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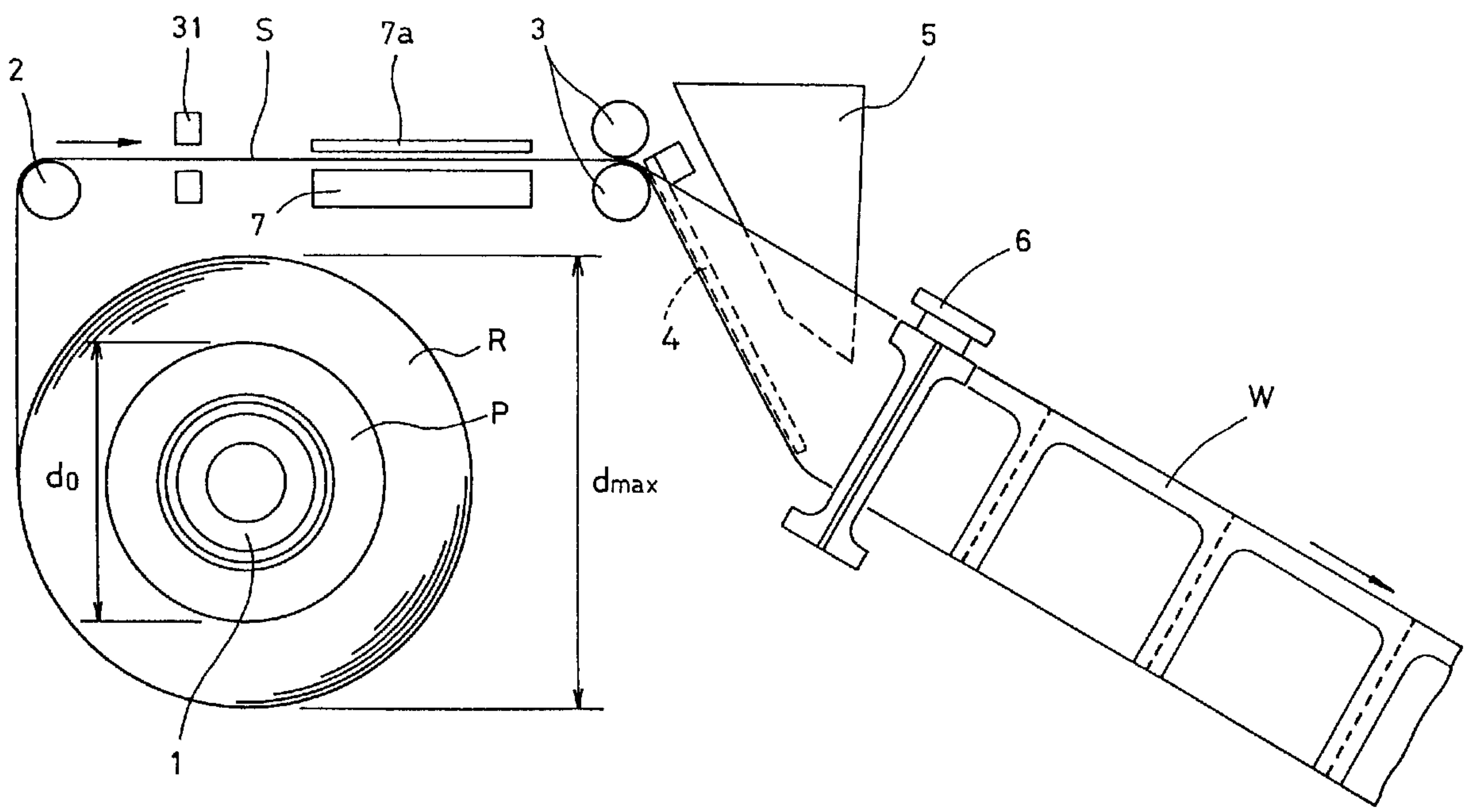

(57) Abrégé/Abstract:
It is desired to prevent disalignment of the edges of a folded sheet by smoothly feeding the sheet while keeping tension fluctuactions to a minimum when the sheet is unwound from a paper roll set in a paper feed unit to a packaging unit even though the paper roll diameter decreases gradually as the sheet is unwound. A sheet length measuring sensor or rotary encoder is provided in the paper feed path through which the packaging sheet unwound from the paper roll is fed toward the packaging unit. An angle sensor is provided which comprises Hall element sensors provide on a support shaft and magnets provided on a core pipe of the paper roll. Any change is the signals from one of these sensors relative to the signal from the other sensor is used to calculate the paper roll winding length, and the sheet tension is adjusted to an optimum, constant level by controlling the sheet braking force stepwise according to the roll diameter measured by the sensors.

ABSTRACT OF THE DISCLOSURE

It is desired to prevent disalignment of the edges of a folded sheet by smoothly feeding the sheet while keeping tension fluctuactions to a minimum when the sheet is unwound from a paper roll set in a paper feed unit to a packaging unit even though, the paper roll diameter decreases gradually as the sheet is unwound. A sheet length measuring sensor or rotary encoder is provided in the paper feed path through which the packaging sheet unwound from the paper roll is fed toward the packaging unit. An angle sensor is provided which comprises Hall element sensors provide on a support shaft and magnets provided on a core pipe of the paper roll. Any change is the signals from one of these sensors relative to the signal from the other sensor is used to calculate the paper roll winding length, and the sheet tension is adjusted to an optimum, constant level by controlling the sheet braking force stepwise according to the roll diameter measured by the sensors.

DEVICE FOR ADJUSTING TENSION APPLIED TO SHEET

BACKGROUND OF THE INVENTION

This invention relates to a device for adjusting the tension applied to a sheet pulled out of a sheet roll in a stepwise manner according to the change in diameter of the sheet roll.

One conventional drug packaging device includes a sheet feed unit rotatably supporting a rolled sheet of heat-fusible packaging paper, and a sealing device provided in a feed path through which the packaging sheet is unwound and fed. Upstream of the sealing device, the sheet is folded in half, drugs are supplied, and the sheet is heat-sealed in the width direction and along the edges by the sealing device to seal the drugs.

When the packaging sheet runs out, a new paper roll is set in the paper feed unit, and the new sheet is unwound and fed. When the sheet is fed, it has to be tensioned uniformly so that the sealing position will not deviate due to inaccurate folding of the sheet. But actually, the tension applied to the sheet changes gradually because the diameter of the paper roll changes gradually as the sheet is unwound.

Examined Japanese utility model publication 1-36832 discloses a sheet tension adjusting device which can apply uniform tension to the sheet even when the diameter of the sheet roll changes. The sheet tension adjusting device disclosed in this publication has a roll support cylinder on which is detachably mounted a sheet roll. A plurality of roll diameter detection sensors are provided at the side of the sheet roll. Signals from these detection sensors are used to control the electromagnetic force produced by an electromagnetic brake provided in the roll support cylinder so that the braking force decreases stepwise as the roll diameter decreases.

With this conventional sheet tension adjusting device, the length of the sheet on the roll, which changes as the sheet is unwound, is detected stepwise by the roll diameter sensors arranged in the diametric direction of the roll. Thus, when the roll diameter decreases to a point where the detection sensor rank changes, the braking force rank of the electromagnetic brake will fluctuate up and down for every rotation due to deviation of the axis of the core shaft, the weight of the sheet, or winding strain.

If this happen, the sheet edges cannot be aligned accurately when the sheet is folded in half. Complete packaging is thus impossible. Since the braking force rank changes sharply, the sheet may suffer a laceration in the width direction.

Light reflecting type detection sensors have a problem in that they are more likely to malfunction. Packaging sheets used for a drug packaging device include semitransparent, or transparent heat-fusible paper and many other kinds of paper. If the end position of such a sheet changes, light is reflected differently, making it impossible to detect the reflected light as a signal. This deteriorates detecting accuracy. Further, it tends to meander under the influence of humidity variations. Detection accuracy may deteriorate due to uneven end faces.

A thermal printer is usually provided upstream of the position where the sheet is folded in half for printing the packaging sheet. If the sheet vibrates, its printing dots may chip, or the durability of a remainder indicator lamp may deteriorate.

Besides this problem, it is essential to provide a function for detecting breakage of a sheet when a sheet has run out of one roll or if a sheet has broken due to excessive braking force, to prevent various devices having the tension adjusting device from stop functioning, to eliminate a waste of time, and to prevent influence on the tension adjusting work itself. But conventional tension adjusting devices have no such function.

An object of this invention is to provide a sheet tension adjusting device which can stably apply suitable tension to the paper feed portion according to the diameter of a paper roll around which is wound an ultra-thin sheet by setting a braking force for every step without producing level changes of the braking force selected in a stepwise manner due to the influence of slight change in the diameter of the paper roll, whereby sheets can e processed without any trouble, and which can cope with breakage of a sheet.

SUMMARY OF THE INVENTION

According to this invention, there is provided a sheet tension adjusting device for adjusting tension of a sheet fed from a paper roll mounted on a roll support cylinder rotatably mounted on a support shaft to a sheet processing station, the device comprising brake means engaging the roll support cylinder for applying a braking force, an angle sensor for detecting the rotation angle of the roll support cylinder, a sheet length sensor for measuring the feed length of the sheet on the sheet feed path to the sheet processing station, and a control unit comprising a tension adjusting unit for calculating the current sheet length or diameter or the diameter of the roll based on the sheet length or the rotation angle measured by either sensor, and adjusting the tension in the sheet being fed to the sheet processing station by adjusting a DC voltage applied to the broke means in a stepwise manner and constantly in each step according to the diameter of the roll to control the braking force of the brake means, and a sheet breakage detection unit for judging that the sheet has broken, based on whether or not one or both of the sheet length sensor and the angle sensor are producing signals.

In this sheet tension adjusting device, two sensors, i.e. the sheet length sensor and the angle sensor are used. When detection signals from the two sensors are received, a change in the amount of winding is directly obtainable from the change in the signal from one sensor while using a predetermined amount of the other sensor as a reference.

By correlating a predetermined range of change in roll length with a change in the roll diameter beforehand, it is possible to select a stepwise control level of the braking force simply by detecting the change in the roll length. Thus, it is possible to adjust the sheet tension to an optimum level for each stage by controlling the braking force according to the roll diameter.

In this case, each rank of the braking force is changed over from a larger to a smaller value within such a range that there will be no trouble in sheet processing due to a change in tension when the braking force is changed in a stepwise manner. Thus, while in the conventional arrangement in which the winding diameter of the paper roll is directly detected by a sensor, each rank of the braking force tends to change sharply near the diameter where the rank of the braking force changes over due to uneven winding, the device of this invention is free of this problem.

Also, when the signals form the two sensors, i.e. the sheet length sensor and the angle sensor are inputted into the control unit, the fact that the sheet has broken is judged by the judging unit based on whether or not there exist signals from the two sensors, separately from the operation for the tension adjustment. Based on the results of judgment, feed of the sheet is stopped, or the tension adjusting device is stopped.

