



(51) International Patent Classification:  
D03D 47/34 (2006.01)

(21) International Application Number:  
PCT/EP2024/061861

(22) International Filing Date:  
30 April 2024 (30.04.2024)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:  
23 177 198.1 05 June 2023 (05.06.2023) EP

(71) Applicant: VANDEWIELE NV [BE/BE]; Michel Vandewielestraat 7, 8510 Kortrijk/Marke (BE).

(72) Inventors: CAUWELIER, Matthias; Hulstsestraat 142, 8520 Kuurne (BE). DEBUF, Geert; Droogveldeweg 1, 9031 Drogen (BE). THIELEMANS, Steven; Rode-Beukendreef 14, 8510 Kortrijk (BE). WILLEMS, Jeroen; Venbergsemolen 235, 5612 DZ Eindhoven (NL). DE-

BROUWERE, Frederik; Vredestraat 10, 8957 Mesen (BE).

(74) Agent: RUTTENSBERGER LACHNIT TROSSIN GOMOLL; Patent- und Rechtsanwälte, PartG mbB, Arnulfstr. 58, 80335 München (DE).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MU, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, CV,

(54) Title: METHOD OF OPERATING A WEAVING MACHINE

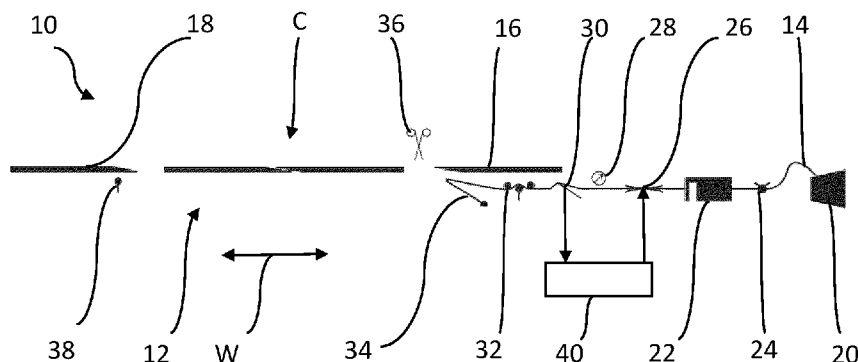


Fig. 1

(57) Abstract: A method of operating a weaving machine for inserting weft threads into sheds formed between warp threads during weaving cycles, the weaving machine comprising at least one weft thread inserting means (12) with an inserting rapier (16) for inserting a weft thread (14) and a receiving rapier (18) for receiving the weft thread (14) inserted by the inserting rapier (16), a weft brake (26) for applying a braking force to the weft thread inserted by the inserting rapier (16) and received by the receiving rapier (18) during a weaving cycle, a weft thread tension sensor (30) for outputting a weft thread tension signal indicative of a weft thread tension, and a weft machine controller (40) for receiving the weft thread tension signal and for controlling the weft brake (26) based on the weft thread tension signal, comprises the steps of decelerating the inserting rapier (16) during a weaving cycle in a deceleration phase prior to a transfer of a weft thread (14) from the inserting rapier (16) to the receiving rapier (18), and controlling the weft brake (26) during the deceleration phase based on a variability parameter indicative of the variability of a transfer occurrence parameter of previous weaving cycles, the transfer occurrence parameter being indicative of the occurrence of the weft thread transfer within a weaving cycle.

GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, ME, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

**Published:**

— *with international search report (Art. 21(3))*

## Method of operating a weaving machine

### Description

The present invention relates to a method of operating a weaving machine for inserting weft threads into sheds formed between warp threads during weaving cycles.

5

For inserting weft threads into sheds that, during each weaving cycle, are formed between the warp threads extending in the warp direction within a rapier weaving machine, weft thread inserting means comprising an inserting rapier for inserting a weft thread into a shed from one side of the shed and a receiving rapier for receiving the weft thread approximately in the center of the shed in the weft direction from the inserting rapier and moving the weft thread transferred to the receiving rapier to the other side of the shed are provided.

10

WO 2019/082 222 A1 discloses a gripper assembly with a bringer gripper acting as an inserting rapier and a taker gripper acting as a receiving rapier of a passive weft inserting means, also known as a negative weft inserting means. The weft thread inserted by the bringer gripper is directly transferred from the bringer gripper to the taker gripper, when both grippers are in a mutually overlapping positioning such that, upon a reverse movement of the bringer gripper, the taker gripper grips the weft thread and, upon a reverse movement of the taker gripper, moves the gripped weft thread to the other end of the shed. In active weft inserting means, also known as positive weft inserting means, active means to operate the clamps of the rapier, that hold the weft thread, such as blades, hooks or cams for example, are used for actuating the closing or the opening of these clamps in order to transfer the weft thread from the inserting rapier to the receiving rapier in the middle of the shed.

20

25

It is the object of the present invention to provide a method of operating a weaving machine for inserting weft threads into sheds formed between warp threads during weaving cycles providing an enhanced weft thread inserting capability with a reduced weft error risk.

30

For achieving this object, the present invention provides a method of operating a weaving machine for inserting weft threads into sheds formed between warp threads during weaving cycles, the weaving machine comprising:

- 5       - at least one weft thread inserting means with an inserting rapier for inserting a weft thread and a receiving rapier for receiving the weft thread inserted by the inserting rapier,
- 10       - a weft brake for applying a braking force to the weft thread inserted by the inserting rapier and received by the receiving rapier during a weaving cycle,
- a weft thread tension sensor for outputting a weft thread tension signal indicative of a weft thread tension,
- 15       - a weft machine controller for receiving the weft thread tension signal and for controlling the weft brake based on the weft thread tension signal.

This method comprises the steps of:

- 20       A) decelerating the inserting rapier during a weaving cycle in a deceleration phase prior to a transfer of a weft thread from the inserting rapier to the receiving rapier,
- B) controlling the weft brake during the deceleration phase based on a variability parameter indicative of the variability of a transfer occurrence parameter of  
25       previous weaving cycles, the transfer occurrence parameter being indicative of the occurrence of the weft thread transfer within a weaving cycle.

