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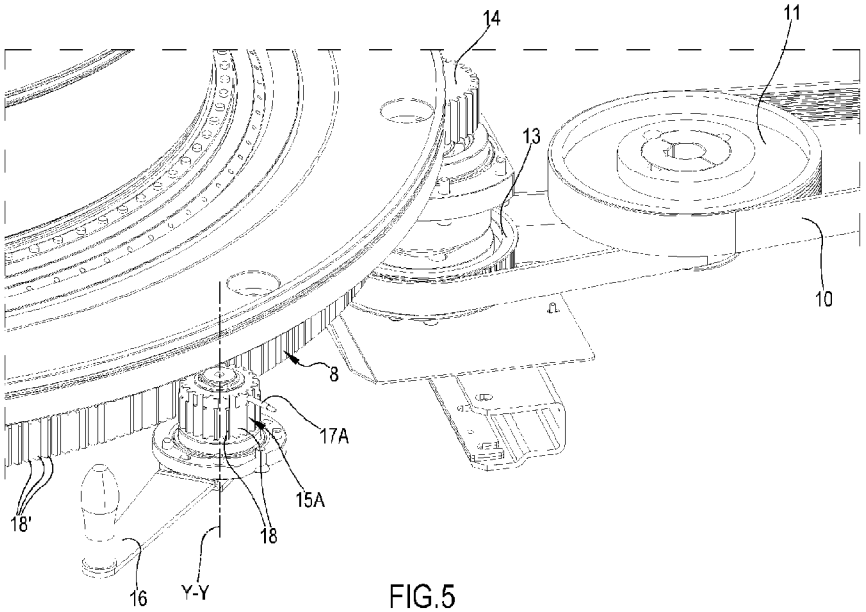

FIG.5

(57) Abstract: A circular weft knitting machine, comprises a base (2) and a textile head (3) mounted on the base (2). The textile head (3) comprises a needle-bearing organ (4) provided with a toothed wheel (8) coaxial to a central axis (X-X) of the needle-bearing organ (4) and presenting a plurality of teeth (18'). A main motor (9) is operatively connected to the toothed wheel (8) for determining the rotation of the needle-bearing organ (4) around the central axis (X-X) and with respect to the base (2). A proximity sensor (17A, 17B) is mounted fixed with respect to the base (2) in such a way to detect the passage of teeth (18') of the toothed wheel (8) and/or of teeth (18) of an auxiliary wheel (15A, 15B) operatively paired to the toothed wheel (8) and emit a respective signal (S1, S2). An electronic control unit (19) is configured to receive and process the signal (S1, S2) deriving from the proximity sensor (17A, 17B) and control organs and/or functioning parameters of the machine (1) as a function of said signal (S1, S2).

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DESCRIPTION

"Circular weft knitting machine and control method of a circular weft knitting machine"

Field of the invention

The present invention has as its object a circular weft knitting machine. The present invention has as its object also a control method of a circular weft knitting machine. In particular, the present invention is relative to the detection of the position and/or speed of rotation of the machine for the purpose of the control of the functioning thereof.

Background of the invention

It is known the use of circular weft knitting machines for the manufacturing of textile items of various type destined, for example, to the manufacturing of garments or of other type.

Circular weft knitting machines comprise a textile head provided with at least one needle-bearing organ (needle-bearing cylinder and/or plate), on which one or more series of needles is/are arranged along a circular path defining a respective circular needle bed. The textile head comprises also devices adapted to control the movement of the needles for the formation of the fabric which presents an overall conformation at least partially tubular. These devices comprise actioning cams arranged around the needle-bearing cylinder and/or facing the needle-bearing plate and operatively connected to needles. The textile head is provided with a plurality of knockover sinkers configured to cooperate with the needles to form the knitted fabric. The knockover sinkers are movably arranged in radial seats obtained in an annular body (sinkers crown) arranged around the needle-holder cylinder. The circular knitting machine comprises a base which constitutes the bearing structure of the knitting machine. Specifically, the base constitutes the ground bearing organ of the knitting machine. The base is also configured to support the textile head, which is mounted to said base. During the knitting the tubular fabric manufactured by the textile head continues downstream, i.e. it is lowered, in the volume below defined by the structure of the base, where it can be collected by special devices. The knitting machine is provided with a main motor, usually mounted on the base plate, which is connected to the needle-bearing organ by means of belts and toothed wheels transmission and determines the rotation of the needle-bearing organ around a central axis thereof. The rotation of the needle-bearing organ determines, through the interaction with the cams, the movement of the needles and other machine organs for the purpose of the formation of the fabric. For example, documents WO2020250075A1, WO2020212817A1, under the name of the same Applicant, describe such a machine.

In known machines such as those above-described, the rotation of the main motor, which moves the needle-bearing organ, is detected by means of an encoder and used by a control electronic unit to determine the

position and speed of the needle-bearing organ and thus to control the machine's organs and parameters during the manufacturing of the fabric according to said position and speed.

Summary

With respect to the above-described circular weft knitting machines, the Applicant has observed that the instant-by-instant knowledge and the sending to the control electronic unit of the exact position and/or speed of the needle-bearing organ are important in order to precisely control and pilot the machine organs and thus manufacture a quality fabric and/or provided with the desired characteristics.

The Applicant has found that the known type machines indirectly detect position and/or speed of the needle-bearing organ and that such detections are not accurate and/or may be subject to errors because they are carried out on the main motor which is connected to the needle-bearing organ by means of a transmission. The transmission can present clearances and/or be of the flexible type, due to the presence of one or more belts, and therefore the signal(s) sent to the control electronic unit does/do not provide the exact position and/or speed of the needle-bearing organ. The deviation between the actual position and/or speed of the needle-bearing organ and the one represented by the signals received by the control electronic unit can also increase over the operating life of the machine, if a frequent and timely maintenance and/or replacement of parts is not carried out, because the flexible belts deform over time and/or the clearances of the transmission elements tend to increase.

It is therefore a purpose of the present invention to propose a circular weft knitting machine and a control method of a circular weft knitting machine capable of overcoming the above-mentioned limitations and drawbacks.

A purpose at the basis of the present invention, in its various aspects and/or embodiments, is to propose a circular weft knitting machine which is capable of precisely controlling the movements of its organs and/or of operating according to set functioning parameters, so as to manufacture quality fabrics and such as to comply with the characteristics of the fabrics that are intended to be manufactured.

A further purpose of the present invention is to propose a control method of a circular weft knitting machine which is precise and reliable.

It is also a purpose of the present invention to propose a circular weft knitting machine and a control method which maintain such reliability and precision over time.

These purposes and others are substantially achieved by a circular weft knitting machine and by a control method for a circular weft knitting machine according to the following aspects and/or embodiments and/or the attached claims.

In a first aspect, the invention refers to a circular weft knitting machine, comprising:

a base configured to lie on the ground;

a textile head mounted on the base; the textile head comprising: a needle-bearing organ presenting a central axis and a plurality of grooves arranged around the central axis, a plurality of needles housed in the grooves, actioning devices mounted fixed on the base, operatively paired or pairable to the needles and configured to determine or allow the movement of the needles along the grooves for the formation of knitted fabric by said needles; the needle-bearing organ comprising a toothed wheel coaxial to the central axis and presenting a plurality of teeth;

a main motor operatively connected to the toothed wheel of the needle-bearing organ for determining the rotation of said needle-bearing organ around the central axis and with respect to the base;

at least one proximity sensor mounted fixed with respect to the base in such a way to detect the passage of teeth of the toothed wheel and/or of teeth of at least one auxiliary wheel operatively paired to the toothed wheel and emit a respective signal;

an electronic control unit operatively connected to said at least one proximity sensor and configured to receive and process the signal deriving from said at least one proximity sensor and control organs of the circular weft knitting machine and/or functioning parameters of the circular weft knitting machine as a function of said signal.

In a second aspect, the invention refers to a control method of a circular weft knitting machine, comprising:

acquiring a signal emitted by at least one proximity sensor positioned for detecting the passage of teeth of a toothed wheel of a needle-bearing organ of a circular weft knitting machine and/or the passage of teeth of at least one auxiliary wheel operatively paired to the toothed wheel, wherein the needle-bearing organ rotates around its own central axis and the toothed wheel is coaxial to said central axis;

control organs of the circular weft knitting machine and/or functioning parameters of the circular weft knitting machine as a function of said signal.

In an aspect, the electronic control unit is configured to calculate a relative position and a speed of the needle-bearing organ around the central axis by means of said signal.

In an aspect, the method of the preceding aspect or of one or more of the following aspects is actuated by means of the machine of the preceding aspect or of one or more of the following aspects and, vice versa, the machine of the preceding aspect or of one or more of the following aspects is configured to actuate the method of the preceding aspect or of one or more of the following aspects.

The Applicant has verified that the machine and/or the method according to the present invention ensure a precise and reliable detection of the speed and/or angular position of the needle-bearing organ around its own central axis. In fact, if the proximity sensor is mounted in such a way to detect the passage of teeth of the toothed wheel, that is a single piece with the needle-bearing organ or anyway is integral to the needle-bearing organ, the electronic control unit directly reads the movement of the needle-bearing organ. If on the other hand the proximity sensor is mounted in such a way to detect the teeth of the auxiliary wheel, the reading is anyway precise because the auxiliary wheel is geared with the toothed wheel.

The Applicant has verified that such detection precision and reliability consequently allow the electronic control unit to pilot the organs of the machine and to control its functioning parameters with precision and reliability.

The Applicant has also verified that the machine and/or the method according to the present invention allow to maintain such precision and reliability over time.

The Applicant has also verified that the machine and/or the method according to the present invention allow to manufacture quality fabrics and provided with the characteristics that are intended to be realized.

The Applicant has also verified that the detection system according to the present invention is affordable and robust and minimally invasive.

Further aspects of the invention are listed below.

In an aspect, the machine comprises said at least one auxiliary wheel operatively paired to the toothed wheel.

In an aspect, said at least one proximity sensor comprises a first proximity sensor and a second proximity sensor mounted on the base; wherein the first proximity sensor emits a respective first signal and the second proximity sensor emits a respective second signal; wherein the electronic control unit is configured to control the organs of the circular weft knitting machine and/or the functioning parameters of the circular weft knitting machine as a function of the first signal and of the second signal.

In an aspect, the first proximity sensor and the second proximity sensor are mounted in different positions on the base.

In an aspect, the electronic control unit is configured to receive and process the first signal and the second signal and discriminate a direction of rotation of the needle-bearing organ around the central axis.

The above-described structure provides the electronic control unit with two phase-shifted waveforms (the first signal and the second signal). By reading only one signal (for example the first signal), information relative to the speed of rotation is obtained, whereas by acquiring the further signal (second signal), the direction of rotation can be discriminated according to the sequence of states produced by the two signals.

