(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 608 458 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
12.02.2020 Bulletin 2020/07

(51) Int Cl.:
D03C 3/32 *(2006.01)* ***D03C 1/14*** *(2006.01)*
D03C 13/00 *(2006.01)*

(21) Application number: **19188246.3**

(22) Date of filing: **25.07.2019**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(30) Priority: **09.08.2018 JP 2018149988**

(71) Applicant: **Tsudakoma Kogyo Kabushiki Kaisha**
Kanazawa-shi, Ishikawa-ken 921-8650 (JP)

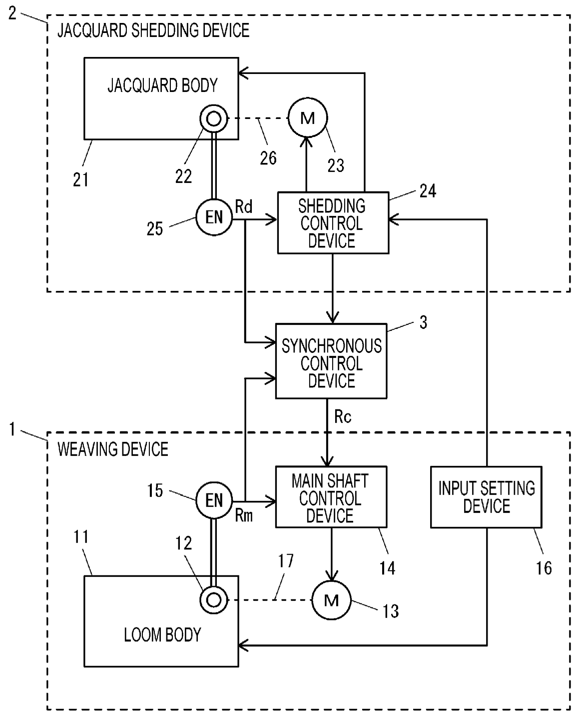
(72) Inventor: **ITO, Naoyuki**
Ishikawa-ken, 921-8650 (JP)

(74) Representative: **Eisenführ Speiser**
Patentanwälte Rechtsanwälte PartGmbB
Postfach 31 02 60
80102 München (DE)

(54) SYNCHRONOUS CONTROL METHOD FOR LOOM AND THE LOOM

(57) In a loom including a shedding device (2) that includes a shedding motor (23) independent from a main shaft motor (13) of the loom as a driving source and that displaces each of healds in an up-down direction as a single drive shaft (22) that is common to all of the healds is driven by the shedding motor (23), a rotation amount of the drive shaft (22) in each weaving cycle is detected at least when the loom is performing a normal operation, and driving of the main shaft motor (13) is controlled so that a main shaft (12) of the loom is rotated so as to be synchronized with the drive shaft (22) in accordance with a detection signal indicating the detected rotation amount.

FIG. 1



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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a synchronous control method for a loom including a shedding device that includes a shedding motor independent from a main shaft motor of the loom as a driving source and that displaces each of healds in an up-down direction as a single drive shaft common to all of the healds is driven by the shedding motor, and relates to the loom.

2. Description of the Related Art

[0002] A Jacquard shedding device is well known as a shedding device that causes warp yarns to perform shedding motion.

[0003] The Jacquard shedding device is configured to displace each of healds independently upward or downward in accordance with a preset pattern in order to cause warp yarns passed through the healds to enter a shed state as a single drive shaft that is common to all of the healds is rotated.

[0004] Regarding a loom including such a Jacquard shedding device, in general, each time the main shaft of the loom is rotated one turn, the drive shaft of the shedding device is rotated 1/2 turn. As a structure for rotating the drive shaft in this way, to date, there are the following two types: a mechanical structure in which the main shaft is used as a driving source; and an electrical structure in which a dedicated motor is used as a driving source.

[0005] With the former mechanical structure, the loom is configured so that the drive shaft of the shedding device and the main shaft of the loom are mechanically coupled to each other by using a shaft, a chain, and the like. However, this structure has a problem in that a large number of mechanical components are necessary and maintenance is very troublesome.

[0006] On the other hand, with the latter electrical structure, the loom is configured so that the drive shaft of the shedding device is driven by a dedicated driving motor (shedding motor) that is independent from the main shaft motor of the loom. With this structure, coupling between the drive shaft of the shedding device and the main shaft of the loom is electrical. Therefore, this structure has advantages in that the number of mechanical components can be reduced and ease of maintenance is improved, compared with the mechanical structure. Japanese Unexamined Patent Application Publication No. 3-249233 discloses a loom in which such an electrical structure is used to couple the drive shaft of the Jacquard shedding device and the main shaft of the loom to each other.

SUMMARY OF THE INVENTION

[0007] The loom described in Japanese Unexamined Patent Application Publication No. 3-249233 synchronously controls driving of the shedding motor so that the rotation of the drive shaft of the shedding device is synchronized with the rotation of the main shaft of the loom.

[0008] In a shedding device, because healds, through which warp yarns keeping a predetermined tension are passed, are displaced up or down, a load that is applied to the drive shaft is large. In addition, in general, a Jacquard shedding device is used to weave a fabric having a complicated woven design. Therefore, in the Jacquard shedding device, the healds are driven in accordance with a complicated pattern, and accordingly, there are many cases where the number of healds that are displaced upward and the number of healds that are displaced downward considerably vary from loom cycle to loom cycle. In this case, a load that is applied to the drive shaft considerably varies from loom cycle to loom cycle.

[0009] Therefore, in order to synchronously control driving of the shedding motor as described above, it is necessary to control driving of the shedding motor so that the rotation of the drive shaft is not delayed or advanced by being affected by the load variation.

[0010] Moreover, the main shaft of the loom is coupled to a beating device, and a load generated by the beating motion (swinging of a reed) is applied to the main shaft of the loom. Therefore, the rotation of the main shaft is not uniform and varies during one turn (in one loom cycle). Accordingly, it is necessary to perform the synchronous control of the shedding motor so that the rotation of the drive shaft follows the rotation of the main shaft that varies in this way.

[0011] Therefore, in a Jacquard shedding device that uses a dedicated driving motor (shedding motor) as a driving source, in general, a high-power synchronous motor (for example, a servomotor), which enables such synchronous control, is used as the shedding motor. However, because such a synchronous motor is expensive, the cost of a loom including the Jacquard shedding device is increased.

[0012] The present invention has been made in consideration of the above circumstances, and an object the present invention is to provide a synchronous control method for a loom with which it is not necessary to use such a high power synchronous motor as a shedding motor in the loom described above and that enables the total cost of the loom to be kept down, and to provide the loom.

[0013] The present invention is based on a loom including a shedding device that includes a shedding motor independent from a main shaft motor of the loom as a driving source and that displaces each of healds in an up-down direction as a single drive shaft that is common to all of the healds is driven by the shedding motor.

[0014] A synchronous control method for a loom according to the present invention includes detecting a rotation amount of the drive shaft in each weaving cycle at least when the loom is performing a normal operation, and controlling driving of the main shaft motor so that a main shaft of the loom is rotated so as to be synchronized with the drive shaft in accordance with a detection signal indicating the detected rotation amount.

[0015] In the synchronous control method for a loom according to the present invention, the controlling of driving of the main shaft motor may include rotating the main shaft by a target rotation amount, the target rotation amount being obtained based on the rotation amount of the drive shaft that is detected at each set period that is preset, in the set period from a time when the target rotation amount is obtained; detecting an actual rotation angle of the main shaft at a time when a rotation angle of the main shaft is expected to reach a set angle that is a preset and predetermined rotation angle of the main shaft; obtaining a deviation of the actual rotation angle from the set angle by comparing the detected actual rotation angle with the set angle; and correcting, at a time when the deviation for a preset number of times is obtained, the target rotation amount that is obtained for the set period after the time, based on the deviation.

[0016] In the synchronous control method for a loom according to the present invention, a control parameter that is used to control the main shaft motor may be changed in accordance with a load that is applied to the drive shaft as the healds are displaced.

[0017] A loom for realizing a synchronous control method according to the present invention is based on a loom including a shedding device and a main shaft control device, the shedding device including a shedding motor independent from a main shaft motor of the loom as a driving source and displacing each of healds in an up-down direction as a single drive shaft that is common to all of the healds is driven by the shedding motor, the main shaft control device controlling driving of the main shaft motor.

[0018] In the present invention, the loom includes a rotation detecting device that detects a rotation amount of the drive shaft in each weaving cycle at least when the loom is performing a normal operation; and a synchronous control device that obtains a rotation amount of a main shaft of the loom so that the main shaft is synchronized with the drive shaft in accordance with a detection signal that is output from the rotation detecting device, the synchronous control device outputting a rotation command signal based on the obtained rotation amount of the main shaft to the main shaft control device.

