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

(11) **EP 2 246 466 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
03.11.2010 Bulletin 2010/44

(21) Application number: **08864134.5**

(22) Date of filing: **25.12.2008**

(51) Int Cl.:
D04B 15/96 *(2006.01)* ***D04B 35/10*** *(2006.01)*

(86) International application number:
PCT/JP2008/003943

(87) International publication number:
WO 2009/081583 (02.07.2009 Gazette 2009/27)

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

(30) Priority: **25.12.2007 JP 2007333189**

(71) Applicant: **Shima Seiki Mfg., Ltd**
Wakayama-shi
Wakayama 641-8511 (JP)

(72) Inventors:
- **DOI, Masayoshi**
  Wakayama-shi
  Wakayama 641-8511 (JP)
- **INUMAKI, Masanori**
  Wakayama-shi
  Wakayama 641-8511 (JP)

(74) Representative: **Carstens, Dirk Wilhelm**
Wagner & Geyer
Gewürzmühlstrasse 5
80538 München (DE)

(54) WEFT KNITTING MACHINE, AND CONTROL METHOD FOR MOBILE CARRIER IN THE WEFT KNITTING MACHINE

(57) A flatbed knitting machine and a control method for a self-moving carrier in a flatbed knitting machine wherein when electric power source is shut off due to emergency stop or other circumstances, synchronization between a carriage and a self-moving carrier is kept so that the knitting can be properly restarted after release of the shut-off of the electric power source. When the electric driving power supplied to the carriage drive motor 6 is shut off due to electric power failure of the commercial AC source 20 or by the operation of the stop switch 22, the carriage 3 is decreased in speed and then stops. The controller 10 derived a predicted position of the carriage 3 and controls the carrier 13 so that a position of the carrier 13 can be synchronized with the predicted position. When the electric power supply is shut off in the middle of the carriage 3 being accelerated alone for e.g. reversal in direction, while the carrier 13 reaches the carrier start position, the carrier 13 is controlled to start up promptly so that the position of the carrier 13 can be synchronized with the predicted position of the decelerating carriage 3.

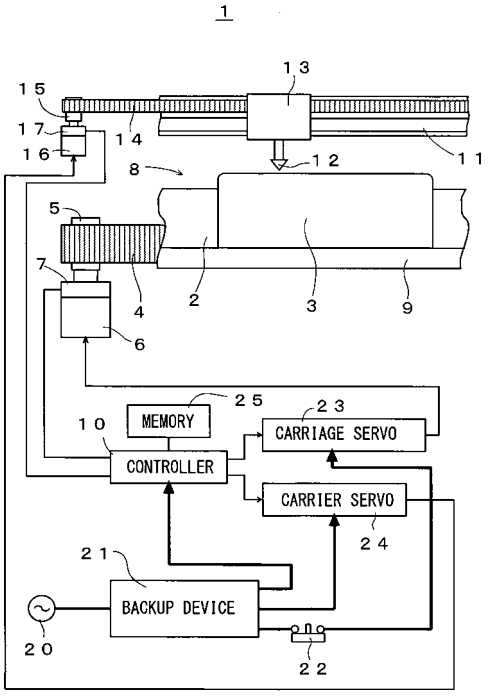

Fig. 1

EP 2 246 466 A1

Description

Technical Field

[0001] The present invention relates to a flatbed knitting machine having a self-moving carrier for feeding a knitting yarn when a knit fabric is knitted with knitting needles driven by a carriage which moves along a needle bed, and to a control method for the self-moving carrier in the flatbed knitting machine.

Background Art

[0002] In general, the flatbed knitting machine for knitting a knit fabric with the knitting needles driven by the carriage moving in reciprocation along the needle bed often employs a system for allowing the carriage to mechanically pull the carrier for feeding the knitting yarn. The carriage mounts cams adapted to act upon the knitting needles, and the carrier is pulled so that its positional relation with the cams can be kept constant. When the pulling of the carrier by the carriage is released, the carrier comes to a stop. In the knitting of intarsia and the like wherein a knit fabric is knitted in the manner that each course of loops of the knit fabric is divided into a plurality of zones with respect to the knitting width and each of those zones is supplied with a separate yarn, when the carrier is at a stop in the way of the adjoining zone, the carrier hinders the knitting of the zone in which the carrier is at a stop. To prevent such a hindrance, the carrier can be retracted or returned by the kick-back operation caused by movement of the carriage. However, such a kick-back operation of the carrier caused by the carriage requires the movement of the carriage which does not directly participate in the knitting of the knit fabric, thus providing a decreased knitting efficiency.

[0003] In the flatbed knitting machine having self-moving carriers, the self-moving carriers are moved separately along the needle bed without being pulled by the carriage (See Patent Citation 1, for example). When the self-moving carrier is used to feed the knitting yarn, since the self-moving carrier can be retracted or returned by its own movement in the knitting of intarsia and the like, the need to drive the carriage for the kick-back operation can be eliminated to avoid decrease in knitting efficiency. By use of this self-moving carrier, a variety of knitting methods can be provided, including e.g. plating wherein a face yarn and a back yarn are fed from two carriers to one cam with a predetermined phase difference.

[0004] Since the carriage is large in weight and thus large in load for driving the knitting needles at the knitting, a main motor for the flatbed knitting machine is used as a driving source for the carriage. The main motor is controlled via e.g. a servo drive system. A position of the carriage is detected directly from its position relative to the needle bed or frame of the flatbed knitting machine or indirectly from rotation of the main motor and the like. A position of the self-moving carrier which is in the middle of moving is also detected and is synchronized with the position of the carriage so as to fall within a certain range.