In an aspect, said at least one auxiliary wheel comprises a first auxiliary wheel and a second auxiliary wheel; wherein the first proximity sensor is mounted in such a way to detect the passage of teeth of the first auxiliary wheel and the second proximity sensor is mounted in such a way to detect the passage of teeth of the second auxiliary wheel.

In an aspect, said at least one auxiliary wheel is directly geared with the toothed wheel or wherein said at least one auxiliary wheel is paired to the toothed wheel by means of an intermediate gear.

In an aspect, between the toothed wheel and said at least one auxiliary wheel there is no flexible-type transmission.

In an aspect, said at least one auxiliary wheel is an auxiliary wheel mechanically connected to the main motor and transmits the movement from said main motor to the toothed wheel.

In an aspect, said at least one auxiliary wheel is an auxiliary wheel paired to a crank by means of a clutch and configured to manually rotate the needle-bearing organ, for example for maintenance operations.

In an aspect, an auxiliary proximity sensor is operatively connected to the electronic control unit.

In an aspect, the auxiliary proximity sensor is mounted fixed with respect to the base.

In an aspect, the auxiliary proximity sensor is housed in a hole obtained in the base.

In an aspect, the auxiliary proximity sensor is configured to detect the passage of a single element integral to the needle-bearing organ and emit a respective auxiliary signal.

In an aspect, the electronic control unit is configured to receive and process the auxiliary signal and discriminate an absolute angular position of the needle-bearing organ around the central axis. The auxiliary signal provides an absolute zero position of the needle-bearing organ.

In an aspect, the single element is a peg or a notch or a tooth.

In an aspect, the teeth of the toothed wheel and/or of said at least one auxiliary wheel present respective heads placed on a head circumference.

In an aspect, said teeth present a respective width measured along the head circumference and spaces delimited between successive teeth present a respective width measured along said head circumference.

In an aspect, the signal of said at least one proximity sensor is defined by a respective square wave.

In an aspect, a ratio between the width of the teeth and the width of the spaces is such that a width of a crest of the square wave is equal or substantially equal to a width of a trough of said square wave.

In an aspect, the first signal and the second signal are defined by respective square waves.

In an aspect, a ratio between the width of the teeth and the width of the spaces is such that a width of a crest of each square wave is equal or substantially equal to a width of a trough of the square wave itself.

In an aspect, a ratio between the width of the teeth and the width of the spaces is such as to compensate characteristics of said at least one proximity sensor, in such a way that a width of a crest of the square wave is equal or substantially equal to a width of a trough of said square wave.

In an aspect, said characteristics comprise a nominal detection distance and/or a hysteresis of the proximity sensor.

In an aspect, a ratio between the width of the teeth and the width of the spaces, measured along the head circumference, is comprised between 0,60 and 0,99, optionally comprised between 0,70 and 0,99, optionally comprised between 0,85 and 0,95.

In an aspect, the teeth of the toothed wheel and/or of said at least one auxiliary wheel present involute profiles.

In an aspect, the toothed wheel and/or said at least one auxiliary wheel presents/present a pitch circumference with a pitch diameter and an outer circumference with an outer diameter and wherein the head circumference of the teeth is comprised between the pitch circumference and the outer circumference.

In an aspect, the width of the teeth measured along the head circumference is greater than a width of the teeth measured along the outer circumference and lower than a width of the teeth measured along the pitch circumference.

In an aspect, said at least one proximity sensor is facing a portion of the toothed wheel and/or of said at least one auxiliary wheel.

In an aspect, said at least one proximity sensor is housed in a hole obtained in the base.

In an aspect, the teeth present, at said portion, the respective heads placed on the head circumference and the teeth themselves present, at a remaining part of the toothed wheel and/or of said at least one auxiliary wheel, the respective heads placed on the outer circumference.

In an aspect, the teeth of said portion of the toothed wheel and/or of said at least one auxiliary wheel present a height lower than a height of the teeth of the remaining part of the toothed wheel and/or of said at least one auxiliary wheel.

In an aspect, the teeth of the toothed wheel and/or of said at least one auxiliary wheel present edges parallel to a respective rotation axis of the toothed wheel and/or of said at least one auxiliary wheel.

In an aspect, said edges are sharp edges.

In an aspect, the proximity sensor is of the magnetic type, optionally with Hall effect, inductive or capacitive or of laser type.

In an aspect, the toothed wheel rotates integrally with the needles.

In an aspect, the toothed wheel is placed on a radially external surface of the needle-bearing organ.

In an aspect, the toothed wheel and/or said at least one auxiliary wheel is/are realized in magnetic or magnetized material, for example cast iron, steel, iron.

In an aspect, a magnetic filter is operatively active near the toothed wheel and/or said at least one auxiliary wheel to remove any metal filings.

In an aspect, the magnetic filter is operatively active near said at least one proximity sensor.

In an aspect, the machine comprises drawing devices mounted on the base below the textile head and actuated by a respective actuator controlled by the electronic control unit, wherein the drawing devices are configured to keep the formed fabric in tension.

In an aspect, a cutter is mounted on the base and actuated by a respective actuator controlled by the electronic control unit, wherein the cutter is configured to cut the formed fabric.

In an aspect, a collector, preferably a winder, is mounted on the base below the textile head and actuated by a respective motor controlled by the electronic control unit, wherein the collector is configured to collect, preferably wrap, the formed fabric.

In an aspect, blowers are mounted at the textile head and/or at yarn guide arranged above the textile head and actuated by at least one actuator controlled by the electronic control unit, wherein the blowers are configured to blow air in such a way to cool and remove dust residues from the bed.

In an aspect, the blowers comprise at least one fan actuated by said at least one actuator and/or a nozzle connected to a compressed air source.

In an aspect, the blowers are mounted on a rotating support actuated in rotation by a motor.

In an aspect, the electronic control unit is configured to manage anomalies of said at least one signal, optionally of the first signal and of the second signal, and emit alarm signals and/or stop the machine.

In an aspect, the electronic control unit is configured to control and pilot the main motor and/or the drawing devices and/or the cutter and/or the collector and/or the blowers as a function of said signal.

In an aspect, the actioning devices comprise actioning cams.

In an aspect, the actioning devices are arranged around the needle-bearing cylinder.

In an aspect, the method comprises: positioning said at least one proximity sensor in such a way to detect the passage of teeth of the toothed wheel of the needle-bearing organ and/or the passage of teeth of said at least one auxiliary wheel.

In an aspect, the method comprises: putting in rotation the needle-bearing organ and the toothed wheel around its own central axis by means of a main motor operatively paired to said toothed wheel.

In an aspect, the method comprises: calculating a relative position and a speed of the needle-bearing organ around the central axis by means of said signal.

In an aspect, acquiring a signal comprises: acquiring a first signal emitted by a first proximity sensor and acquiring a second signal emitted by a second proximity sensor.

In an aspect, controlling comprises: controlling the organs of the circular weft knitting machine and/or the functioning parameters of the circular weft knitting machine as a function of the first signal and of the second signal.

In an aspect, said at least one signal is defined by a square wave.

In an aspect, the first signal and the second signal are defined by respective square waves.

In an aspect, a width of a crest of each square wave is equal or substantially equal to a width of a trough of the square wave itself.

In an aspect, the method comprises: positioning the first proximity sensor and positioning the second proximity sensor in such a way that the first signal and the second signal are offset from each other.

In an aspect, the method comprises: positioning the first proximity sensor and positioning the second proximity sensor in such a way that crests of the first signal and crests of the second signal are always partially overlapping each other.

In an aspect, the method comprises: realizing the teeth of the toothed wheel and/or the teeth of said at least one auxiliary wheel in such a way that a width of a crest of the square wave is equal or substantially equal to a width of a trough of said square wave.

In an aspect, the method comprises: realizing the teeth of the toothed wheel and/or the teeth of said at least one auxiliary wheel in such a way to compensate characteristics of said at least one proximity sensor and such that a width of a crest of the square wave is equal or substantially equal to a width of a trough of said square wave.

In an aspect, said characteristics comprise a nominal detection distance and/or a hysteresis of the proximity sensor.

In an aspect, the method comprises: discriminating a direction of rotation of the needle-bearing organ around the central axis by means of the first signal and the second signal.

In an aspect, the method comprises: acquiring an auxiliary signal emitted by an auxiliary proximity sensor positioned for detecting the passage of a single element integral to the needle-bearing organ.

In an aspect, the method comprises: discriminating an absolute angular position of the needle-bearing organ around the central axis by means of the first signal, the second signal and the auxiliary signal.

In an aspect, controlling the organs of the circular weft knitting machine and/or the functioning parameters comprises: controlling and piloting the main motor and/or the drawing devices and/or the cutter and/or the collector and/or the blowers as a function of said signal.

Further characteristics and advantages will result better from the detailed description of a preferred but non-exclusive embodiment of a circular weft knitting machine and of a control method of a circular weft knitting machine according to the present invention.

Description of figures

This description will be expressed herein with reference to the attached figures, provided for illustrative purposes only and therefore non-limiting, wherein:

- figure 1 is an overall 3D view of a circular weft knitting machine according to the present invention;
- figure 2 shows the machine of figure 1 with some parts removed to better highlight others;
- figure 3 is a two-plans section of a portion of the machine as shown in figures 1 and 2;
- figure 4 is a 3D view of an assembly of the machine as shown in the preceding figures;
- figure 5 is an enlargement of the assembly of figure 4;
- figure 6 shows enlarged elements of the assembly as shown in figures 4 and 5;
- figure 7 is a partial schematic view of a toothed wheel belonging to the group of figures 4, 5 and 6;
- figure 8 shows a development of the toothed wheel of figure 7 associated to a signal generated by a proximity sensor;
- figure 9 shows signals generated by two proximity sensors;

- figures 10, 11 and 12 show abnormal signals of the two proximity sensors.

Detailed description

With reference to the above-mentioned figures, a circular weft knitting machine according to the present invention has been overall indicated with the numerical reference 1.

The circular weft knitting machine 1 comprises a base 2, constituting the bearing structure of the machine and configured to lie on the ground. A textile head 3 is mounted on the base 2 and is provided with a needle-bearing organ 4, with a plurality of needles movably mounted on the needle-bearing organ 4 and with command means adapted to selectively actuate the plurality of needles to allow the manufacturing of a tubular fabric "T".

The needle-bearing organ 4 shown is a needle-bearing cylinder. In not shown embodiments, the needle-bearing organ 4 can comprise a needle-bearing plate combined with the needle-bearing cylinder. The machine 1 can be single-needle bed or double-needle bed. The needle-bearing organ 4 presents a central axis "X-X" and a plurality of grooves arranged around the central axis "X-X" and a plurality of needles housed in the grooves. The grooves and the needles of the needle-bearing organ 4 are not shown, as they can be of conventional type and known in the technical reference field.