The method of the present invention considers that, within each weaving cycle, controlling the braking force applied to a weft thread immediately prior to the transfer  
30       thereof from the inserting rapier to the receiving rapier is important for keeping the weft thread under an appropriate tension while, at the same time, making sure that the transfer occurs at an appropriate point of time within a respective weaving cycle. While applying a high braking force is helpful for avoiding the occurrence of weft thread loops

when decelerating the inserting rapier prior to the transfer of the weft thread and, thereby, also decelerating the front end of the weft thread clamped in the inserting rapier, an excessive braking force applied to the weft thread increases the risk of a weft thread failure. Excessively reducing the braking force not only increases the risk of loops occurring during the transfer, but also leads to an undesired delay of the transfer within a weaving cycle, which results in a missed transfer, a higher tension during transfer or a weft thread failure.

By controlling the braking force applied to a weft thread immediately prior to the transfer thereof from the inserting rapier to the receiving rapier based on a parameter that is indicative of the variability of a parameter reflecting the occurrence of the transfer of a weft thread within a weaving cycle, the braking force can be adjusted such that, on the one hand, looping or ballooning of a weft thread during the transfer thereof is avoided and, on the other hand, a transfer of a weft thread from the inserting rapier to the receiving rapier at a desired point of time within a weaving cycle is supported substantially independent of the speed with which a weaving machine is operated.

As the point of time within a weaving cycle at which a weft thread is transferred from the inserting rapier to the receiving rapier, is picked up by the receiving rapier and starts moving with the receiving rapier is clearly reflected in the weft thread tension signal, the method of present invention further comprises a transfer determining step for determining the transfer occurrence parameter based on the weft thread tension signal.

Each weaving cycle of a weaving machine may correspond to a predetermined angular range of rotation of a weaving machine main shaft and, in the transfer determining step, a transfer angle at which, within the predetermined angular range of rotation, the weft thread transfer has occurred may be determined as the transfer occurrence parameter.

In a preferred embodiment, the predetermined angular range of rotation is 360°.

Upon the transfer of a weft thread from the inserting rapier to the receiving rapier, a rather high acceleration of the weft thread is generated when the weft thread starts moving together with the receiving rapier. Such a high acceleration at the beginning of this movement leads to a sharp increase of the weft thread tension so that, in the transfer determining step, it may be determined that the weft thread transfer has occurred, when the weft thread tension exceeds a weft thread tension threshold value and/or a gradient of the weft thread tension exceeds a weft thread tension gradient threshold value.

10 For enhancing the reliability of the method of the present invention, the transfer-determining step may be carried out for a plurality of weaving cycles, preferably for each weaving cycle, and the previous weaving cycles may comprise a predetermined number of preceding weaving cycles.

15 For using a well-known mathematical operation and providing a parameter that reflects the variability of the transfer occurrence parameter substantially independent of the operating speed of a weaving machine, the variability parameter may be determined based on a variance of the transfer occurrence parameter of the previous weaving cycles.

20

In particular, the variability parameter may be determined as the standard deviation of the transfer occurrence parameter of the previous weaving cycles, which means that the variability parameter is determined as the square root of the variance of the transfer occurrence parameter during the previous weaving cycles.

25

For adjusting the braking force in an appropriate manner and, thereby, avoiding negative effects like looping, ballooning or failure of a weft thread, step B) may comprise controlling the weft brake such that the variability parameter is below a predetermined variability parameter threshold value and/or within a predetermined variability parameter value range.

30

If the weft thread tension signal is indicative of the weft thread tension between the weft brake and the weft insertion means, the weft thread tension indicated by the weft

thread tension signal is a reliable parameter for appropriately adjusting the braking force of the weft brake.

The present invention will now be explained with reference to the enclosed drawings in which:

Fig. 1 is a schematic representation of a weaving machine and weft insertion means associated therewith;

Fig. 2 shows the position of an inserting rapier, a receiving rapier and a weft thread transferred therebetween during one weaving cycle;

Fig. 3 shows the position of a weft thread in the weft direction during one weaving cycle;

Fig. 4 shows the speed of the weft thread transferred from an inserting rapier to a receiving rapier during one weaving cycle;

Fig. 5 shows the weft thread acceleration during one weaving cycle;

Fig. 6 shows the weft thread tension during one weaving cycle;

Fig. 7 shows the level of the braking force applied to a weft thread during one weaving cycle;

Fig. 8 shows, in the upper part thereof, a variation of a braking force applied to a weft thread during a plurality of consecutive weaving cycles, and shows, in the lower part thereof, a transfer position of the weaving machine during the plurality of consecutive weaving cycles in association with the variation of the braking force.

Fig. 1 shows, in a schematic manner, a loom or weaving machine 10. The weaving machine 10 has a weft insertion means 12 for inserting a weft thread 14 into a shed

formed between non-shown warp threads extending in a warp direction of the weaving machine 10. The weft insertion means 12 comprises an inserting rapier 16 and a receiving rapier 18 that, in Fig. 1, are shown in a retracted position in which these rapiers 16, 18 are withdrawn from the shed formed between the warp threads, and are shown in an advanced position in which respective gripper portions of these rapiers 16, 18 inserted into the shed are positioned such as to overlap each other in the area of a center C of the shed in a weft direction W for transferring the weft thread 14 inserted into the shed by the inserting rapier 16 to the receiving rapier 18. In the preferred embodiment shown in Fig. 1, the weft insertion means 12 is embodied as a passive or negative weft insertion means arranged for directly transferring the weft thread 14 from the inserting rapier 16 to the receiving rapier 18 without using active means to open or to close the clamps of the rapiers for clamping the weft.

