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(54) **Device and process for the precision measurement of the length of thread wound onto a bobbin**

(57) Process for measuring the length of the yarn wound onto a bobbin which, at discreet intervals, determines the length of yarn wound in a tangential direction, the length of yarn wound in an axial direction, combining them to obtain the precise partial length wound spirally onto the bobbin at each interval and integrating the partial lengths progressively indicated during the advancement of the bobbin to obtain the overall length.

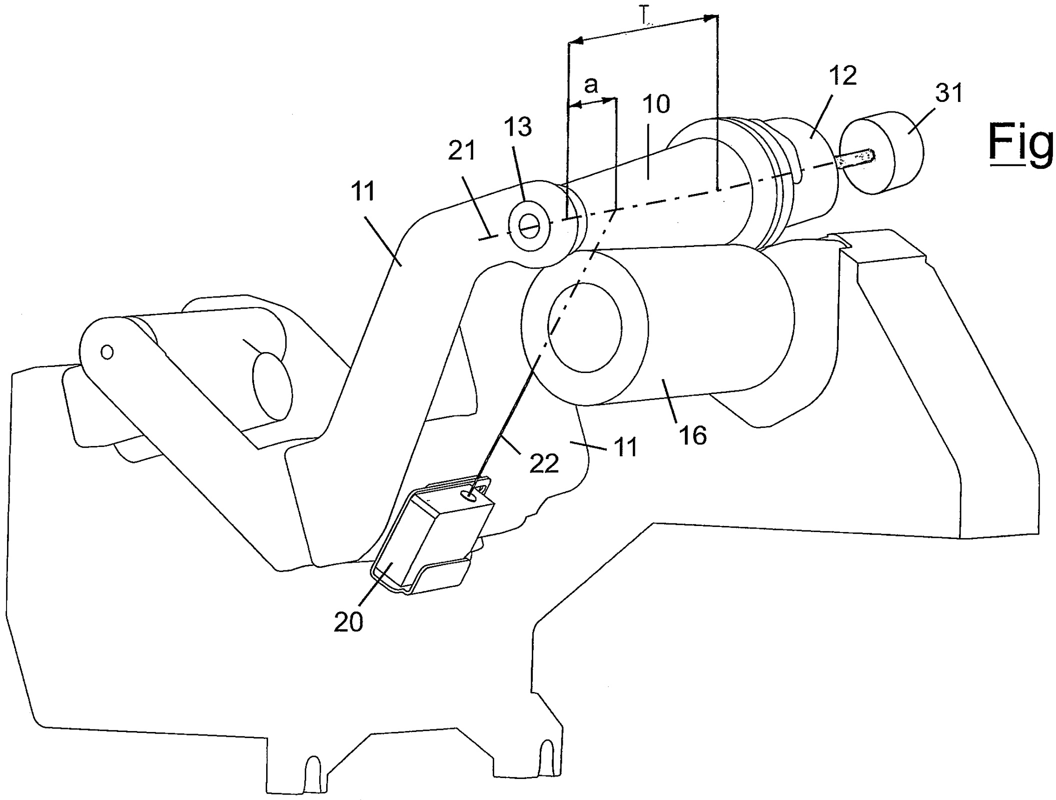

Fig. 2

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Description

[0001] The present invention relates to a device and process for the precision measurement of the length of the thread wound onto a bobbin in an automatic bobbin-winder. The invention is described herein with reference to the winding of the thread onto the conical tube forming a conical bobbin, moved with a driving roll having a straight cylindrical shape, but with the notification that it can also be applied in the formation of straight cylindrical bobbins, moved in rotation on conical rolls.