[0005] The flatbed knitting machine is provided with a stop switch for stopping the knitting operation. By operation of the stop switch, a driving power supply for driving the main motor and others for driving the carriage is shut off. The electric power supply for driving the carriage is shut off due to electric power failure or by operation of a power shutdown device, as well.

Patent Citation 1: Japanese Examined Patent Publication No. Hei 3-62821

Disclosure of the Invention

Technical Problem

[0006] The flatbed knitting machine having the self-moving carrier requires that the carriage and the carrier be constantly synchronized to ensure the yarn feed for the reliable knitting and production of a variety of knit fabrics. However, when the power supply to drive the carriage is shut off or interrupted by the power source of the flatbed knitting machine being shut off due to electric power failure or by the operation of the stop switch, the carriage and the carrier are not synchronized. When the power supply is shut off in the middle of moving, the carriage comes free from the control of the servo driver, so that it gradually slows down and eventually stops. If moving at a speed of e.g. 1m/s for the knitting of the knit fabric, the carriage will move over the order of 100mm until it comes to a stop. When being not synchronized with the carriage, the carrier comes to a stop, so that there occurs a zone where the knitting yarn is not fed from the carrier, while only the knitting needles are driven for knitting. In that zone, no new loops are formed with the knitting needles, resulting in a press-off stitch fault.

[0007] At an outside of the knitting width, there is provided a zone where in association with decrease or increase in speed of the carriage when reversed in moving direction, the carrier is brought to a halt to allow only the carriage to move. At the start of the carriage after reversed in moving direction, a sequence is performed to allow only the carriage

to be accelerated in this zone and then allow the carriage to be synchronized with the carrier, while also allowing the carrier to move. It is to be noted here that when the electric power supply to drive the carriage is shut off due to e.g. a necessity of emergency operation of the stop switch when the carriage is in the zone in which only the carriage is moved, the carriage cannot stop immediately. When the stop position of the carriage is in the zone in which the carrier as well is moved, the carriage already passes past the position at which the carrier starts moving, when restarting to move after release of the shut-off of the electric power. This causes the press-off stitch fault.

[0008] It is an object of the present invention to provide a flatbed knitting machine having a self-moving carrier which is constructed so that even when electric power supply to drive a carriage is shut off by e.g. an operation of the stop switch, the carriage and the self-moving carrier can be synchronized to properly restart knitting after release of the shut-off of the electric power supply, and a control method for the self-moving carrier in the flatbed knitting machine.

Technical Solution

[0009] The present invention provides a flatbed knitting machine provided with a carriage which moves along a needle bed on which knitting needles are arranged in parallel and mounts a cam to allow the knitting needles to be selectively driven for knitting, and a carrier which moves separately from the carriage by its own movement, while being synchronized with the carriage in position to feed a knitting yarn to the knitting needles driven for the knitting,
the flatbed knitting machine comprising:

a sensor for detecting a position of the carriage, being capable of detecting position of the carriage at least until the carriage stops even when electric power supply to drive the carriage is shut off during a process of the movement of the carriage, and
a controller for controlling movement of the carrier in a manner that when the electric power supply to drive the carriage is shut off during a process of the movement of the carriage, a position of the carrier can be synchronized with a position of the carriage detected by the sensor until the movement of the carriage stops.

[0010] The present invention provides the flatbed knitting machine further comprising a memory for storing positions of said carriage on a time-series basis,
wherein said controller operates to derive a predicted position of the carriage based on the positions of the carriage stored in the memory and control the carrier to move with said synchronized position with the predicted position being kept.

[0011] The present invention provides the flatbed knitting machine, wherein said controller
controls said carriage so that at the start-up of the carriage, only the carriage can be accelerated alone until a prescribed condition for start-up moving the carrier is satisfied, and then controls said carrier to start up so that it can be synchronized with the carriage while moving,
followed by controlling the carrier so that when the electric power supply for driving the carriage is shut off in the process of only the carriage being accelerated alone, the carrier can be started up to be synchronized with the carriage while moving, if the condition for start-up moving the carrier is satisfied until carriage stops.

[0012] The present invention provides a control method for controlling movement of a self-moving carrier in a flatbed knitting machine provided with a carriage which moves along a needle bed on which knitting needles are arranged in parallel and mounts a cam to allow the knitting needles to be selectively driven for knitting, and a carrier which moves separately from the carriage by its own movement, while being synchronized with the carriage in position to feed a knitting yarn to the knitting needles driven for the knitting, when electric power supply to drive the carriage is shut off in a process of movement of the carriage,
wherein even when the electric power supply to drive the carriage is shut off, a position of the carriage is to be capable of detecting at least until the carriage stops, and
wherein when the electric power supply to drive the carriage is shut off in the process of the carriage and the carrier being synchronized with each other while moving, the movement of the carrier is controlled so that the synchronized position of the carrier with the position of the carriage can be kept until the carriage stops.

Advantageous Effects

[0013] According to the present invention, when the electric power supply for the drive is shut off in the process of the movement of the carriage, the controller controls the movement of the carrier so that the synchronized position of the carrier with the position of the carriage can be kept until the carriage stops. This can provide the result that even when the electric power supply to drive the carriage is shut off by e.g. an operation of the stop switch, synchronization between the carriage and the self-moving carrier can be kept to restart knitting without any problem after release of the shut-off of the electric power supply.

[0014] According to the present invention, the controller operates to derive a predicted position of the carriage based

on the positions of the carriage stored in the memory on a time-series basis. The carrier can be controlled so that its position can be promptly synchronized with the predicted position of the carriage.