The base 2 comprises an upper supporting ring or element 5, upon which it is mounted the textile head 3 in such a way that the needle-bearing organ 4 can rotate around the central axis "X-X". This vertical axis "X-X", when the machine 1 is correctly placed on the ground, is substantially vertical. The base 2 comprises a bottom base 6 destined to be placed on the ground. In the shown embodiment, the bottom base 6 comprises three legs.

Actioning devices 7 (figure 7) arranged around to the needle-bearing organ 4 are configured to determine or allow the movement of the needles along the grooves for the formation of knitted fabric by said needles. In the shown embodiment, the actioning devices 7 comprise actioning cams mounted fixed on the base 2. The actioning cams are not shown in detail as they can be of a known type.

The needle-bearing organ 4 is supported by means of a bearing by the supporting ring 5 and presents a toothed wheel 8 coaxial to the central axis "X-X" and presenting a plurality of teeth. The toothed wheel 8 of the example shown is placed radially outside with respect to the needle-bearing cylinder and is housed, together with the bearing, in a circular seat delimited in the supporting ring 5. The toothed wheel 8 is better visible in figures 4, 5 and 6. The toothed wheel 8 rotates integrally with the needle-bearing organ 4 and with the needles.

A main motor 9 is operatively connected to the toothed wheel 8 of the needle-bearing organ 4 for determining the rotation of said needle-bearing organ 4 around the central axis "X-X" and with respect to the base 2 and to the actioning cams. The main motor 9, visible in figure 4, is housed in one of the legs of the bottom base 6 and is connected to the toothed wheel 8 by means of a flexible type transmission which serves to transmit the movement from said main motor to the toothed wheel. In particular, the flexible type transmission comprises a

first belt 10 wrapped on the shaft of the main motor 9 and on a first pulley 11. A second belt 12 is wrapped on a second pulley, not visible, coaxial and integral to the first pulley 11 and on a third pulley 13 coaxial and integral to an auxiliary wheel 14 geared with the toothed wheel 8 (figure 4 and 5). The first pulley 11 and the second pulley are mounted rotatably on the base 2. Also the third pulley 13 and the auxiliary wheel 14 are mounted rotatably on the base 2.

As it can be noted, the machine 1 comprises auxiliary wheels 15A, 15B, 15C mounted in idle mode on the base 2 and geared with the toothed wheel 8. The toothed wheel 8, the auxiliary wheel 14 and the auxiliary wheels 15A, 15B, 15C present for example involute profiles. The auxiliary wheels 15 are arranged in different angular positions around the central axis "X-X". Each auxiliary wheel 15A, 15B, 15C mounted in idle mode is furthermore paired to a crank 16 by means of a clutch. Cranks 16 are configured to manually rotate the needle-bearing organ 4 when the machine 1 is stopped, for example to carry out maintenance operations.

A first auxiliary wheel 15A mounted in idle mode and a second auxiliary wheel 15B mounted in idle mode are respectively paired to a first proximity sensor 17A and to a second proximity sensor 17B mounted on the base 2. The first proximity sensor 17A and the second proximity sensor 17B are housed in respective through holes obtained in a radially outer wall of the supporting ring 5 and one end of each proximity sensor 17A, 17B is facing towards teeth of the respective first auxiliary wheel 15A and second auxiliary wheel 15B. The first proximity sensor 17A and the second proximity sensor 17B are mounted fixed on the base 2 and, during the functioning of the machine 1 and the rotation of the needle-bearing cylinder, the first auxiliary wheel 15A and the second auxiliary wheel 15B are dragged in rotation and the teeth of the first auxiliary wheel 15A and of the second auxiliary wheel 15B slide respectively in front of the first proximity sensor 17A and of the second proximity sensor 17B. The first proximity sensor 17A is mounted in such a way to detect the passage of teeth 18 of the first auxiliary wheel 15A and the second proximity sensor 17B is mounted in such a way to detect the passage of teeth 18 of the second auxiliary wheel 15B.

In the shown embodiment, the first proximity sensor 17A and the second proximity sensor 17B are cylinders oriented along radial directions with respect to the respective axes of rotation "Y-Y" of the first auxiliary wheel 15A and of the second auxiliary wheel 15B.

The first auxiliary wheel 15A and the second auxiliary wheel 15B are substantially identical and also the first proximity sensor 17A and the second proximity sensor 17B are substantially identical, so that in the following it will be described, with reference to figures 5, 6, 7 and 8, only the structure and the functioning of the assembly formed by the first auxiliary wheel 15A and by the first proximity sensor 17A.

The first proximity sensor 17A is of the Hall-effect magnetic type, the functioning principle thereof is known per se and is therefore not described in detail herein. The first auxiliary wheel 17A comprises a plurality of straight teeth 18, i.e. the teeth 18 are arranged parallel to the respective rotation axis "Y-Y". The teeth 18 of the first

auxiliary wheel 17A are realized in a material such that they can interact with the Hall effect first proximity sensor 17A, i.e. in a magnetic or magnetized material, for example cast iron, steel, iron.

In order to optimize the functioning of the Hall effect first proximity sensor 17A, an operatively active magnetic filter can furthermore be implemented at the first auxiliary wheel 15A in such a way as to remove and move away from the first proximity sensor 17A any metal filings generated by the interaction between the toothed wheel 8 and the first auxiliary wheel 15A.

In alternative embodiments, the proximity sensor(s) can be of different types, for example inductive or capacitive, laser.

The first auxiliary wheel 17A presents a pitch circumference “Cp” with a pitch diameter “dp” and an outer circumference “Ce” with an outer diameter “de”. As it is known, it is called pitch diameter “dp” of a toothed wheel the diameter associated to the circumference (pitch circumference “Cp”) that passes where the width of the teeth is equal to the width of the spaces. The outer circle that externally limits the top of the teeth determines instead the outer diameter “de”.

The first auxiliary wheel 17A presents an own portion, clearly visible in figure 6, wherein the teeth 18 present a height lower than a height of the teeth 18 of the remaining part of the first auxiliary wheel 17A, i.e. wherein, with respect to a project drawing wherein the teeth 18 are shaped and dimensioned in such a way to have the correct transmission performance, the teeth 18 are lowered. At this portion, a head circumference “Ct” of the teeth 18 does not correspond to the outer circumference “Ce” but is comprised between the pitch circumference “Cp” and the outer circumference “Ce” (figure 7). The head circumference “Ct” presents a head diameter “dt” (or discharged diameter) lower than the outer diameter “de” and greater than the pitch diameter “dp” (figure 7). It follows that a width “Lt” of the teeth 18 measured along the head circumference “Ct” is greater than a width “Le” of the teeth 18 measured along the outer circumference “Ce” and lower than a width “Lp” of the teeth 18 measured along the pitch circumference “Cp” (figure 8). Furthermore, the width “Lt” of the teeth 18 measured along the head circumference “Ct” is greater than a width “Lv” of the spaces measured along the head circumference “Ct”. Furthermore, the teeth 18 of the first auxiliary wheel 15A present sharp edges.

The first proximity sensor 17A detects the presence or absence of a tooth 18 within its nominal range and switches between two statuses by emitting a first signal “S1” which is a square wave: crest of the square wave at the passage of a tooth and trough of the square wave at the passage of a space (figure 8).

A ratio between the width “Lt” of the teeth 18 measured along the head circumference “Ct” and the width “Lv” of the spaces measured along the head circumference “Ct” is calculated (and the teeth of the mentioned portion processed/discharged accordingly) taking into account the characteristics of the first proximity sensor 17A (as the nominal detection distance and/or hysteresis) in such a way that a width “Ac” of a crest of the square wave of the first signal “S1” is equal or substantially equal to a width “Ag” of a trough of the square wave itself (Ac = Ag, figure 8). Usually this “Lt/Lv” ratio is less than one, for example comprised between 0.60 and 0.99, preferably

between 0.85 and 0.95. In other words, the electronic equivalent (Ac = Ag) of the pitch circumference “Cp” (which passes where the width of the teeth is equal to the width of the spaces) is obtained by having the first proximity sensor 17A read the teeth 18 on the head circumference “Ct” where Lt < Lg. If, on the other hand, the teeth 18 were discharged up to the effective pitch circumference “Cp”, the width “Ac” of the crests of the square wave would be greater than the width “Ag” of the troughs and a crest of the first signal “S1” would overlap two adjacent crests of the second signal “S2”. In this case, in order to ensure that the leading “Fs” and trailing “Fd” edges of the signals “S1”, “S2” follow one another according to a predetermined rhythm, it would be necessary to carry out accurate mechanical machining procedures and/or electronic regulations for each of the machines. The above also applies to the assembly formed by the second auxiliary wheel 15B and the second proximity sensor 17B. Figure 9 shows the first signal “S1” emitted by the first proximity sensor 17A and a second signal “S2” emitted by the second proximity sensor 17B. As it can be seen, the first signal “S1” and the second signal “S2” are both defined by respective square waves and are offset from each other so that the crests are partially overlapping. The first proximity sensor 17A and the second proximity sensor 17B can be appropriately positioned with respect to the teeth 18 respectively of the first auxiliary wheel 15A and of the second auxiliary wheel 15B in such a way that the first signal “S1” and the second signal “S2” are offset from each other. If, as just shown, the width “Ac” of the crest of the square wave is equal to the width “Ag” of the trough of the square wave itself for both signals, a precise positioning of the first and of the second proximity sensor 17A, 17B is not necessary because there will anyway be a minimum phase shift and a minimum overlap of the crests of the two signals “S1”, “S2”.

The machine 1 comprises and is controlled by an electronic control unit 19, schematically shown in figure 6. The electronic control unit 19 is operatively connected to the first proximity sensor 17A and to the second proximity sensor 17B and is configured to receive and process the first signal “S1” and the second signal “S2” and control organs of the machine 1 and/or functioning parameters of the machine 1 also as a function of said signals “S1”, “S2”. By reading only one of the two signals (for example, the first signal “S1”), the electronic control unit 19 calculates a rotation speed of the needle-bearing cylinder, whereas, by acquiring the further signal (second signal “S1”), the electronic control unit 19 discriminates the direction of rotation according to the sequence of statuses produced by the two signals “S1”, “S2”.

The machine 1 comprises furthermore an auxiliary proximity sensor 20 integral to the base 2 and configured to detect the passage of a single element 21, for example a peg, integral to the needle-bearing organ 4 and emit a respective auxiliary signal “S3”. The auxiliary proximity sensor 20 and the peg are schematically shown in figure 3. Instead of the peg, said single element 21 can assume another shape, it can for example be a notch or a tooth.

Also the auxiliary proximity sensor 20 is operatively connected to the electronic control unit 19. The electronic control unit 19 is configured to receive and process the auxiliary signal “S3” and to discriminate an absolute

angular position of the needle-bearing organ 4 around the central axis "X-X". The auxiliary signal "S3" is a squared pulse (figure 9) which is received by the electronic control unit 19 every 360° of rotation of the needle-bearing organ 4 and provides an absolute zero position of said needle-bearing organ 4.