For forwarding the weft thread 14 to the inserting rapier, a bobbin 20 for providing the weft thread 14 and a feeder 22 buffering a portion of the weft thread 14 are provided. If required, a knot detector 24 can be provided or can be integrated into the feeder 22. Following to the feeder 22, a weft brake 26 arranged for applying a braking force to the weft thread 14, a weft detector 28 for detecting a movement of the weft thread 14, a weft tension sensor 30 for outputting a weft thread tension signal indicative of the tension of the weft thread 14 between the weft brake 26 and the one of the rapiers 16, 18 by means of which the weft thread 14 is gripped, a weft thread recuperator 32 as well as a weft selector 34 are provided in the weaving machine 10. If a plurality of different weft threads 14 are provided for generating specific weft thread patterns, such a weft selector 34 is used for offering the one weft thread that is to be used in a specific weaving cycle to the inserting rapier 16. Further, a weft scissor 36 is provided for cutting the weft thread 14 after a portion thereof has been inserted into a shed and for clamping the weft thread 14 and presenting it to the inserting rapier before its next portion will be inserted into the next shed formed between the warp threads. Further, a weft release actuator 38 is associated with the receiving rapier 18 for releasing the weft thread 14 from the receiving rapier 18 after the receiving rapier 18 has approached its retracted position and the weft thread 14 has been inserted into the shed.

It is to be noted that the weaving machine 10 may comprise a plurality of such weft insertion means 12 for simultaneously inserting a plurality of weft threads into a plurality of sheds formed between the warp threads and/or for inserting a plurality of weft threads at different levels, for example, if the weaving machine 10 is a face-to-face carpet weaving machine. Each such weft insertion means 12 may comprise an inserting rapier 16 and a receiving rapier 18 and, if the weft insertion means 12 is an active or positive weft insertion means, additionally may comprise active means for transferring the weft thread from the inserting rapier to the receiving rapier.

Fig. 2 shows the movement of the inserting rapier 16, the receiving rapier 18 and the weft thread 14 transferred therebetween during one weaving cycle. It is to be noted that, normally, such a weaving cycle is defined by one complete rotation of a main shaft of the weaving machine 10. If the weaving machine 10 is a carpet weaving machine, the weaving shaft of the weaving machine 10 makes about 130 to 200 or even up to 250 rotations per minute, which means that, per minute, a corresponding number of weft thread insertion operations are carried out by the weft insertion means 12. As the width of a carpet to be woven by such a carpet weaving machine may be up to about 5.3 meters, during each weft thread inserting operation, the weft thread 14 is moved by the inserting rapier 16 and the receiving rapier 18 through the shed having a corresponding extension of up to more than 5 meters in the weft direction W.

Fig. 3, 4, and 5 show, for one weaving cycle, i.e. for one complete rotation of the weaving machine main shaft by an angle of rotation of  $360^\circ$ , the position of the front end of the weft thread 14 gripped by the inserting rapier 16 and the receiving rapier 18, respectively, in the weft direction W, the speed of the front end of the weft thread 14, as well as the acceleration thereof. It can be seen that, at the beginning of each inserting operation when the inserting rapier 16 starts moving toward the center C of the shed substantially corresponding to machine width position 0 shown in Fig. 2 and 3, there is a sharp increase of the acceleration of the weft thread 14, as is the case after the transfer has occurred and the receiving rapier 18 having received and gripped the weft thread 14 starts moving and pulling the weft thread 14 toward the other lateral end of the shed formed between the warp threads.

Fig. 6 shows the weft thread tension signal indicative of the tension of the weft thread 14 as detected by the weft tension sensor 30. It can be seen in Fig. 6 that, with an increasing speed of the weft thread 14, the tension of the weft thread 14 also increases while, in a phase in which the inserting rapier 16 approaches the area of the center C of the shed and decelerates for transferring the weft thread 14 to the also decelerating receiving rapier 18, the tension of the weft thread 14 decreases.

Once the weft thread 14 has been transferred to the receiving rapier 18 and the receiving rapier 18 starts accelerating for pulling the weft thread 14 toward the other end of the shed, there is a sharp increase of the tension of the weft thread 14 that is reflected in the weft thread tension signal in the area of a machine position between  $180^\circ$  and  $200^\circ$  of the rotation of the weaving machine main shaft within the shown weaving cycle. After this transfer peak of the weft thread tension has occurred, there is a corresponding sharp decrease of the weft thread tension and, thereafter, the tension of the weft thread 14 increases with the increasing speed of the receiving rapier 18 and, upon approaching the other end of the shed, decreases with the decreasing speed of the receiving rapier 18.

The transfer peak contained in the weft thread signal output by the weft tension sensor 30 is a clear indicator for the occurrence of the transfer of the weft thread 14 from the inserting rapier 16 to the receiving rapier 18. The position of the weaving machine at which this transfer occurs can be determined as a transfer occurrence parameter P. If the weaving machine position is defined as being an angle of rotation within the angular range of rotation of the weaving machine main shaft, for example, corresponding to  $360^\circ$ , the transfer occurrence parameter P shown in Fig. 6 can be determined as being the transfer angle at which, within the predetermined angular range of rotation of the weaving machine main shaft of  $360^\circ$ , the transfer has occurred. It is to be noted that, for example, it can be determined that the transfer has occurred, when the weft thread tension exceeds a predetermined weft thread tension threshold T shown in Fig. 6 or when the gradient of the weft thread tension exceeds an associated weft thread tension gradient threshold.

Fig. 7 shows that, for ensuring an appropriate movement of the weft thread 14 during each weaving cycle, the weft brake 26 is controlled such as to provide different levels of the braking force applied to the weft thread 14. In a starting phase of the weft insertion cycle, a braking force of a substantially constant intermediate level is applied during a zone Z1 for keeping the weft thread 14 under tension when presenting the weft thread 14 to the inserting rapier 16 and before the inserting rapier 16 starts moving.

Thereafter, the braking force is reduced to a substantially constant lower level applied to the weft thread 14 in a zone Z2 of the weft insertion cycle for avoiding an excessive tensioning of the weft thread 14 in a phase in which the speed of the inserting rapier 16 and, therefore, the speed of the front end of the weft thread 14 increases.

Prior to reaching the transfer position in the area of the center C of the shed formed between the warp threads, the braking force is increased to a substantially constant high level for keeping the weft thread 14 under tension while the speed of the inserting rapier 16 and the front end of the weft thread 14 decreases to 0 during a zone Z3 for transferring the weft thread 14 to the receiving rapier at the end of zone Z3.