Other features and objects of the present invention will become apparent from the following description made with reference to the accompanying drawings, in which:

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a partial schematic view of a paper feed unit and a packaging unit of a packaging device;

Fig. 2 is a vertical sectional view of the paper feed unit with a roll of paper mounted thereon;

Fig. 3 is a schematic block diagram of a control circuit of a tension adjusting device for a packaging sheet;

Fig. 4 is a side view a paper feed unit as viewed in the direction of arrow VI-VI of Fig. 2;

Fig. 5 is a side view of the paper feed unit as viewed in the direction of the arrow V-V of Fig. 2;

Fig. 6 is a schematic view of an angle sensor;

Fig. 7A-7D are schematic views of different type angle sensors;

Fig. 8A and 8B are views showing basic function of the tension adjusting device;

Fig. 9 is a flowchart showing a special operation mode;

Fig. 10 is a flowchart showing a normal operation mode;

Fig. 11 is a graph showing the relationship between the DC voltage applied and the winding length during the special mode;

Fig. 12 illustrates how a slip detection sensor detects slipping;

Fig. 13 is a flow chart for explaining the function of detecting the breakage of sheet; and

Fig. 14 is a diagram for explaining how the signals from the sensor are used.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Embodiments of this invention are described with reference to the drawings. Fig. 1 is a schematic diagram of a drug packaging machine, showing mainly a paper feed unit and a packaging unit. The paper feed unit has a support shaft 1 on which is rotatably mounted a core pipe P on which is wound a roll R of a drug packaging paper sheet S. The sheet S is unwound from the roll R, and fed through feed rollers 2, 3 to the packaging unit.

In the packaging unit, the sheet is longitudinally folded in half by a triangular plate 4. Drugs are dropped into the space defined in the folded sheet. The sheet is then heat-sealed widthwise and along both side edges at predetermined intervals by heating rollers 6 with perforators. While the packaging unit includes numerous other parts, only essential parts are shown for simplicity.

Fig. 2 is a partial vertical section of the paper feed unit in which the roll paper R and the core pipe P are set. As shown, the support shaft 1 comprises a center shaft 1a having one end thereof fixed to a support plate 11 by a nut, an outer shaft 1b integrally mounted around the center shaft 1a, and a hollow shaft 1c rotatably mounted on the outer shaft 1b through bearings 12 provided near both ends of the outer shaft 1b.

The center shaft 1a has a shaft head 13 at one end. The outer shaft 1b has a flange 14 at the same one end. The hollow shaft 1c has a flange 15 at the other end. The core pipe P and the roll paper R, mounted on the hollow shaft 1c, are rotatable relative to the support shaft 1. A plurality of magnets 16 are provided on the inner peripheral surface of the flange 15 at suitable intervals. Ferromagnetic (iron) members 17 are provided along the circumference of an end face of the core pipe P. The magnets 16 attract the ferromagnetic member 17 to detachably mount the core pipe P and the roll paper R on the hollow shaft 1c.

Packaging sheet S unwound from the roll paper R is suitably tensioned by a motor brake 20 engaging the hollow shaft 1c. The motor brake 20, mounted on the support plate 11, is connected to a gear unit 21 through a transmission belt, not shown. The gear unit 21 has an output shaft on which is mounted a pinion 22 in mesh with a large gear 23 provided on the outer peripheral surface of the flange 15. Thus, by activating the motor brake 20, braking force is applied to the hollow shaft 1c.

The motor brake 20 is a small AC motor powered by a DC voltage. As will be described below, braking force is variable in four stages according to the tension in the packaging sheet S being unwound by changing the DC voltage applied in four stages.

As shown in Fig. 3, the control unit 30 receives the signals from a rotary angle sensor assembly comprising four magnets 24 and four Hall element sensors 25, and a sheet displacement sensor comprising a proximity switch 26 and projections 27.

Specifically, the control unit accurately calculates the length of the sheet S unwound from the paper roll R based on the sheet length sensor signal of the first embodiment and the signal from the rotation angle sensor, and adjusts the braking force corresponding to the variation in diameter of the roll R to adjust the tension applied to the sheet.

As shown in Fig. 6, the four magnets 24 of the second embodiment are provided on the inner peripheral surface of the core pipe P at angular intervals of 67.5° around the axis of the pipe P, while the four Hall element sensors 25 are provided at one end of the support shaft 1 at equal angular intervals of 90° around the axis of the pipe P.

The numbers and positions of magnets 24 and sensors 25 are however not limited to those shown in Fig. 6. Fig. 7 shows some variations of their numbers and arrangement. In any variation, the Hall element sensor or sensors 25 produces a pulse signal every time the core pipe P rotates 22.5° .

Also, instead of the combination of magnets 24 and Hall elements 25, photosensors may be used to detect the rotation of the core pipe P. Such photosensors comprise light emitting diodes and light interceptors and are fixed to one end of the support shaft 1 (outer shaft 1b) as with the Hall elements 25.

More particularly, such photosensors are mounted on an extension or mounting seats provided on the flange end of the outer shaft 1b, while projections are provided on the core pipe P at angular intervals of 22.5° so as to pass between the light emitting diodes and the light interceptors of the photosensors. The numbers of the photosensors and the projections are the same as the Hall element sensors 25 and the magnets 24.

Fig. 3 schematically shows a block diagram of a circuit for controlling various parts of the device for feeding packaging sheet from the paper feed unit and packaging drugs. Its control unit 30 receives signals from an end sensor 31, those from a rotary encoder 32 provided near the feed rollers 3, and those from a revolving speed counter 33 mounted on the output shaft of a motor 6a coupled to the shaft of one of the heating rollers 6, and produces, based on one of the above signals, outputs for activating the motor brake 20 or the motor 6a. Numeral 34 indicates an input unit for inputting external data.

Fig. 5 is a side view as viewed in the direction of arrow VI-VI of Fig. 2, and mainly shows the position of the displacement detection sensor for the packaging sheet. In this example, a single proximity switch 26 is provided on the support plate 11. Sixteen projections 27 are provided on the flange 15 of the rotatable hollow shaft 1c of the support shaft 1.

If there is a difference in pitch between the rotation angle sensor signal detected by the Hall element sensors 25 and the signal detected by the displacement detection sensor, the control unit determines that there is a displacement.

In the drug packaging device, drugs are packaged while adjusting the sheet tension in the following manner.

In this embodiment, the maximum diameter d_{max} and the minimum diameter d_0 of the roll paper R to be set in the paper feed unit are known beforehand. As shown in Fig. 8, braking force produced by the motor brake 20 is varied in four stages according to the signal from the rotary encoder 32 to apply suitable tension to the sheet by adjusting the braking force according to the changing diameter of the paper roll R.

The roll paper R shown has a maximum diameter d_{max} = 160 mm, minimum diameter $d_0 \fallingdotseq$ 64 mm, and sheet thickness γ = 30 μm. In this case, braking force produced by the motor brake is varied every time the diameter of the paper roll R decreases (160 - 64)/4 = 24 mm.

The length L of the sheet forming a roll R of a given diameter is given by the following formula:

$$L = [(d_0+2\times\gamma) + (d_0+2\times 2\gamma) +\cdots+ (d_0+2\times(n-1)\gamma + (d_0+2\times n\gamma)]\pi$$

$$= [nd_0 + 2(1+2+\cdots+n-1+n)\gamma]\pi$$

$$= [nd_0 + 2 \times \frac{n(n+1)}{2}\gamma]\pi$$

$$= [d_0+ (n+1)\gamma)] n\pi \qquad \cdots(1)$$

(wherein n is the number of turns)

The diameter of the roll R is given as follows:

$$d_{max} = d_0 + 2 \times n\gamma \qquad \cdots(2)$$

From Formula (1), the length L_{max} of the sheet forming the roll R when the roll diameter is maximum is:

$L_{max} = [64 \times n + n(n+1) \times 30n \times 10^{-3}]\pi$

From Formula (2), $d_{max} = 64 + 2 \times 30n \times 10^{-3} = 160$ (mm)

Thus, $n = 96/6 \times 10^{-2} = 1600$

Hence, $L_{max} = (64+1601\times 30\times 10^{-3}) \times 1600\pi$

$= 562,688$ (m)

Now, let the diameter range of the roll paper divide into four stages N = 1 (largest), 2 (second largest), 3 (third largest) and 4 (smallest). The maximum sheet length of the roll in each stage is given by the following formulas:

where N = 1, $L_{max} = 562,688$ (m), (n = 1600, d_{max} = 160) where N = 2, L_{max} = 376,800 (m), (n = 1200, d_{max} = 136)

where N = 3, L_{max} = 221,056 (m), (n = 800, d_{max} = 112)

where N = 4, L_{max} = 95,456 (m), (n = 400, d_{max} = 88)

In Figs. 8A, 8B, for the convenience of the description of operation, the number and arrangement of magnets 24 and Hall element sensors 25 are different from those in the abovesaid embodiment. But its basic operation is the same in that one pulse signal is produced for every 22.5° rotation.

As shown Fig. 8A, when the radius of the paper roll is large, the angle sensor produces fewer pulses while the packaging sheet is unwound by the length l. As the paper roll radius decreases as shown in Fig. 8B, the number of pulses increases. If the pulse numbers when the paper roll radius is at its maximum and minimum is 3 and 10, respectively, the range of pulse numbers from 3-10 are divided into four stages so as to apply D/C currents that can apply suitable tension corresponding to the respective stages to the motor brake 20 to adjust the braking force.

There is the following relationship between the above tension level N = 1-4 and the pulse number. Provide the maximum and minimum diameters of the paper roll R are

160 mm and 64 mm, respectively, the length of the sheet unwound from the roll when the roll diameter is maximum will be $\pi \times 160$ mm. Since the angle sensor 25 produces one pulse signal for every 22.5° rotation (16 pulses for every full turn), the sheet is unwound by $\pi \times 160/16 =$ 314 m/m. For the unwound length of 3140 m/m, the pulse number will be 10.

When the roll diameter is minimum, there is the following relation between the length of sheet unwound and the pulse number. That is, since $\pi \times 64/16 =$ 129.5 m/m, for the unwound length of 3140 m/m, the pulse number will be $3140/1295 \times 10 = 24.2$.

The pulse number and the DC voltage for every tension level N are determined as follows:

Tension Level N	Pulse Number	DC Voltage
N = 1	10-13	25V
N = 2	14-17	16V
N = 3	18-21	12V
N = 4	22-24.2	8V

In the above description, the tension level N is adjusted according to the pulse number for a given unwound length of sheet. But the tension level may be determined based on the unwound length of sheet when a predetermined number of pulses have been produced. More detailed description of this method follows:

Figs. 9 and 10 are flowcharts showing the operation of the tension adjusting device. Specifically, Fig. 10 is a flowchart of a special mode to be carried out before the normal mode of the tension adjusting device. Fig. 10 is a flowchart of the normal mode.

In the special mode shown in Fig. 9, the control unit checks various conditions for the normal packaging operations in the packaging unit so that the normal mode can be carried out smoothly. Before the normal packaging operation, packaging sheet has to be correctly set in the packaging unit. The packaging sheet is usually set manually by inching. The control mode passes this special mode.

In Step S0, the control unit determines if the current mode is the special mode. The special mode starts if any one of the following conditions is met: i.e. the actuation of the end sensor or joint seal, and the detection of inching mode or reverse rotation of the winding length sensor. The joint seal is activated while one paper roll has run out and a new roll is being set and spliced to the preceding sheet.

The inching mode starts by switching on the control unit before the start of all of the operations, and the packaging sheet is manually set in the above-described manner.

The special mode is necessary because a new, complete paper roll is not always set but there is the possibility that a used roll paper having e.g. half the diameter of a new roll may be set. If the roll set has only half the diameter of a new paper roll, the tension is initially adjusted to an intermediate level smaller than the tension corresponding to the diameter of the new roll.

If the current mode is judged to be the special mode in Step S0, the tension is set at the maximum level in Step SS1, and various sensors (reference sensor, rotation number counter, winding length sensor, core pipe slip sensor) are activated (Step SS2). In this state, the packaging sheet is fed little by little by manual inching, and the signals from the sheet length sensor or rotary encoder 32, and the angle sensors or Hall element sensors 25.