The machine 1 comprises drawing devices, per se known, mounted on the base 2 below the textile head 3 configured to keep tensioned the formed fabric "T" that descends downwards (figures 2 and 3). The machine 1 comprises furthermore a winder mounted on the base 2 below the textile head 3 configured to collect, preferably wrap, the formed fabric "T".

The machine 1 can comprise furthermore a cutter, not shown and, for example, of known type, configured to cut the formed fabric "T" and allow the opening thereof.

The drawing devices are actuated by a respective actuator controlled by the electronic control unit 19. The winder is actuated by a respective motor controlled by the electronic control unit 19. The cutter is actuated by a respective actuator controlled by the electronic control unit 19.

In the machine 1 shown by way of example, the drawing devices and the winder are integrated in a drawing and/or collection group 22, movably housed in a collection space delimited between the legs of the bottom base 6 and closed by a carter 100 (figures 1 and 2). The drawing and/or collection group 22 is configured to open and spread, or even possibly to draw, the fabric "T" manufactured by the textile head 3, wrapping it in a single layer and continuously on a collection roller, not visible in figure 2 as it is hidden behind a spreading roller 23. The spreading roller 23 (also referred to as the tensioning roller) is mounted upward with respect to the collection roller and is configured to interact with the fabric "T" advancing towards the collection roller in such a way as to spread it before the wrapping on the collection roller.

The shown drawing and/or collection group 22 is hanged to the needle-bearing organ 4, in such a way as to be suspended within the collection space and to rotate together with the needle-bearing organ 4. The cutter, not shown, is part of the drawing and/or collection group 22 and is configured to cut the formed "T" fabric and allow the above-mentioned opening and wrapping thereof into a single layer.

The machine 1 comprises furthermore blowers mounted at the textile head 3 and/or at yarn guide arranged above the textile head 3. The blowers are configured to blow air in such a way to cool and remove residual dust from the bed. The blowers are actuated by one actuator or by several actuators controlled by the electronic control unit 19. The blowers are mounted on a rotating support actuated in rotation by a motor. In the machine 1 shown by way of example, the blowers comprise fans 24 and nozzles, not visible in the attached figures, connected to a compressed air source.

The electronic control unit 19 is configured, according to a control method of a circular weft knitting machine according to the present invention, to control and pilot the main motor 9 and/or the drawing devices and/or the cutter and/or the collector and/or the blowers and to control the functioning parameters of the machine 1 as a function of the first signal "S1", of the second signal "S2" and of the auxiliary signal "S3", or of the relative and

absolute angular position, of the direction of rotation and of the speed of rotation of the needle-bearing organ 4.

The electronic control unit 19 is furthermore configured to manage anomalies of the first signal "S1" and the second signal "S2" and emit alarm signals and/or stop the machine 1. For example, in case of missing signals, as in figure 10, this means that the electrical connection of the proximity sensor and/or the proximity sensor itself is defective. Figure 11 shows the situation wherein the second proximity sensor 17B is faulty or disconnected. Figure 12 shows the situation wherein the second proximity sensor 17B is short-circuited. A further check that can be made by the control unit 19 is to count the number of teeth detected in a 360° turn of the needle-bearing organ 4 by the first sensor 17A and/or by the second sensor 17B and to check that this number is correct using the auxiliary signal "S3", which gives an indication of the closure of the turn.

In alternative and not shown embodiments, the first proximity sensor 17A and the second proximity sensor 17B can be positioned in such a way to read the teeth 18' of the toothed wheel 8. In this case, a portion of the toothed wheel 8 can present teeth 18' of lower height, as above shown with reference to the first auxiliary wheel 15A.

In further embodiments, the first proximity sensor 17A can be positioned to read the teeth 18' of the toothed wheel 8 whereas the second proximity sensor 17B reads the teeth 18 of the respective second auxiliary wheel 17B. In further embodiments, the first proximity sensor 17A and the second proximity sensor 17B can be positioned in such a way to read the teeth 18 of the auxiliary wheel itself and this auxiliary wheel can also be the auxiliary wheel 14 of the above shown flexible transmission. In further embodiments, not shown, the auxiliary wheel or the auxiliary wheels 15A, 15B combined with the proximity sensors 17A, 17B, instead of being directly geared with the toothed wheel 8, is/are paired to the toothed wheel 8 by means of a respective intermediate gear.

In embodiment variants, the width "Ac" of the crest and the width "Ag" of the trough of the first signal "S1" and/or of the second signal "S2" can also be different from each other. In this case, the positioning of the first proximity sensor 17A and the second proximity sensor 17B must be done in such a way that the overlap between the two signals allows to discriminate the direction of rotation of the needle-bearing organ 4.

In further not shown embodiments and always within the scope of the present invention, the machine 1 is not provided with the auxiliary proximity sensor 20 and the electronic control unit 19 to calculate a speed of rotation, a direction of rotation and a relative angular position of the needle-bearing organ 4 but not the absolute angular position.

In further not shown embodiments and always within the scope of the present invention, the machine 1 comprises a unique proximity sensor 17A which allows the electronic control unit 19 to calculate a rotation speed and a relative angular position of the needle-bearing organ 4 but not to discriminate the direction of rotation and the absolute angular position.

The present invention obtains important advantages.

The invention allows to detect in real time and with precision the position and/or the speed and/or the direction of rotation of the needle-bearing organ without errors due to, for example, the reading carried out with an encoder on the main motor and the deformability/elasticity of the transmission between the main motor and the needle-bearing organ.

The invention allows to control the machine efficiently, in particular it allows to pilot the organs of the machine and to control its functioning parameters with precision and reliability. Knowing the position of the cylinder in real time, the electronic control unit is able to calculate the amount of manufactured fabric and the manufacturing speed and then to cut when and how much is needed, to draw, to collect as much as it is needed and to move the fans to cool and remove the dust effectively.

The invention allows to safely stop the machine based on proximity sensor signals.

The invention allows to optimize the functioning of the machine and then to save energy.

Furthermore, the system adopted for the control is simple, reliable and affordable.

List of elements and symbols

circular weft knitting machine 1

base 2

textile head 3

needle-bearing organ 4

central axis "X-X"

rotation axis "Y-Y"

upper supporting ring or element 5

bottom base 6

actioning devices 7

toothed wheel 8

tubular fabric "T"

main motor 9

first belt 10

first pulley 11

second belt 12

third pulley 13

auxiliary wheel 14

auxiliary wheels 15A, 15B, 15C mounted in idle mode

crank 16

first proximity sensor 17A

second proximity sensor 17B
teeth 18, 18'
electronic control unit 19
auxiliary proximity sensor 20
single element 21
drawing and/or collection group 22
spreading roller 23
fans 24
carter 100
head circumference "Ct"
pitch circumference "Cp"
outer circumference "Ce"
head diameter "dt"
pitch diameter "dp"
outer diameter "de"
width "Lt" of the teeth measured along the head circumference "Ct"
width "Lp" of the teeth measured along the pitch circumference "Cp"
width "Le" of the teeth measured along the outer circumference "Ce"
width "Lv" of the spaces measured along the head circumference "Ct"
width "Ac" of a crest
a width "Ag" of a trough
first signal "S1"
second signal "S2"
auxiliary signal "S3"
leading edge "Fs"
trailing edge "Fd"

CLAIMS

1. Circular weft knitting machine, comprising:

a base (2) configured to lie on the ground;

a textile head (3) mounted on the base (2); the textile head (3) comprising: a needle-bearing organ (4) presenting a central axis (X-X) and a plurality of grooves arranged around the central axis (X-X), a plurality of needles housed in the grooves, actioning devices (7) mounted fixed on the base (2), operatively paired or pairable to the needles and configured to determine or allow the movement of the needles along the grooves in order to form the knitted fabric by said needles; the needle-bearing organ (4) comprising a toothed wheel (8) coaxial to the central axis (X-X) and presenting a plurality of teeth (18');

a main motor (9) operatively connected to the toothed wheel (8) of the needle-bearing organ (4) for determining the rotation of said needle-bearing organ (4) around the central axis (X-X) and with respect to the base (2);

at least one proximity sensor (17A, 17B) mounted fixed with respect to the base (2) in such a way to detect the passage of teeth (18') of the toothed wheel (8) and/or of teeth (18) of at least one auxiliary wheel (15A, 15B) operatively paired to the toothed wheel (8) and emit a respective signal (S1, S2);

an electronic control unit (19) operatively connected to said at least one proximity sensor (17A, 17B) and configured to receive and process the signal (S1, S2) deriving from said at least one proximity sensor (17A, 17B) and control organs of the circular weft knitting machine (1) and/or functioning parameters of the circular weft knitting machine (1) as a function of said signal (S1, S2).

2. Machine according to claim 1, wherein said at least one proximity sensor (17A, 17B) comprises a first proximity sensor (17A) and a second proximity sensor (17B) mounted on the base (2); wherein the first proximity sensor (17A) emits a respective first signal (S1) and the second proximity sensor (17B) emits a respective second signal (S2); wherein the electronic control unit (19) is configured to control the organs of the circular weft knitting machine (1) and/or the functioning parameters of the circular weft knitting machine (1) as a function of the first signal (S1) and of the second signal (S2).

3. Machine according to claim 2, wherein the electronic control unit (19) is configured to calculate a relative position and a speed of the needle-bearing organ (4) around the central axis (X-X) through said signal (S1, S2); wherein the electronic control unit (19) is configured to receive and process the first signal (S1) and the second signal (S2) and discriminate a direction of rotation of the needle-bearing organ (4) around the central axis (X-X).

4. Machine according to claim 2 or 3, wherein said at least one auxiliary wheel (15A, 15B) comprises a first auxiliary wheel (15A) and a second auxiliary wheel (15B); wherein the first proximity sensor (17A) is

mounted in such a way to detect the passage of teeth (18) of the first auxiliary wheel (15A) and the second proximity sensor (17B) is mounted in such a way to detect the passage of teeth (18) of the second auxiliary wheel (15B).

5. Machine according to one of the claims from 1 to 4, comprising an auxiliary proximity sensor (20) operatively connected to the electronic control unit (19); the auxiliary proximity sensor (20) being mounted fixed with respect to the base (2) and being configured to detect the passage of a single element (21) integral with the needle-bearing organ (4) and emit a respective auxiliary signal (S3); wherein the electronic control unit (19) is configured to receive and process the auxiliary signal (S3) and discriminate an absolute angular position of the needle-bearing organ (4) around the central axis (X-X).