[0002] Bobbin-winders generally consist of a series of heads or winding units aligned along the front of the machine and equipped with common service devices for their management; they are all independent of each other and consequently the bobbins in formation can have different advance degrees in their winding. With reference to the scheme of figure 1, which briefly illustrates the collecting section of the wound thread, the bobbin 10 is held by the bobbin-holder arm 11 equipped with two dead centres 12, 13 which are engaged with the conical tube 14 at the base of the bobbin. The conical bobbin in formation 10 rests on its driving roll or collecting cylinder 16, driven by a motor M. Said collecting cylinder is equipped with traversing throats 17 which distribute the thread 18 with an axial backward and forward movement on the surface of the bobbin 10, whereas the rotating cylinder transmits the torque necessary for its winding. The number of traversing helixes situated on the driving cylinder 16 of the bobbin varies according to the yarn counts and density of the bobbin to be obtained; the driving cylinder generally has 1.5-2-2.5-3 helixes for each turn. The pitch of the helix can be constant or variable.

[0003] The bobbin 10 in formation progressively increases in dimension and weight. The resting pressure of the bobbin on its collection cylinder 16 has a great influence on the density of the bobbin itself. In figure 1, the bobbin 10 is shown already close to its final dimension.

[0004] The length of thread wound onto each of the bobbins, has a real value which significantly varies between the winding units which form the bobbin-winder. It mainly depends on the slippages between the surface of the bobbin 10 and the surface of the roll 16 pulling it. There are many reasons for these slippages. Firstly, there is a geometrical reason due to the conicity of the bobbin 10 which rests on the straight driving or collection cylinder 16. In a single axial coordinate of the resting line of the bobbin on its cylinder, there is a "neutral" point, in which the surface of the bobbin has the same linear (or tangential) rate as the surface of the cylinder. In the other points of the resting line of the bobbin there is slippage: towards the tip, the tangential rate is lower, towards the base, the tangential rate is higher in relation to the lesser or greater diameter. The return rate of the thread correspondingly has a pulsating trend. The axial coordinate of the "neutral" point is not constant during the whole winding period of the bobbin, said axial coordinate can vary in both a controlled manner for the modulation of the rate of the bobbin acting on the relative axial displacement between the bobbin-holder arm and the driving cylinder, and also without control.

[0005] Cylindrical bobbins can also have slippages, even if less marked, due to the variation in the flattening of the bobbin on the cylinder or to parallelism defects between the cylinder and bobbin, as well as construction imperfections or in the position between the parts, or maintenance faults. Variations in the friction coefficient between the various bobbin-winding units can occur due to variations in temperature or humidity, paraffining of the thread, variations in the flow of the bearings of the dead centres due to fouling or lubrication defects. All of these factors cause slippage between the various winding units resulting in differences in length between the bobbins contemporaneously produced which can reach 2-3%.

[0006] In the subsequent use of these bobbins, for example in weaving, various bobbins are used contemporaneously in the parallel feeding of the same machine and at the end of the bobbin which is the first to be exhausted, all the bobbins must be discharged and substituted with new bobbins: in industrial practice, the residual yarn wound onto other non-exhausted bobbins is lost. Particularly when working with high-quality yarns, these non-exhausted bobbins represent a significant cost whether the residual yarn be recovered or disposed of.

[0007] The average slippage which occurs on a bobbin-winder is in the order of 1.5%. In current practice, an average overall correction of the theoretical length established, is inserted into the control unit of the machine, currently a correction factor K, which should recover the average slippage of the bobbins. The corrective effect is obtained as the average of bobbins reaches the desired length, but there is a certain number of bobbins however, which, as a result of dispersion of the slippage causes, have a lesser or greater length than the average with a Gaussian-type distribution of the real length of $\pm$ 2%.

[0008] In the known art, at the beginning of each operating batch the correction factor K is determined as follows. A final length to be obtained MF is set on the control unit of the machine. A certain number of operating winding units are activated: it is even more preferable if the whole machine is activated. It is initially assumed that each bobbin is pulled by its cylinder without slippage. For each winding unit N_c revs of the activating cylinder 16 are measured, the diameter of the cylinder being known, for each revolution of the cylinder the length M_c of thread wound is known. In each bobbin-winding unit, the bobbin-winding is terminated when the value of the product N_c M_c is equal to MF. When the bobbins are finished, they are weighed or unwound and measured, comparing the effective final length value with the theoretical value MF established. Their ratio corresponds to the correction factor K to be introduced into the control unit of the machine to correct the MF for the subsequent bobbins. If the theoretical value established MF, for example, is 1 kg of yarn per bobbin and the actual average value measured on the sample bobbins is 0.984 kg, the correction factor K will be equal to 1/0.984.