[0015] According to the present invention, at the start-up, only the carriage is accelerated alone. Even when the electric power supply to drive the carriage is shut off in the process of only the carriage being accelerated alone, the carrier is synchronized with the carriage, if the condition for start-up moving the carrier is satisfied by the time the carriage stops. Hence, the knitting can be restarted properly after release of the shut-off of the electric power supply to drive the carriage.

[0016] Further, according to the present invention, even when the electric power supply to drive the carriage is shut off in the process of movement of the carriage, the movement of the carrier is controlled so that the synchronized position of the carrier with the position of the carriage can be kept until the carriage stops. This can provide the result that even when the electric power supply to drive the carriage is shut off by e.g. the operation of the stop switch, the synchronization between the carriage and the self-moving carrier can be kept. This can enable the knitting to be restarted properly after the release of the shut-off of the electric power supply.

Brief Description of Drawings

[0017]

[Fig.1] Fig. 1 is a block diagram showing a schematic electric structure of a flatbed knitting machine 1 as a certain embodiment of the present invention.

[Fig.2] Fig. 2 is a diagram showing a concept of a manner that a position of a carriage 3 decreased in speed after shut-off of electric power supply to drive the carriage is predicted based on the data about past positions of the carriage stored in memory, 25 in the flatbed knitting machine 1 of Fig. 1.

[Fig.3] Fig. 3 shows diagrams showing concepts of processes that the flatbed knitting machine 1 of Fig. 1 controls the carriage 3 at the time of start-up and at the time of shut off of the electric power supply to drive the carriage.

[Fig.4] Fig. 4 is a flow chart showing overall control procedures by a controller 10 of Fig. 1.

Explanation of References

[0018]

1	Flatbed knitting machine
2	Needle bed
3	Carriage
6	Carriage drive motor
7, 17	Encoder
8	Needle bed gap
10	Controller
13	Carrier
20	Commercial alternating-current source
21	Backup device
22	Stop switch
25	Memory

Best Mode for Carrying Out the Invention

[0019] Fig. 1 shows a schematic electric structure of a flatbed knitting machine 1 as a certain embodiment of the present invention. In the flatbed knitting machine 1, knitting needles arranged in parallel on a needle bed 2 are driven selectively by cams mounted on a carriage 3 to knit a knit fabric. The carriage 3 is driven to move in reciprocation in a right and left direction as viewed in the drawing figure. The right and left direction defined here corresponds to a longitudinal direction of the needle bed 2. The carriage 3 is connected to a timing belt 4 extending between both lengthwise ends of the needle bed 2. The timing belt 4 is driven via a drive pulley 5 at one lengthwise end of the needle bed 2. The drive pulley 5 is mounted on an output shaft of a carriage drive motor 6. A rotation angle of the output shaft is detected by an encoder 7. The needle bed 2 usually are provided to form a pair, and the paired needle beds are arranged opposite to each other across a needle bed gap 8 into or from which ends of the knitting needles are advanced or retracted. The other needle bed, not shown, arranged across the needle bed gap 8 has also the same structure as the needle bed 2. A carriage rail 9 is arranged to support the carriage 3 so that the carriage 3 can move in reciprocation in a longitudinal direction of the needle bed 2. A controller 10 is provided to control the movement of the carriage 3. The controller 10 including CPU controls the flatbed knitting machine 1 provided with the carriage 3 in accordance with preset programs.

[0020] In the flatbed knitting machine 1, a self-moving carrier 13 equipped with a yarn feeder 12 is moves in reciprocation along a yarn guide rail 11 arranged over the needle bed gap 8. A knitting yarn used for the knitting of a knit fabric is fed from the yarn feeder 12 to the knitting needles. The carrier 13 is connected to a timing belt 14 extending between both ends of the yarn guide rail 11. The timing belt 14 is driven via a drive pulley 15 at one lengthwise end of the yarn guide rail 11. The drive pulley 15 is mounted on an output shaft of a carrier drive motor 16. A rotation angle of the output shaft is detected by an encoder 17. Although more than one yarn guide rails 11 and carriers 13 thus arranged over the needle bed gap 8, only one yarn guide rail 11 and one carrier 13 are just illustrated in the drawing figure and their remaining parts are omitted. The carriage 3 and the carrier 13 can be driven not only via their respective driving means, illustrated as an example, but via different driving means.

[0021] Data corresponding to rotation angles of the output shaft of the carriage drive motor 6 detected by the encoder 7 and data corresponding to rotation angles of the output shaft of the carrier drive motor 16 detected by the encoder 17 are entered into the controller 10. Based on the data entered, the controller 10 controls the carriage 3 and the carrier 13 so that they can be synchronized with each other to keep their positional relation constant. The carriage 3 could mount two or more cams for driving the knitting needles. If the carriage 3 mounts two or more cams for driving the knitting needles, multiple knitting drive can be performed in a single stroke of one reciprocating movement of the carriage 3. In this case, two or more carriers 13 are moved in synchronization to correspond in position to the respective cams. In the knitting of plating, the two or more carriers 13 are moved in synchronization so that one used for a front yarn and another used for a back yarn can be in a shifted positional relation with the single cam mounted on the carriage 3.

[0022] An electric power to drive the carriage drive motor 6 is supplied to a carriage servo 23 from e.g. a commercial alternating-current source 20 as an external power source through a backup device 21 serving as a power source for the flatbed knitting machine and through a stop switch 22. The carriage servo 23 is used for servo drive of the carriage drive motor 6. The backup device 21 includes a large-capacity condenser and a magnetic circuit breaker, and the electric power is supplied to the stop switch 22 through the magnetic circuit breaker. When the electric power received from the commercial alternating-current source 20 is stopped due to electric power failure or other circumstances, the magnetic circuit breaker is tripped and the electric driving power supplied to the carriage drive motor 6 through the carriage servo 23 is shut off. When the stop switch 21 is operated due to an emergency situation or other circumstances in the process of receiving the electric power, as well, the electric power supply to drive the carriage 3 is shut off.