[0019] In the loom according to the present invention, the synchronous control device may include a calculating unit that obtains a target rotation amount based on a rotation amount of the drive shaft that is detected at each set period that is preset, the target rotation amount being a rotation amount by which the main shaft is to be rotated in the set period from a time when the target rotation amount is obtained; an angle detector that obtains an actual rotation angle of the main shaft at a time when a rotation angle of the main shaft is expected to reach a set angle that is a preset and predetermined rotation angle of the main shaft; and a comparing unit that obtains a deviation of the actual rotation angle obtained by the angle detector from the set angle by comparing the actual rotation angle with the set angle; and the calculating unit may include a correcting unit that corrects, at a time when the deviation for a preset number of times is obtained, the target rotation amount that is obtained for the set period after the time, based on the deviation.

[0020] In the loom according to the present invention, the synchronous control device may have a function of changing a control parameter that is used to control the main shaft motor in accordance with a load that is applied to the drive shaft as the healds are displaced.

[0021] With the present invention, because synchronous control of the drive shaft and the main shaft is performed so that the rotation of the main shaft of the loom is synchronized with the rotation of the drive shaft of the shedding device, it is not necessary that the shedding motor have an ability of maintaining the synchronous state of the drive shaft, in which a large load is applied to the main shaft during weaving as described above. Thus, an inexpensive induction motor, instead of an expensive synchronous motor, can be used as the shedding motor, and accordingly the cost of the shedding device can be reduced.

[0022] Because the rotation of the main shaft is made to synchronize with the rotation of the drive shaft, it is necessary to use a synchronous motor as the main shaft motor, and accordingly the cost of the main shaft motor increases. However, when a load that is applied to the drive shaft (a load due to displacing of the healds) and a load that is applied to the main shaft (a load due to swinging of the reed) are compared with each other, the load that is applied to the main shaft is about a half of the load that is applied to the drive shaft and is sufficiently small. Therefore, even in a case where a synchronous motor is used as the main shaft motor, the main shaft motor may be an inexpensive motor whose power is lower than that of the shedding motor of existing looms. Accordingly, although the cost of the main shaft motor itself is increased to some extent, the cost of the entirety of the loom can be reduced compared with a case where a synchronous motor is used as the shedding motor.

[0023] In the present invention, by controlling driving of the main shaft motor so that the target rotation amount of the main shaft is corrected, even in a case where a mismatch between the rotation amounts of the drive shaft and the main shaft occurs, the mismatch is eliminated and a state in which the rotation of the main shaft is more accurately synchronized with the rotation of the drive shaft can be maintained.

[0024] To be specific, in the present invention, although the rotation of the main shaft is synchronized with the rotation of the drive shaft, a mismatch between the rotation amounts of the drive shaft and the main shaft may occur for some reason (for example, abnormal vibration of the loom).

[0025] Therefore, an actual rotation angle of the main shaft at a time when the rotation angle of the main shaft is expected to reach the set angle is detected, and the mismatch (deviation) between the rotation amounts is obtained by comparing the detected actual rotation angle with the set angle. In addition, by controlling driving of the main shaft motor so as to correct the target rotation amount of the main shaft based on the obtained deviation, the mismatch can be eliminated. As a result, it is possible to maintain a state in which the main shaft is more accurately synchronized with the drive shaft.

[0026] In the present invention, by changing a control parameter that is used to control the main shaft motor in accordance with a load that is applied to the drive shaft, a load on the main shaft motor can be suppressed.

[0027] To be specific, the load that is applied to the drive shaft varies from loom cycle to loom cycle as described above, and accordingly the rotation of the drive shaft varies from loom cycle to loom cycle. In the present invention, because the rotation of the main shaft is made to follow the rotation of the drive shaft that varies, the load on the main shaft motor is large when the variation is large.

[0028] Therefore, by changing the control parameter so as to reduce the followability of the rotation of the main shaft to the rotation of the drive shaft in a weaving cycle in which the load that is applied to the drive shaft is large, the load on the main shaft motor can be suppressed in a case where variation in the rotation of the drive shaft is large.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029]

Fig. 1 is a block diagram illustrating an example of the structure of a loom according to the present invention;

Fig. 2 is a block diagram illustrating an example of the structure of a synchronous control device; and

Fig. 3 is a block diagram illustrating another example of the structure of a synchronous control device.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0030] Fig. 1 illustrates an example of a loom to which the present invention is applied. A loom according to the present embodiment is composed of a weaving device 1 that includes a loom body 11 including a weft insertion device, a beating device, and the like (not shown); and a Jacquard shedding device 2 that includes a Jacquard body 21, which is disposed above the weaving device 1 (the loom body 11), as a shedding device that causes warp yarns to perform shedding motion. The Jacquard shedding device 2 uses a dedicated motor (a shedding motor 23) that is independent from a motor of the loom body 11 (a main shaft motor 13) as a driving source. The Jacquard body 21 is mechanically independent from the loom body 11.

[0031] The weaving device 1 further includes, in addition to the loom body 11, which includes a main shaft 12 and which performs weaving by using the aforementioned weft insertion device, the beating device, and the like, the main shaft motor 13 for rotating the main shaft 12 of the loom body 11, and a main shaft control device 14 for controlling the rotation of the main shaft motor 13. The weaving device 1 includes a main-shaft-side encoder 15 for detecting the rotation amount of the main shaft 12 that is rotated as described above, and an input setting device 16 for inputting and setting set values of weaving conditions and the like.

[0032] The main shaft motor 13 is coupled to the main shaft 12 of the loom body 11 via a drive transmission mechanism 17 such as a speed reducer. In the present embodiment, the main shaft motor 13 is a synchronous motor. Examples of the synchronous motor include an IPM motor. The main shaft 12 is rotated by the main shaft motor 13. In addition, the beating device, which is included in the aforementioned loom body 11, is configured so that a reed that is coupled to the main shaft 12 is swung due to the rotation of the main shaft 12. Accordingly, in the beating device, as the main shaft 12 is rotated as described above, the reed is swung and beating motion is performed.

[0033] Moreover, in the weaving device 1, weaving is performed as the aforementioned weft insertion device performs weft insertion. Devices related to weaving, such as the weft insertion device, are controlled in accordance with a rotation angle of the main shaft 12 (hereafter, referred to as "crank angle") that is detected. Therefore, the weaving device 1 includes the main-shaft-side encoder 15 for detecting the crank angle. The main-shaft-side encoder 15 outputs a detection signal corresponding to the detected crank angle (hereafter, referred to as "main-shaft-side detection signal Rm") to a device controller (not shown) for controlling the operation of each device.

[0034] The main-shaft-side detection signal Rm is output also to the main shaft control device 14 that controls driving of the main shaft motor 13. In addition, the main shaft control device 14 is configured to control driving of the main shaft motor 13 based on a rotation command signal Rc (described below) that is input and the main-shaft-side detection signal Rm from the main-shaft-side encoder 15.

[0035] The input setting device 16 is a device for inputting and setting set values of weaving conditions for the weaving operation. The weaving conditions include a set rotation speed that is a rotation speed (rotation speed in a normal operation) of the loom that is assumed (set) for a weaving operation at the time, a warp shedding pattern in which the (upper, lower) positions of the warp yarns for each weaving cycle are set, and the like. The input setting device 16 includes, for example, a touch panel display device. The input setting device 16 allows an operator to input and set the aforementioned set values by using a setting screen displayed on the display device. The input setting device 16 is connected to the loom body 11, and is configured to transmit the set values, which have been input and set, to corresponding device controllers in the loom body 11.

[0036] The Jacquard shedding device 2 includes a plurality of healds (not shown) that correspond in number to the warp yarns and through each of which a corresponding one of the warp yarns is inserted, the Jacquard body 21 that forms a warp shed by displacing the healds in the up-down direction, the shedding motor 23 that is a driving source of the Jacquard body 21, and a shedding control device 24 that controls the rotation of the shedding motor 23. The Jacquard shedding device 2 further includes a shedding-side encoder 25, which is a rotation amount detection device that detects the rotation amount of a drive shaft 22 of the Jacquard body 21 rotated by the shedding motor 23.

[0037] The Jacquard body 21 includes the single drive shaft 22, and is configured to displace the healds in the up-down direction as the drive shaft 22 is rotated. That is, the single drive shaft 22 of the Jacquard body 21 is common to all of the healds. The drive shaft 22 is coupled to the shedding motor 23 via a drive transmission mechanism 26 such as a speed reducer. In the present embodiment, the shedding motor 23 is an induction motor. Because the structure of the Jacquard body 21 itself is well known, detailed descriptions thereof will be omitted. The Jacquard body 21 includes a driving mechanism (not shown) that includes a structure for converting the rotation of the drive shaft 22 into motion in the up-down direction. The driving mechanism is coupled to each of the healds via a rope (wire) that is provided so as to correspond to the heald and that is connected to the heald. The driving mechanism is configured so that the healds are displaced in the up-down direction in accordance with the rotation of the drive shaft 22.