[0009] The operation is then set for the whole bobbin-winder by inserting the final theoretical length data MF for each bobbin corrected with the correction factor K revealed. On the subsequent production, the correction factor K is sample controlled, possibly adjusting it and re-establishing it on the control unit. The correction factors K are revealed and catalogued for each different operation for possible re-use.

[0010] This length detection method does not take into account the fact that the yarn is spirally wound with an axial length component due to the traversing movement with which the thread is distributed on the bobbin.

[0011] More recently alternative systems have been proposed for determining the length of the bobbin based on the detection of the winding yarn rate, for example in US patent 5,652,509. According to this prior art, the system is based on a thread sensor, consisting of two readers of the thread characteristics (for example the thread image) positioned at a distance L, precise and relatively small. The space/time correlation between the images revealed in sequence by the two readers allows the transit rate of the thread to be determined, moment by moment, should the yarn have frequent identifiable and significant irregularities.

[0012] These systems have difficulties with respect to the preparation and functioning both in the presence of pulsating rates, as in the case of conical bobbins, and also when the thread is regular and compact, i.e. its twisting hides its basic irregularities. If, within the distance interval L, the thread has the possibility of rotating around itself, there is a further dispersion of the measurements from winding unit to unit. Sensors of this type are therefore insensitive to slippages between bobbin and cylinder, but have other difficulties relating to calibration and considerable calculation capacity in short times.

[0013] An objective of the present invention is therefore to provide a device and process for measuring the length of the yarn wound onto a bobbin, which overcomes the drawbacks of the measuring systems according to the known art and gives a precise and reliable measurement.

[0014] The present invention is described herein with reference to its main application to the formation of conical bobbins, for illustrative and non-limiting purposes, as the device and process according to the present invention can find advantageous applications in the formation of cylindrical bobbins or on machines different from bobbin-winders.

[0015] In its accepted meaning as a measuring process of the length of yarn wound onto a bobbin, the present invention is defined in claim 1. Its preferred variants or embodiments are defined in the dependent claims from 2 to 9.

[0016] In its more general meaning as a measuring device of the length of yarn wound onto a bobbin, the present invention is defined in claim 10. Its preferred variants or embodiments are defined in the dependent claims from 11 to 14.

[0017] The measuring system according to the present invention is based on the following logic. The real rising and winding rate of the yarn, insensitive to both slippage and flattening of the bobbin, is directly proportional to the number of revs of the bobbin multiplied by the actual diameter of the bobbin with respect to its tangential component V_y.

$$V_y = \omega_r \ \phi_r/2 \qquad (a)$$

wherein ω_r indicates the angular rate of the bobbin and ϕ_r indicates the bobbin diameter revealed. According to a preferred variant of the invention, said diameter is revealed in a point which is relatively distant from the contact line between the bobbin and activation cylinder so as not to be substantially influenced by the deformation of the bobbin pressed against said cylinder. According to the present invention, the transversal component of the rate V_x due to the traversing, is also taken into account during the measuring.

$$V_x = \omega_c \ T/2 \ \pi \ N_e \qquad (b)$$

wherein ω_c is the angular rate of the cylinder, T is the traversing run and N_e is the number of helixes of the cylinder. The actual resulting rate V is then determined by the composition of the two rates determined as follows:

$$V = [V_x^2 + V_y^2]^{1/2} \qquad (c)$$

[0018] This determination logic of the real winding thread rate is insensitive to any kind of slippage and cause and supplies much greater precision information than that provided by the systems of the known art.