In Step SS5, the control unit calculates the sheet length of the paper roll based on these signals using the above-described formulas to determine whether the roll has the maximum diameter or not, e.g. half the maximum diameter. If this calculation is not possible (NO), Step SS3 is carried out again. If possible, the control unit determines in Step SS7 if the conditions for reentering the special mode are all removed. If they are, the tension is adjusted to a suitable level in Step SS8. Steps SS9 and SS10 are steps for detecting slipping of the core pipe, which will be described later.

During tension adjustment in Step SS8, a DC voltage corresponding to maximum tension is set at 25 V if the paper roll has a maximum diameter (new) and at about 20 V if the paper roll diameter is about half the maximum diameter to prevent any abrupt change in tension.

When the tension has been adjusted to a suitable level, the program returns to Step S0 to determine whether or not to carry out the special mode operation again. This time, the program proceeds to the normal mode [A].

In the normal mode shown in Fig. 10, an inching mode switch is manually changed over, and then in Step S1, the previously set data is read out, and the various sensors are kept turned on (S2). By this time, the normal operation of the packaging unit has started. At the start of the normal operation, the tension is controlled to the DC current value suitably set in the special mode.

Then in Steps S3, S4 and S5, the sheet length signal and angle sensor signal are inputted in the same manner as in the special mode to calculate the sheet length of the roll. This calculation is carried out substantially in the above-described manner. If, as a result of calculation, the roll R turns out to be an unused, full-volume roll, the DC voltage is set at 25 V, 16 V, 12 V or 8V in Step S7, S9, S11 or S13 according to the judgment in Steps S6, S8, S10 and S12, in the same way as in the first embodiment. Fig. 11 shows the relationship between the above-described winding length and the DC voltage control.

After the tension control has been carried out via any of the abovementioned routes, the control unit determines if the core pipe is slipping in Step S14 based on the signal from the proximity switch 26. As shown in Fig. 5, the switch 26 is provided opposite to the 16 ferromagnetic projections, and produces a pulse signal every time the core pipe rotates 22.5° in exactly the same manner as the Hall element angle sensors 25.

In the embodiments, the angle sensors 25 and 26 are different types, but they may be of the same type. The time chart of Fig. 12 shows the relationship between the pulse signals produced by the angle sensors and the rotation angle. As shown, the pulse signals by the slip detection sensor can be obtained synchronously with the pulse signals by the winding length detecting sensor unless the winding condition changes with tension.

But if the rotation resistance of the motor brake 20 produced by each of the above-described DC voltages is inappropriate, for example, if the tension is too large at the tension level N = 2, the paper roll R will rotate strongly together with the core pipe P. This may cause a shift in the position where the ferromagnetic members 17 are attracted to the magnets 16. If this happens, although the Hall element sensors 25 keep producing pulse signals at regular angular intervals of 22.5° , the proximity switch 26 may produce two pulse signals simultaneously and fails to produce a signal when the core pipe rotates another 22.5° .

Fig. 12 shows how pulse signals change when such a position shift occurs. As shown, the slip detection sensor fails to produce pulse signals at positions C and D after the core pipe has made a complete turn. Instead, pulse signals are produced between D and A with some displacement.

In such a case, the control unit can determine that the slip detection sensor has failed to produce a pulse signal at position C by referring to the signal from the winding length detection sensor. If, for example, the DC current of 16 V is too high at the level N = 2, so that the tension is too high, the voltage may be reduced to 14 V to adjust the tension to a suitable level. With this voltage adjustment, a pulse signal can be produced at any desired position after position D.

After adjusting any position shift of the core pipe P due to sheet tension variation, the control unit checks in Step S16 if paper is still wound on the pipe P based the signal from the end sensor 31. If the sensor 31 has not yet detected the terminal end of the paper, the

Step S3 operation is carried out, that is, the sheet tension is controlled according to the winding length of the paper roll by repeating the above calculations.

The tension control mode ends when the end sensor 31 detects the terminal end of the packaging sheet S. If it is necessary or desired to continuous packaging thereafter, the program returns to the special mode to replace the roll R with a new one and connect the sheet ends.

Steps SS9 and SS10 are shown by chain lines in the flow chart for the special mode, which means that these steps are not essential. If provided, though, their functions are the same as Steps S14, S15 in the slip detection operation in the normal mode.

The above description has been made on the assumption that the paper roll R is a full-volume roll. If a roll about half the maximum diameter is set in the paper feed unit, after the tension has been adjusted in the special mode to a level slightly larger than the tension during the normal mode when the full-volume roll is unwound to about half the maximum diameter, the normal mode is started. It is thus possible to smoothly start the normal mode without the possibility of an abrupt rise in tension.

In the description of the above embodiments, we have described the sensor assembly comprising the proximity switch 26 and projections 27 as a sensor for detecting "slip" of the pipe P relative to the hollow shaft K. But this sensor assembly may be used as a substitute for the sensor assembly comprising the magnets 24 and Hall element sensor 25 as an angle detector sensor.

The former sensor assembly comprising the proximity switch 26 and projections 27 keeps outputting a pulse signal at the same timing as the angle detection by the Hall element sensor 25 as shown in Fig. 12., as long as no abnormal braking force is applied from the motor 20 (due e.g. to failure of the braking motor 20). Thus, it is possible to use this pulse signal as an angle detection signal.

If the proximity switch is used as an angle detection sensor, the Hall element sensor 25, which is used as an angle detection sensor, is unnecessary and can be omitted. In this case, the angle sensor including the proximity switch 26 acts both as an angle sensor and a slip detection sensor. In order for this sensor to act as a slip detection sensor, a reference signal is needed. Such a reference signal can be provided by the rotary encoder 32.

If abnormal braking force is applied form the braking motor 20, that is, if the motor 20 stops, the hollow shaft K and its flange 15 will stop. Slip thus occurs between the pipe P and the flange 15. If paper is being fed even slightly in this state, the rotary encoder 33 will produce a signal. Thus, the proximity switch 26 can detect that the pipe is slipping relative to the flange 15 from the fact that the pulse signal from the encoder 33 does not coincide with the pulse signal from the proximity switch 26.

In the above embodiments, the angle detection sensor, shift detection sensor and winding length detection sensor (rotary encoder) are all used to determine the diameter of the winding. But it is also possible to detect that the sheet has been cut, using some of these sensors. This function is useful because the sheet tension adjusting device of each embodiment is used with a drug packaging device, and a sheet fed to the packaging device may be cut due to an excessive braking force applied thereto or due to the fact that one of the sheet rolls has run out of sheet.

In the above embodiment, the feed length is detected by the rotary encoder 32. Based on the feed length detected, the sheet length wound on the roll is calculated. Based on the winding length thus calculated, which is a pulse signal of the angle detection sensor or Hall element sensor 25, a winding radius is calculated to adjust the braking force. Also, the "shift" of the core pipe P relative to the flange 15 is detected by the proximity switch 26 as a shift detection sensor. The signals from these sensors can also be used to detect that the sheet has been cut, in the following manner. There are two cases in which the cutting of the sheet is detected.

In the first case, sheet is cut between the paper roll R and the rotary encoder 32. In this case, one or either of the angle detection sensor, which is the Hall element sensor 25 and the shift detection sensor, which is the proximity switch 26 is not producing pulse signals, while the rotary encoder 32 is producing a length measuring signal of the sheet feed length.

In this case, the control circuit 30 can determine that the sheet has been cut by the addition of a program for determining that the sheet has been cut. Based on this judgment, the control circuit 30 transmits a control signal to the motor 6a of the heating rollers 6 to stop the rollers 6, and also transmits a control signal to the feed device for feeding drugs to the packaging device to stop the feed of drugs. The fact that the sheet has been cut is displayed on a display (not shown).

In Fig. 3, the rotary encoder 32 is shown to be mounted on the shaft of a feed roller 3. The rollers 3 shown are a pair of rollers for feeding sheet by sandwiching it therebetween. One of the rollers is driven by a motor, not shown. The rotary encoder 32 is mounted on the shaft of the other roller 3 that is not driven.

The unillustrated motor is driven synchronously with the motor 6a for the heating rollers 6. But it may be omitted, and the feed rollers 3 may be driven by the motor 6a through a belt.

Fig. 13 shows a flowchart of an embodiment having the above-described program for judging that the sheet has broken. As shown, steps S17-S19 are inserted between Steps S4 and S5 of the flowchart of Fig. 10. In S17, it is judged whether or not signals from the sheet length sensor and the angle sensor have been obtained. If data are obtained, the program proceeds to S5.

But if data are not obtained (No), its time is measured in S18. If data are not obtained for a predetermined time, it is judged that the sheet has broken. Thus, an error message is displayed, and if necessary, the abovementioned drive control is stopped. The state of sensor signals when such data are not obtained is shown in Fig. 14. For the second and subsequent rotations of the core pipe P, the state of sensor signals is shown in Fig. 14. For the second and subsequent rotations of the core pipe P, the state in which no sensor signals are inputted is shown. The above process is the same for the next case, too.

The second case is the case where the sheet is not being fed at all. In this case, among the three detection sensors, one or either of the angle detection sensor and the shift detection sensor, and the sheet feed length detection sensor by the rotary encoder 32 are not producing signals at all, whereas the revolution number counter 33, shown in Fig. 3, can count the revolution number signal. In this case, it is possible to detect the cutting of the sheet by providing the judgment program so as to judge that the sheet has been cut. The control after the judgment that the sheet has been cut is the same as in the first case.

The rotary encoder 32 may be provided on the shaft of a feed roller 3 as shown, or on the shaft of the motor 6a for the heating rollers 6. The judgment programs are exactly the same for both of the abovementioned two cases.

If the sheet is cut in either of the above two cases, the judgment program is provided so as to judge that the sheet has been cut if no signal is detected by one or either of the shift detection sensor and the angle detection sensor, while signals are detected by both the rotary encoder 32 and the revolution number counter 33. The control after the judgment that the sheet has been cut is the same as in the first case.

This embodiment is applied to the arrangement in which as shown in Fig. 2 the magnets 16 and ferromagnetic members 17 are provided between the core pipe P and the flange portion 15 of the hollow shaft 1c so that the core pipe P can shift relative to the hollow shaft 1c (flange

15). But this embodimeent is applicable to the arrangement, too, in which instead of such magnetic fixing means, protrusions made up of integral magnets 16 and ferromagnetic members 17 are provided on the flange portion 15 (or on the core pipe P) so that the core pipe P cannot shift in the rotational direction relative to the flange portion 15. In this case, no shift detection sensor is provided because the core pipe P does not shift.

In this case, the proximity sensor 26 can be used as an angle detection sensor. Thus, this sensor or the angle detection sensor comprising the Hall element sensor 25 is used. In this example, even if the sheet is cut halfway or the sheet is not fed at all, no detection signal is produced by the angle detection sensor. Thus, depending on whether the rotary encoder 32 is mounted on the shaft of a roller 3 or the shaft of the motor 6a, the fact that the sheet has been cut is detected by the judgment program which judges that the rotary encoder 32 is or is not producing a signal while the rotation counter 33 is producing a signal.

The sheet cut detection function by means of various sensors and judgment program is necessary in a device of the type in which such data as the feed length of the sheet, winding length, winding diameter are temporarily stored in a memory (RAM), because if the device is stopped and turned off while sheet is being fed, interim data disappear and cannot be used at the restart.

By storing final results in an electrically erasable/programmable read only memory (EEPROM), the judgment results are not erased when reset, so that the device can be restarted correctly.

