the common driving gear (21) in a manner such that a layout angle between two of the driving motors disposed at two positions around the driving gear (21) is not equal to an angle determined by multiplying a pitch angle of gear teeth of the driving gear (21) by an integer. 15 20

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FIG. 1

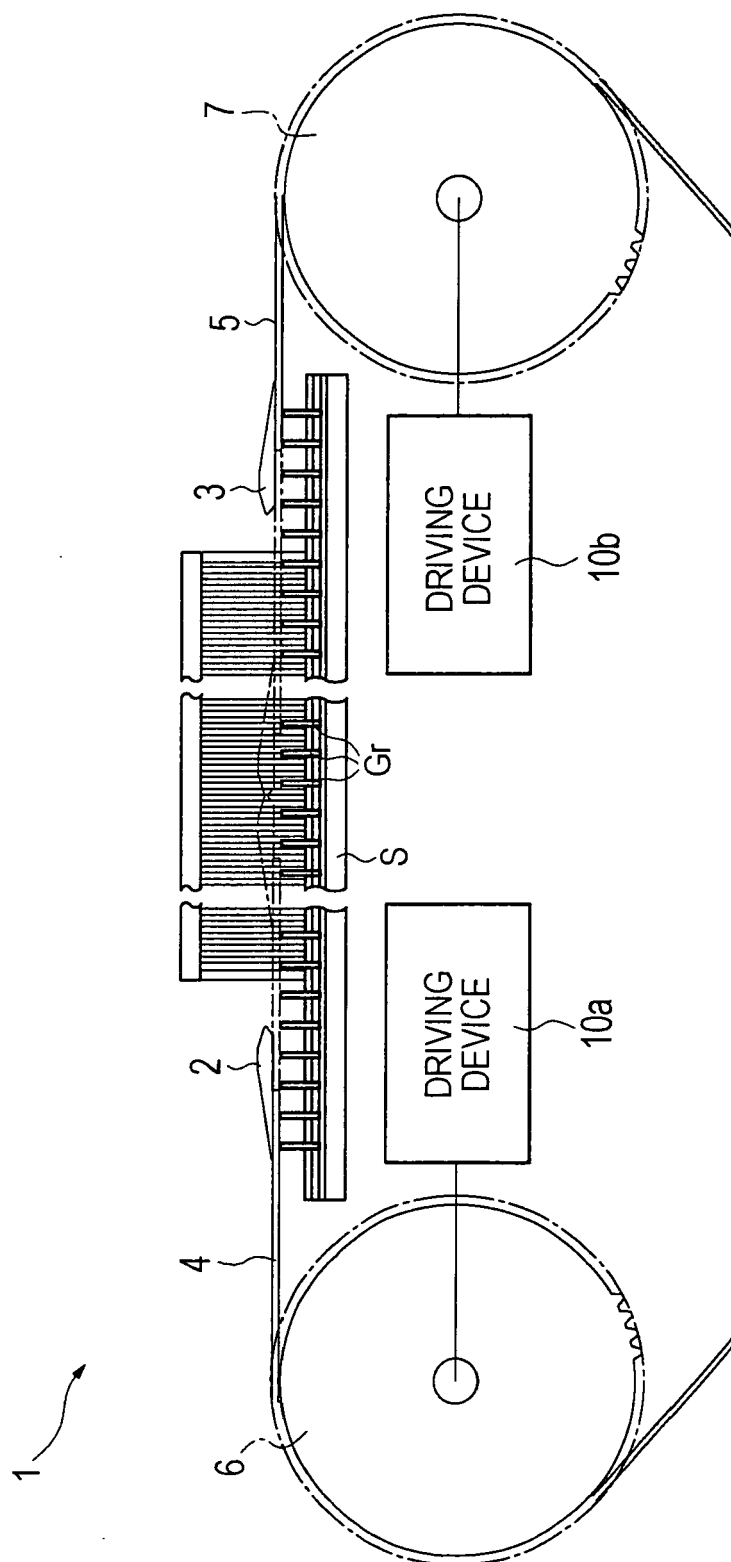


FIG. 2

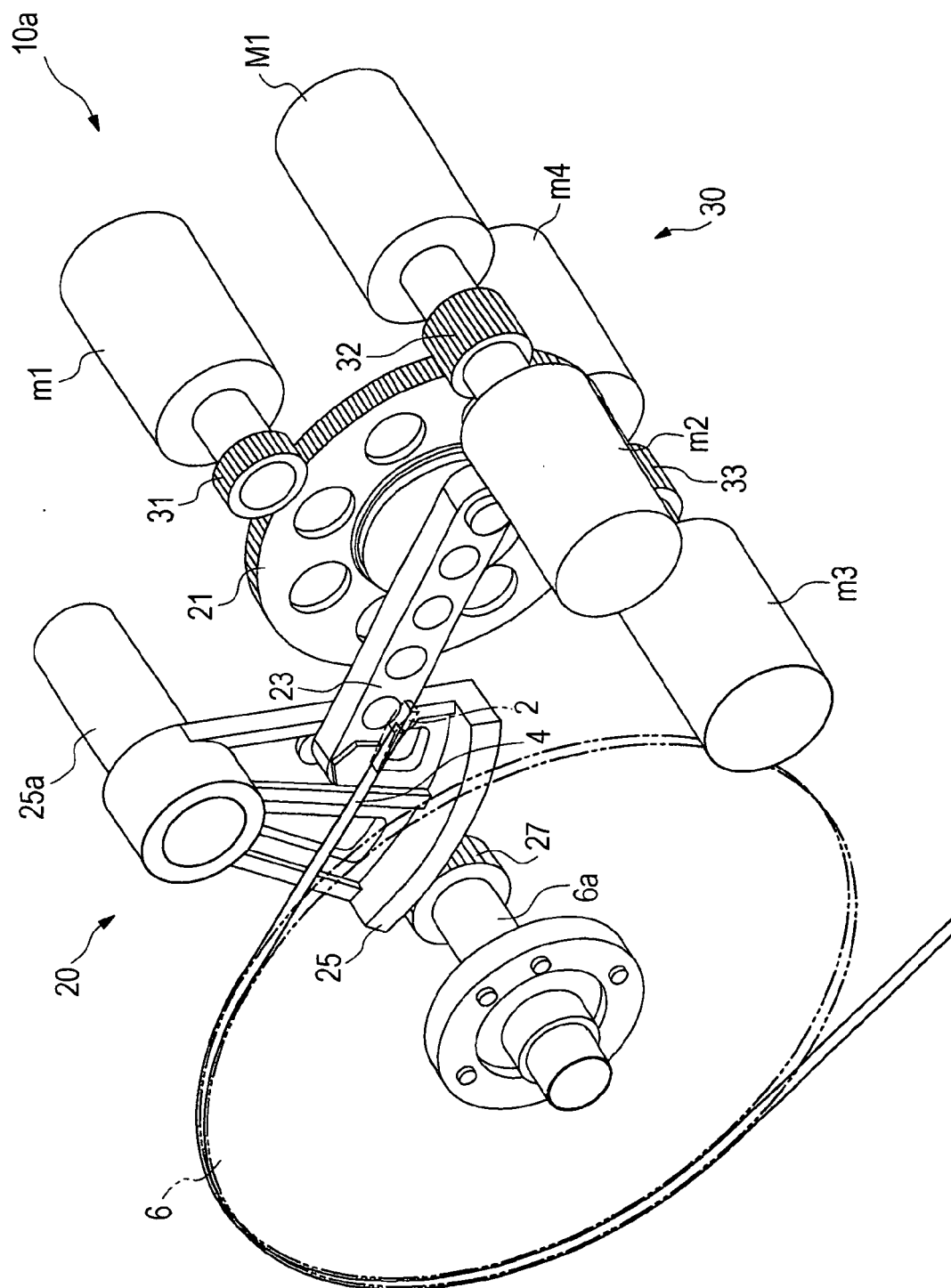