[0038] The shedding control device 24 is connected to the input setting device 16 of the weaving device 1 and is connected also to the shedding-side encoder 25. In addition, to the shedding control device 24, a set rotation speed and a shedding pattern, which are included in the aforementioned weaving conditions, are transmitted from the input setting device 16. A detection signal corresponding to the rotation amount of the drive shaft 22 that is detected by the shedding-side encoder 25 (hereafter, referred to as "shedding-side detection signal Rd") is output from the shedding-side encoder 25 to the shedding control device 24. In the present embodiment, the driving mechanism is configured to cause each heald to perform weaving motions for two weaving cycles when the drive shaft 22 is rotated one turn. Accordingly, in the present embodiment, the drive shaft 22 is rotated 1/2 turn in one loom cycle. Therefore, the shedding control device 24 is configured to control driving of the shedding motor 23 based on a set rotation speed and the shedding-side detection signal Rd so that the drive shaft 22 is driven with a rotation speed that is 1/2 of the set rotation speed. The shedding control device 24 is configured to control the Jacquard body 21 (driving mechanism) so that the healds are displaced in accordance with the shedding pattern.

[0039] In the loom including the weaving device 1 and the Jacquard shedding device 2 described above, according to the present invention, the loom includes a synchronous control device 3 that obtains the rotation amount of the main shaft 12 so that the main shaft 12 of the loom body 11 of the weaving device 1 is rotated so as to be synchronized with the drive shaft 22 of the Jacquard body 21 of the Jacquard shedding device 2 in accordance with the shedding-side detection signal Rd of a rotation detecting device (the shedding-side encoder 25) in a normal operation. The synchronous control device 3 outputs the rotation command signal Rc based on the obtained rotation amount of the main shaft 12 to the main shaft control device 14.

[0040] As illustrated in Fig. 1, the synchronous control device 3 is connected to the shedding-side encoder 25 and the main-shaft-side encoder 15 at input ends thereof, and is connected to the main shaft control device 14 at an output end thereof. As illustrated in Fig. 2, the synchronous control device 3 includes components such as a calculating unit 31, a determination unit 32, an angle detector 33, and a comparing unit 34. Specifics of these components are as follows.

[0041] As illustrated in Fig. 2, the calculating unit 31 includes a rotation amount calculating unit 35 and a correcting unit 36. Among these, the rotation amount calculating unit 35 is connected to the shedding-side encoder 25 and the correcting unit 36 at input ends thereof, and is connected to the main shaft control device 14 at an output end thereof. The correcting unit 36 is connected to the comparing unit 34 at an input end thereof, and is connected to the rotation amount calculating unit 35 at an output end thereof.

[0042] The rotation amount calculating unit 35 is configured to obtain, at each preset period (for example, 0.5 msec, hereafter, referred to as "set period"), a rotation amount of the drive shaft 22 (hereafter, referred to as "drive shaft rotation amount") in the set period based on the shedding-side detection signal Rd output from the shedding-side encoder 25 during the set period. Moreover, the rotation amount calculating unit 35 is configured, each time the drive shaft rotation amount is obtained in this way (at each set period), to obtain, from the obtained drive shaft rotation amount, a target rotation amount that is a rotation amount by which the main shaft 12 is to be rotated in a period until the shedding-side detection signal Rd is next input (during the set period).

[0043] The target rotation amount, which is a rotation amount for causing of the rotation of the main shaft 12 to follow the rotation of the drive shaft 22, is a rotation amount with which the rotation angle of the main shaft 12 reaches, at a time 0.5 msec (the set period) after the drive shaft rotation amount is next obtained, a rotation angle corresponding to the rotation angle of the drive shaft 22 at a time when a drive shaft rotation used to obtain the target rotation amount was obtained. The rotation angle corresponding to the rotation angle of the drive shaft 22 is twice the rotation angle of the drive shaft 22. Accordingly, the target rotation amount can be obtained by multiplying the drive shaft rotation amount by 2.

[0044] To be specific, on the weaving device 1 side, usually, one weaving operation (an operation for weaving, including one weft insertion, beating, and the like) is performed as the main shaft 12 is rotated one turn. In weaving using a loom, the one weaving operation is repeatedly performed, and the one weaving operation corresponds to one cycle of the loom ("one loom cycle" (also referred to as "one weaving cycle")). As described above, the Jacquard shedding device 2 according to the present embodiment is configured so that each heald performs motions for two weaving cycles each time the drive shaft 22 rotates one turn. In other words, with the Jacquard shedding device 2, a motion for one weaving cycle is performed with 1/2 turn of the drive shaft 22. Accordingly, the main shaft 12 should be driven so that the main shaft 12 rotates one turn while the drive shaft 22 rotates 1/2 turn, and therefore the target rotation amount is twice the drive shaft rotation amount.

[0045] In addition, the rotation amount calculating unit 35 is configured to generate, based on the obtained target rotation amount, the rotation command signal Rc that is used by the aforementioned main shaft control device 14 to control the main shaft motor 13 and that enables the main shaft 12 to be rotated with the target rotation amount; and to output the rotation command signal Rc to the main shaft control device 14.

[0046] The synchronous control device 3 according to the present embodiment is configured to correct the rotation amount of the main shaft 12 based on a deviation between the shedding-side detection signal Rd and the main-shaft-side detection signal Rm.

[0047] To be specific, because the rotation amount calculating unit 35 is configured as described above and the main shaft control device 14 drives the main shaft motor 13 in accordance with the rotation command signal Rc, it is expected that the main shaft 12 is rotated so as to follow the rotation of the drive shaft 22 with a delay of the set period (0.5 msec) during one turn thereof (in one weaving cycle). Accordingly, if the time when the rotation angle of the main shaft 12 reaches a preset and predetermined rotation angle in one rotation of the main shaft 12 ("set angle" in the present invention, hereafter referred to as "set angle") is compared with the time when the drive shaft 22 reached a rotation angle of the drive shaft 22 corresponding to the set angle (hereafter, referred to as "reference angle"), it is expected that the time when the main shaft 12 reaches the set angle is the set period (0.5 msec) after the time when the drive shaft 22 reached the reference angle. However, as the case may be, for some reason (for example, abnormal vibration of the loom), a mismatch between the rotation amounts of the drive shaft 22 and the main shaft 12 may occur, and the time when the main shaft 12 reaches the set angle may become advanced or delayed by more than 0.5 msec relative to the time when the drive shaft 22 reached the reference angle.

[0048] Therefore, the synchronous control device 3 according to the present embodiment is configured to correct the rotation amount of the main shaft 12 based on the shedding-side detection signal Rd of the shedding-side encoder 25 and the main-shaft-side detection signal Rm of the main-shaft-side encoder 15. The synchronous control device 3 includes, as components for performing the correction, the determination unit 32, the angle detector 33, the comparing unit 34, and the correcting unit 36 included in the calculating unit 31.

[0049] In the present embodiment, 0° (360°) is set as the set angle of the main shaft 12, and 180° and 360° (0°) are each set as the reference angle of the drive shaft 22 corresponding to the set angle.

[0050] The determination unit 32 is connected to the shedding-side encoder 25 at an input end thereof, and is connected to the angle detector 33 at an output end thereof. The determination unit 32 is configured to obtain the rotation angle of the drive shaft 22 based on the shedding-side detection signal Rd output from the shedding-side encoder 25. In addition, the determination unit 32 is configured to determine whether the obtained rotation angle of the drive shaft 22 has reached the reference angle (180°, 360° (0°)) and, to output, 0.5 msec (the set period) after the time when it is determined that the rotation angle has reached the reference angle, a signal that indicates a timing at which the crank angle is to reach the set angle (0°) (hereafter, referred to as "reference signal T0") to the angle detector 33.

[0051] The angle detector 33 is connected to the main-shaft-side encoder 15 and the determination unit 32 at input ends thereof, and is connected to the comparing unit 34 at an output end thereof. The angle detector 33 is configured to be capable of obtaining the crank angle based on the main-shaft-side detection signal Rm output from the main-shaft-side encoder 15. In addition, the angle detector 33 is configured to obtain the crank angle at the time when the reference signal T0 is output from the determination unit 32. Moreover, the angle detector 33 is configured to output a signal that indicates the obtained crank angle (hereafter, referred to as "angle signal θ") to the comparing unit 34.

[0052] The comparing unit 34 is connected to the angle detector 33 at an input end thereof, and is connected to the correcting unit 36 of the calculating unit 31 at an output end thereof. The comparing unit 34 is configured, when the angle signal θ is output from the angle detector 33, to obtain a deviation of the crank angle from the set angle by comparing the crank angle indicated by the angle signal θ with the set angle (0°), that is, a rotation angle that the crank angle is expected to reach at the time when the reference signal T0 is output, and to output a deviation signal $\Delta\theta$ that indicates the obtained deviation to the calculating unit 31. Here, "deviation" includes 0. That is, if the deviation is 0, the comparing unit 34 outputs the deviation signal Δθ corresponding to deviation = 0 to the calculating unit 31. The deviation is obtained so as to have a positive value if the rotation of the main shaft 12 is delayed relative to the rotation of the drive shaft 22 and a negative value if the rotation of the drive shaft 22 is advanced relative to the rotation of the drive shaft 22.