According to the present invention, the current winding length of the roll and the winding diameter are determined based on the change in the signal from one of the sheet length sensor and the angle sensor relative to the signal from the other sensor, and the sheet tension is adjusted by selecting a braking force corresponding to the diameter. Also, breakage of the sheet can be detected from the presence or absence of the signals from the sheet length sensor and the angle sensor. In this arrangement, even if data on the full winding length is not known, it is possible to adjust the sheet tension by selecting a braking force corresponding to the roll diameter corresponding to the current winding length determined based on the measurement data. Thus, it is possible to smoothly adjust the sheet tension without the possibility of abrupt change in tension. Also breakage of the sheet can be detected.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A sheet tension adjusting device for adjusting tension of a sheet fed from a paper roll mounted on a roll support cylinder rotatably mounted on a support shaft to a sheet processing station, said device comprising brake means engaging said roll support cylinder for applying a braking force, an angle sensor for detecting the rotation angle of the roll support cylinder, a sheet length sensor for measuring the feed length of the sheet on the sheet feed path to the sheet processing station, and a control unit comprising a tension adjusting unit for calculating the current sheet length or diameter or the diameter of the roll based on the sheet length or the rotation angle measured by either sensor, and adjusting the tension in the sheet being fed to the sheet processing station by adjusting a DC voltage applied to said brake means in a stepwise manner and constantly in each step according to the diameter of the roll to control the braking force of said brake means, and a sheet breakage detection unit for judging that the sheet has broken, based on whether or not one or both of said sheet length sensor and said angle sensor are producing signals.

2. The sheet tension adjusting device as recited in claim 1 wherein the control unit includes a special mode in which, before a normal mode in which the tension in the sheet is adjusted while the sheet is being fed, a paper winding length of the roll is calculated based on the signals from the sheet length sensor and the angle sensor in the same manner as in the normal mode by an inching operation in which the sheet is intermittently fed by a predetermined length, and based on the roll diameter calculated from the paper winding length,

the braking force is adjusted to an intermediate level before the start of the normal mode to adjust the tension in the sheet beforehand.

3. The sheet tension adjusting device as recited in claim 1 wherein the control unit detects any deviation in position between the paper roll detachably mounted on the roll support cylinder and the roll support cylinder in a normal mode and/or a special mode based on an inconsistency between the signal from an angle sensor provided between the roll support cylinder and a support plate of the support shaft for detecting the rotation angle of the roll support cylinder and the signal from the angle sensor provided between the paper roll and the support shaft for detecting the rotation angle of the paper roll.

4. The sheet tension adjusting device as set forth in any one of claims 1 to 3 wherein said sheet length sensor is a rotary encoder or a rotation number counter.

5. The sheet tension adjusting device as recited in any one of claims 1 to 3 wherein said angle sensor comprises a Hall element sensor and a magnet.

6. The sheet tension adjusting device as recited in any one of claims 1 to 3 wherein said angle sensor comprises a photosensor and a projection.

7. The sheet tension adjusting device as recited in claim 5 wherein said angle sensor comprises a single Hall element sensor or photosensor and a plurality of magnets or projections, or a plurality of Hall element sensors or

photosensors and a single magnet or projection so that a pulse signal is produced for each of equally divided angular pitches for one full rotation.

8. The sheet tension adjusting device as recited in any one of claims 1 to 3 wherein said angle sensor comprises a proximity switch and a ferromagnetic member.

9. The sheet tension adjusting device as recited in claim 5 wherein said paper roll is a sheet of paper wound around a core pipe, said magnet being provided on the core pipe.

10. The sheet tension adjusting device as recited in claim 6 wherein said paper roll is a sheet of paper wound around a core pipe, said projection being provided on the core pipe.

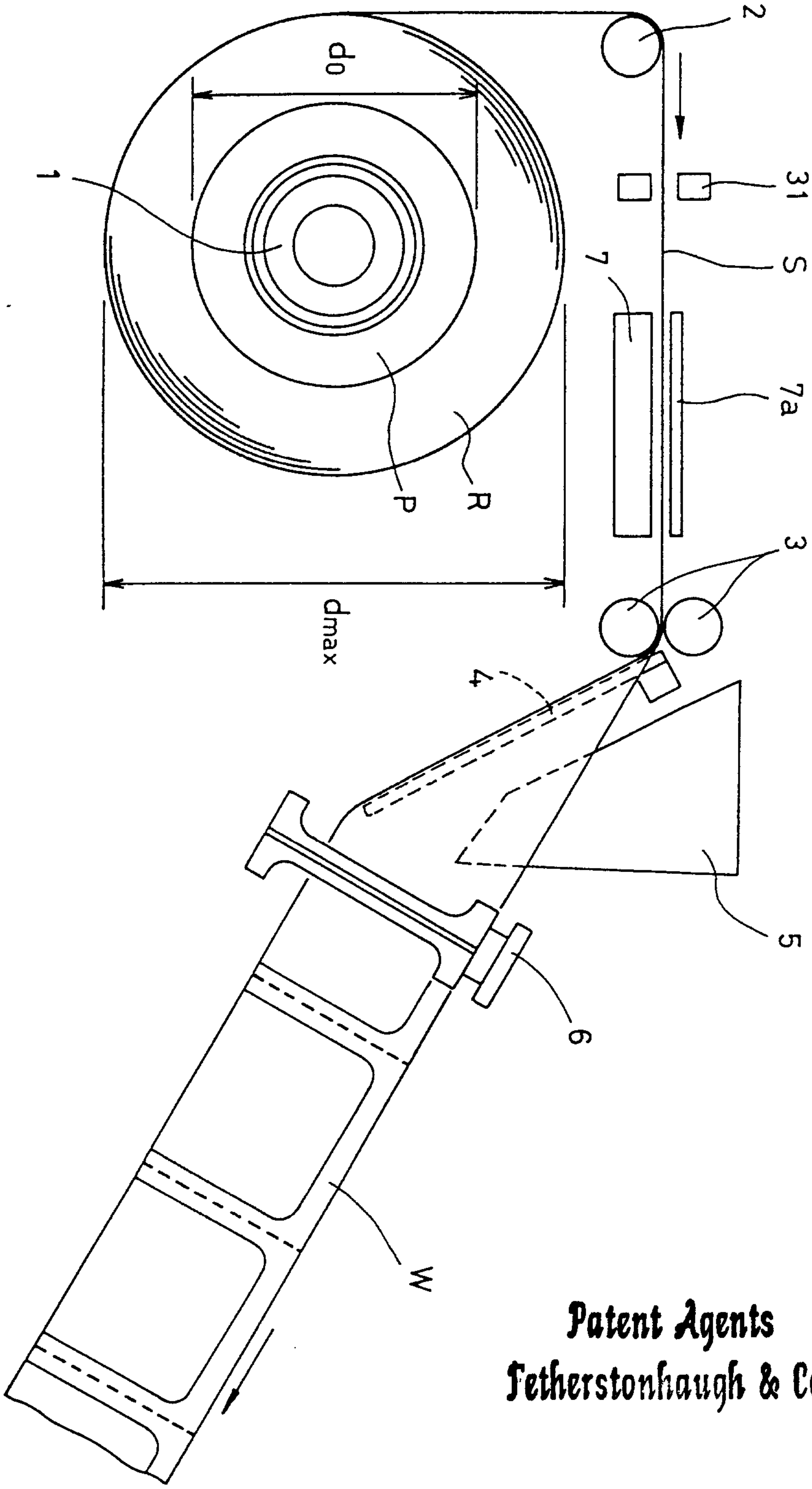

FIG. 1

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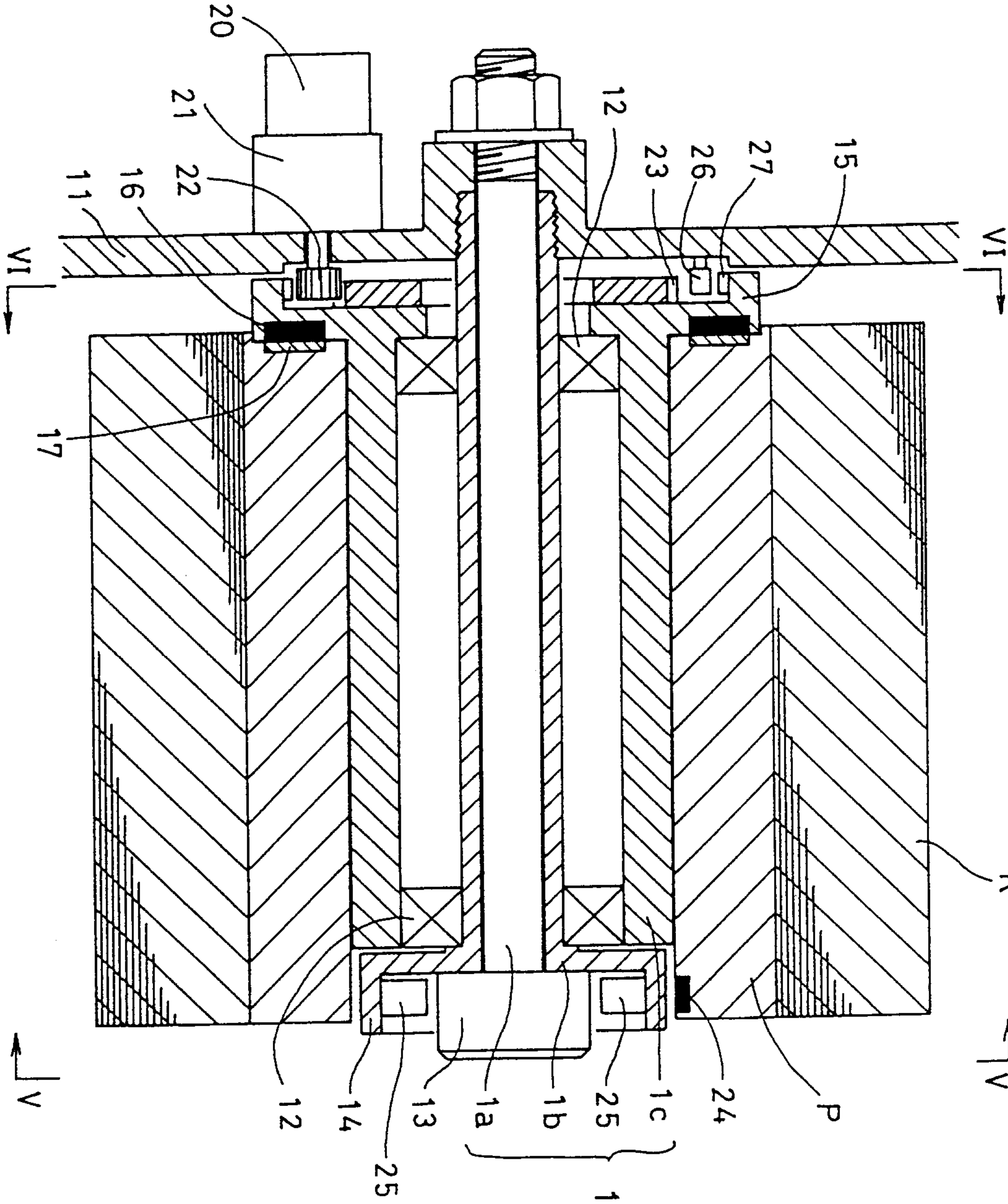