6. Machine according to one of the claims from 1 to 5, wherein the teeth (18, 18') of the toothed wheel (8) and/or of said at least one auxiliary wheel (15A, 15B) present respective heads arranged on a head circumference (Ct); wherein said teeth (18, 18') present a respective width (Lt) measured along the head circumference (Ct), wherein spaces delimited between successive teeth (18, 18') present a respective width (Lv) measured along said head circumference (Ct); wherein the first signal (S1) and the second signal (S2) are defined by respective square waves; wherein a ratio between the width (Lt) of the teeth (18, 18') and the width (Lv) of the spaces is such that a width (Ac) of a crest of each square wave is equal or substantially equal to a width (Ag) of a trough of the square wave itself.

7. Machine according to claim 6, wherein a ratio between the width (Lt) of the teeth (18, 18') and the width (Lv) of the spaces is comprised between 0,60 and 0,99, optionally comprised between 0,85 and 0,95.

8. Machine according to claim 6 or 7, wherein the toothed wheel (8) and/or said at least one auxiliary wheel (15A, 15B) presents/present a pitch circumference (Cp) with a pitch diameter (dp) and an outer circumference (Ce) with an outer diameter (de) and wherein the head circumference (Ct) of the teeth (18, 18') is comprised between the pitch circumference (Cp) and the outer circumference (Ce) and the width (Lt) of the teeth (18, 18') measured along the head circumference (Ct) is greater than a width (Le) of the teeth (18, 18') measured along the outer circumference (Ce) and lower than a width (Lp) of the teeth (18, 18') measured along the pitch circumference (Cp).

9. Machine according to claim 8, wherein said at least one proximity sensor (17A, 17B) is facing a portion of the toothed wheel (8) and/or of said at least one auxiliary wheel (15A, 15B); wherein the teeth (18, 18') present, at said portion, the respective heads placed on the head circumference (Ct) and the teeth (18, 18')

themselves present, at a remaining part of the toothed wheel (8) and/or said at least one auxiliary wheel (15A, 15B), the respective heads placed on the outer circumference (Ce).

10. Machine according to one of the claims from 1 to 10, wherein the electronic control unit (19) is configured to control and pilot the main motor (9) and/or drawing devices and/or a cutter and/or a collector and/or blowers as a function of said signal (S1, S2).

11. Control method of a circular weft knitting machine, comprising:

acquiring a signal (S1, S2) emitted by at least one proximity sensor (17A, 17B) positioned for detecting the passage of teeth (18') of a toothed wheel (8) of a needle-bearing organ (4) of a circular weft knitting machine (1) and/or the passage of teeth (18) of at least one auxiliary wheel (15A, 15B) operatively paired to the toothed wheel (8), wherein the needle-bearing organ (4) rotates around an its own central axis (X-X) and the toothed wheel (8) is coaxial to said central axis (X-X);

controlling organs of the circular weft knitting machine (1) and/or functioning parameters of the circular weft knitting machine (1) as a function of said signal (S1, S2).

12. Method according to claim 11, wherein acquiring a signal (S1, S2) comprises: acquiring a first signal (S1) emitted by a first proximity sensor (17A) and acquiring a second signal (S2) emitted by a second proximity sensor (17B).

13. Method according to claim 12, comprising: positioning the first proximity sensor (15A) and positioning the second proximity sensor (15B) in such a way that the first signal (S1) and the second signal (S2) are offset from each other and the crests of the first signal (S1) and crests of the second signal (S2) are always partially overlapping each other.

14. Method according to claim 12 or 13, wherein the first signal (S1) and the second signal (S2) are defined by respective square waves; wherein it is provided to realize the teeth (18') of the toothed wheel (8) and/or the teeth (18) of said at least one auxiliary wheel (15A, 15B) in such a way to compensate characteristics of said at least one proximity sensor (17A, 17B) and such that a width (Ac) of a crest of the square wave is equal or substantially equal to a width (Ag) of a trough of said square wave.

15. Method according to claim 14, wherein said characteristics comprise a nominal detection distance and/or a hysteresis of the proximity sensor (17A, 17B).