[0053] The correcting unit 36 of the calculating unit 31 is connected to the comparing unit 34 at an input end thereof, and is connected to the rotation amount calculating unit 35 at an output end thereof. The correcting unit 36 is configured, when the deviation signal Δθ is input from the comparing unit 34, based on the deviation that is indicated by the deviation signal Δθ, to obtain a correction rotation amount for correcting the target rotation amount of the main shaft 12 obtained by the rotation amount calculating unit 35 as described above.

[0054] To be specific, the correcting unit 36 is configured to store a deviation that is indicated by the deviation signal Δθ each time the deviation signal Δθ is input from the comparing unit 34 and to calculate, when the number of times the deviation signal Δθ has been input reaches a preset number of times (for example, 10 times (10 weaving cycles), hereafter referred to as "set number of times"), the average value of the deviations for the set number of times (hereafter, referred to as "deviation average value"). Note that the time when the deviation signal Δθ is output from the comparing unit 34 is a time when the set period (0.5 msec) has elapsed from the time when the drive shaft 22 reached the reference angle, and is a time when the drive shaft rotation amount at this time is obtained by the correcting unit 36 (that is, the time when the target rotation amount of the main shaft 12 is obtained based on the drive shaft rotation amount and when the rotation command signal Rc is generated and output).

[0055] The correcting unit 36 is configured to obtain a correction rotation amount based on a deviation average value each time the deviation average value is obtained as described above. To be specific, in the present embodiment, in the correcting unit 36, a plurality of correction rotation amounts corresponding to a plurality of expected deviations have been set beforehand so as to each correspond to a magnitude of deviation, and the correcting unit 36 selects a correction rotation amount corresponding to the magnitude of the deviation average value obtained as described above. Regarding the correction rotation amount, in a case where the deviation average value > 0, because this a state in which the rotation of the main shaft 12 is delayed relative to the rotation of the drive shaft 22, a rotation amount that increases the value of the target rotation amount, that is, a rotation amount such that the correction rotation amount > 0 is set. In a case where the deviation average value < 0, because this is a state in which the rotation of the main shaft 12 is advanced relative to the rotation of the drive shaft 22, a rotation amount that decreases the value of target rotation amount, that is, a rotation amount such that the correction rotation amount < 0 is set. In a case where the deviation average value = 0, a rotation amount that does not increase or decrease the value of the target rotation amount, that is, the correction rotation amount = 0 is set. In addition, the correcting unit 36 is configured to output, to the rotation amount calculating unit 35, the correction signal C corresponding to the correction rotation amount obtained in this way each time the correction rotation amount is obtained (each time the deviation average value is calculated).

[0056] The rotation amount calculating unit 35 is configured, when the correction signal C is output from the correcting unit 36, to correct the target rotation amount of the main shaft 12 obtained at the time, based on a correction rotation amount indicated by the correction signal C. That is, the rotation amount calculating unit 35 is configured, when the deviation average value is obtained as described above at a time when the correction rotation amount is obtained by the correcting unit 36, that is, at a time when the deviation signal Δθ at the set number of times is output from the comparing unit 34, outputs the rotation command signal Rc to be output at the time as a signal corresponding to a rotation amount that is obtained by adding a correction rotation amount corresponding to the deviation average value to the target rotation amount.

[0057] Accordingly, in a case where the deviation average value > 0, that is, in a case where the rotation of the main shaft 12 is delayed relative to the rotation of the drive shaft 22, because the correction rotation amount > 0, the rotation amount calculating unit 35 outputs the rotation command signal Rc corresponding to a new target rotation amount in which the value of the target rotation amount (a rotation amount that is twice the drive shaft rotation amount) is increased. In a case where the deviation average value < 0, that is, in a case where the rotation of the main shaft 12 is advanced relative to the rotation of the drive shaft 22, because the correction rotation amount < 0, the rotation amount calculating unit 35 outputs the rotation command signal Rc corresponding to a new target rotation amount in which the value of the target rotation amount is reduced. Moreover, in a case where the deviation average value = 0, that is, in a case where there is no mismatch between the rotation amounts of the drive shaft 22 and the main shaft 12, because the correction rotation amount = 0, the rotation amount calculating unit 35 outputs the rotation command signal Rc corresponding to the target rotation amount.

[0058] In the present embodiment, the synchronous control device 3 may be a device such that the components thereof each include a circuit that is composed of circuit elements having respective functions, or a computer that is programmed so as to have the functions of the components may operate as the synchronous control device 3. The synchronous control device 3, the main shaft control device 14, the shedding control device 24, and the input setting device 16 may be independent devices (including computers that operate as the devices);

or one computer may operate as a plurality of devices.

[0059] The operational effects of a loom including the synchronous control device 3 according to the present embodiment are as described below in (1) to (8).

(1) When an operation button (not shown) is pressed to start the operation of the loom, the shedding control device 24 of the Jacquard shedding device 2 starts driving the shedding motor 23. Accordingly, rotation of the drive shaft 22 is started. The shedding motor 23 is driven so that the drive shaft 22 is rotated at a rotation speed that is 1/2 of a set rotation speed that is preset as a weaving condition.

(2) When the rotation of the drive shaft 22 is started, the shedding-side encoder 25 detects the rotation amount, and accordingly the shedding-side detection signal Rd corresponding to the rotation amount is output from the shedding-side encoder 25 to the synchronous control device 3.

(3) In addition, in the synchronous control device 3, at each set period (0.5 msec) from the time when the rotation of the drive shaft 22 is started as described above, based on the shedding-side detection signal Rd from the shedding-side encoder 25, the rotation amount calculating unit 35 of the calculating unit 31 obtains the drive shaft rotation amount in the preceding set period.

(4) Moreover, in the calculating unit 31 (the rotation amount calculating unit 35) of the synchronous control device 3, each time the drive shaft rotation amount is obtained in this way (that is, at each set period), the target rotation amount of the main shaft 12 is obtained as described above based on the obtained drive shaft rotation amount. When the target rotation amount of the main shaft 12 is obtained in this way, the rotation command signal Rc corresponding to the target rotation amount is output from the rotation amount calculating unit 35 to the main shaft control device 14 of the weaving device 1.

(5) As the rotation command signal Rc is output, the main shaft control device 14 controls driving of the main shaft motor 13 so that the main shaft 12 rotates by the target rotation amount indicated by the rotation command signal Rc in the set period from the time. As a result, in the loom, the main shaft 12 is rotated so as to follow the rotation of the drive shaft 22 with a delay of the set period (0.5 msec). That is, the loom enters a state in which the main shaft 12 is rotated so as to be synchronized with the rotation of the drive shaft 22.

(6) Thus, with the loom described above, because the drive shaft 22 of the Jacquard shedding device 2 is rotated based on the set rotation speed and the main shaft 12 of the weaving device 1 is rotated so as to be synchronized with (follow) the rotation of the drive shaft 22, compared with existing looms in which the drive shaft 22 is rotated so as to be synchronized with the rotation of the main shaft 12, an inexpensive induction motor, instead of an expensive synchronous motor used in existing looms, can be used as the shedding motor 23. Also regarding the main shaft motor 13, an inexpensive synchronous motor may be used in consideration of a load that is applied to the main shaft 12. Therefore, the cost of the entirety of the loom can be reduced.

(7) As described above, driving of the main shaft motor 13 is controlled so that the main shaft 12 is rotated so as to be synchronized with the rotation of the drive shaft 22. In addition, in the loom according to the present embodiment, control for correcting the target rotation amount of the main shaft 12 is performed at a predetermined time, as necessary, so that a state in which the rotation of the main shaft 12 is more accurately synchronized with the rotation of the drive shaft 22 is maintained. Specifics are as follows.

In the loom according to the present embodiment, at a time when the crank angle is expected to reach the set angle (360° (0°)), that is, at a time when the set period (0.5 msec) has elapsed from the time when the rotation angle of the drive shaft 22 reached the reference angle, in the synchronous control device 3, the reference signal TO is output from the determination unit 32 to the angle detector 33.

Accordingly, the angle detector 33 obtains a crank angle (actual crank angle) at the time based on the main-shaft-side detection signal Rm output from the main-shaft-side encoder 15, and the angle signal θ corresponding to the actual crank angle is output to the comparing unit 34.

In the comparing unit 34, the obtained actual crank angle is compared with the set angle (0°) that the crank angle is expected to reach at the time when the reference signal T0 is output, thereby obtaining the deviation. The comparing unit 34 outputs the deviation signal $\Delta\theta$ corresponding to the obtained deviation to the correcting unit 36 of the calculating unit 31.