FIG. 2

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FIG. 3

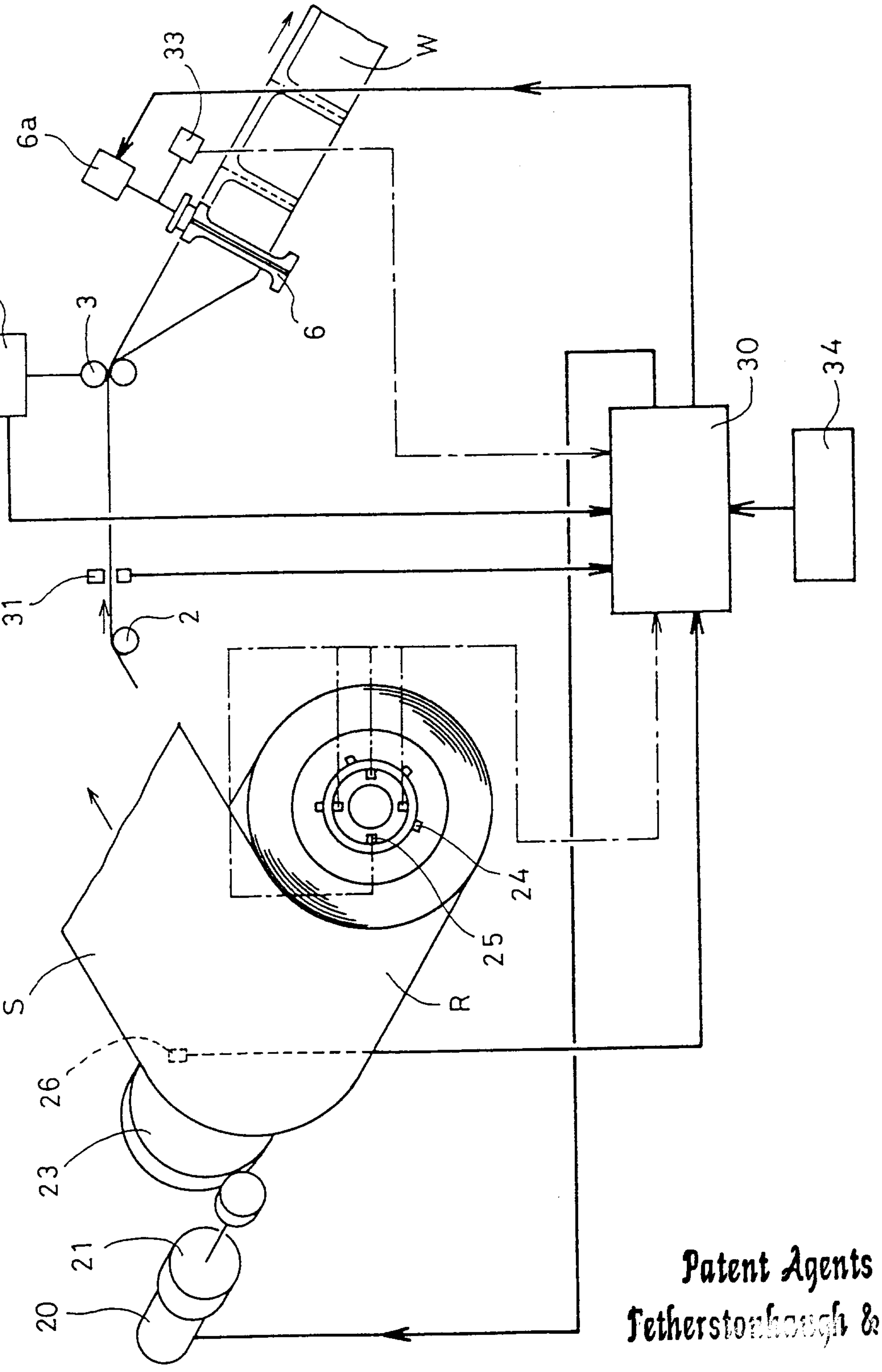

FIG. 4

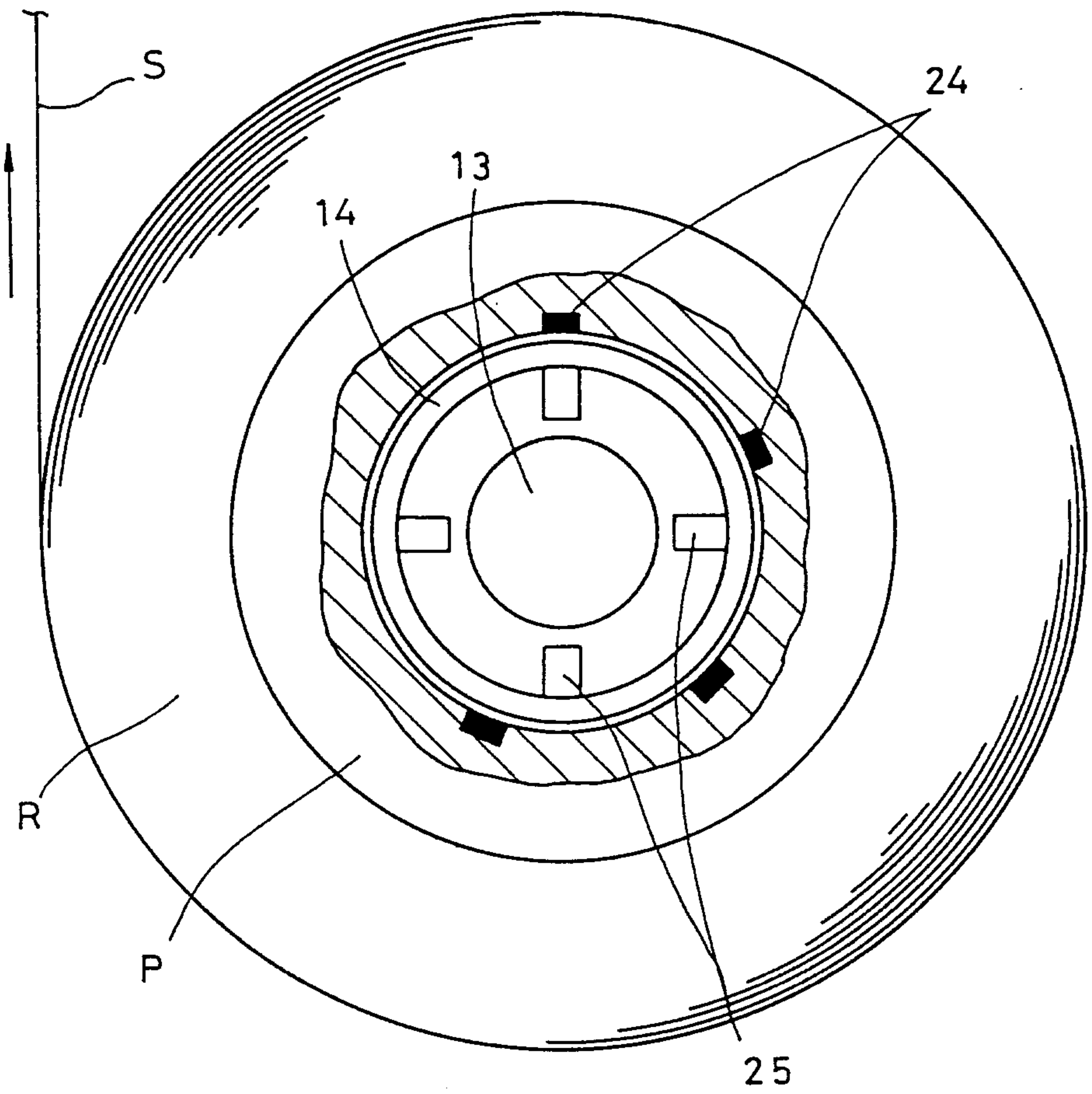

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FIG. 5

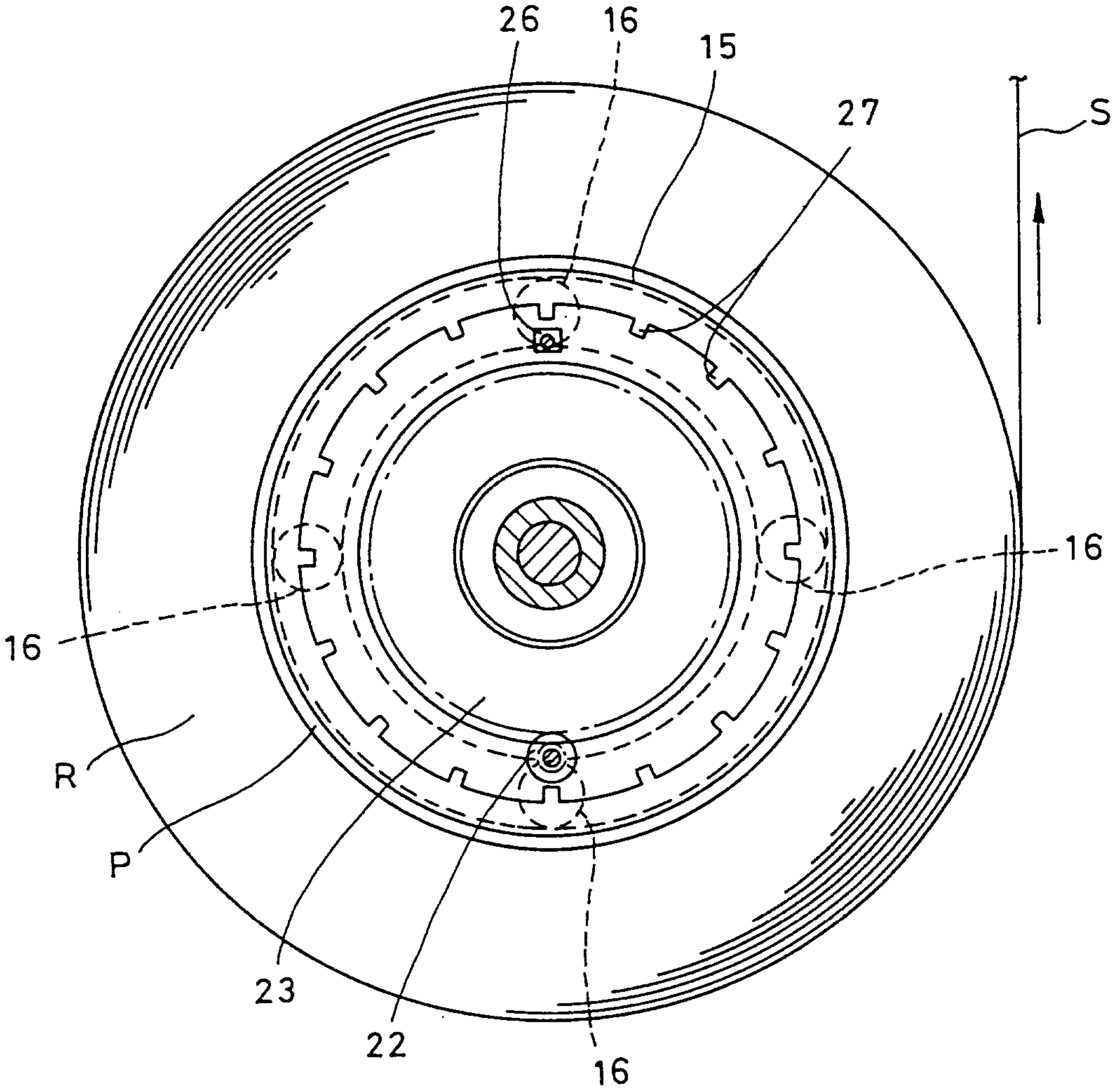

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FIG. 6

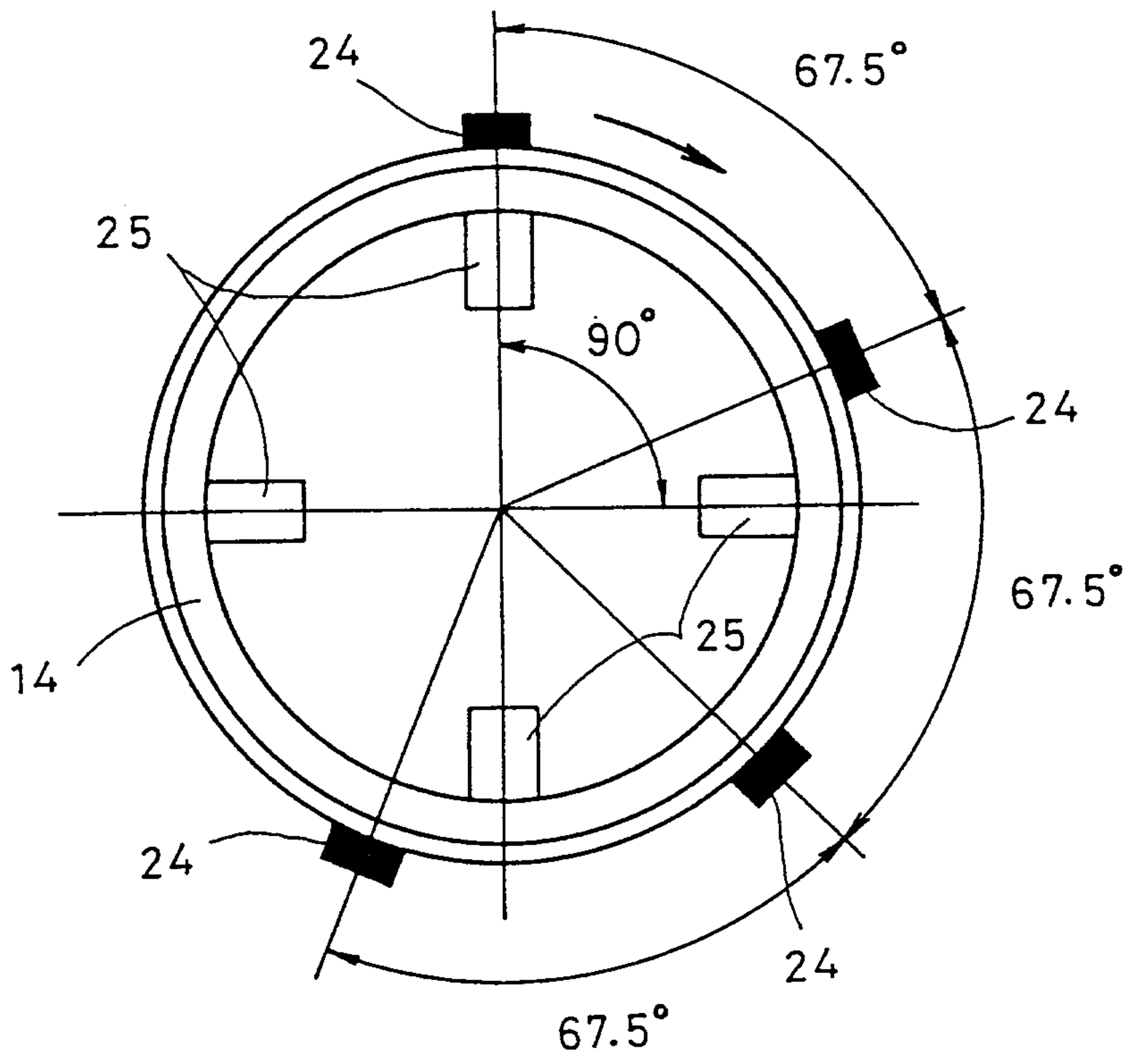

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FIG. 7A