[0019] The measuring process of the length of yarn wound onto a bobbin is effected with the following steps. The length of yarn wound onto the conical bobbin is measured at discreet winding intervals, and the length of yarn m_{fy} measured in a tangential direction and in the interval is according to the formula:

$$m_{fy} = \Delta N_r \; \pi \; \phi_r \qquad (d)$$

wherein ΔN_r is the number of revs of the bobbin in the interval and ϕ_r indicates the bobbin diameter revealed during the same interval.

[0020] Contemporaneously, within the same interval the length of thread wound m_{fx} measured in an axial direction, is measured according to the formula:

$$m_{fx} = \Delta N_c \; T/N_e \qquad (e)$$

wherein ΔN_c is the number of revs of the cylinder in the interval, T is the traversing run and N_e is the number of helixes of the cylinder. The total length m_f wound within the measurement range therefore results from the composition of the two components:

$$m_f = [\; m_{fx}^2 + m_{fy}^2 \;]^{1/2} \qquad (f)$$

or

$$m_f = [\; (\Delta N_c \; T \;/\; N_e)^2 + (\Delta N_r \; \pi \; \phi_r)^2]^{1/2} \qquad (g)$$

[0021] The overall length of wound thread is therefore measured by integrating the partial lengths progressively recorded during the advancement of the bobbin. If the measuring intervals are sufficiently small to assume that the diameter ϕ_r does not substantially vary during each of these intervals and that the return rate of the thread is constant, the progressive length therefore faithfully corresponds to the sum of the lengths m_f revealed from the beginning of the bobbin.

[0022] Discreet measuring intervals of the length wound can be simply equal time intervals, for example by effecting a measurement every two seconds, and then summing the lengths measured. These intervals do not necessarily have to be the same as each other.

[0023] According to a preferred embodiment of the present invention, discreet measuring intervals are adopted with reference not to time but to the progressive number of revs of the activation cylinder from the beginning of the bobbin, for example every hundred revs of the cylinder. In this way, the partial lengths measured each time are cleared of the effects of the rotation periods at a variable rate due to interruptions in the thread and subsequent joinings, winding modulations to avoid tangling on the bobbin, or periods of transitory movement for any reason. In addition to this, there is the advantage of the simplification that the first of the addends of the expression (g) is a fixed term which does not have to be determined each time.

[0024] The measurement of the real diameter of the bobbin, according to the preferred embodiment of the present invention, is effected with a distance sensor 20, for example a reflection laser sensor, assembled integrally on the bobbin-holder arm 11, as shown in figure 2, in a fixed geometrical position and oriented for measuring the distance between the surface of the bobbin and the emitter, preferably according to a straight line 22, intersecting the axis of the bobbin 21 and orthogonal thereto, in an axial coordinate having a value a. In this way the decreasing measurement of the distance from the bobbin also supplies the measurement of the radius of the growing bobbin, as the geometry of the arm is fixed and the arm moves integrally with the growing bobbin. The deformation of the surface of the bobbin in the supporting line on the cylinder does not influence the measurement of the diameter as the measuring point is suitably situated at a due distance from said line, as illustrated in figure 2. The bobbin 10 is shown in the figure in its dimension in the initial phase of its formation.

[0025] In the case of conical bobbins, the axial positioning of the sensor 20 determines the axial coordinate in which the measurement of the diameter is effected and influences the value of the measurement of the ϕ revealed in that coordinate. Said axial coordinate can simply be the coordinate of the barycentre of the bobbin. The axial coordinate of diameter sensor can also be selected differently. Once said axial coordinate and the conicity of the bobbin are known, it is easy to know the diameter in each axial coordinate of the bobbin. With reference to the diagram of figure 3, at a certain advancement degree of the bobbin, by measuring the diameter of the bobbin ϕ_a at the axial coordinate a and knowing the conicity α of a bobbin having a height T (equal to the traversing run), the diameter ϕ_{tip} of the tip of the bobbin and the diameter ϕ_{base} of the base of the bobbin prove to be

$$\phi_{tip} = \phi_a - 2a \text{ tang } \alpha \qquad \text{(h)}$$

$$\phi_{base} = \phi_{tip} + 2T \text{ tang } \alpha \qquad \text{(i)}$$

whereas the average diameter of the bobbin $\phi_{average}$ proves to be:

$$\phi_{average} = (\phi_{tip} + \phi_{base})/2 = \phi_a + (T-2a) \text{ tang } \alpha \qquad \text{(l)}$$