In the correcting unit 36, the deviation average value is obtained from the deviation signals $\Delta\theta$ for the set number of times as described above, and the correction signal C corresponding to a correction rotation amount obtained based on the deviation average value is output to the rotation amount calculating unit 35 of the calculating unit 31.

In the rotation amount calculating unit 35, the target rotation amount of the main shaft 12 is corrected based on the correction rotation amount. The correction is made to the target rotation amount of the main shaft 12 obtained at a time when the deviation average value is calculated (at a time when the deviation signal $\Delta\theta$ at the set number of times is output from the comparing unit 34). The rotation command signal Rc corresponding to the corrected target rotation amount of the main shaft 12 is output from the rotation amount calculating unit 35 to the main shaft control device 14, and the main shaft motor 13 is driven by the main shaft control device 14 based on the corrected target rotation amount of the main shaft 12.

(8) Accordingly, even in a case where a mismatch between the rotation amounts of the drive shaft 22 and the main shaft 12 occurs for some reason as described above, with the loom according to the present embodiment, because the synchronous control device 3 performs correction control to correct the rotation amount of the main shaft 12 at a predetermined time so as to eliminate the mismatch, it is possible to maintain a state in which the rotation of the main shaft 12 is more accurately synchronized with the rotation of the drive shaft 22.

[0060] The present invention is not limited to the embodiment described above (the above embodiment) and may be carried out in any of modified embodiments (1) to (9) described below.

(1) In the above embodiment, on the assumption that weaving is performed so that a state of the Jacquard shedding device in which the rotation angle of the drive shaft is 0° (360°) or 180° corresponds to a state of the weaving device (loom body) in which the crank angle is 0°, driving of the main shaft is controlled based on the drive shaft rotation amount.

The above assumption is based on a configuration such that the Jacquard shedding device drives the healds so that the healds enter a closed state when the rotation angle of the drive shaft = 0° (360°) or 180° and so that weaving is performed under weaving conditions under which the warp yarns are in a closed state at a beating time when the crank angle = 0°. However, weaving using a loom (not limited to the loom according to the present invention) is not necessarily performed so that the crank angle = 0°, which is a crank angle at the time of beating (beating angle), coincides with a cross timing at which the warp yarns enter a closed state. Depending on the weaving conditions, weaving may be performed so that the cross timing is set at a time before the crank angle becomes 0°, for example, at a time when the crank angle becomes 300°.

The present invention is applicable, concerning the relationship between the beating angle and the cross timing, not only to the case where weaving is performed so that the beating angle coincides with the cross timing as in the above embodiment but also to a case where weaving is performed so that the beating angle and the cross timing differ from each other. To be specific, in a case where the Jacquard shedding device is configured so that the warp yarns enter a closed state when the rotation angle of the drive shaft is 0° (360°) or 180° as described above and where weaving is performed so that the Jacquard shedding device causes the warp yarns to enter a closed state when, for example, the crank angle in the loom body is 300°, driving of the main shaft is controlled so that the crank angle reaches 300° at a time when a preset period (in the above embodiment, 0.5 msec) has elapsed after the time when the rotation angle of the drive shaft reached 0° (360°) or 180°.

(2) In the above embodiment, regarding the set angle determined in one rotation of the main shaft, a rotation angle based on an actual crank angle obtained from the reference angle of the drive shaft corresponding to the set angle is compared with the set angle, and correction of the target rotation amount of the main shaft is performed based on a deviation (deviation average value) that is obtained as a result of the comparison. In addition, in the above embodiment, the set angle is 0°.

However, in the present invention, the set angle is not limited to 0°, and may be a rotation angle other than 0°. However, if correction of the target rotation amount of the main shaft is performed during a weft insertion operation, weft insertion may be influenced. Therefore, preferably, the set angle is a rotation angle at which a weft insertion operation is not performed (a rotation angle in a period from the time when a weft insertion operation finishes to a time when the next weft insertion operation starts).

In a case where the set angle is a rotation angle other than 0°, naturally, the reference angle of the drive shaft is an angle corresponding to the set angle other than 0°. To be specific, in a case where the set angle is 20°, in a loom that performs weaving so that the cross timing and the beating angle coincide with each other as in the above embodiment, the reference angle is 10° (20°/2) and 190° (20°/2 + 180°).

In a loom that performs weaving so that the cross timing and the beating angle differ from each other (with an angle difference between the cross timing and the beating angle) as in the example describe above, the reference angle is an angle corresponding to the angle difference. To be specific, for example, in a loom in which the crank angle corresponding to the rotation angle 0° of the drive shaft is set at 300°, because the rotation of the drive shaft is advanced by 30° (corresponding to a crank angle of 60°) relative to the rotation of the main shaft, in a case where the set angle is 20°, the reference angle is 40° (10° + 30°) and 220° (190° + 30°).

(3) In the above embodiment, correction of the target rotation amount of the main shaft (hereafter, simply referred to as "correction") is performed at a time when the deviation at the set number of times, which is preset, is obtained as described above. In addition, in the above embodiment, the set number of times is 10 times.

However, in the present invention, the set number of times is not limited to 10 times, and may be another number of times (for example, 30 times). A set number of times in the present invention is not limited to a plurality of times as described above and may be a single time. In this case, each time the deviation is obtained, that is, each time the main shaft rotates one turn, the correction is performed. Moreover, even in a case where the set number of times is set at a plurality of times, the correction need not be performed based on the deviation average value as in the above embodiment, and the correction may be performed based on a (single) deviation obtained at the set number of times.

(4) In the above embodiment, regarding calculation of the deviation average value, the deviation is obtained each time the main shaft rotates one turn, and, at a time when the deviation at the set number of times is obtained, the deviation average value is calculated based on the deviations for the set number of times.

However, in the present invention, instead of using such a calculation method, the deviation average value may be obtained from the average value of actual crank angles for the set number of times and the set value of the set angle. In this case, the angle detector of the synchronous control device may have a function of obtaining the average value. To be specific, the angle detector may be configured to store an actual crank angle that is obtained each time the main shaft rotates one turn, obtain the average value of the stored actual crank angles for the set number of times at the set number of times, and output the average value to the comparing unit. In addition, the comparing unit may calculate the deviation (deviation average value) based on the average value of the actual crank angles output from the angle detector and the set value of the set angle.

(5) In the above embodiment, control related to the correction is performed so that the correction is finished through three processes: a process (first process) of obtaining a deviation based on the set angle and the actual crank angle; a process (second process) of obtaining a correction rotation amount based on the deviation; and a process (third process) of correcting the target rotation amount by using the obtained correction rotation amount. In addition, in the above embodiment, the three processes are performed continuously (at the same time, concerning control). To be specific, at a time when the reference signal is output, that is, at a time when the crank angle is expected to reach the set angle (at a time when the set period has elapsed from the time when the rotation angle of the drive shaft reached the reference angle), the first process, the second process, and the third process are performed (although the three processes are successively performed, because the time required to perform the three processes is sufficiently shorter than the set period, it can be regarded that the three processes are performed at the same time.).

However, in the present invention, the three processes need not be performed at the same time and may be performed at different times. For example, the first process and the second process may be performed at the time when the reference signal is output, and the third process may be performed at a time when n set periods ($n \geq 1$) have elapsed after the time when the reference signal is output. Because the target rotation amount is obtained each time the set period elapses as described above, the target rotation amount to be corrected is a target rotation amount that is obtained at a time when the third process is performed. Alternatively, in the above case, instead of performing the first process and the second process at the same time, the second process and the third process may be performed at the same time.

(6) In the above embodiment, the correction is performed by using the correction rotation amount corresponding to the obtained deviation (deviation average value).

However, in the present invention, the correction rotation amount in the correction is not limited a value corresponding to a deviation that is obtained as in the above embodiment, and may be a fixed value (fixed rotation amount) that is preset. In this case, as a result of the comparing unit obtaining the deviation (deviation average value), whether the deviation is a positive deviation or a negative deviation is determined, and accordingly a deviation signal corresponding to the sign of the deviation is output from the comparing unit to the calculating unit (correcting unit). The correction is performed so as to add or subtract, in accordance with the sign of the deviation that is indicated by the deviation signal, a correction rotation amount that has a positive fixed value that is preset with respect to the target rotation amount. To be specific, if the deviation signal output from the comparing unit indicates a positive deviation, that is, if the rotation of the main shaft is delayed relative to the rotation of the drive shaft, the correction is performed so as to add a fixed rotation amount to the target rotation amount. If the deviation signal output from the comparing unit indicates a negative deviation, that is, if the rotation of the main shaft is advanced relative to the rotation of the drive shaft, the correction is performed so as to subtract a fixed rotation amount from the target rotation amount.