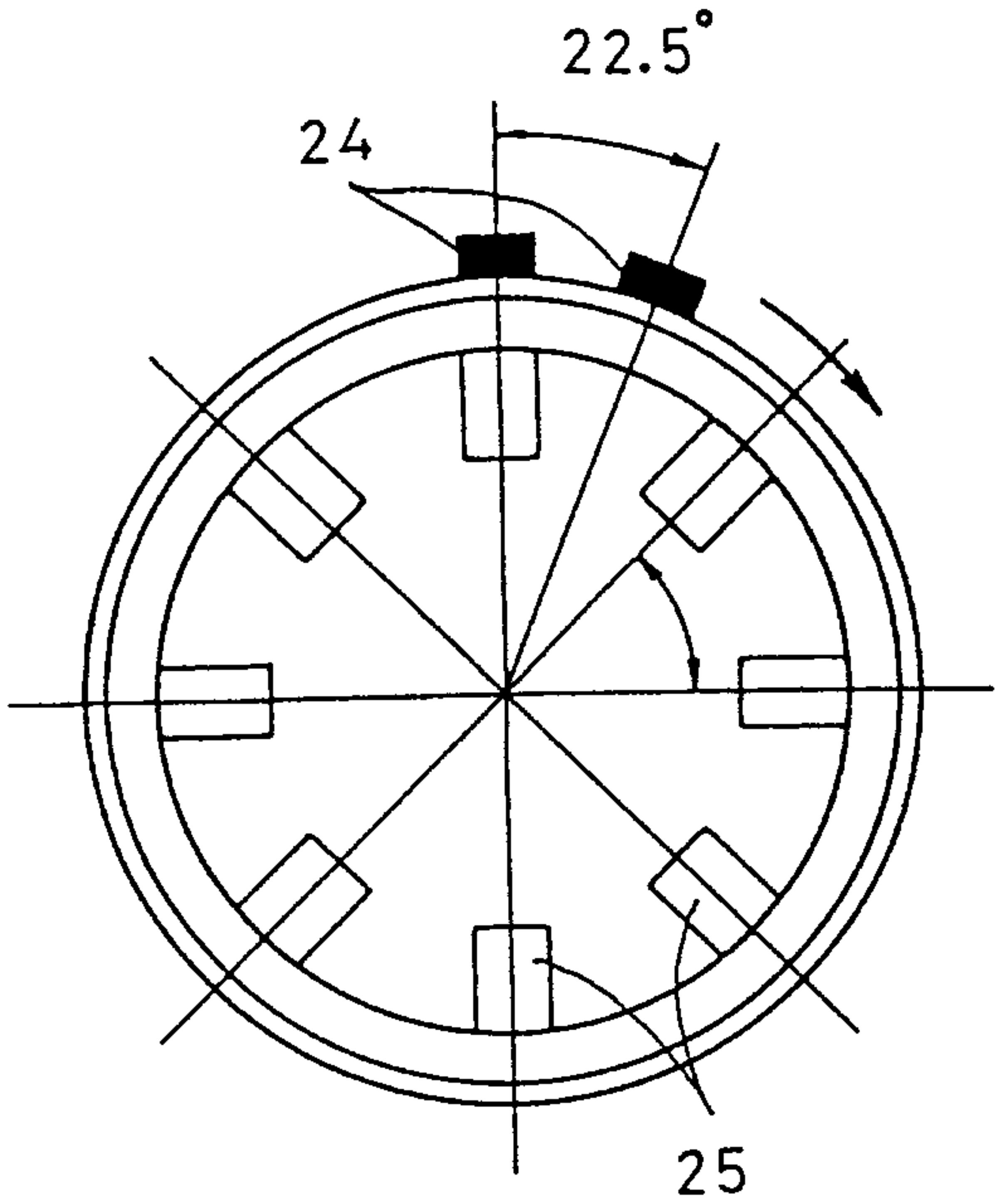

FIG. 7B

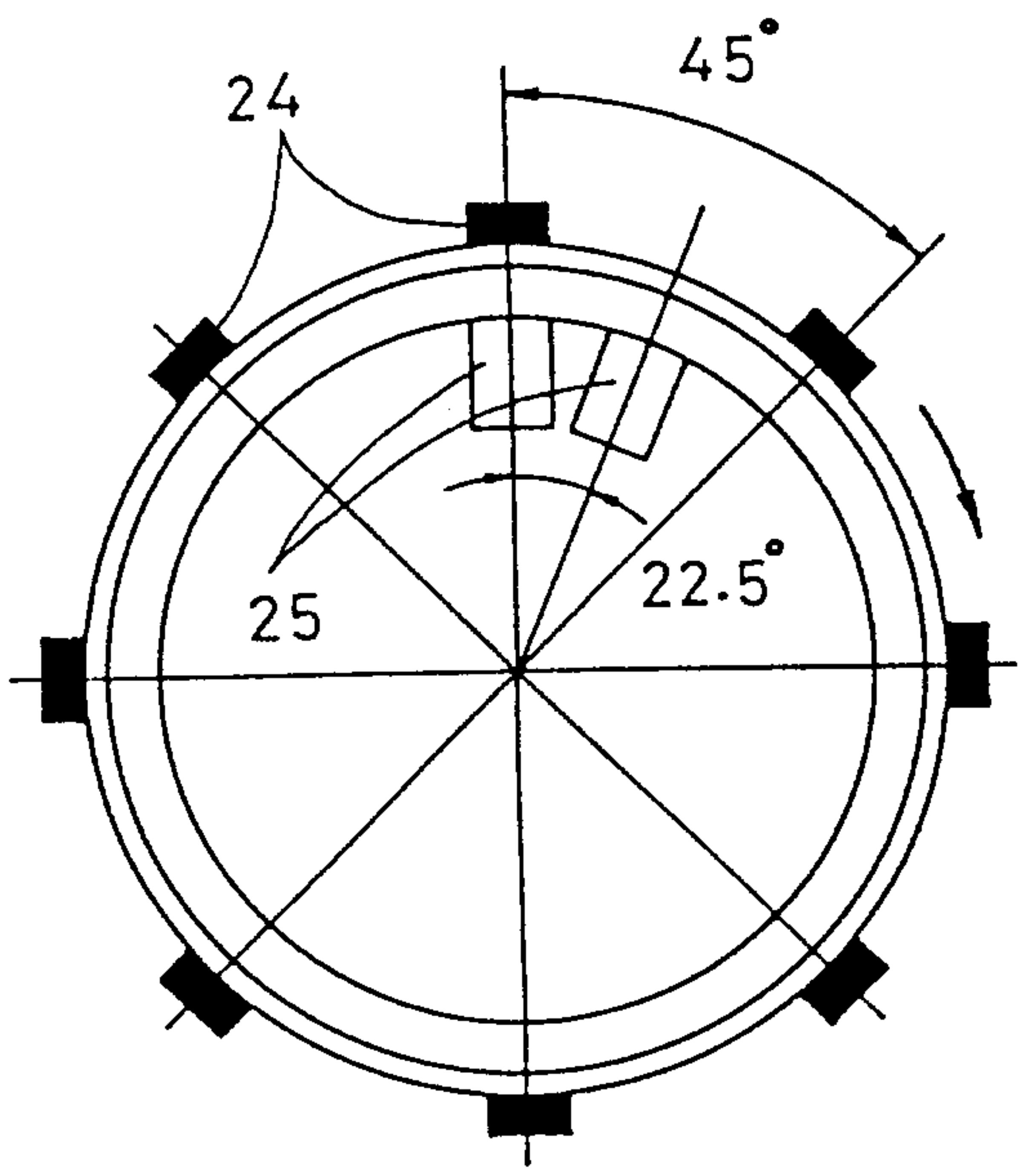

FIG. 7C

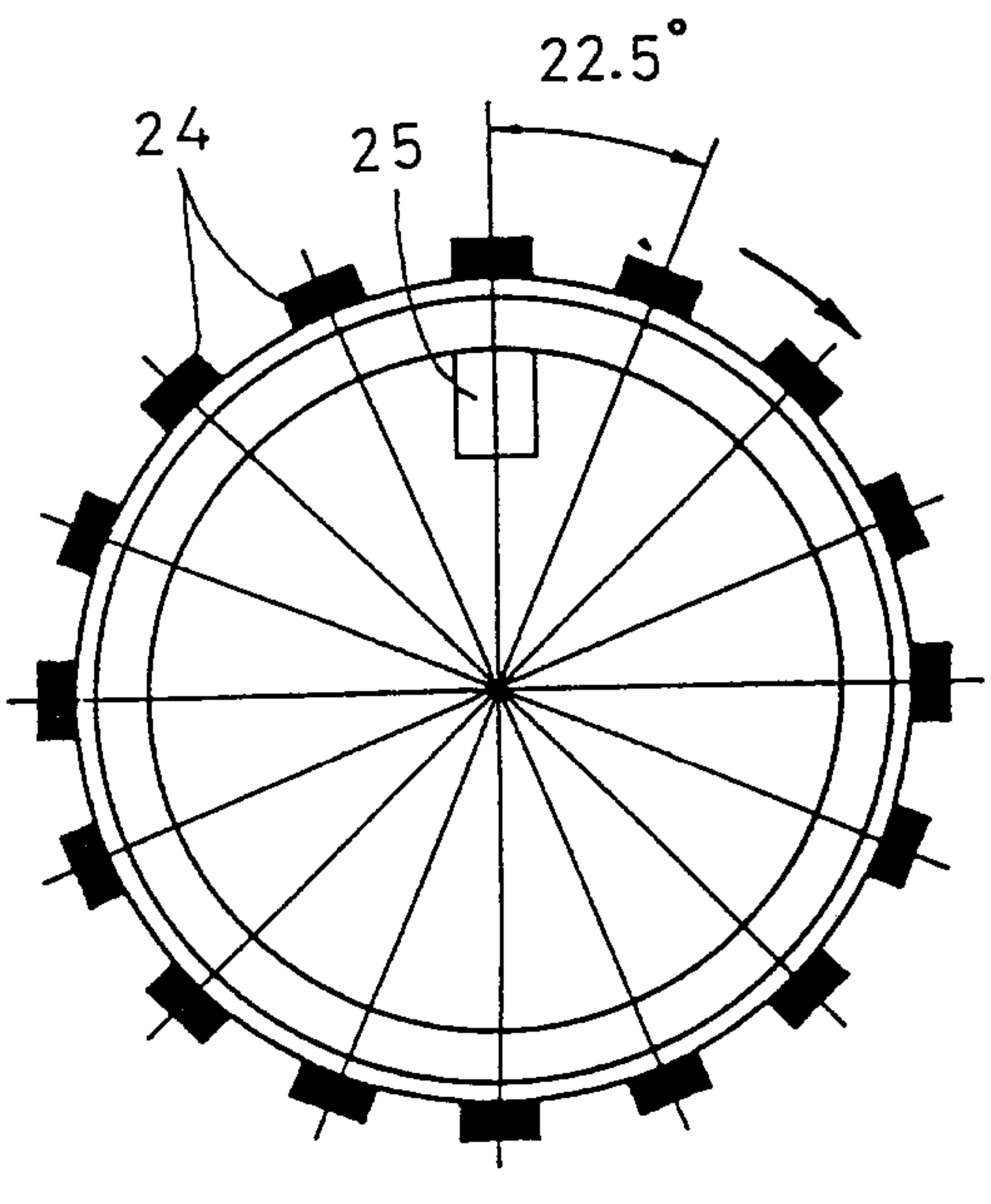

FIG. 7D

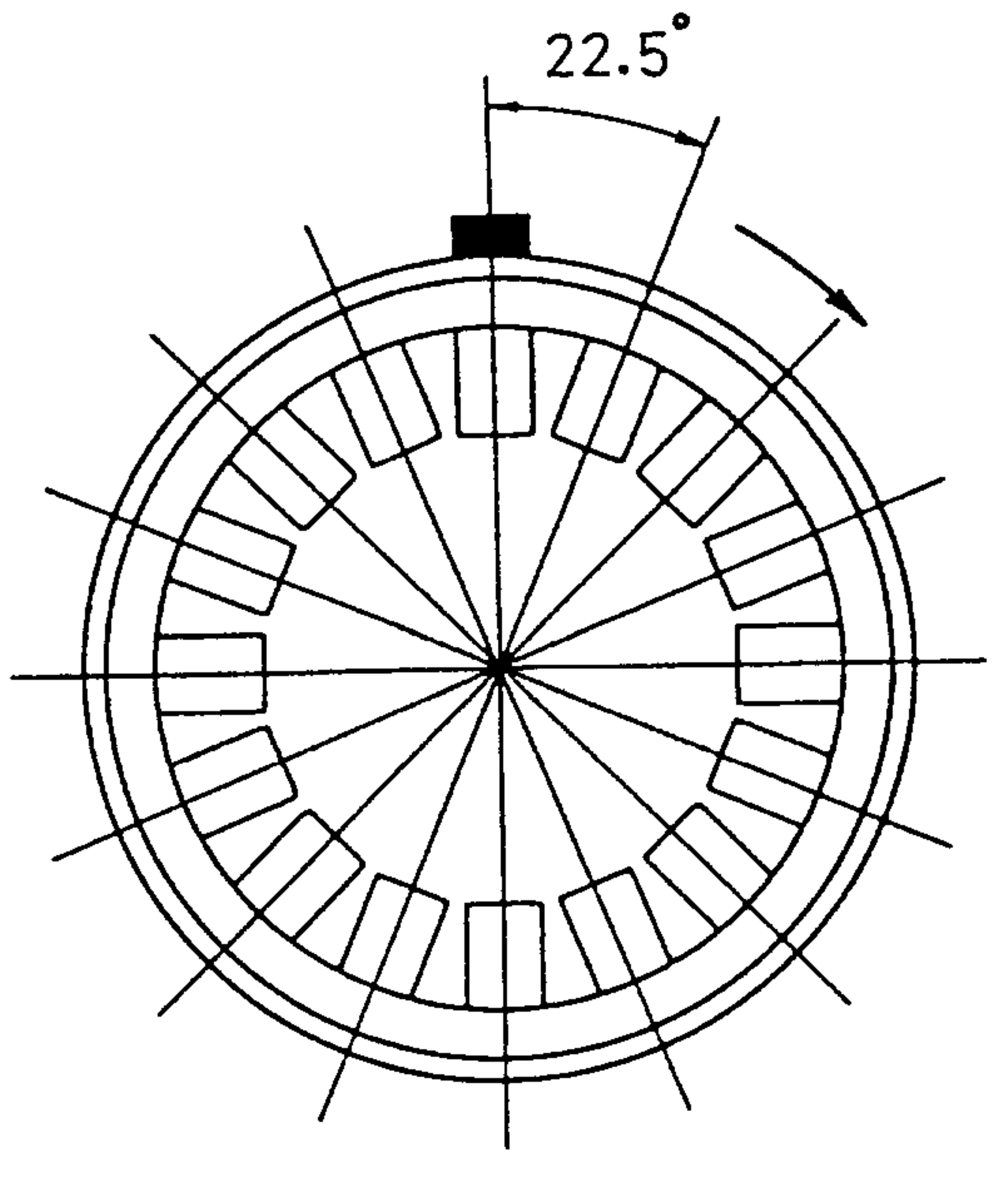

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FIG. 8A

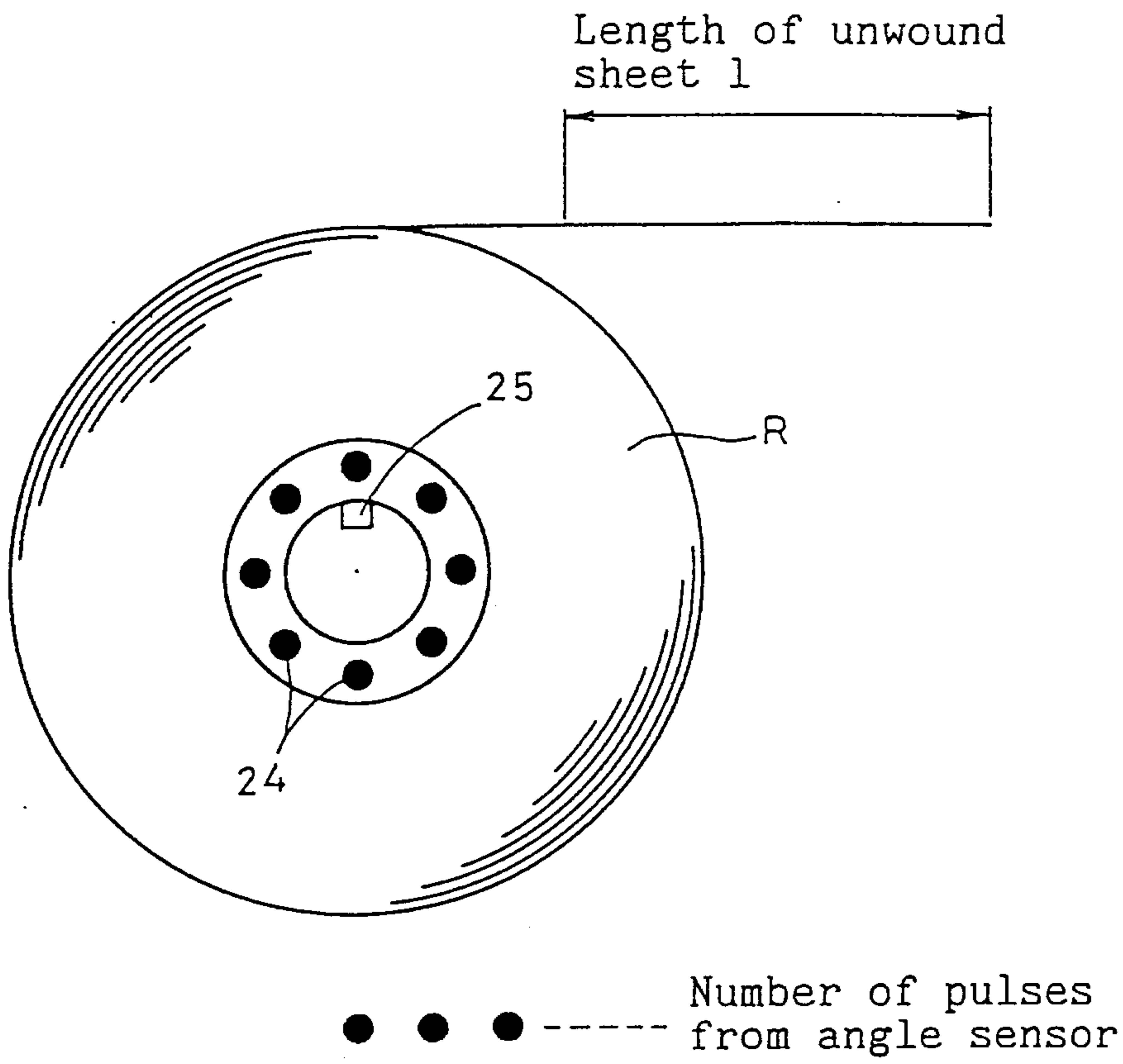

Length of unwound sheet 1
25
R
24
Number of pulses from angle sensor

FIG. 8B

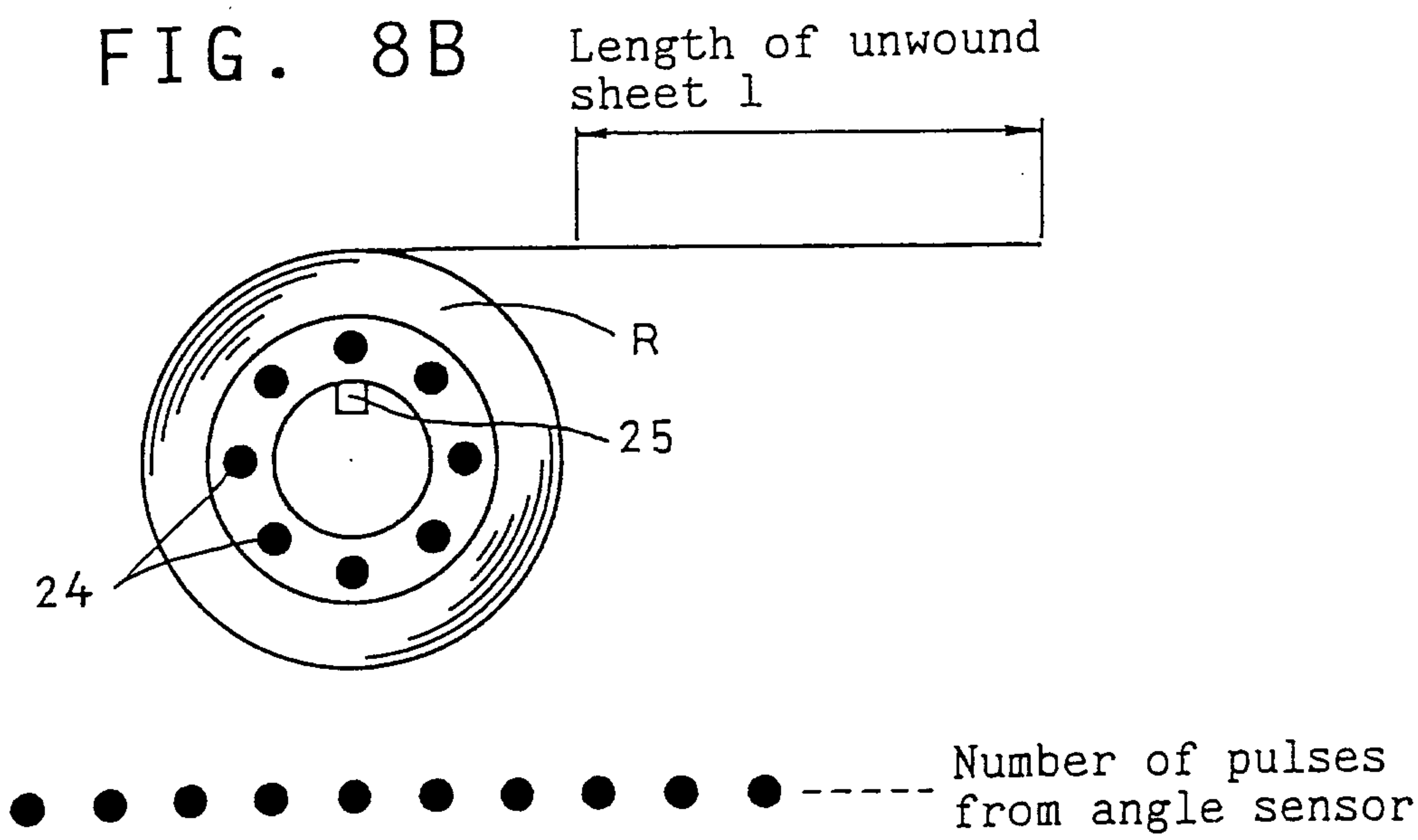
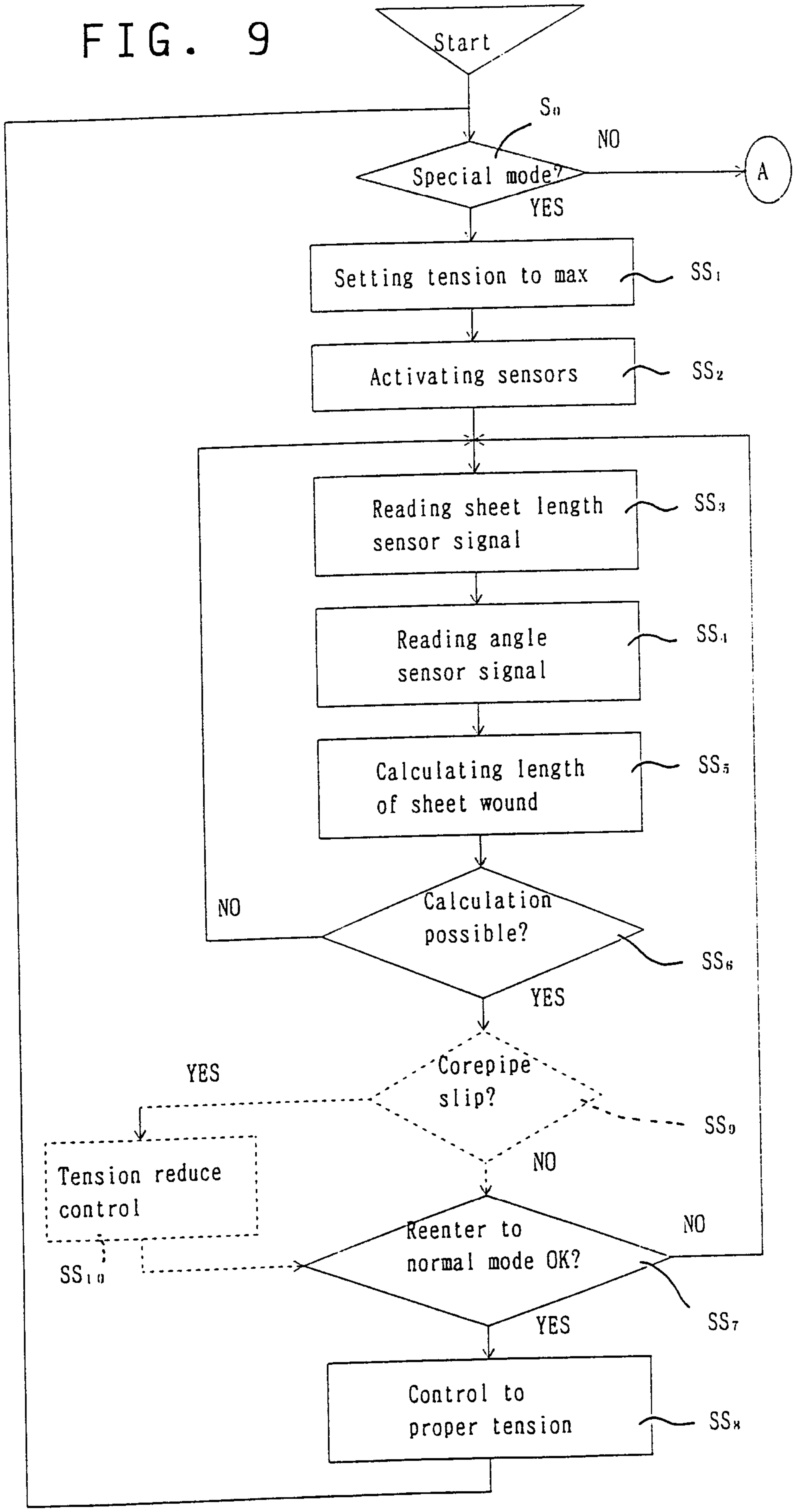