[0026] Once the geometry of the bobbin is known, the measurement of the diameter of the bobbin corresponding to a certain axial coordinate allows the diameter of the spiral wound in each axial coordinate of its generatrix to be calculated, according to a linear law if the cylinder has a helix cavity with a constant pitch or according to a law of weight if said helix has a variable pitch.

[0027] As described so far, the measuring device of the length of yarn wound onto a bobbin according to the present invention consists of the following components:

- a progressive revolution counter 30 for the activation cylinder of the bobbin,
- a progressive revolution counter 31 for the bobbin. The above revolution counters can be produced with different techniques. The revolution counter, for example, can be produced as a disk integral with the rotating part - for example with a keyed disk 30 inserted onto the axis of the activation cylinder 16 in figure 1, or on the bearing of the mandrel of the bobbin-holder arm - having an outer surface with magnetic poles N-S and a Hall-effect probe suitably positioned for revealing the passage of said rotating poles. With each passage of a N polar expansion (or also the opposite S) the sensor generates an electric impulse, transmitted to the control unit with the line 33. As the number of poles arranged on the circumference of the magnetic disk is known, it is possible, by counting the number of impulses, to determine the number of revolutions effected. If the measurement is repeated at known intervals (regular and irregular), it is thus possible to determine the rotation rate of the disk and consequently of the cylinder or bobbin. Possible alternatives can be obtained by integrally applying toothed wheels of ferromagnetic material to the rotating part, controlled with induction probes, or with wheels with N holes or teeth controlled with an optical blockage fork (emitter + receiver), or a reflecting disk with opaque "notches" in the circumference controlled with an optical reflection sensor.
- a measurer 20 of the diameter of the bobbin 10, preferably firmly positioned on the bobbin-holder arm. It can be produced with various procedures. For the direct measurement of the diameter a reflection laser can be used, which calculates the distance between the sensor and the object by means of the triangulation technique, or a so-called "flight time" laser which measures the time displacement between the ray emitted and that reflected: the greater the distance, the greater the displacement/delay will be. Alternatively, as the geometry of the bobbin-holder arm is known, the detection of the geometrical position of the arm with respect to the activation cylinder allows the measurement of the diameter of the bobbin to be obtained. Said detection can be effected, for example, with an angular potentiometer which provides the measurement of the rising of the bobbin-holder arm with respect to the activation cylinder: when the geometry of the group is known, the diameter of the bobbin can be determined. Analogously, the measurement of a distance of a point integral with the bobbin-holder arm with respect to a point integral with the cylinder group, by means of an induction or magnetic or optical sensor allows the diameter of the bobbin in formation to be obtained.

[0028] Reflection laser sensors, which form one of the preferred embodiments of the invention, can be easily assembled with precision on the bobbin-holder arm 11, for example with the help of positioning templates, whereby it is possible to fall within the tolerances requested for the precise measuring of the bobbin diameter with these types of sensors.

[0029] With respect to the bobbin length measuring systems of the known art, the measuring process and device according to the present invention offer considerable advantages among which the following are worthy of mention. The measurement is insensitive to slippages, as a velocity measurement is effected directly on the bobbin, and also insensitive to the slippage variation of the bearings and to environmental factors. The measurement is also insensitive to the higher or lower density of the bobbin, as the measurement of the bobbin diameter can be effected in an area which is not influenced by the flattening of the bobbin. The reading is independent of the type and count of the yarn, which can be single, twisted, regular or irregular, smooth or hairy.

[0030] The calculation of the length is simple, it does not require a high calculating capacity or high processing rate. The application of the device does not hinder the thread run and is in a protected position with respect to impact or contacts, also accidental.