(7) In the example described above, the synchronous control device is configured so that a mismatch (deviation) between the rotation amounts of the main shaft and the drive shaft is eliminated by the correction, that is, the synchronous control device is configured to have such a correction function.

However, in the present invention, the synchronous control device is not limited to a device that is configured to have such a correction function. The synchronous control device may be configured to output an alarm signal to the loom body in response to occurrence of the deviation. In this case, if a slight mismatch between the rotation amounts is allowed, the synchronous control device may be configured to output the alarm signal when the deviation exceeds a preset allowance. In addition, the loom body may be configured, when the alarm signal is output from the synchronous control device, to output a message indicating that, for example, a synchronization mismatch has occurred between the shedding device and the weaving device on a display device, such as the input setting device in the above embodiment. Moreover, the loom body may be configured to perform, in response to outputting of the alarm signal, a stopping operation in addition to (or instead of) displaying of the message.

(8) As described above, in the present invention, driving of the main shaft motor is controlled so that the main shaft follows the rotation of the drive shaft. In general, a Jacquard shedding device is used to weave a fabric having a complicated woven design. The shedding pattern is set for one repeat that is composed of a plurality of weaving cycles, and weaving is performed as healds are repeatedly driven in accordance with the shedding pattern. Moreover, when weaving a fabric having the complicated woven design, the shedding pattern may be set so that the number of warp yarns that are located at upper positions in each weaving cycle in one repeat of the shedding pattern and the number of warp yarns that are located at lower positions in the weaving cycle considerably differ from each other.

In the Jacquard shedding device, each heald is mechanically urged in one of upward and downward directions (generally, downward), and is displaced in the other direction by the Jacquard body (driving mechanism). Accordingly, a load is applied to the drive shaft when displacing the healds as described above, and the magnitude of the load is proportional to the number of healds that are displaced in the other direction.

With the present invention, an inexpensive induction motor can be used as the shedding motor as described above. In this case, however, depending on the magnitude of the load that is applied to the drive shaft, the rotation of the drive shaft may be influenced by the load.

Regarding the influence of the load on the rotation of the drive shaft, naturally, the influence increases as the load increases, and variation in the rotation speed may occur depending on the magnitude of the load. However, although the magnitude of the load is proportional to the number of healds that are displaced in the other direction as described above, the number of healds that are displaced in the other direction is determined by the relationship between the vertical positions of the warp yarns at the time of the largest shed in each weaving cycle, which are set in the shedding pattern, and the vertical positions of the warp yarns at the time of the largest shed in the next weaving cycle subsequent to the weaving cycle. Warp yarns that are set at positions in the other direction at the time of the largest shed in each weaving cycle and that are to be set at positions in the other direction at the time of the largest shed in the next weaving cycle start to be displaced toward the positions in the other direction at about the middle of the next weaving cycle.

Accordingly, in the case where the shedding pattern is set so that the number of warp yarns that are located at upper positions in each weaving cycle and the number of warp yarns that are located at lower positions in the weaving cycle considerably differ from each other as described above, in one or more specific weaving cycles in one repeat of the shedding pattern, a situation in which the rotation speed of the drive shaft varies at about the middle of the weaving cycle occurs. In this case, if driving of the main shaft is controlled so that the rotation of the main shaft follows the rotation of the drive shaft as described above, because the drive control is performed so as to sharply change the rotation speed of the main shaft at about the middle of the weaving cycle, the load that is applied to the main shaft motor becomes large.

It is possible to predict whether such variation in the rotation speed occurs at about the middle of the weaving cycle from the shedding pattern in consideration of the weaving condition at the time. If it is expected beforehand that such variation in the rotation speed will occur, a control parameter that is used to control driving of the main shaft motor in the main shaft control device may be changed (for example, the control gain may be reduced). By doing so, it is possible to suppress variation in the rotation of the main shaft motor by reducing the followability of the main shaft motor, and accordingly a load that is applied to the main shaft motor can be suppressed.

In this case, however, because the followability of the main shaft motor is reduced even in a weaving cycle in which variation in the rotation speed of the drive shaft does not occur, a mismatch between the drive shaft and the main shaft may occur, and weft insertion may be influenced in the weaving cycle.

Therefore, in the present invention, the synchronous control device may be configured to change a control parameter that is used to control the main shaft motor in accordance with the magnitude of a load that is applied to the drive shaft. To be specific, the synchronous control device may be configured to change the control parameter in each weaving cycle in one repeat of the shedding pattern based on the shedding pattern. As a component for performing this, the synchronous control device includes a parameter changer. Hereafter, the structure of the parameter changer will be described in detail with reference to Fig. 3. In Fig. 3, components that are the same as those of the above embodiment are denoted by the same numerals.

First, it is assumed that the main shaft control device 14 is configured to change a control parameter that is used to control driving of the main shaft motor 13 in accordance with an output from the synchronous control device 3. Here, the control parameter is a control gain. The control gain is a control parameter for changing the followability of the main shaft motor 13, and it is possible to reduce the followability of the main shaft motor 13 by reducing the value of the control gain.

In general, a shedding pattern stored in the shedding control device 24 is set so as to include weaving steps (one weaving step = one weaving cycle) in one repeat of the shedding pattern. Therefore, it is assumed that the shedding control device 24 is configured to recognize the present weaving step based on the shedding-side detection signal Rd from the shedding-side encoder 25 and to output a step signal S indicating the step number at a time when the weaving step is updated.

As illustrated in Fig. 3, the synchronous control device 3 includes a parameter changer 37 in addition to the components of the above embodiment. The parameter changer 37 is connected to the shedding control device 24 and the input setting device 16 of the weaving device 1 at input ends thereof, and is connected to the main shaft control device 14 at an output end thereof. In addition, in the parameter changer 37, control gains having a plurality of values are preset (stored) so as to correspond to the weaving cycles in one repeat of the shedding pattern (weaving steps).

Regarding the control gains, to be specific, first, a reference control gain, which is a control gain that is considered to be appropriate for control in a case where variation in the rotation speed of the drive shaft 22 (and further variation in the rotation speed of the main shaft motor 13 that is controlled to be driven so that the main shaft 12 follows the rotation of the drive shaft 22) does not occur, is set. In addition, for each of weaving steps (weaving cycles) in which variation in the rotation speed of the drive shaft 22 is expected to occur based on the shedding pattern, a control gain that is lower than the reference control gain is set so as to correspond to the step number. On the other hand, for each of the other weaving steps, the reference control gain is set so as to correspond to the step number. The control gains are input and set by the input setting device 16. The control gains, which have been input and set, are transmitted to the parameter changer 37 and stored in the parameter changer 37.

The parameter changer 37 is configured, when the step signal S is output from the shedding control device 24, to select a value of the control gain corresponding to the step number indicated by the step signal S and to output a gain signal G indicating the value to the main shaft control device 14.

In the main shaft control device 14, when the gain signal G is output from the parameter changer 37, based on the gain signal G, the value of the control gain used to control driving of the main shaft 12 is changed to a value corresponding to the control gain indicated by the gain signal G.

With the synchronous control device 3 configured as described above, driving of the main shaft motor 13 is controlled in each weaving cycle in one repeat of the shedding pattern by using a control gain that corresponds to the weaving cycle (weaving step) and that is set as described above. Thus, in a weaving cycle in which a load that is applied to the drive shaft 22 is large, variation in the rotation of the main shaft motor 13 is suppressed in order to reduce the followability of the main shaft motor 13, and accordingly a load on the main shaft motor 13 is reduced. In a weaving cycle in which a load that is applied to the drive shaft 22 is small, the followability of the main shaft motor 13 is not reduced, and therefore occurrence of a synchronization mismatch between the drive shaft 22 and the main shaft 12 can be prevented.

In the above description, the control parameter is a control gain. However, the control parameter is not limited to a control gain and may be another control parameter, such as a time constant that is related to the responsiveness of the main shaft motor 13.

In the above description, the control parameter is changed by using a method of selecting a control gain from control gains having a plurality of values that have been set beforehand. However, a method for changing the control parameter is not limited to such a method. For example, the control parameter may be changed by using a method such as calculating the control gain based on the magnitude of a load that is applied to the drive shaft 22. In this case, the magnitude of a load that is applied to the drive shaft 22 may be calculated based on the shedding pattern (to be specific, the number of healds that are displaced in each weaving cycle).

(9) Heretofore, examples in which the present invention is applied to a loom that includes a Jacquard shedding device as a shedding device have been described. However, regarding a loom to which the present invention is applied, the shedding device is not limited to the Jacquard shedding device. The shedding device may be a dobby shedding device that uses a so-called rotary driving method in which a heald frame is displaced in the up-down direction by using a single drive shaft and in which the drive shaft is rotated by a shedding motor that is independent from the main shaft motor of the loom. That is, the present invention is applicable also to a loom that includes such a dobby shedding device.