[0023] The electric power is supplied from the backup device 21 to a load which is lighter than the carriage 3 including the carrier 13, as well, including, for example, the carrier servo 24 used for the servo drive of the carrier motor 16, and the controller 10. When the electric power from the commercial alternating-current source 20 is interruped due to electric power failure or other circumstances, the backup power stored in the condenser situated within the backup device 21 is supplied to such a load. The condenser has a capacity enough large for the back-up power to be supplied on a time scale of seconds. The carrier servo 24 can be structured so that even when the electric power supply for driving is shut off, the electric power can be regenerated from the carrier motor 16 to extend the electric power supply by several seconds until the electric power supply is shutoff.

[0024] When the electric driving power supplied from the commercial alternating-current source 20 to the carriage drive motor 6 is shut off due to e.g. electric power failure of the commercial alternating-current source 20 or by the operation of the stop switch 22, the carriage 3 is decreased in speed and then stops. The controller 10 controls the carrier 13 to keep the synchronization between the position of the carrier 13 and that of the carriage 3, as mentioned later. The controller 10 is structured so that even when the electric power received from the commercial alternating-current source 20 is shut off, the power can be supplied from the backup device 21 to the controller 10 during at least this controlling process. The carrier servo 24 to drive the carrier motor 16 may be structured to regenerate the electric power so as to increase the time until the carrier motor 16 stops, as previously mentioned.

[0025] The controller 10 is provided with a memory 25 for the purpose of proper control on the synchronization between the position of the carriage 3 and the position of the carrier 13. The data on the positions of the carriage 3 are stored in the memory 2 5 at regular time intervals, e.g. once for every 1ms. The memory 25 includes a given region allocated to store the data on the positions of the carriage 3. When the data is fully stored in the entire region, the oldest data stored is overwritten by entering new data in that region.

[0026] The carriage drive motor 6 and the carrier drive motor 16 are operated via the carriage servo 23 and carrier servo 24, respectively, under control of the controller 10. The electric power supplied from the main source 20 of electric power is supplied to the carriage drive motor 6 by the servo driver 25 under the control of the controller 10. When the electric power supply is shut off, the carriage servo 23 uses the regenerative electric power generated by the carriage drive motor 6 as an electric generator, to keep the state in which the rotation angle can be detected by the encoder 7. A backup power source which can supply the electric power for longer hours than the backup device 21 from which the backup power is supplied, and a nonvolatile flash memory are used for the memory 25. The data on the positions of the carriage 3 held during halts of the flatbed knitting machine 1 can be read out from this memory 25 even at the restart of the flatbed knitting machine 1 after halted.

[0027] Fig. 2 shows a concept of a manner that a position of the carriage 3, decreased in speed for example after

operation of the emergency stop switch 21, is predicted based on the data on past positions of the carriage 3 stored in memory 25 of Fig. 1. The data indicating the past positions of the carriage 3 are stored in the memory 25 on a time-series basis of e.g. once for every 1ms. The position of the carriage 3 is calculated based on the rotation angle of the output shaft of the carriage drive motor 6 output from the encoder 7. A linear encoder or the like which can do the position detection directly along the needle bed 2, the carriage rail 9, or the like may be provided to detect that position. The memory 25 has a storage area large enough to store the data on at least three positions required to predict the following points. A 1ms-later predicated position is derived as P3 from the data on three past positions of 3ms, P0, P1 and P2, including the present position.

Where P2 is the present position, P1 is a 1ms past position, P0 is a 2ms past position, dP1 is a difference between P0 and P1, and dP2 is a difference between P1 and P2, the following equations are given:

$$dP1 = P1 - P0 \qquad \ldots (1)$$

$$dP2 = P2 - P1 \qquad \ldots (2).$$

When the decrease in speed continues, it is expected that a difference dP3 between the 1ms-later position P3 and the present position P2 decrease further than dP2 only by the difference between dP1 and dP2. It follows from this that:

$$dP3 = dP2 - (dP1 - dP2) = 2dP2 - dP1 \qquad \ldots (3)$$

It follows from this equation that the 1ms-later position P3 can be predicted as:

$$P3 = P2 + dP3 = P2 + (2dP2 - dP1) \qquad \ldots (4)$$

[0028] The controller 10 of Fig. 1 controls the carriage drive motor 6 and the carrier drive motor 16 so that the position of the carriage 3 and the position(s) of the one or more than one carriers 13 are synchronized, keeping their positional relation constant. When the flatbed knitting machine 1 is in proper operation with the electric power supplied from the main power source 20, the carriage 3 is controlled by the carriage drive motor 6 to be increased or decreased in speed so as to properly move in reciprocation along the needle bed 2 within a range determined depending on a knitting width of a knitted fabric to be knitted. When the electric power supply to the carriage servo 23 is shut off in the state in which the position of the carrier 13 is synchronized with the position of the carriage 3, the controller 10 operates to derive a predicted position of the carriage 13 and control the position of the carrier 13 to be synchronized with the predicted position.