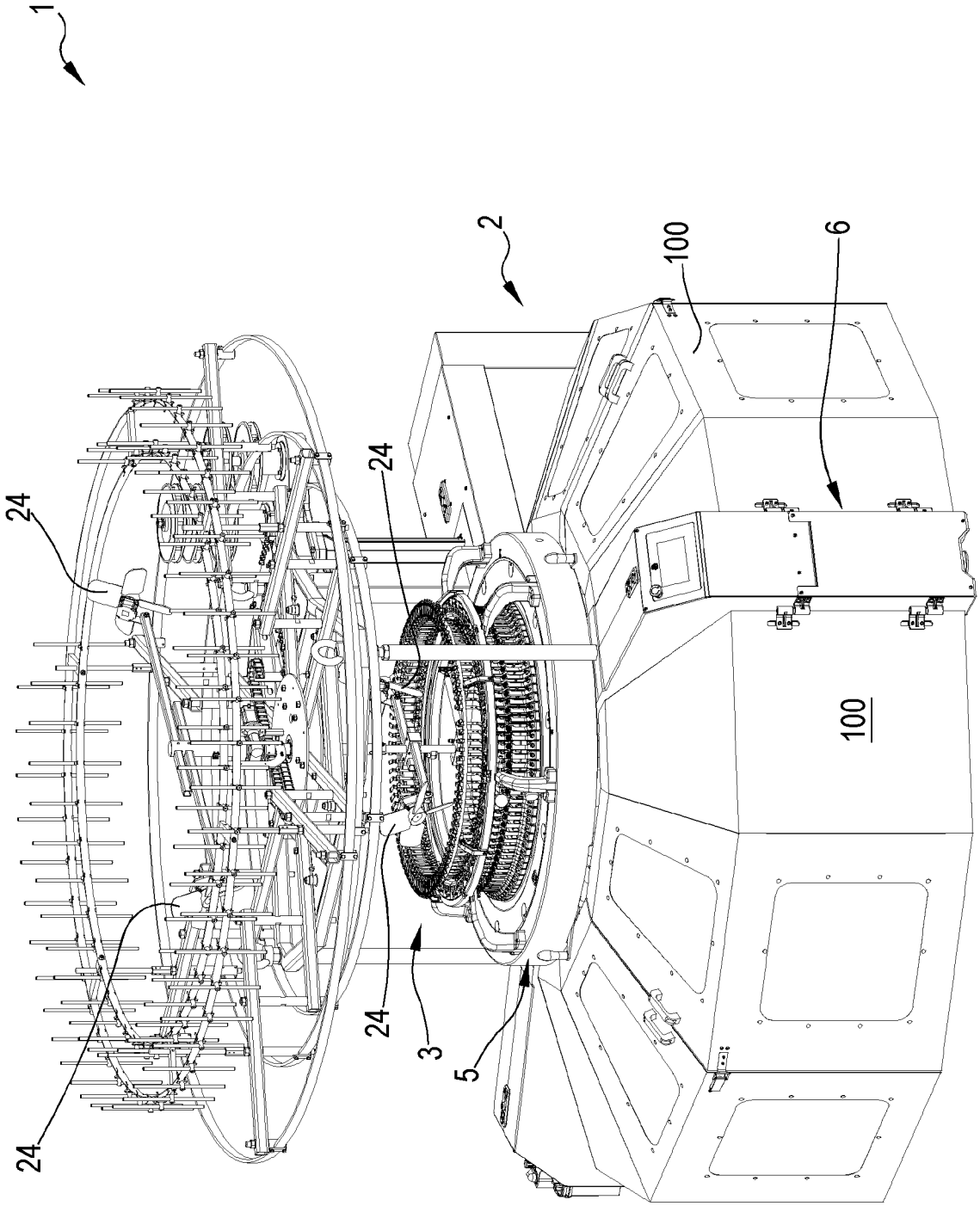


FIG.1

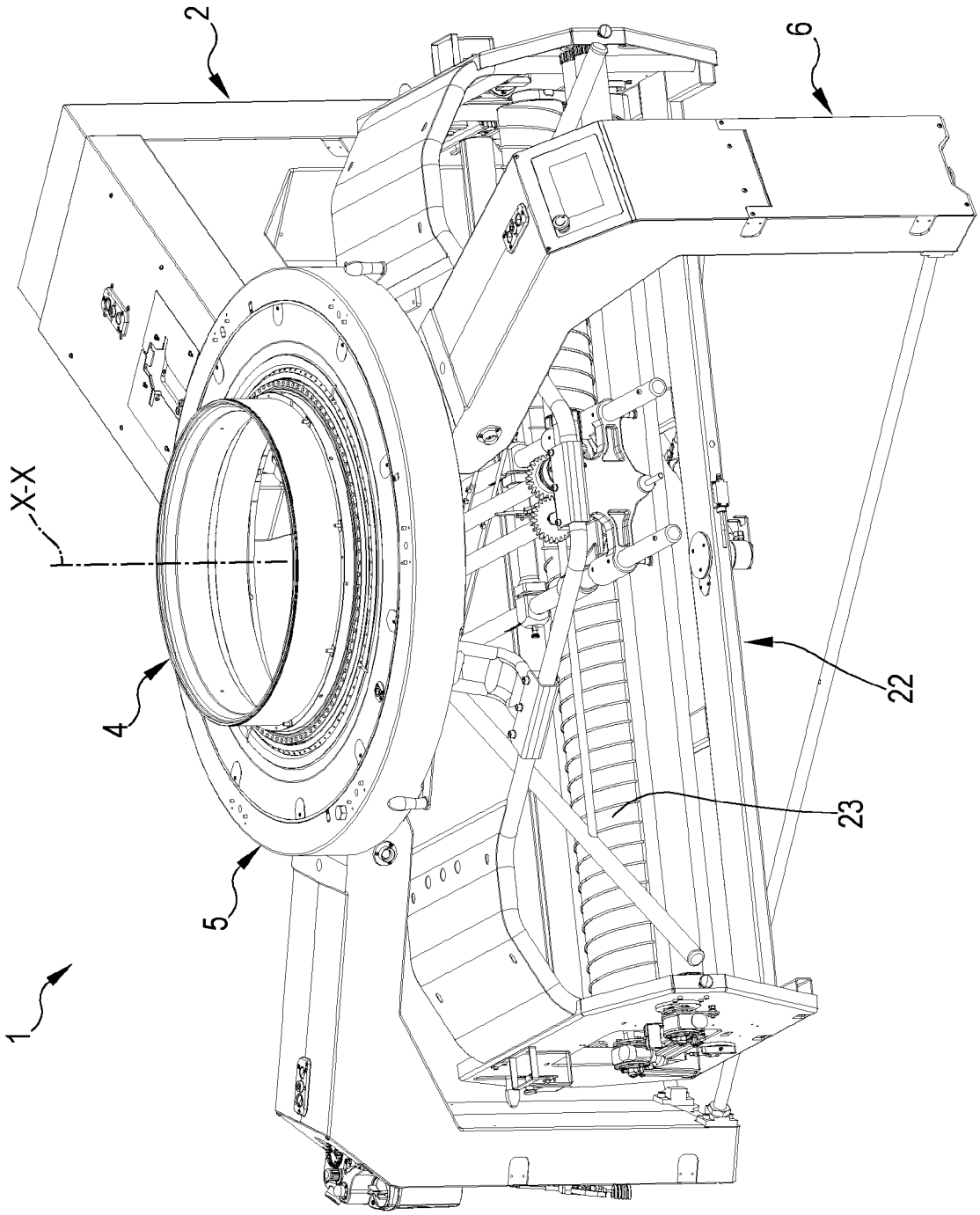


FIG.2

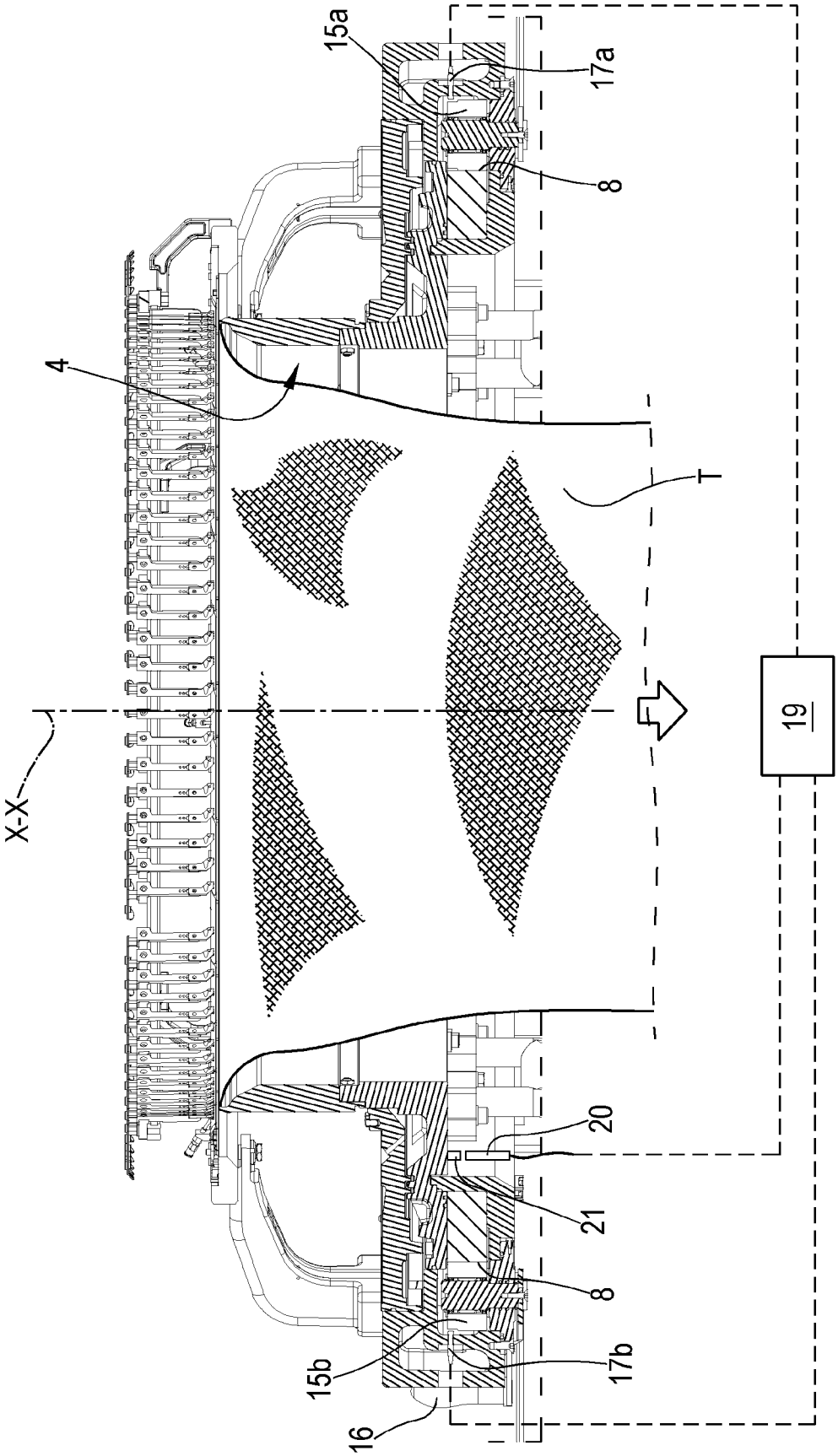