[0061] The present invention is not limited to the embodiments described above and may be appropriately modified within the spirit and scope thereof.

Claims

1. Asynchronous control method for a loom, the loom including a shedding device (2) that includes a shedding motor (23) independent from a main shaft motor (13) of the loom as a driving source and that displaces each of healds in an up-down direction as a single drive shaft (22) that is common to all of the healds is driven by the shedding motor (23), the method comprising:

   detecting a rotation amount of the drive shaft (22) in each weaving cycle at least when the loom is performing a normal operation; and
   controlling driving of the main shaft motor (13) so that a main shaft (12) of the loom is rotated so as to be synchronized with the drive shaft (22) in accordance with a detection signal indicating the detected rotation amount.

2. The synchronous control method for a loom according to claim 1, wherein the controlling of driving of the main shaft motor (13) includes

   rotating the main shaft (12) by a target rotation amount, the target rotation amount being obtained based on the rotation amount of the drive shaft (22) that is detected at each set period that is preset, in the set period from a time when the target rotation amount is obtained,
   detecting an actual rotation angle of the main shaft (12) at a time when a rotation angle of the main shaft (12) is expected to reach a set angle that is a preset and predetermined rotation angle of the main shaft (12),
   obtaining a deviation of the actual rotation angle from the set angle by comparing the detected actual rotation angle with the set angle, and
   correcting, at a time when the deviation for a preset number of times is obtained, the target rotation amount that is obtained for the set period after the time, based on the deviation.

3. The synchronous control method for a loom according to claim 1 or 2, wherein a control parameter that is used to control the main shaft motor (13) is changed in accordance with a load that is applied to the drive shaft (22) as the healds are displaced.

4. A loom comprising a shedding device (2) and a main shaft control device (14), the shedding device (2) including a shedding motor (23) independent from a main shaft motor (13) of the loom as a driving source and displacing each of healds in an up-down direction as a single drive shaft (22) that is common to all of the healds is driven by the shedding motor (23), the main shaft control device (14) controlling driving of the main shaft motor (13),
   the loom comprising:

   a rotation detecting device that detects a rotation amount of the drive shaft (22) in each weaving cycle at least when the loom is performing a normal operation; and
   a synchronous control device (3) that obtains a rotation amount of a main shaft (12) of the loom so that the main shaft (12) is synchronized with the drive shaft (22) in accordance with a detection signal that is output from the rotation detecting device, the synchronous control device (3) outputting a rotation command signal based on the obtained rotation amount of the main shaft (12) to the main shaft control device (14).

5. The loom according to claim 4, wherein the synchronous control device (3) includes

   a calculating unit (31) that obtains a target rotation amount based on a rotation amount of the drive shaft (22) that is detected at each set period that is preset, the target rotation amount being a rotation amount by which the main shaft (12) is to be rotated in the set period from a time when the target rotation amount is obtained,
   an angle detector (33) that obtains an actual rotation angle of the main shaft (12) at a time when a rotation angle of the main shaft (12) is expected to reach a set angle that is a preset and predetermined rotation angle of the main shaft (12), and
   a comparing unit (34) that obtains a deviation of the actual rotation angle obtained by the angle detector (33) from the set angle by comparing the actual rotation angle with the set angle, and

   wherein the calculating unit (31) includes a correcting unit (36) that corrects, at a time when the deviation for a preset number of times is obtained, the target rotation amount that is obtained for the set period after the time, based on the deviation.

6. The loom according to claim 4 or 5, wherein the synchronous control device (3) has a function of changing a control parameter that is used to control the main shaft motor (13) in accordance with a load that is applied to the drive shaft (22) as the healds are displaced.

FIG. 1

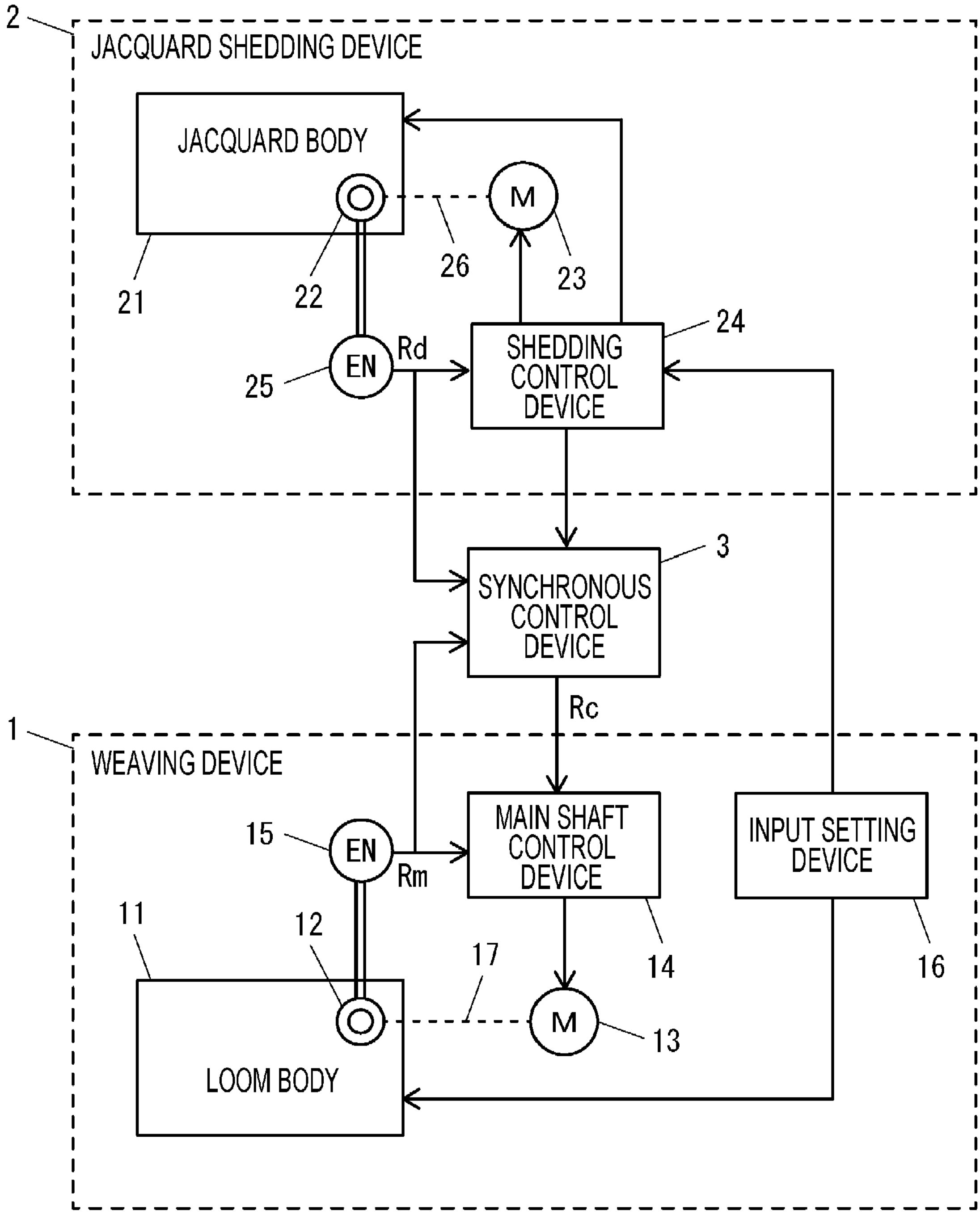

2
JACQUARD SHEDDING DEVICE
JACQUARD BODY
M
21
22
26
23
EN
Rd
SHEDDING CONTROL DEVICE
24
25
SYNCHRONOUS CONTROL DEVICE
3
Rc
1
WEAVING DEVICE
15
EN
MAIN SHAFT CONTROL DEVICE
INPUT SETTING DEVICE
Rm
11
12
17
14
16
M
13
LOOM BODY