Claims

1. A process for the measuring of the length of the yarn wound onto a bobbin **characterized by** the sequence of the following steps, effected at discreet measuring intervals of the winding and for each interval:

   - determination of the length of yarn m_{fy} wound in a tangential direction,
   - determination of the length of yarn m_{fx} wound in an axial direction,
   - composition of the two lengths of yarn wound in a tangential and axial direction to obtain the partial length m_f spirally wound onto the bobbin at each interval progressively indicated,
   - integration of the partial lengths m_f progressively indicated during the formation of the bobbin to obtain the length progressively wound.

2. The process for measuring of length of yarn according to claim 1, **characterized by** the following steps:

   - determination of the length of yarn m_{fy} wound in a tangential direction, on the basis of the measurement of the number of revs of the bobbin ΔN_r in the interval and the bobbin diameter revealed ϕ_r during the same interval, according to the formula:

   $$m_{fy} = \Delta N_r \ \pi \ \phi_r$$

   - determination of the length of yarn m_{fx} wound in axial direction in the same interval on the basis of the measurement of the number of revs ΔN_c of the cylinder in the interval, according to the formula:

   $$m_{fx} = \Delta N_c \ T/N_e$$

   T being the traversing run and N_e is the number of helixes of the cylinder,
   - composition of the two tangential and axial components according to the formula:

   $$m_f = [(\Delta N_c \ T \ / \ N_e)^2 + (\Delta N_r \ \pi \ \phi_r)^2]^{1/2}$$

   - integration of the partial lengths m_f progressively indicated during the formation of the bobbin.

3. The process for measuring the length of yarn according to claim 1, **characterized in that** the discreet measuring intervals refer to the progressive number of revs of the activation cylinder from the start of the bobbin.

4. The process for measuring the length of yarn according to claim 2, **characterized in that** the diameter ϕ_r of the bobbin is measured in the axial coordinate of the barycentre of the bobbin.

5. The process for measuring the length of yarn according to claim 2, **characterized in that** the measurement of the diameter of the bobbin ϕ_r is effected with a distance sensor, assembled integrally onto the bobbin-holder arm.

6. The process for measuring the length of yarn according to claim 5, **characterized in that** the measurement of the diameter of the bobbin ϕ_r is effected with a reflection laser sensor.

7. The process for measuring the length of yarn according to claim 5, **characterized in that** the measurement of the diameter of the bobbin ϕ_r is effected in a point suitably positioned at a due distance from the supporting line on the cylinder, so that the deformation of the surface of the bobbin does not influence the measurement of the diameter of the bobbin.

8. The process for measuring the length of yarn according to claim 2, **characterized in that** the measurement of the diameter of the bobbin ϕ_r is effected by detecting the geometrical position of the arm itself with respect to the activation cylinder.

9. The process for measuring the length of yarn according to claim 8, **characterized in that** the detection of the geometrical position of the arm with respect to the activation cylinder is effected with an angular potentiometer which provides the measurement of the rising of the bobbin-holder arm (11) with respect to the activation cylinder (16).

10. Device for measuring the length of the yarn wound onto a bobbin comprising the following components:

    - a progressive revolution counter (31) for the activation cylinder of the bobbin,
    - a progressive revolution counter (30) for the bobbin,
    - a measurer (20) of the diameter of the bobbin ϕ_r.

11. The device for measuring the length of the yarn wound onto a bobbin according to claim 10, **characterized in that** the revolution counter devices (30, 31) are produced as magnetic disks integral with the rotating part, equipped with N-S magnetic poles associated with a Hall-effect probe positioned for revealing the passage of said rotating poles.

12. The device for measuring the length of the yarn wound onto a bobbin according to claim 10, **characterized in that** the measurer (20) of the diameter of the bobbin ϕ_r is a distance sensor firmly positioned on the bobbin-holder arm.