For avoiding an excessive tensioning of the weft thread 14 upon the transfer thereof to the receiving rapier 18, the weft brake 30 is controlled such as to provide a substantially constant reduced level of the braking force during a zone Z4 following zone Z3 and the transfer of the weft thread. This reduced level of the braking force is maintained while the receiving rapier 18 having gripped the front end of the weft thread 14 accelerates and, therefore, the speed thereof increases, as shown in Fig. 4.

For keeping the weft thread 14 under tension during the deceleration of the receiving rapier 18 and approaching the other end of the shed, the weft brake 30 is controlled such as to apply a substantially constant increased braking force during a zone Z5, followed by a zone Z6 of a substantially constant intermediate level of the braking force at the end of the weaving cycle at which the receiving rapier 18 and weft thread 14 inserted into the shed come to a standstill and the weft release actuator 38 is activated for releasing the weft thread 14 from the receiving rapier 18.

It is to be noted that, in the transition phases between immediately adjacent ones of the above-referenced zones Z1 to Z6, the weft brake 30 may be controlled such as to provide a substantially linear transition between the different levels of the braking force used in the successive zones Z1 to Z6.

The control of the braking force applied to the weft thread 14 by means of the weft brake 30 during zone Z3 immediately prior to the transfer of the weft thread 14 from the inserting rapier 16 to the receiving rapier 18 is important for avoiding weft errors and for ensuring that the transfer of the weft thread 14 occurs at an appropriate point of time and an appropriate angle of the weaving machine main shaft, respectively, within a weaving cycle. Applying a too low braking force during zone Z3 increases the risk of a looping or ballooning of the weft thread 14 immediately prior to the transfer and during the transfer of the weft thread 14 and leads to a delay of the transfer. This can be seen in Fig. 8 showing, for a plurality of consecutive weaving cycles, that a reduction of the braking force leads to a shift of the transfer position being the angular position of the weaving machine main shaft within a weaving cycle at which the transfer occurs to a later point of time and a higher value of the transfer angle defining the transfer parameter P, respectively. Fig. 8 shows that, with a stepwise increase of the braking force, this delay decreases and the transfer angle shifts to a lower value, which means that the transfer takes place at an earlier point of time within a weaving cycle.

Fig. 8 further shows that, with an increasing braking force and a decreasing delay of the transfer, the variability of the transfer occurrence parameter P that, in the shown embodiment, is defined by the transfer angle, also decreases. This is indicated by dotted lines in Fig. 8 showing the fluctuation range of the transfer occurrence parameter. In the shown example, this fluctuation range is represented by the vertical distance between the dotted lines, and the vertical distance between each dotted line and a mean value of the transfer occurrence parameter corresponds to the double of the standard deviation of the transfer occurrence parameter (P). Therefore, controlling the braking force to a sufficient high level avoids an excessive delay of the transfer of the weft thread 14 from the inserting rapier 16 to the receiving rapier 18 and, at the same time, leads to a reduced variation of the point of time and the transfer angle,

respectively, at which the transfer occurs within a weaving cycle. Further, avoiding a too low braking force avoids the risk of a looping or ballooning of a not sufficiently decelerated weft thread 14 immediately prior to or during the transfer of the front end of the weft thread 14 from the inserting rapier 16 to the receiving rapier 18.

5

Considering this specific influence of the braking force applied to the weft thread 14 in zone Z3 immediately prior to the transfer of the weft thread from the inserting rapier 16 to the receiving rapier 18, the weaving machine 10 and the weft insertion means 12, respectively, are controlled based on the weft tension signal output by the weft tension sensor 30 to a weft machine controller 40. The weft machine controller 40 that, for example, provides a sampling of the weft tension signal continuously output by the weft tension sensor 30 with a desired sampling frequency of some hundreds or thousands hertz, controls the weft brake 26 by outputting a control signal for adjusting the braking force applied during zone Z3, for example, as a constant braking force within a weaving cycle based on a variability parameter indicative of the variability of the transfer occurrence parameter P, i.e. the transfer angle, of previous weaving cycles. The previous weaving cycles, for example, may comprise a predetermined number of, for example, some hundred weaving cycles preceding the weaving cycle for which the braking force to be applied to the weft thread 14 in zone Z3 has to be determined.

20

For determining the variability parameter indicative of the variability of the transfer occurrence parameter P, i.e. the transfer angle, the standard deviation of the transfer occurrence parameter P of the previous weaving cycles comprising the predetermined number of immediately preceding weaving cycles is calculated and is used as a control parameter. As long as the variability parameter represented by the standard deviation of the transfer occurrence parameter P is above an associated variability parameter threshold value or is outside an associated variability parameter value range, the braking force is increased so that, as shown in Fig. 8, with an increasing braking force the delay of the transfer is reduced and the variability of the transfer occurrence parameter P defining the position of transfer is also reduced. This can, for example, be done in a PID-control manner so that, with a decreasing deviation of the variability parameter from the associated variability parameter threshold value or the associated

30

variability parameter value range, the variation of the braking force to be used in zone Z3 of the next weaving cycle is decreased.

The levels of the braking force that are to be used in zones Z1, Z2 and Z4 to Z6 are of less relevance for the correct transfer of the weft thread 14 from the inserting rapier 16 to the receiving rapier 18. The levels of the braking force for these zones Z1, Z2 and Z4 to Z6, for example, may be adjusted to predetermined fixed values or may be proportional to the level of the braking zone Z3.

By controlling the weft brake with using the standard deviation of the transfer occurrence parameter as the feedback control parameter and, thereby, adjusting the braking force applied to the weft thread such that the variability of the transfer occurrence parameter is below the associated threshold value or within the associated value range, the weft thread is kept under a sufficient high tension for avoiding a looping or ballooning thereof prior to and during the transfer from the inserting rapier to the receiving rapier and, thereby, ensuring that the transfer takes place within the weaving cycle at a desired point of time and transfer angle, respectively, with a rather low deviation from an optimum point of time and transfer angle, respectively. While this allows operating the weaving machine with a high speed of operation, i.e. a high number of rotations of the weaving machine main shaft and a corresponding high number of weaving cycles per minute, at the same time an excessive tensioning of the weft thread and the risk of a failure thereof can be avoided.