FIG. 2

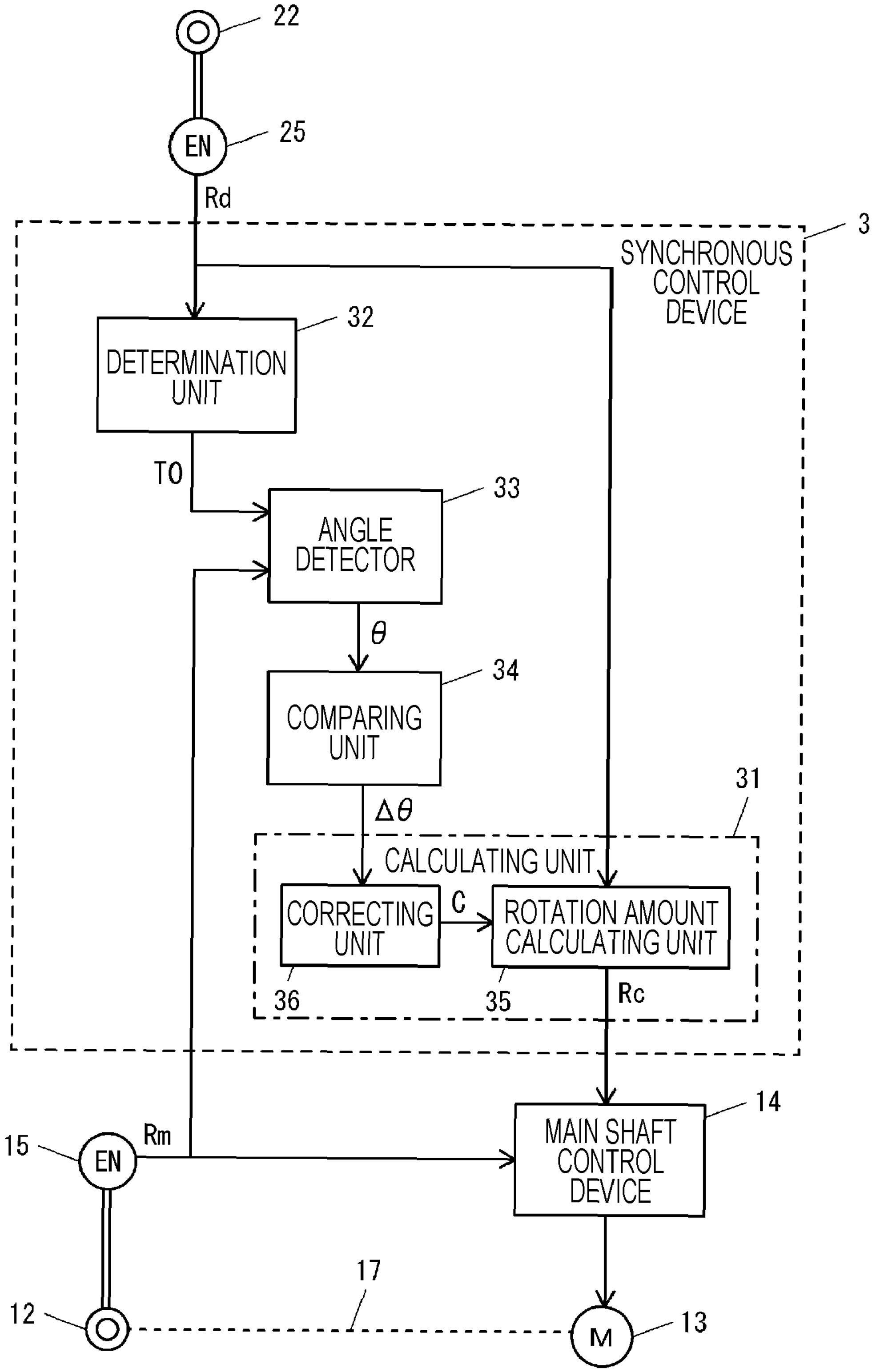
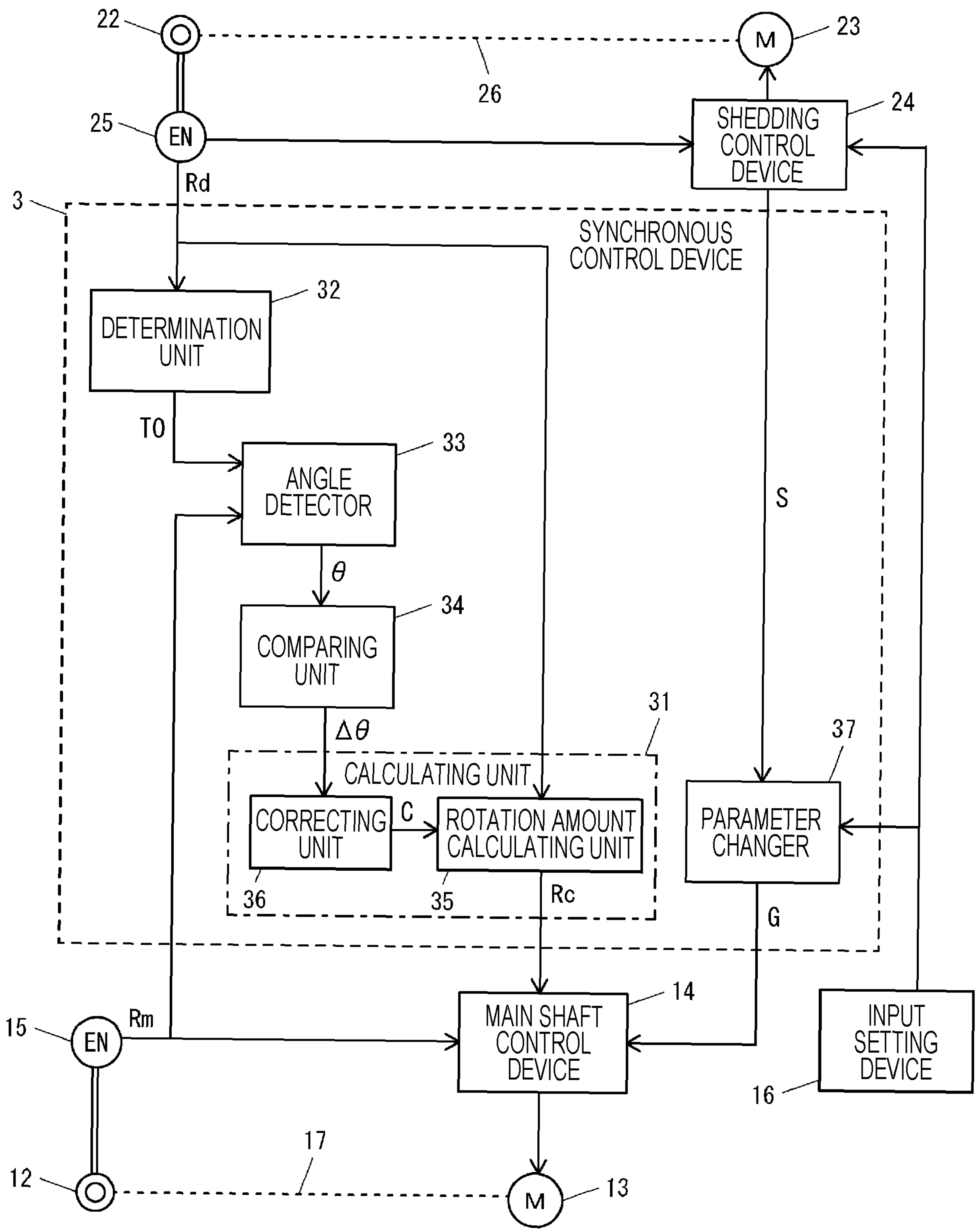

22
25
EN
Rd
3
SYNCHRONOUS CONTROL DEVICE
32
DETERMINATION UNIT
TO
33
ANGLE DETECTOR
θ
34
COMPARING UNIT
Δθ
31
CALCULATING UNIT
CORRECTING UNIT
C
ROTATION AMOUNT CALCULATING UNIT
36
35
Rc
14
MAIN SHAFT CONTROL DEVICE
15
EN
Rm
17
12
M
13

FIG. 3


22
23
M
26
25
EN
SHEDDING CONTROL DEVICE
24
Rd
3
SYNCHRONOUS CONTROL DEVICE
DETERMINATION UNIT
32
T0
ANGLE DETECTOR
33
S
θ
COMPARING UNIT
34
31
Δθ
37
CALCULATING UNIT
CORRECTING UNIT
C
ROTATION AMOUNT CALCULATING UNIT
PARAMETER CHANGER
36
35
Rc
G
MAIN SHAFT CONTROL DEVICE
14
15
EN
Rm
INPUT SETTING DEVICE
16
17
12
M
13

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EUROPEAN SEARCH REPORT

Application Number
EP 19 18 8246

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 0 893 525 A1 (RUETI AG MASCHF [CH]) 27 January 1999 (1999-01-27) * abstract * * claims 1-4 * * figures 1-3 * * column 1, line 1 - line 40 * * column 2, line 1 - line 40 * * column 3, line 1 - line 6 * -----	1-6	INV. D03C3/32 D03C1/14 D03C13/00
A	EP 2 118 350 A1 (PICANOL NV [BE]) 18 November 2009 (2009-11-18) * claims 1-3 * * figures 1,2 * * paragraphs [0001], [0006] - [0008], [0011], [0019] - [0021], [0024], [0025], [0027], [0036], [0037], [0044] * -----	1-6	
A	CN 103 306 000 A (SUZHOU KINWAY TECHNOLOGIES INC) 18 September 2013 (2013-09-18) * the whole document * -----	1-6	TECHNICAL FIELDS SEARCHED (IPC)
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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	15 November 2019	Heinzelmann, Eric

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 19 18 8246

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15-11-2019

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REFERENCES CITED IN THE DESCRIPTION

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