13. The device for measuring the length of the yarn wound onto a bobbin according to claim 12, **characterized in that** the measurer (20) of the diameter of the bobbin ϕ_r is a reflection laser sensor.

14. The device for measuring the length of the yarn wound onto a bobbin according to claim 10, **characterized in that** the distance measurer (20) is suitable for revealing the diameter of the bobbin ϕ_r (10) in a point duly distant from the supporting line on the cylinder (16), so that the deformation of the surface of the bobbin does not influence the measurement of the diameter of the bobbin.

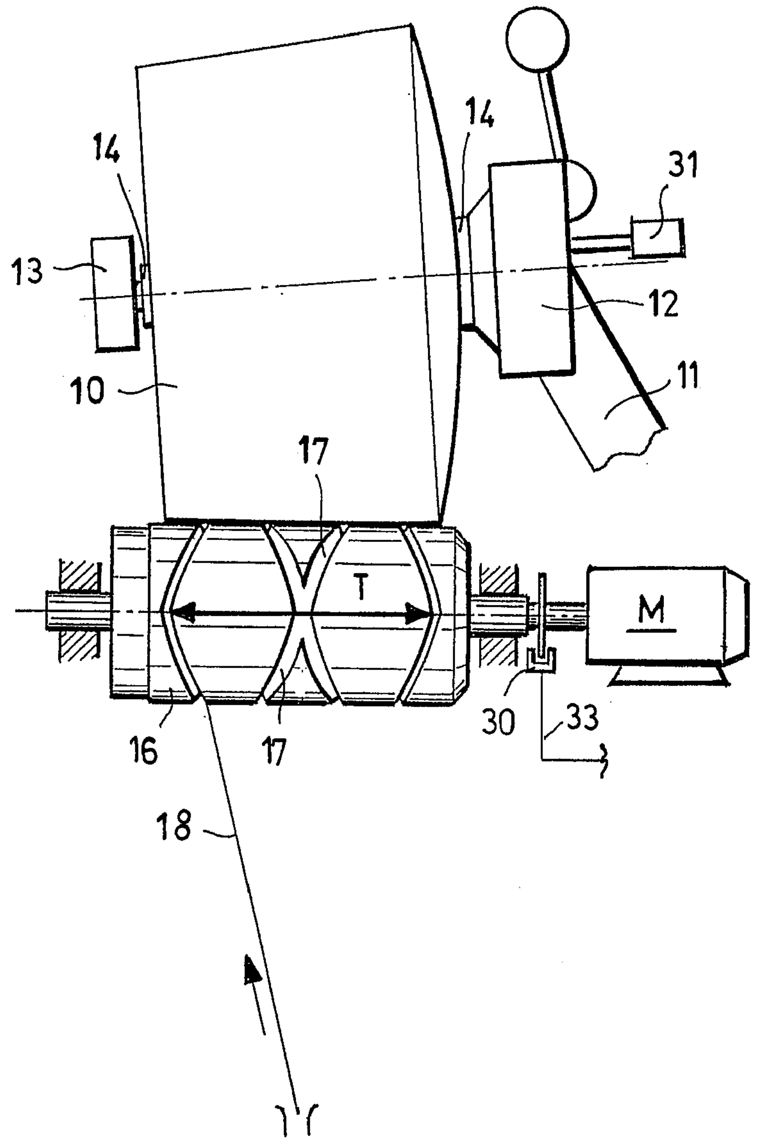
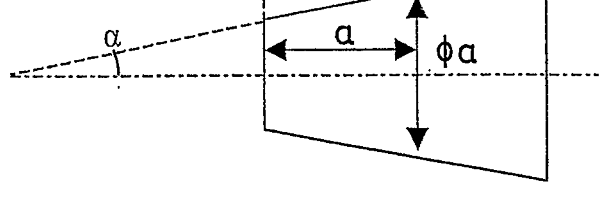