[0029] Fig. 3 shows a concept of a manner to control the carriage 3 when the electric power supply to drive the carriage is shut off at the start-up of the carriage 3. It is usual that after being moved to e.g. a position on the outer side of the one end of the knitting width end and on the outer side of the carrier 13, the carriage 3 is reversed in direction. According to the start-up sequence of the carriage after reversed in direction, at the time of t0, the carriage in the resting state starts moving toward the other end of the knitting width at a constant speed, as shown in solid line in Fig. 3(a). At that time, the carrier 13 is on standby at a position on the outer side of the one end of the knitting width and near the end of the knitting width. Since the carriage 3 is moved alone until the time of t1, it is needless to say that the carriage 3 is not synchronized with the carrier 13 until then. At the time of t1, the carriage 3 reaches a carrier start position where the carrier 13 starts moving, and the carrier 13 starts moving to the other side of the knitting width, as shown in broken line. Since the carrier 13 smaller in load than the carriage 3 can be accelerated at a more rapid pace, the carrier 13 reaches the velocity equal to that of the carriage 3 at the time of t2 and then keeps its synchronized positional relation with the carriage 3. When being synchronized with the carrier 13, the carriage 3 can drive the knitting needles into action to knit a knit fabric using a knitting yarn fed to the knitting needles from the yarn feeder 12 of the carrier 13. When the electric power supply to the carriage servo 23 is shut off after the synchronization, the control may be exercised, while a predicted position of the carriage 3 is derived, as shown in Fig. 2.

[0030] As shown in Fig. 3(b), a possible shut-off of the electric power supply to the carriage servo 23 may occur between the time t1 and the time t2, as well. When the electric power supply is shut off at the time of tx between those two points in time, the acceleration of the carriage 3 proceeding from the time of t0 is interrupted at the time of tx, as

indicated in bold solid line. In other words, after the time of tx, the acceleration is not continued but is switched to deceleration, as shown in the startup sequence indicated in two-dot chain line. The controller 10 then controls the carrier 13 so that the position of the carrier 13 can be promptly synchronized with the predicted position of the carriage 3 after the time of tx, as shown in bold broken line. Since the carrier 13 is smaller in load, the carrier 13 can be accelerated at a further rapid pace. Since the carriage 13 is decreased in speed after the time of tx, the synchronization can be obtained quickly. After synchronized, the carrier 13 can be controlled so that its position can be aligned with the predicted position, while the predicted position of the carriage 3 is derived.

[0031] A possible shut-off of the electric power supply to the carriage servo 23 may occur between the time t0 and the time t1 while the carriage 3 is accelerated alone. When a position at which the carriage 3 decelerated due to the shut-off of the power supply comes to a stop does not arrive at the carrier start-up position, there is no need to start up the carrier 13. The carrier 13 need not be controlled for synchronization until the shut-off of the power supply is released to restart the operation and the carriage 3 arrives at the carrier start-up position. When the carriage arrives at the carrier start-up position before the carriage 3 decreasing in speed comes to a stop, the carrier 13 may be controlled so that its position can be immediately synchronized with the predicted position of the carriage 3, as in the case of the possible shut-off of the electric power supply which may occur between the time t1 and the time t2, as shown in Fig. 3(b).

[0032] Fig. 4 shows overall control procedures of the carrier 13 by the controller 10 described above. In the normal operation of the flatbed knitting machine 1, in the step s1, the present position of the carriage 3 is stored in the memory 25. In the step s2, decision is made whether the stop switch 22 was pushed, or whether the commercial alternating-current source 20 was shut off due to the electric power failure. This decision is made by for example monitoring voltage of the carriage servo 23 on the input side. When the electric power supply is not interrupted, a target position of the carrier 13 with respect to a 1ms-later target position of the carriage 3 is calculated in the step s3. The target position of the carriage 3 can be set in accordance with the sequence for the operations including for example acceleration at start-up, constant-speed motion after acceleration, as shown in solid line extending from the time t0 in Fig. 3(a), and deceleration at the interruption, not shown. In the step s4, the calculated target position of the carrier 13 is output to the carrier servo 24 and the carrier drive motor 16 is controlled. In the normal knitting process, a series of procedures between the steps s1 and s4 are repeated to control the carriage 3 and the carrier 13 so that they can be synchronized with each other, while moving.

[0033] When it is decided in the step s2 that the electric power supply was shut off due to the push operation of the stop switch 21 or due to electric power failure of the commercial alternating-current source 20, the 1ms-later position of the carriage 3 is predicted in the way of thinking as shown in Fig. 2, in the step s5. Sequentially, in the step s6, decision is made whether the carrier 13 and the carriage 3 are not yet synchronized with each other. When already synchronized, the target position of the carrier 13 with respect to the 1ms-later predicated position of the carriage 3 is calculated in the step s7, then going to the step s4. By synchronizing the position of the carrier 13 with this predicted position of this carriage 3, the carrier 13 and the carriage 3 can be kept in the synchronized state even after the electric power supply is shut off.

[0034] The state of before t1 of Fig. 3(a) is decided as the carrier 13 and the carriage 3 being not yet synchronized, in the step s6. This state corresponds to, for example, the state that the carriage 3 passed past the end of the knitting width to be reversed in travelling direction. In this case, decision is made in the step s8 whether the predicted position of the carriage 3 passed past the carrier start-up position. When the predicted position of the carriage 3 passed past the carrier start-up position, the target position of the carrier 13 with respect to the 1ms-later predicted position of the carriage 3 is calculated in the step s9. This corresponds to the way of synchronizing the carrier 13 and the carriage 3 with each other instantly. When the predicted position of the carriage 3 does not yet pass past the carrier start-up position, the target position of the carrier 13 is not calculated and is not set in the step s8, then going to the step s4. In the step s4, since the target position of the carrier to be output is not presented, only the carriage 3 is moved, while the carrier 13 remains stationary.