FIG. 3

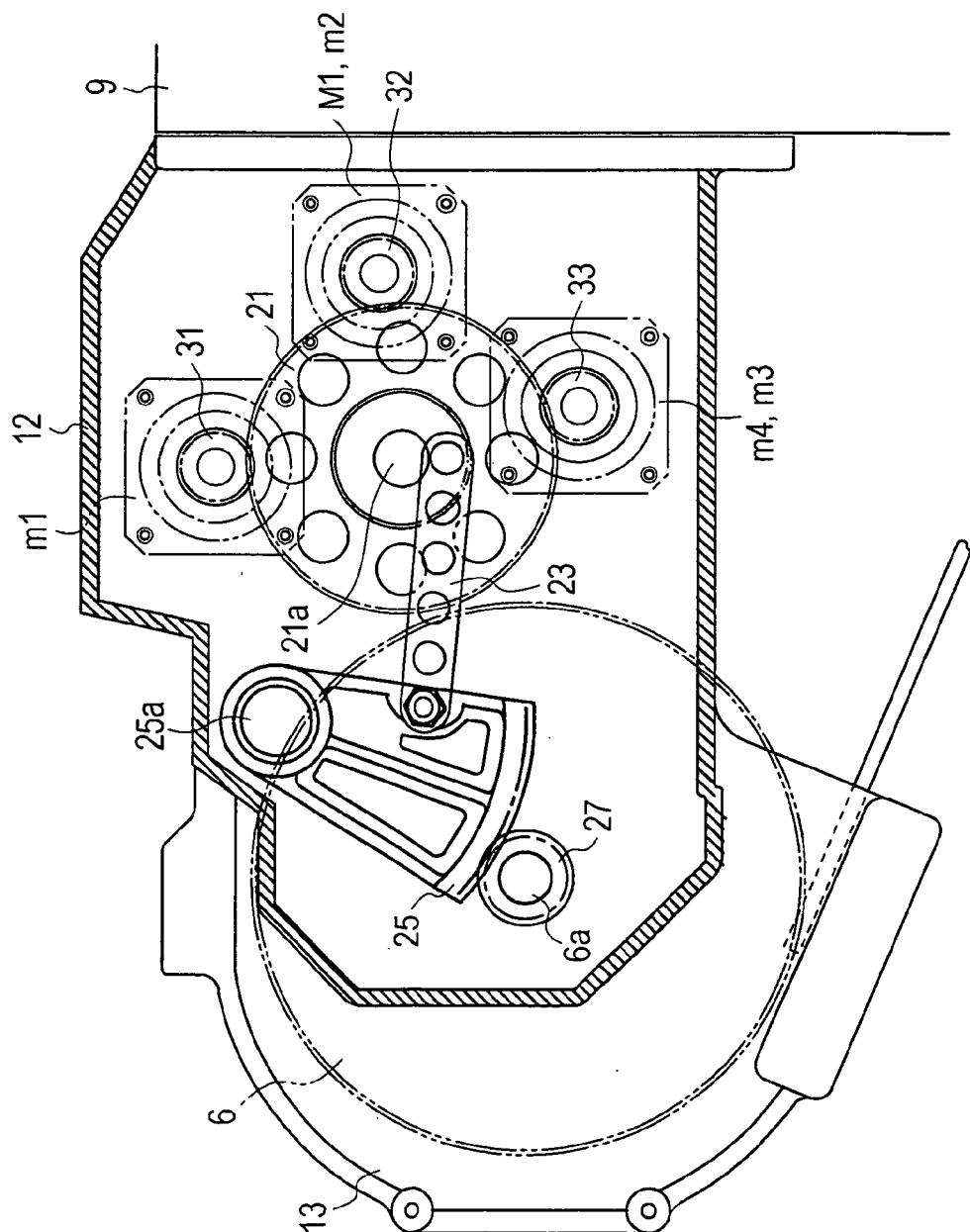
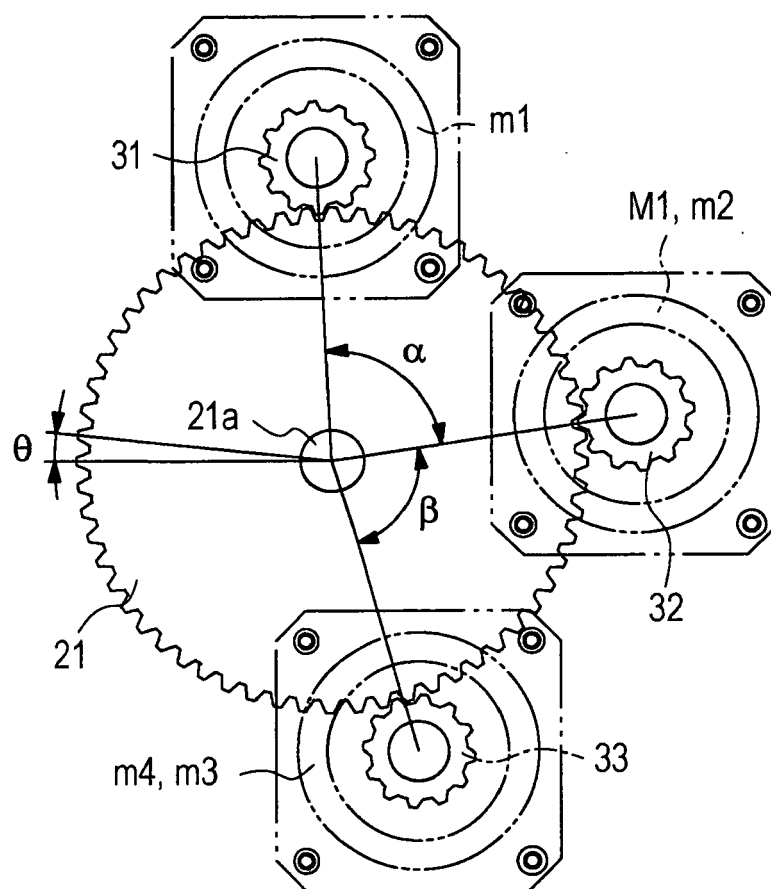


FIG. 4



**REFERENCES CITED IN THE DESCRIPTION**

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