When controlling the weft brake such that the variability of the transfer occurrence parameter is within the desired value range or below the associated threshold value, the control is substantially independent of the operating speed of the weaving machine. In particular, when determining the variability parameter based on the variance or the standard deviation of the transfer occurrence parameter, the associated variability parameter threshold value and variability parameter value range, respectively, can be used for the entire range of the operating speed at which a weaving machine can be operated. The variability parameter is also substantially independent of the type of the weft threads used in weaving processes. This is of particular advantage if, in one and the same weaving process, different types of weft threads can be selected by means

of a weft selector. This means that one and the same control method using the same threshold value or the same value range for the variability of the transfer occurrence parameter, for example, the standard deviation thereof, can be used for adjusting the braking force applied to the weft thread without making any adjustments due to a variation of the operating speed of the weaving machine or the use of different types of weft threads.

While, in association with the above embodiment a weaving cycle is represented by one complete revolution of a weaving machine main shaft and the transfer occurrence parameter defining the position of the transfer of weft thread within such a weaving cycle is referred to as being an angular position of the weaving machine main shaft within the value range of 0° to 360°, such a weaving cycle can be defined in an other manner. For example, the rotation or movement of an other component of a weaving machine that, as is the case with the weaving machine main shaft, repeats with each weaving cycle can be used as the basis for defining the weaving cycle and for defining the position of the transfer of a weft thread within a value range associated with such a repeated movement. A weaving cycle can also be determining in a time based manner. If, for example, a weaving machine is operated with a speed of 200 weaving cycles per minute, each weaving cycle takes 300 ms. The start of each weaving cycle may be triggered by a start command of the weaving machine controller, and the transfer occurrence parameter can be defined as being a particular point of time within the value range of 0 ms corresponding to the start of the weaving cycle and 300 ms corresponding to the end of the weaving cycle.

## Claims

1. A Method of operating a weaving machine for inserting weft threads into sheds formed between warp threads during weaving cycles, the weaving machine comprising:

- at least one weft thread inserting means (12) with an inserting rapier (16) for inserting a weft thread (14) and a receiving rapier (18) for receiving the weft thread (14) inserted by the inserting rapier (16),

- a weft brake (26) for applying a braking force to the weft thread inserted by the inserting rapier (16) and received by the receiving rapier (18) during a weaving cycle,

- a weft thread tension sensor (30) for outputting a weft thread tension signal indicative of a weft thread tension,

- a weft machine controller (40) for receiving the weft thread tension signal and for controlling the weft brake (26) based on the weft thread tension signal,

the method comprising the steps of:

A) decelerating the inserting rapier (16) during a weaving cycle in a deceleration phase (Z3) prior to a transfer of a weft thread (14) from the inserting rapier (16) to the receiving rapier (18),

B) controlling the weft brake (26) during the deceleration phase (Z3) based on a variability parameter indicative of the variability of a transfer occurrence parameter (P) of previous weaving cycles, the transfer occurrence parameter (P) being indicative of the occurrence of the weft thread transfer within a weaving cycle.

2. The method of claim 1, further comprising a transfer-determining step for determining the transfer occurrence parameter (P) based on the weft thread tension signal.
- 5 3. The method of claim 2, wherein each weaving cycle corresponds to a predetermined angular range of rotation of a weaving machine main shaft, and wherein, in the transfer determining step, a transfer angle at which, within the predetermined angular range of rotation, the weft thread transfer has occurred is determined as the transfer occurrence parameter (P).
- 10 4. The method of claim 3, wherein the predetermined angular range of rotation is 360°.
- 15 5. The method of one of claims 2 to 4, wherein, in the transfer determining step, it is determined that the weft thread transfer has occurred, when the weft thread tension exceeds a weft thread tension threshold value (T) and/or a gradient of the weft thread tension exceeds a weft thread tension gradient threshold value.
- 20 6. The method of one of claims 2 to 5, wherein the transfer-determining step is carried out for a plurality of weaving cycles, preferably for each weaving cycle.
7. The method of one of claims 1 to 6, wherein the previous weaving cycles comprise a predetermined number of preceding weaving cycles.
- 25 8. The method of one of claims 1 to 7, wherein the variability parameter is determined based on a variance of the transfer occurrence parameter (P) of the previous weaving cycles.
- 30 9. The method of claim 8, wherein the variability parameter is determined as the standard deviation of the transfer occurrence parameter (P) of the previous weaving cycles.

10. The method of one of claims 1 to 9, wherein step B) comprises controlling the weft brake (26) such that the variability parameter is below a predetermined variability parameter threshold value and/or within a predetermined variability parameter value range.

5

11. The method of one of claims 1 to 10, wherein the weft thread tension signal is indicative of the weft thread tension between the weft brake (26) and the weft insertion means (12).