Claims

1. A flatbed knitting machine provided with a carriage which moves along a needle bed on which knitting needles are arranged in parallel and mounts a cam to allow the knitting needles to be selectively driven for knitting, and a carrier which moves separately from the carriage by its own movement, while being synchronized with the carriage in position to feed a knitting yarn to the knitting needles driven for the knitting,
the flatbed knitting machine comprising:

    a sensor for detecting a position of the carriage, being capable of detecting position of the carriage at least until the carriage stops even when electric power supply to drive the carriage is shut off during a process of the movement of the carriage, and

a controller for controlling movement of the carrier in a manner that when the electric power supply to drive the carriage is shut off during a process of the movement of the carriage, a position of the carrier can be synchronized with a position of the carriage detected by the sensor until the movement of the carriage stops.

2. The flatbed knitting machine according to claim 1 further comprising a memory for storing positions of said carriage on a time-series basis,
wherein said controller operates to derive a predicted position of the carriage based on the positions of the carriage stored in the memory and control the carrier to move with said synchronized position with the predicted position being kept.

3. The flatbed knitting machine according to claims 1 or 2,
wherein said controller
controls said carriage so that at the start-up of the carriage, only the carriage can be accelerated alone until a prescribed condition for start-up moving the carrier is satisfied, and then controls said carrier to start up so that it can be synchronized with the carriage while moving,
followed by controlling the carrier so that when the electric power supply for driving the carriage is shut off in the process of only the carriage being accelerated alone, the carrier can be started up to be synchronized with the carriage while moving, if the condition for start-up moving the carrier is satisfied until carriage stops.

4. A control method for controlling movement of a self-moving carrier in a flatbed knitting machine provided with a carriage which moves along a needle bed on which knitting needles are arranged in parallel and mounts a cam to allow the knitting needles to be selectively driven for knitting, and a carrier which moves separately from the carriage by its own movement, while being synchronized with the carriage in position to feed a knitting yarn to the knitting needles driven for the knitting, when electric power supply to drive the carriage is shut off in a process of movement of the carriage,
wherein even when the electric power supply to drive the carriage is shut off, a position of the carriage is to be capable of detecting at least until the carriage stops, and
wherein when the electric power supply to drive the carriage is shut off in the process of the carriage and the carrier being synchronized with each other while moving, the movement of the carrier is controlled so that the synchronized position of the carrier with the position of the carriage can be kept until the carriage stops.

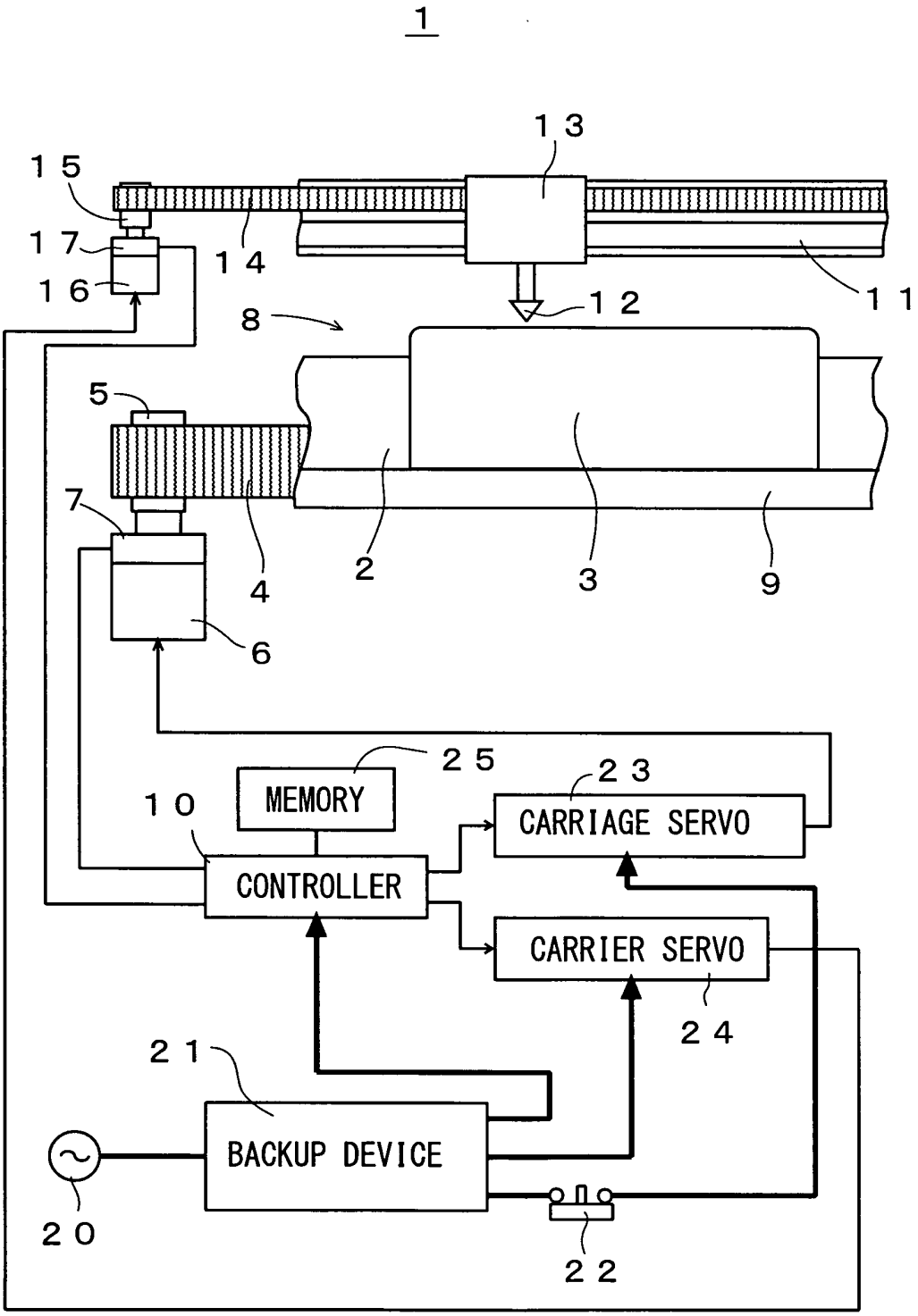
1
13
15
17
16
14
12
11
8
5
7
4
2
3
9
6
25
23
10
MEMORY
CARRIAGE SERVO
CONTROLLER
CARRIER SERVO
24
21
BACKUP DEVICE
20
22