Fig.1

Fig.3



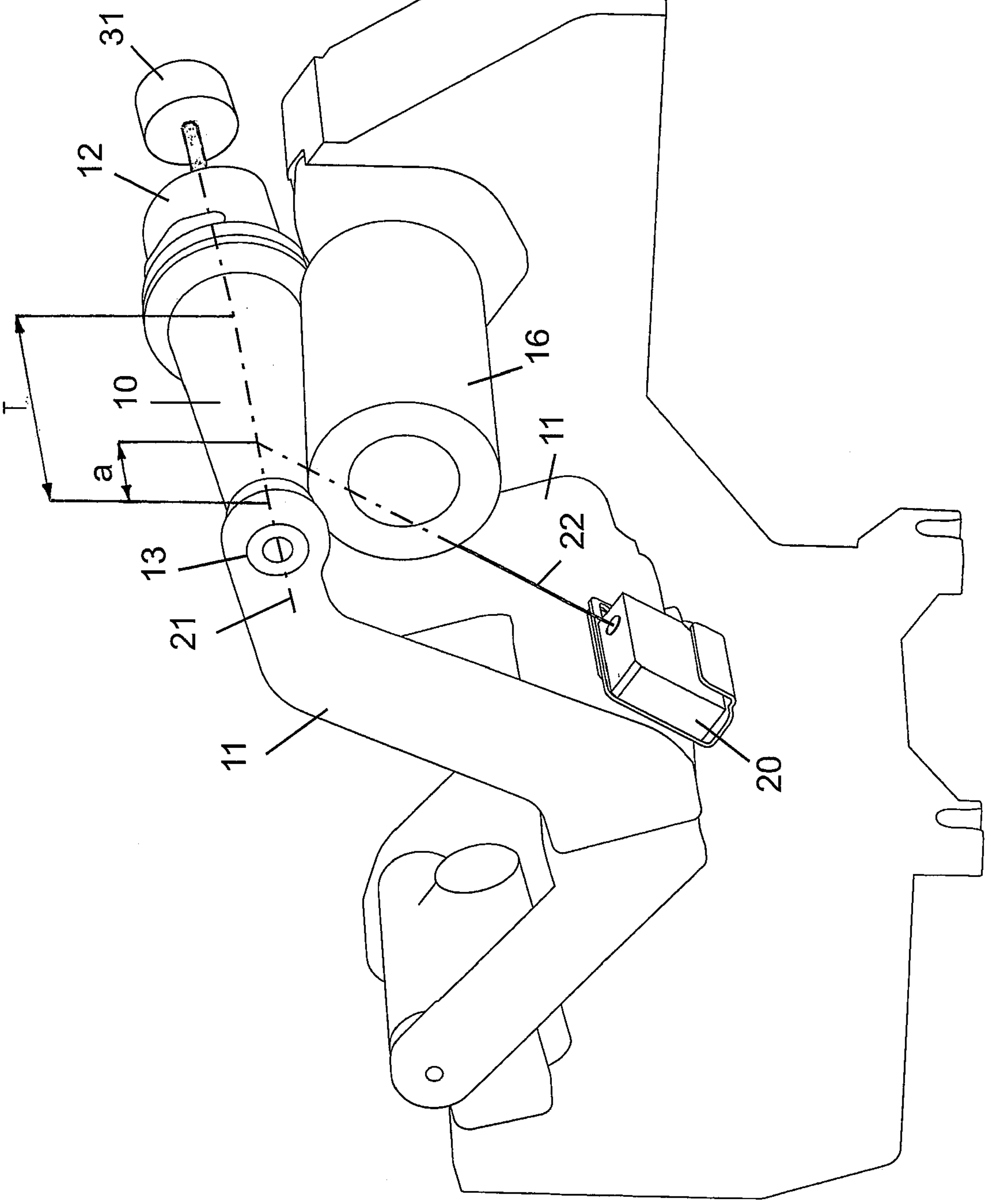


Fig. 2

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EUROPEAN SEARCH REPORT

Application Number
EP 06 12 1012

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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	23 February 2007	Pollet, Didier

CATEGORY OF CITED DOCUMENTS

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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