10

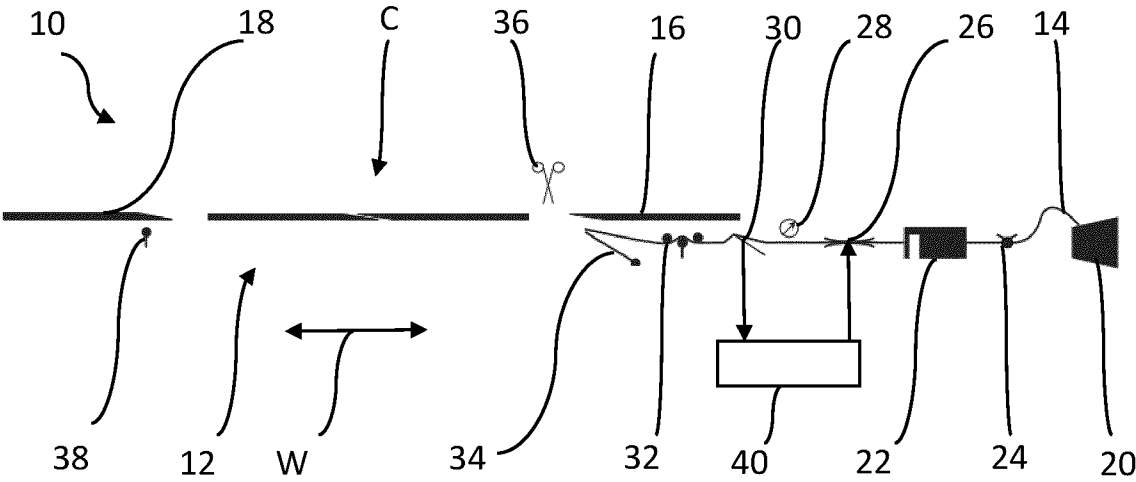


Fig. 1

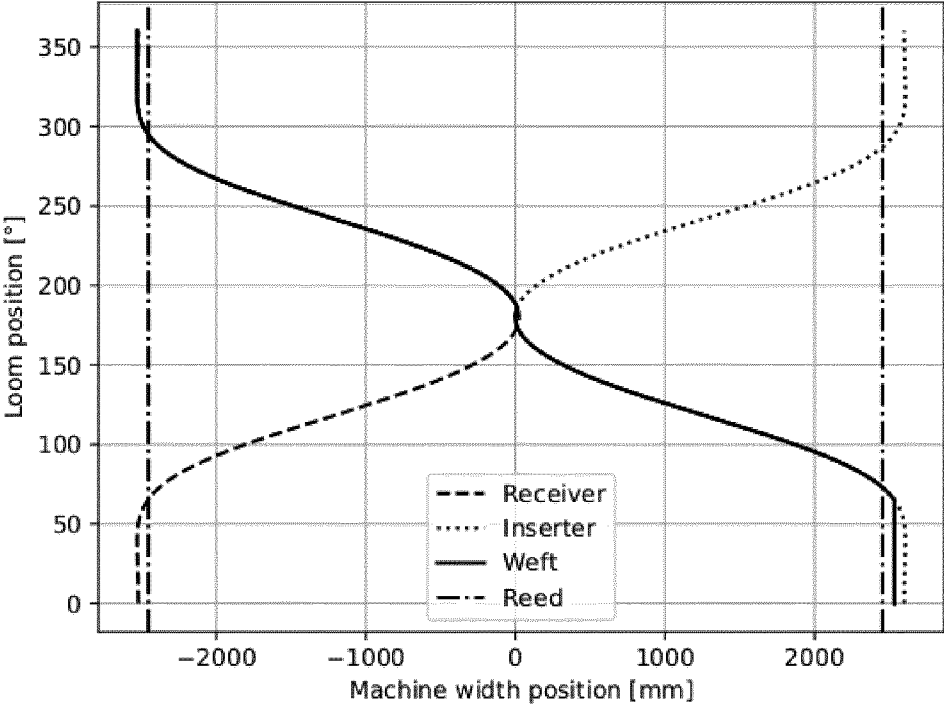


Fig. 2

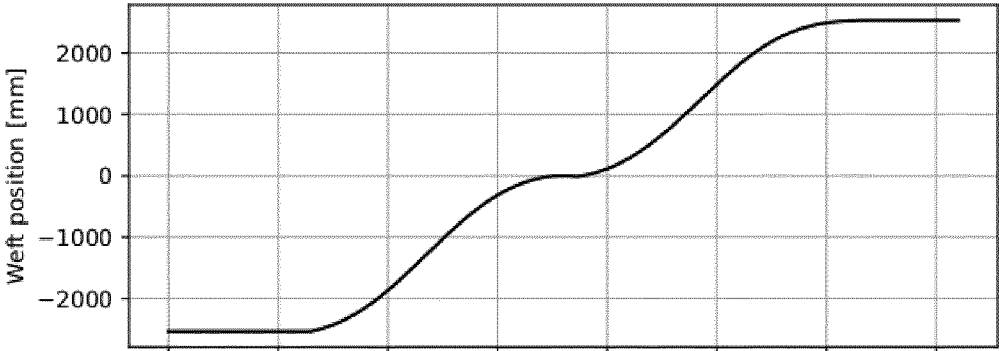


Fig. 3

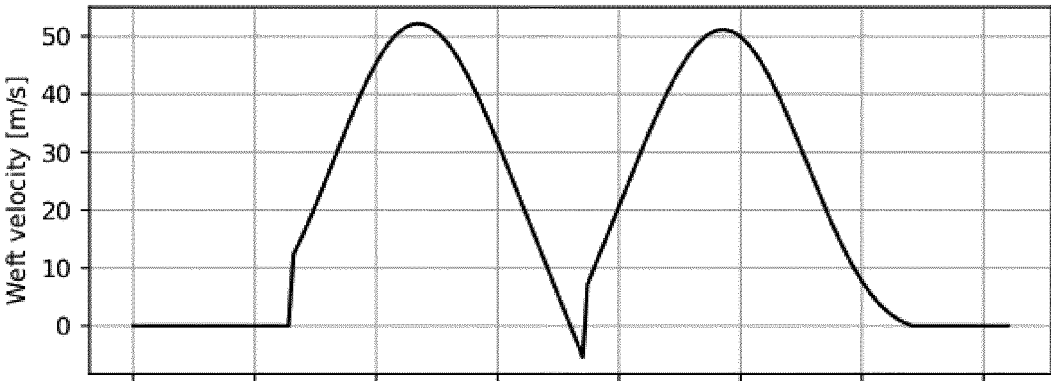


Fig. 4

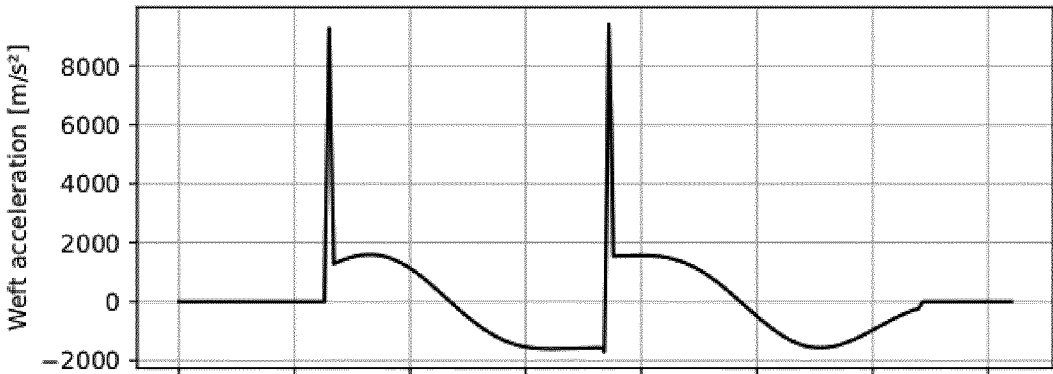


Fig. 5

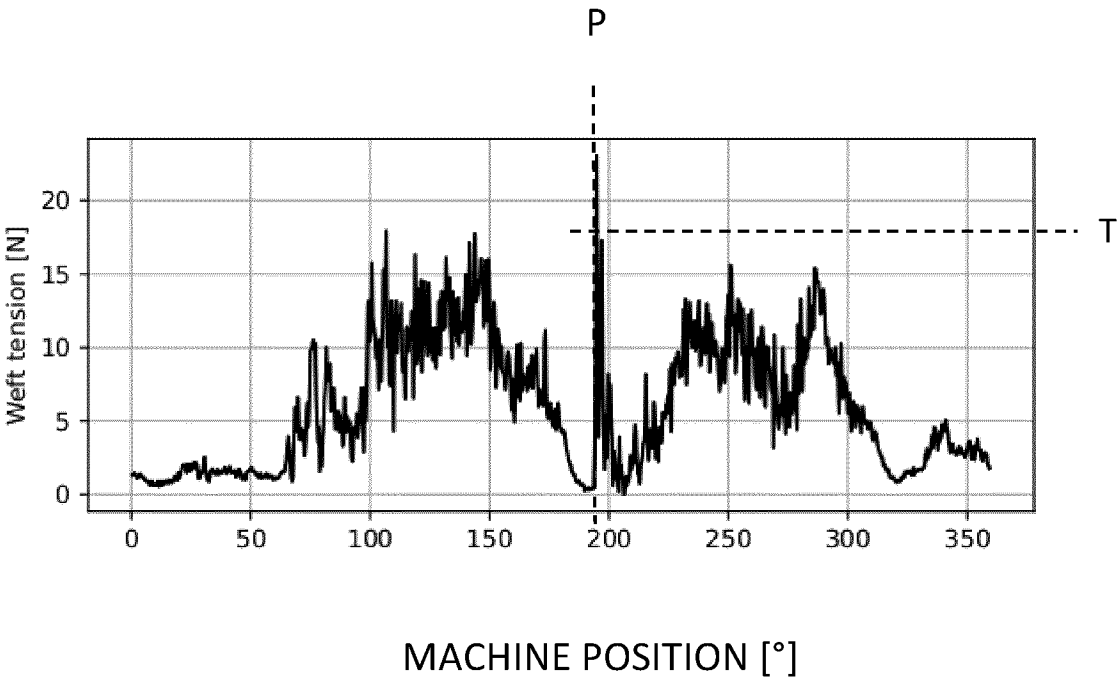


Fig. 6

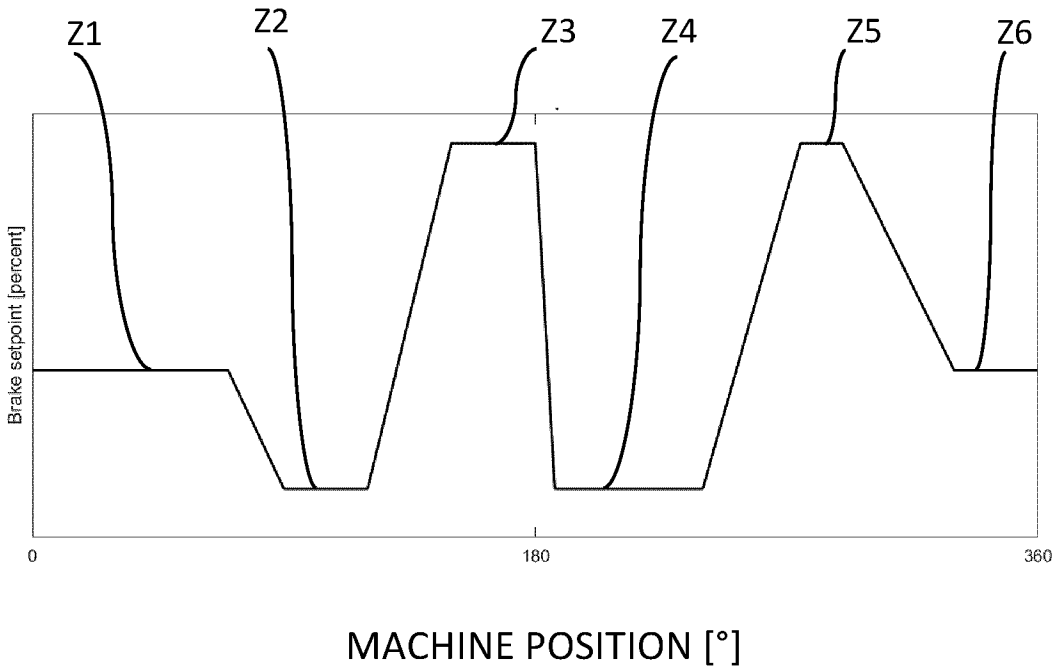


Fig. 7

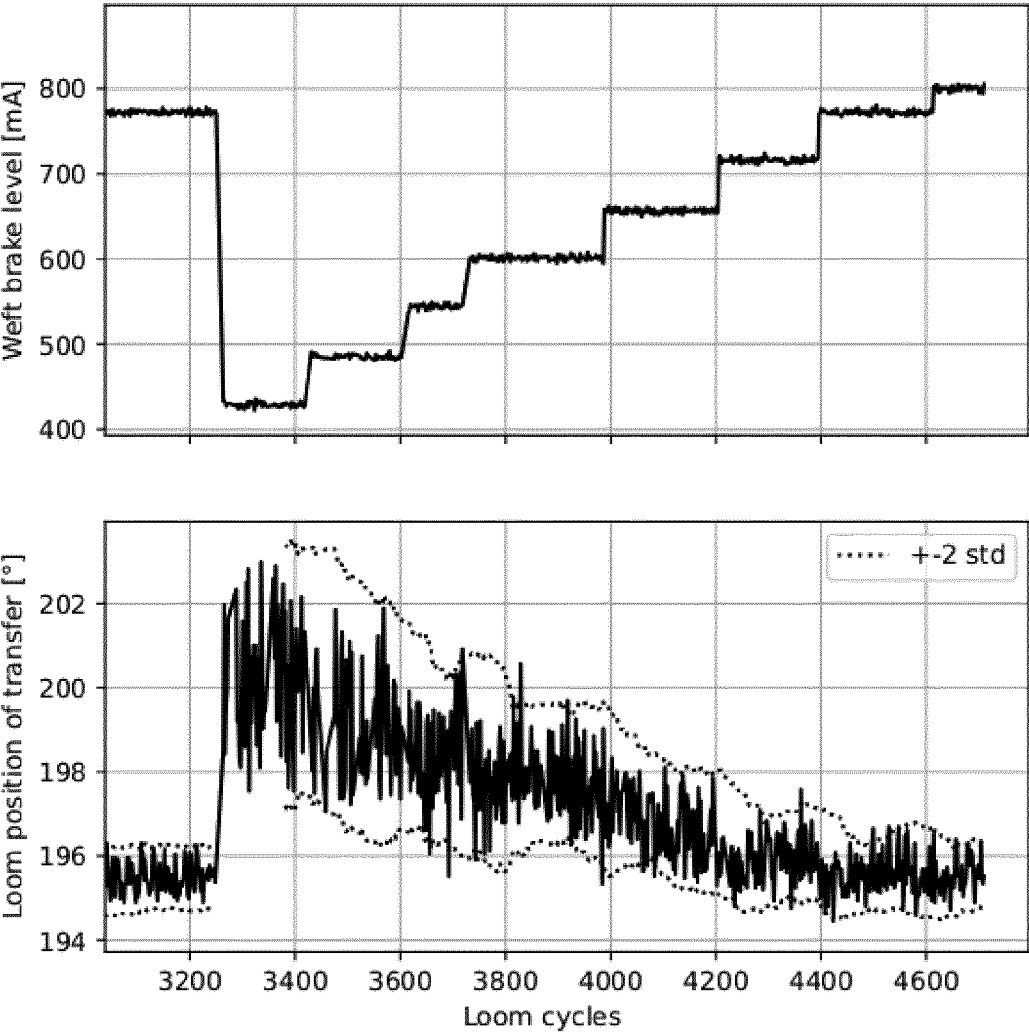


Fig. 8

## INTERNATIONAL SEARCH REPORT

International application No  
PCT/EP2024/061861

**A. CLASSIFICATION OF SUBJECT MATTER**

INV. D03D47/34  
ADD.

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)  
D03D

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

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

EPO-Internal

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                                                                                                                                                                                                                                                                | Relevant to claim No. |
|-----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| X         | EP 1 314 806 B1 (LGL ELECTRONICS SPA [IT])<br>13 December 2006 (2006-12-13)<br>abstract<br>claims 1-3<br>figures 1-3<br>paragraph [0001] - paragraph [0004]<br>paragraph [0007]<br>paragraph [0008]<br>paragraph [0010]<br>paragraph [0012]<br>paragraph [0015] - paragraph [0018]<br>paragraph [0020]<br>paragraph [0022] - paragraph [0026]<br>-----<br>- / - - | 1 - 11                |



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

18 June 2024

Date of mailing of the international search report

03/07/2024

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040,  
Fax: (+31-70) 340-3016

Authorized officer

Heinzelmann, Eric

## INTERNATIONAL SEARCH REPORT

International application No  
PCT/EP2024/061861