Fig. 1

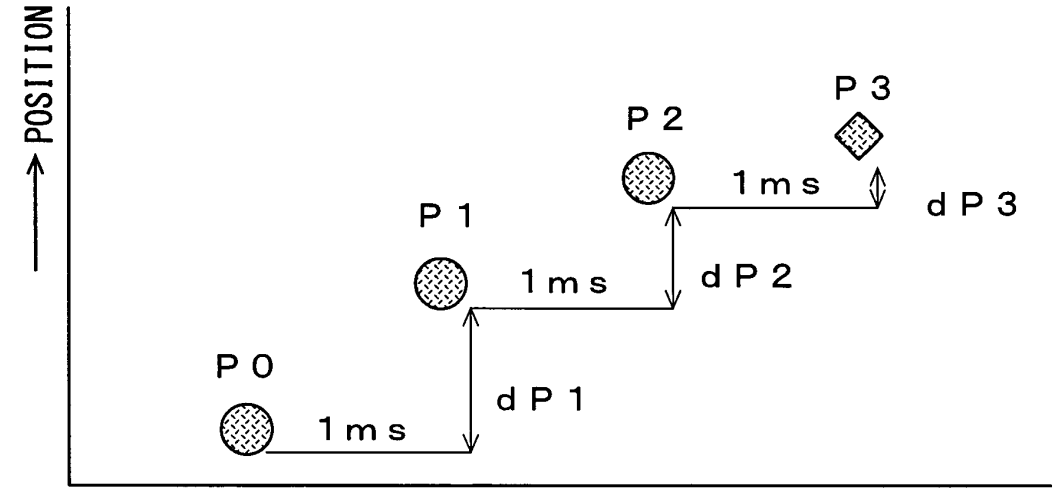
POSITION
P 3
P 2
1 m s
d P 3
P 1
1 m s
d P 2
P 0
d P 1
1 m s
TIME

Fig. 2

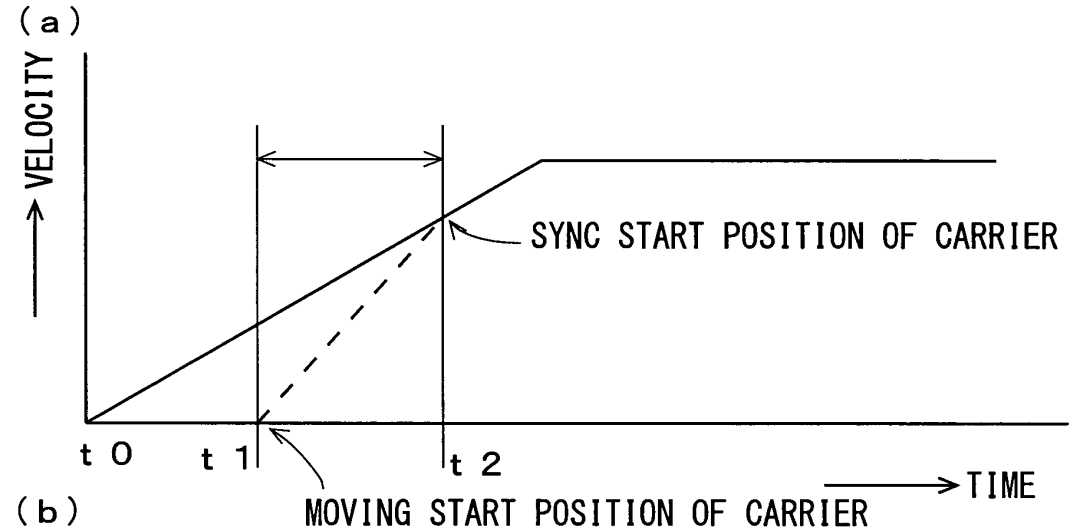
(a)
VELOCITY
SYNC START POSITION OF CARRIER
t 0
t 1
t 2
TIME
(b)
MOVING START POSITION OF CARRIER
VELOCITY
t 0
t 1
t x
t 2
t y
TIME