FIG.3

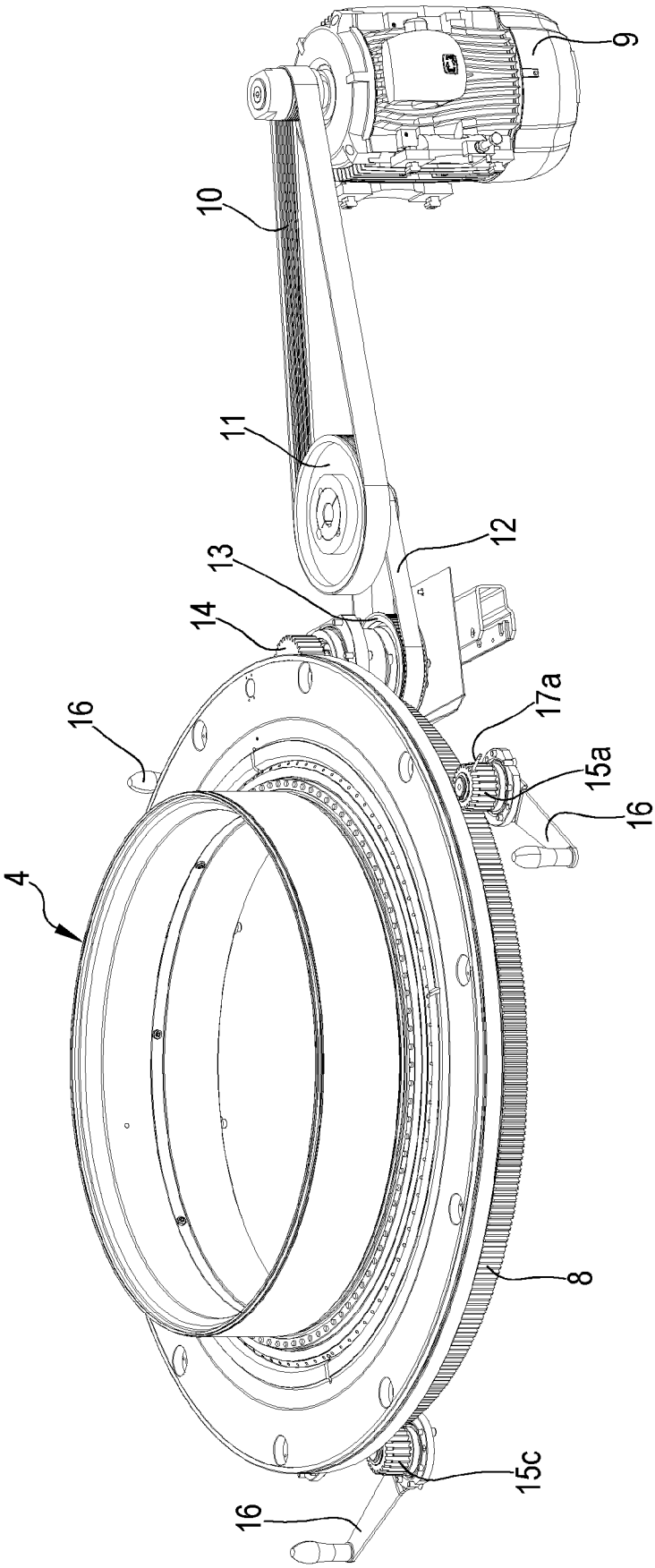


FIG.4

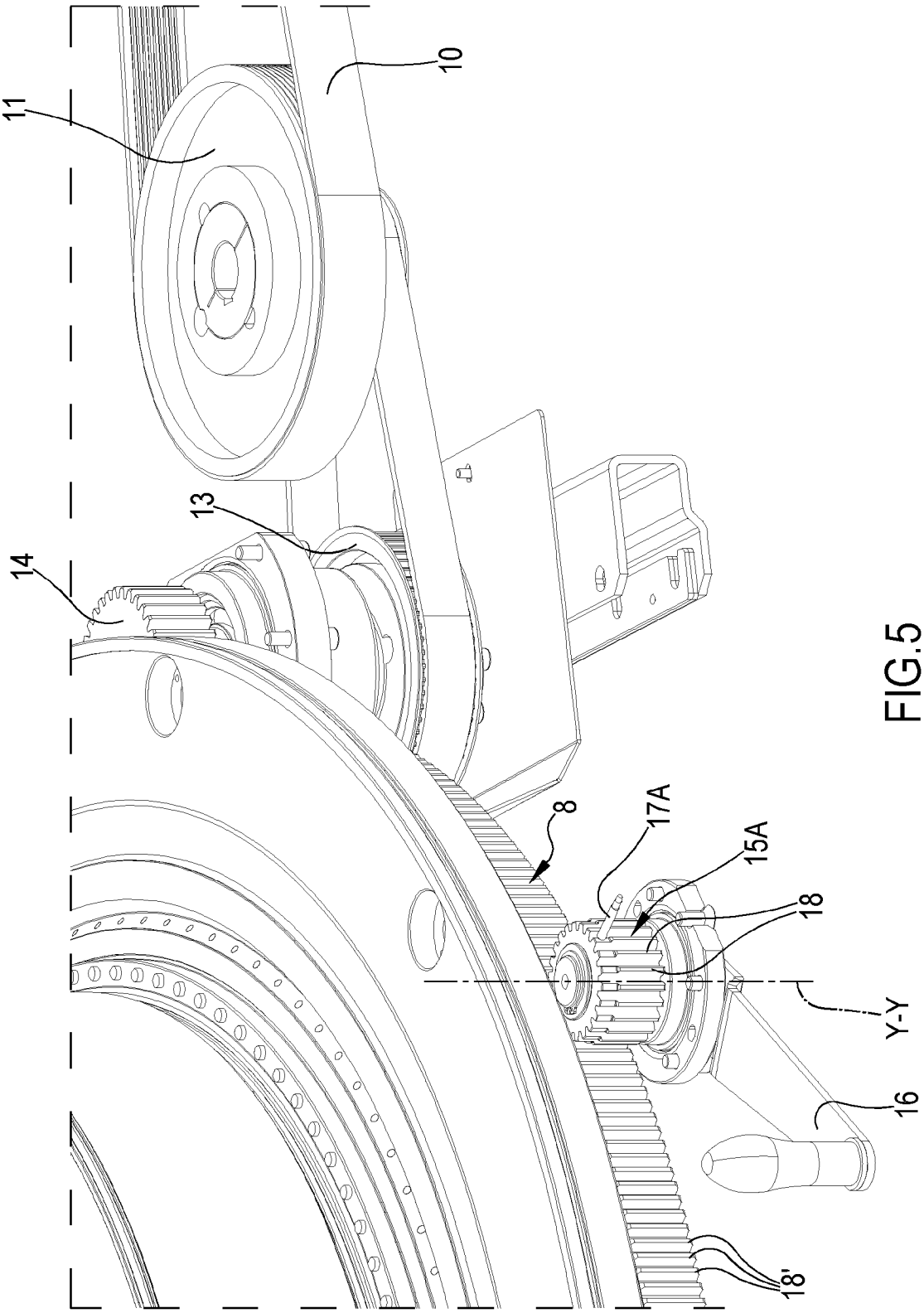
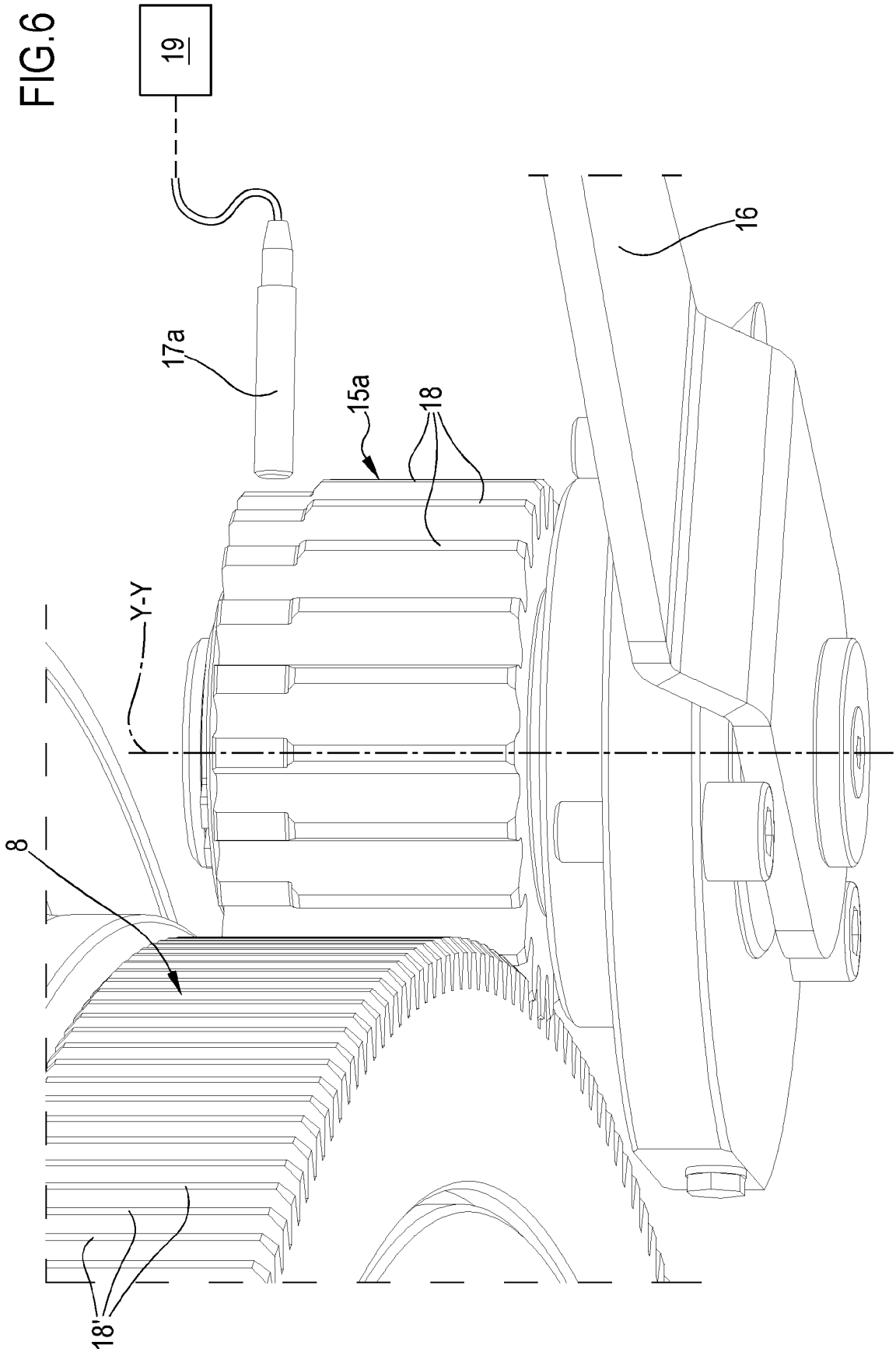