| C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT |                                                                                                                                                                                                                                                                                                                                          |                       |
|------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| Category*                                            | Citation of document, with indication, where appropriate, of the relevant passages                                                                                                                                                                                                                                                       | Relevant to claim No. |
| X                                                    | EP 1 664 412 B1 (IRO AB [SE])<br>27 May 2009 (2009-05-27)<br>abstract<br>claims 1, 7, 10-14<br>figures 1-5<br>paragraph [0002]<br>paragraph [0004]<br>paragraph [0020] - paragraph [0029]<br>paragraph [0034]<br>paragraph [0037]<br>paragraph [0038]<br>-----                                                                           | 1-7,9-11              |
| X                                                    | US 5 476 122 A (SCHUSTER RAINER [DE] ET<br>AL) 19 December 1995 (1995-12-19)<br>the whole document<br>-----                                                                                                                                                                                                                              | 1-11                  |
| X                                                    | US 6 418 977 B1 (THOLANDER LARS HELGE<br>GOTTFRID [SE]) 16 July 2002 (2002-07-16)<br>abstract<br>claims 1, 12<br>figures 1-4<br>column 1, line 1 - line 33<br>column 2, line 15 - line 19<br>column 3, line 25 - line 53<br>column 4, line 66 - column 5, line 13<br>column 5, line 26 - line 36<br>column 5, line 46 - line 63<br>----- | 1-11                  |

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2024/061861

| Patent document<br>cited in search report | Publication<br>date | Patent family<br>member(s) | Publication<br>date         |
|-------------------------------------------|---------------------|----------------------------|-----------------------------|
| EP 1314806                                | B1                  | 13-12-2006                 | CN 1399022 A 26-02-2003     |
|                                           |                     |                            | DE 60216713 T2 08-11-2007   |
|                                           |                     |                            | EP 1314806 A2 28-05-2003    |
| EP 1664412                                | B1                  | 27-05-2009                 | CN 1856610 A 01-11-2006     |
|                                           |                     |                            | DE 10343506 A1 14-04-2005   |
|                                           |                     |                            | EP 1664412 A1 07-06-2006    |
|                                           |                     |                            | WO 2005033391 A1 14-04-2005 |
| US 5476122                                | A                   | 19-12-1995                 | NONE                        |
| US 6418977                                | B1                  | 16-07-2002                 | CN 1333848 A 30-01-2002     |
|                                           |                     |                            | DE 19858682 A1 21-06-2000   |
|                                           |                     |                            | EP 1141456 A1 10-10-2001    |
|                                           |                     |                            | US 6418977 B1 16-07-2002    |
|                                           |                     |                            | WO 0037721 A1 29-06-2000    |