Fig. 3

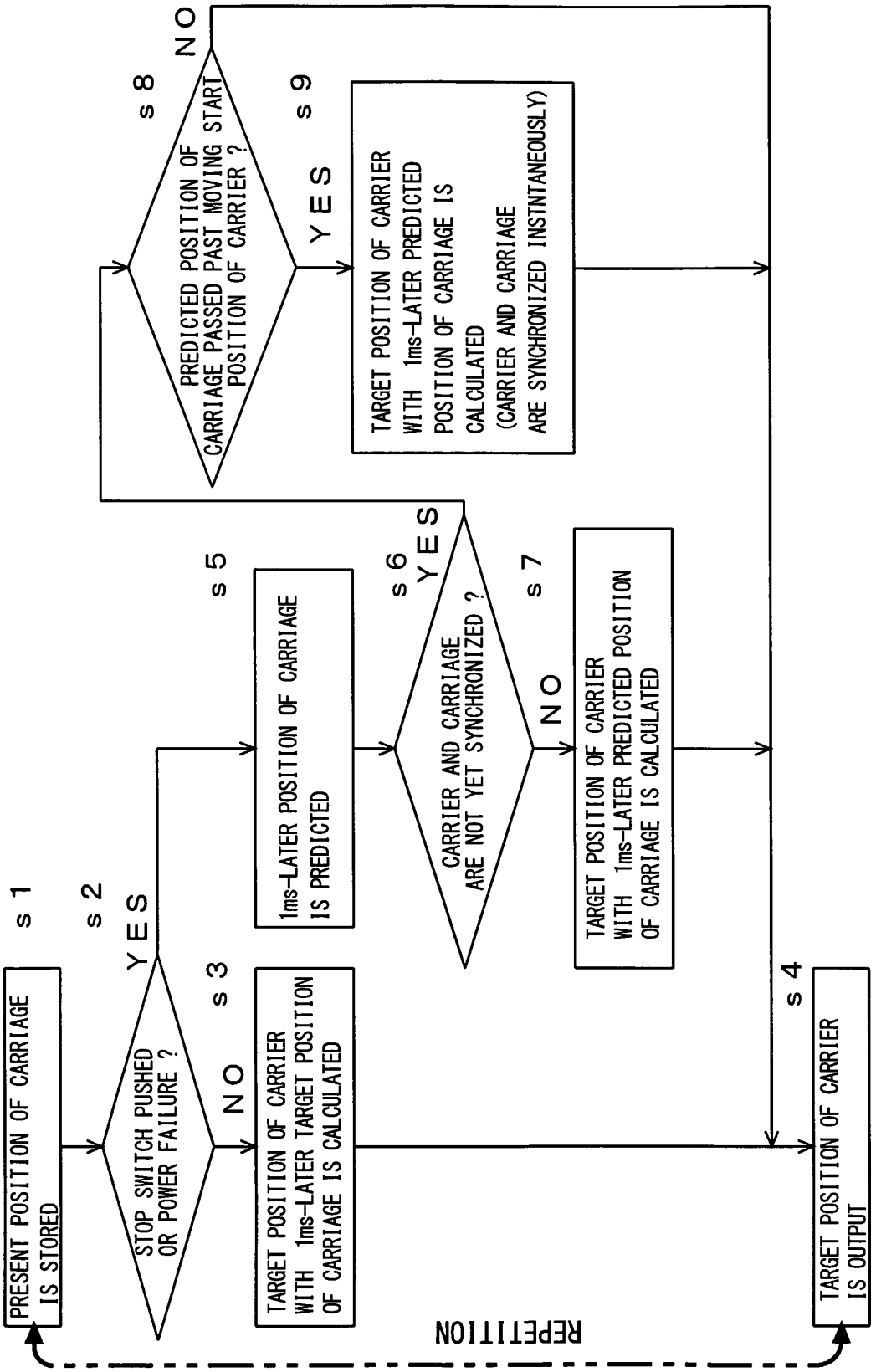
PRESENT POSITION OF CARRIAGE IS STORED
s 1
STOP SWITCH PUSHED OR POWER FAILURE ?
s 2
YES
NO
TARGET POSITION OF CARRIER WITH 1ms-LATER TARGET POSITION OF CARRIAGE IS CALCULATED
s 3
1ms-LATER POSITION OF CARRIAGE IS PREDICTED
s 5
CARRIER AND CARRIAGE ARE NOT YET SYNCHRONIZED ?
s 6
YES
NO
TARGET POSITION OF CARRIER WITH 1ms-LATER PREDICTED POSITION OF CARRIAGE IS CALCULATED
s 7
PREDICTED POSITION OF CARRIAGE PASSED PAST MOVING START POSITION OF CARRIER ?
s 8
YES
NO
TARGET POSITION OF CARRIER WITH 1ms-LATER PREDICTED POSITION OF CARRIAGE IS CALCULATED (CARRIER AND CARRIAGE ARE SYNCHRONIZED INSTNTANEOUSLY)
s 9
TARGET POSITION OF CARRIER IS OUTPUT
s 4
REPETITION

Fig. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2008/003943

A. CLASSIFICATION OF SUBJECT MATTER
D04B15/96(2006.01)i, *D04B35/10*(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
D04B15/94-15/99, 35/10-35/20

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2009
Kokai Jitsuyo Shinan Koho	1971-2009	Toroku Jitsuyo Shinan Koho	1994-2009

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 3-62821 B2 (Ikenaga Co., Ltd.), 27 September, 1991 (27.09.91), & DE 69023837 C	1,2,4 3
Y A	JP 2004-76172 A (Precision Fukuhara Works, Ltd.), 11 March, 2004 (11.03.04), & DE 10334207 A & CN 1482297 A & TW 277671 B	1,2,4 3
A	JP 5-209345 A (Atelier de Construction Steiger S.A.), 20 August, 1993 (20.08.93), & US 5417087 A & EP 526406 A2 & DE 69210132 C & CH 686089 A & MX 9204497 A	1-4

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search 15 January, 2009 (15.01.09)	Date of mailing of the international search report 27 January, 2009 (27.01.09)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (April 2007)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2008/003943

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 8-127948 A (Shima Seiki Mfg., Ltd.), 21 May, 1996 (21.05.96), & US 5588311 A & EP 709506 A1 & DE 69508696 C	1-4

Form PCT/ISA/210 (continuation of second sheet) (April 2007)

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP HEI362821 B **[0005]**