FIG.5

FIG.6



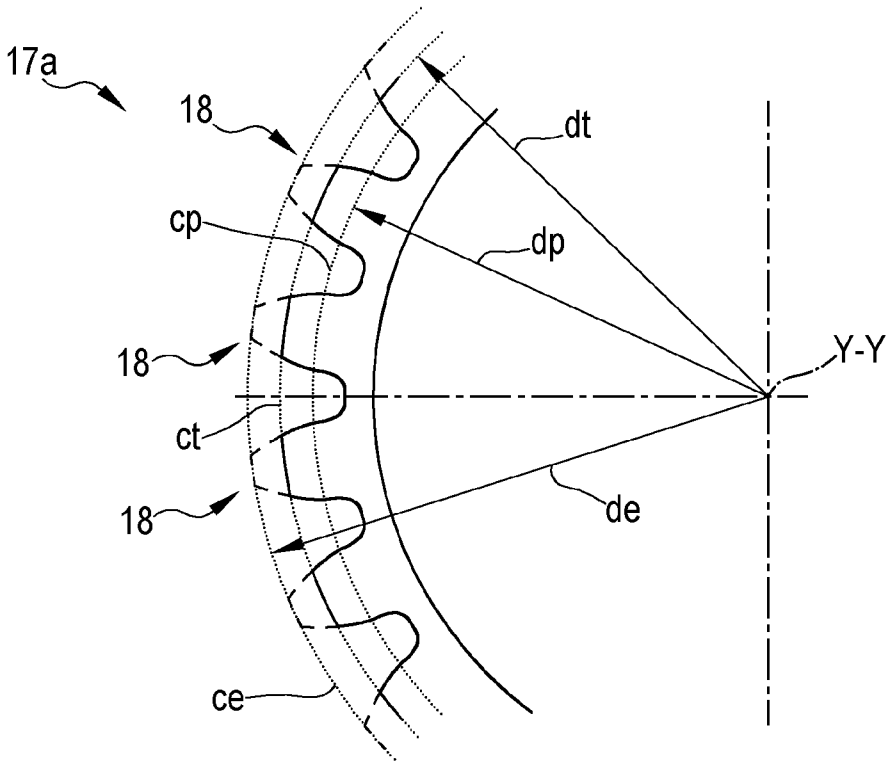

17a
18
dt
cp
dp
18
Y-Y
ct
18
de
ce

FIG.7

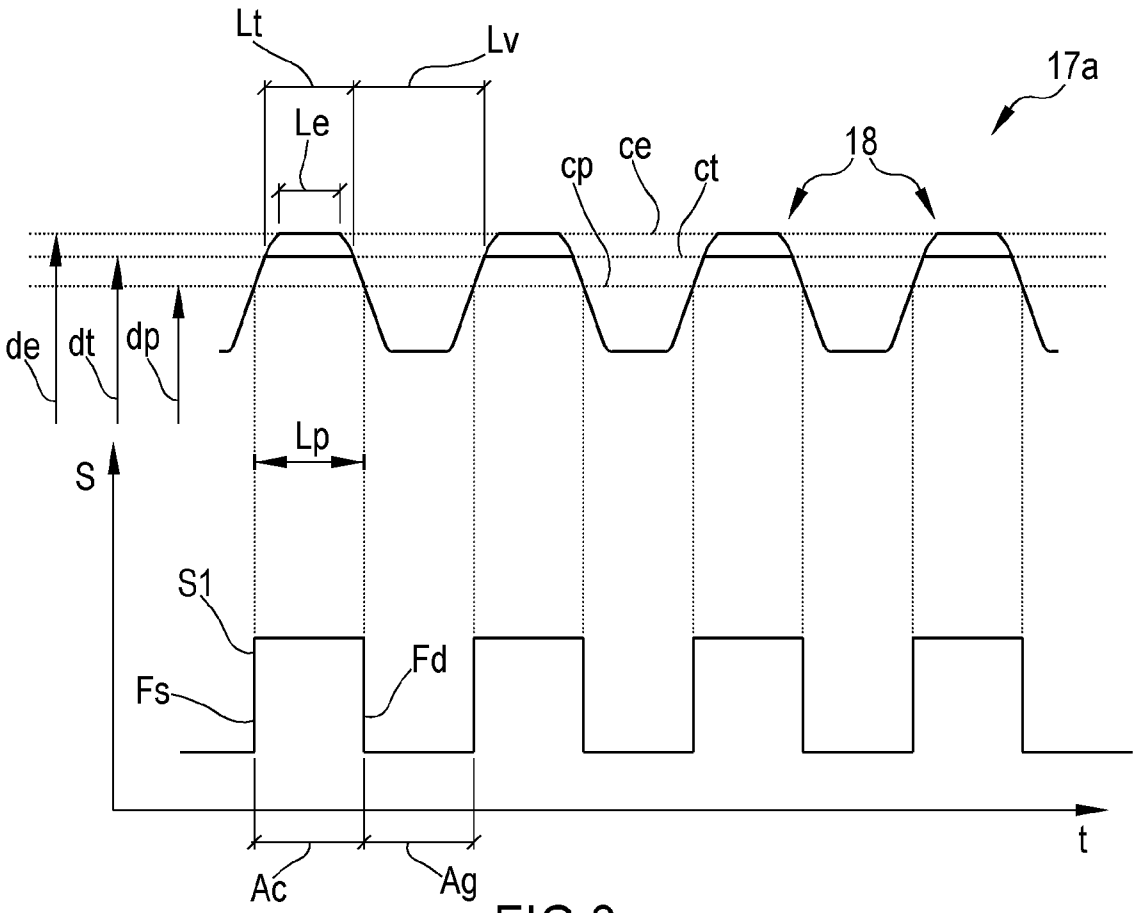

Lt
Lv
17a
Le
cp
ce
ct
18
de
dt
dp
Lp
S
S1
Fd
Fs
t
Ac
Ag

FIG.8

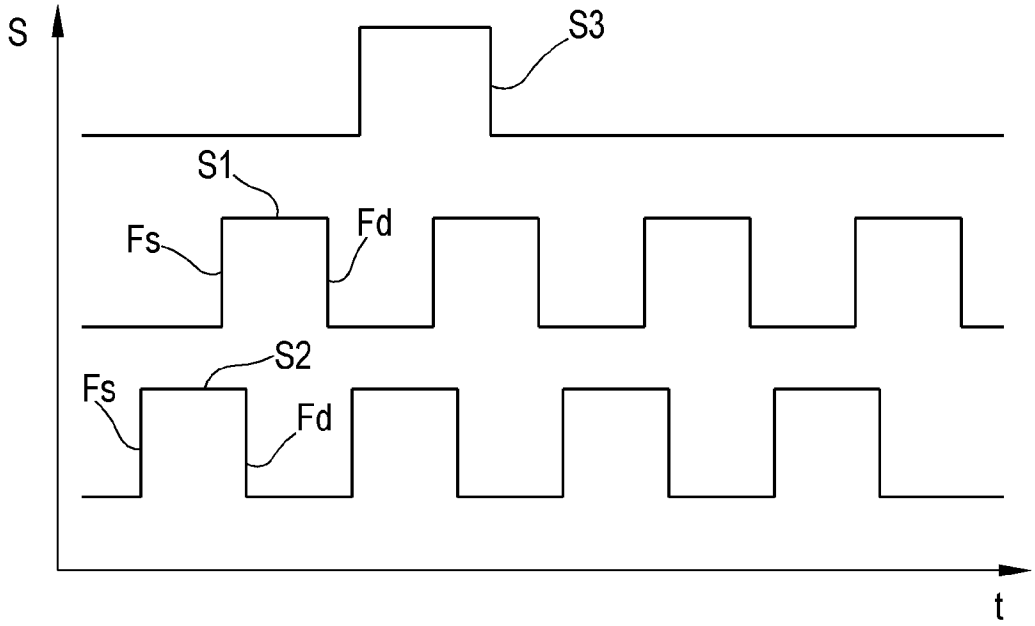


FIG.9

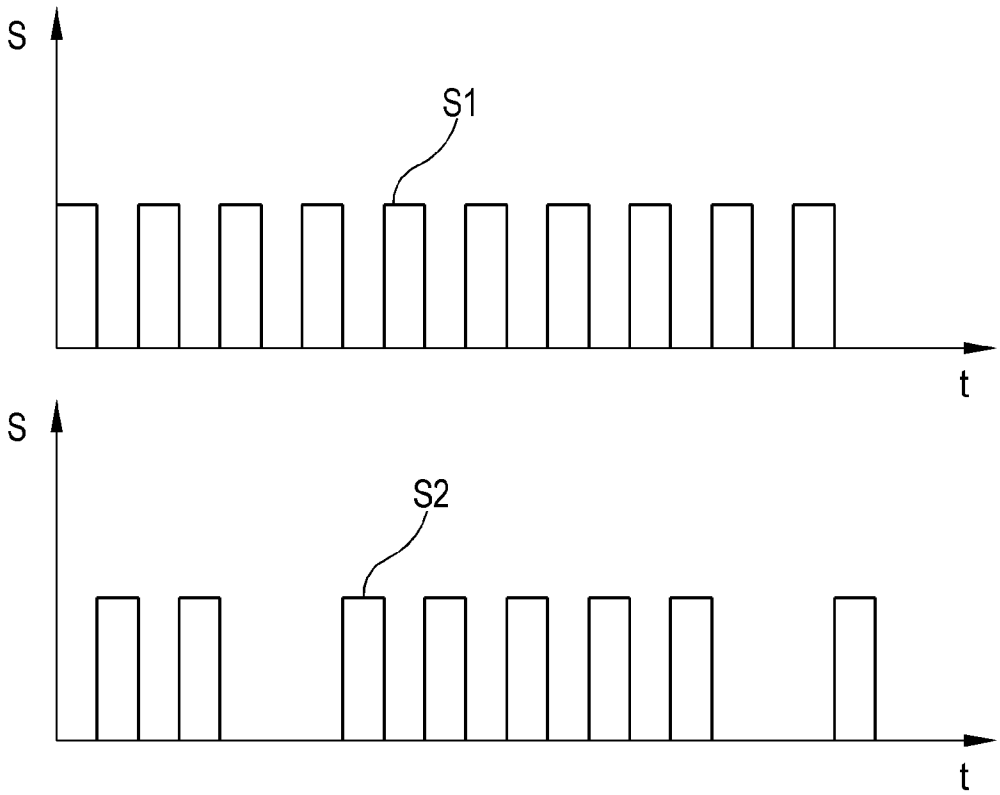


FIG.10

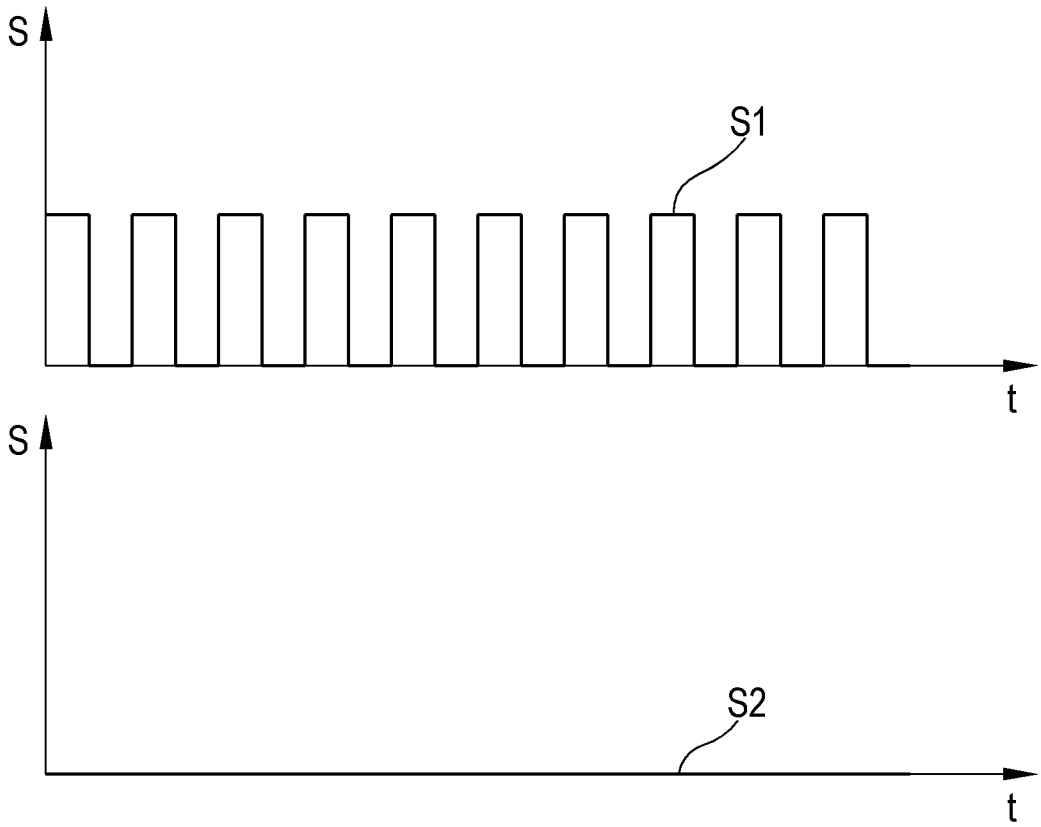


FIG.11

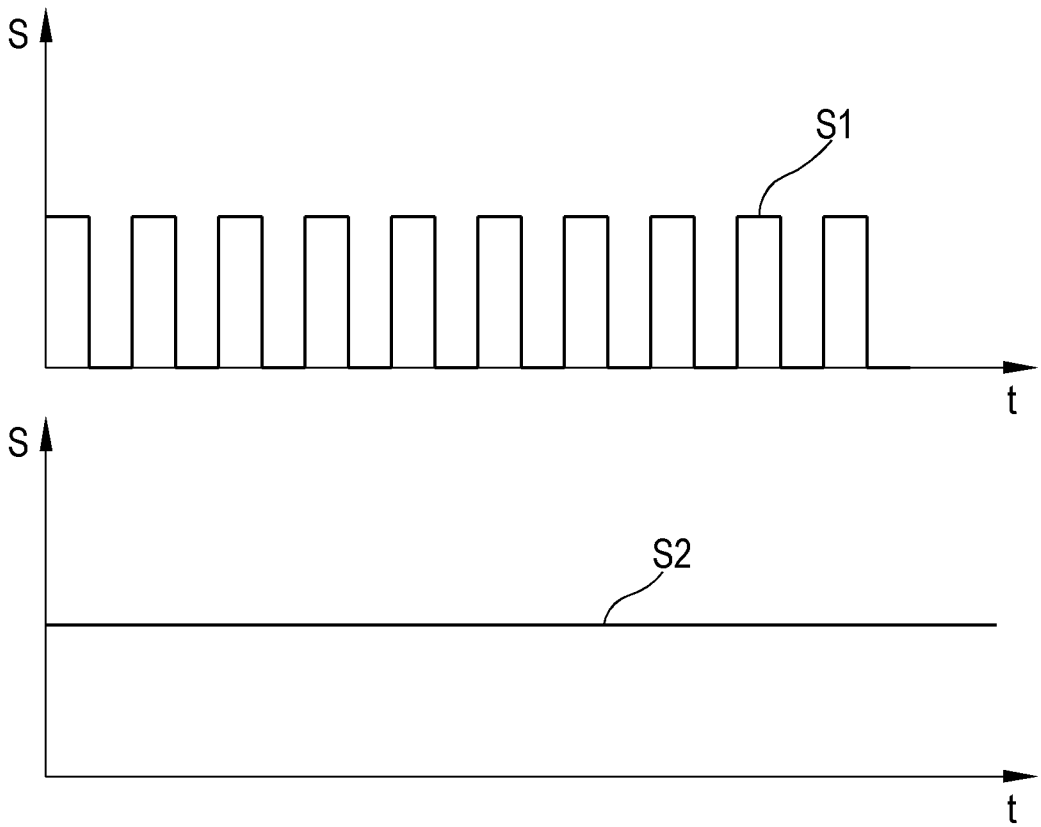


FIG.12

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2024/055503

A. CLASSIFICATION OF SUBJECT MATTER
INV. D04B15/16 D04B15/99
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)
D04B

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	KR 2000 0027002 A (PAI LUNG MACHINERY MILL CO LTD) 15 May 2000 (2000-05-15)	1,2,4-15
A	claims 1-3; figures 1-2	3
X	US 3 955 383 A (HASEGAWA JUNZO ET AL) 11 May 1976 (1976-05-11)	1,2,4-15
A	claim 1; figure 6	3
A	US 2005/021167 A1 (BURGER WILHELM [DE]) 27 January 2005 (2005-01-27) claim 30	3

☐ 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	Date of mailing of the international search report
7 August 2024	09/09/2024

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Messai, Sonia

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2024/055503

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
KR 20000027002 A	15-05-2000	NONE	
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