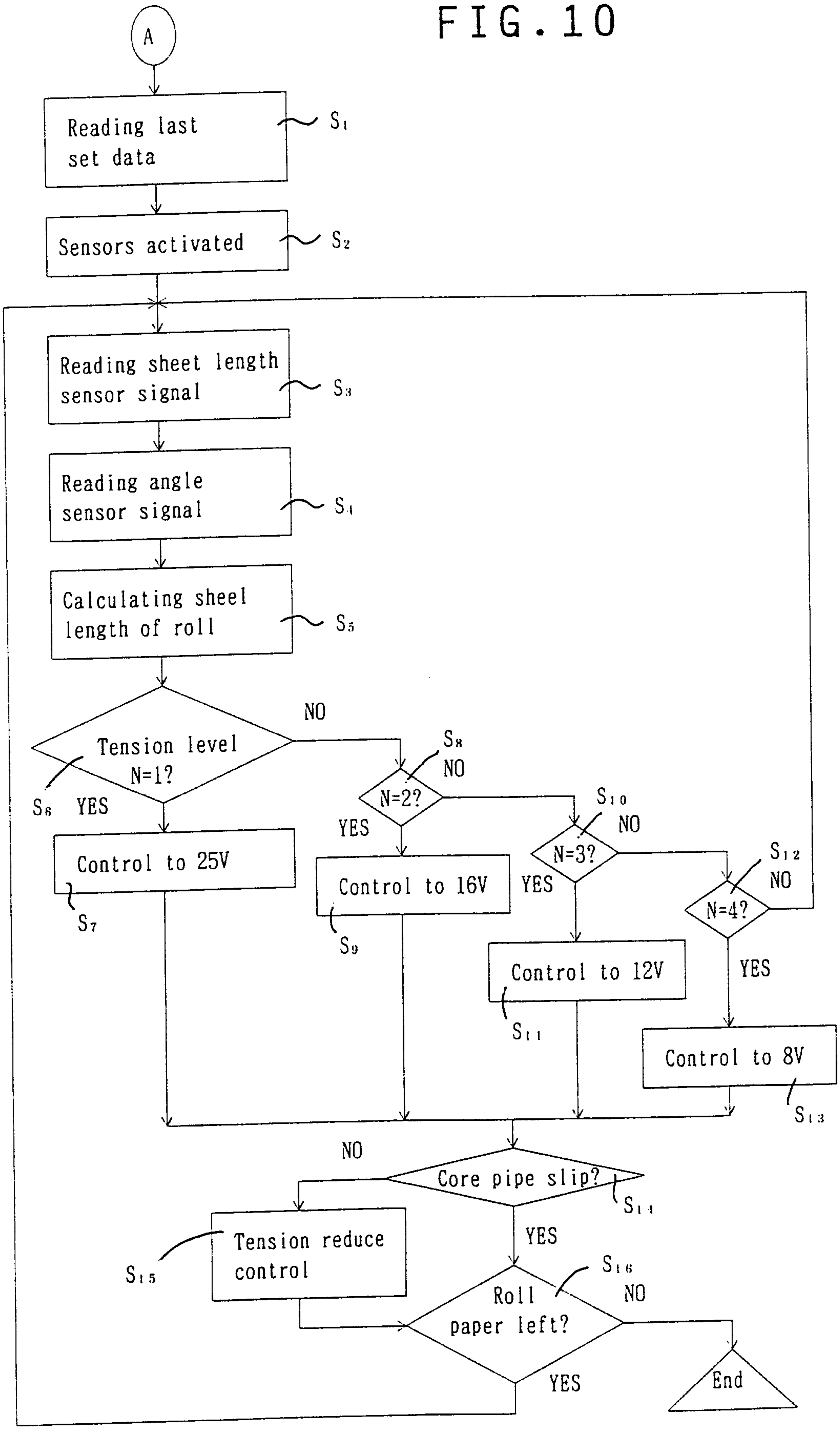

Length of unwound sheet 1
R
25
24
Number of pulses from angle sensor

FIG. 9



Start
S0
Special mode?
NO
A
YES
Setting tension to max
SS1
Activating sensors
SS2
Reading sheet length sensor signal
SS3
Reading angle sensor signal
SS4
Calculating length of sheet wound
SS5
NO
Calculation possible?
SS6
YES
YES
Corepipe slip?
SS9
Tension reduce control
NO
SS10
Reenter to normal mode OK?
NO
SS7
YES
Control to proper tension
SS8

FIG. 10



A
Reading last set data
S1
Sensors activated
S2
Reading sheet length sensor signal
S3
Reading angle sensor signal
S4
Calculating sheel length of roll
S5
Tension level N=1?
S6
YES
NO
Control to 25V
S7
S8
N=2?
YES
NO
Control to 16V
S9
S10
N=3?
YES
NO
Control to 12V
S11
S12
N=4?
YES
NO
Control to 8V
S13
Core pipe slip?
S14
NO
YES
Tension reduce control
S15
Roll paper left?
S16
NO
YES
End

FIG. 11

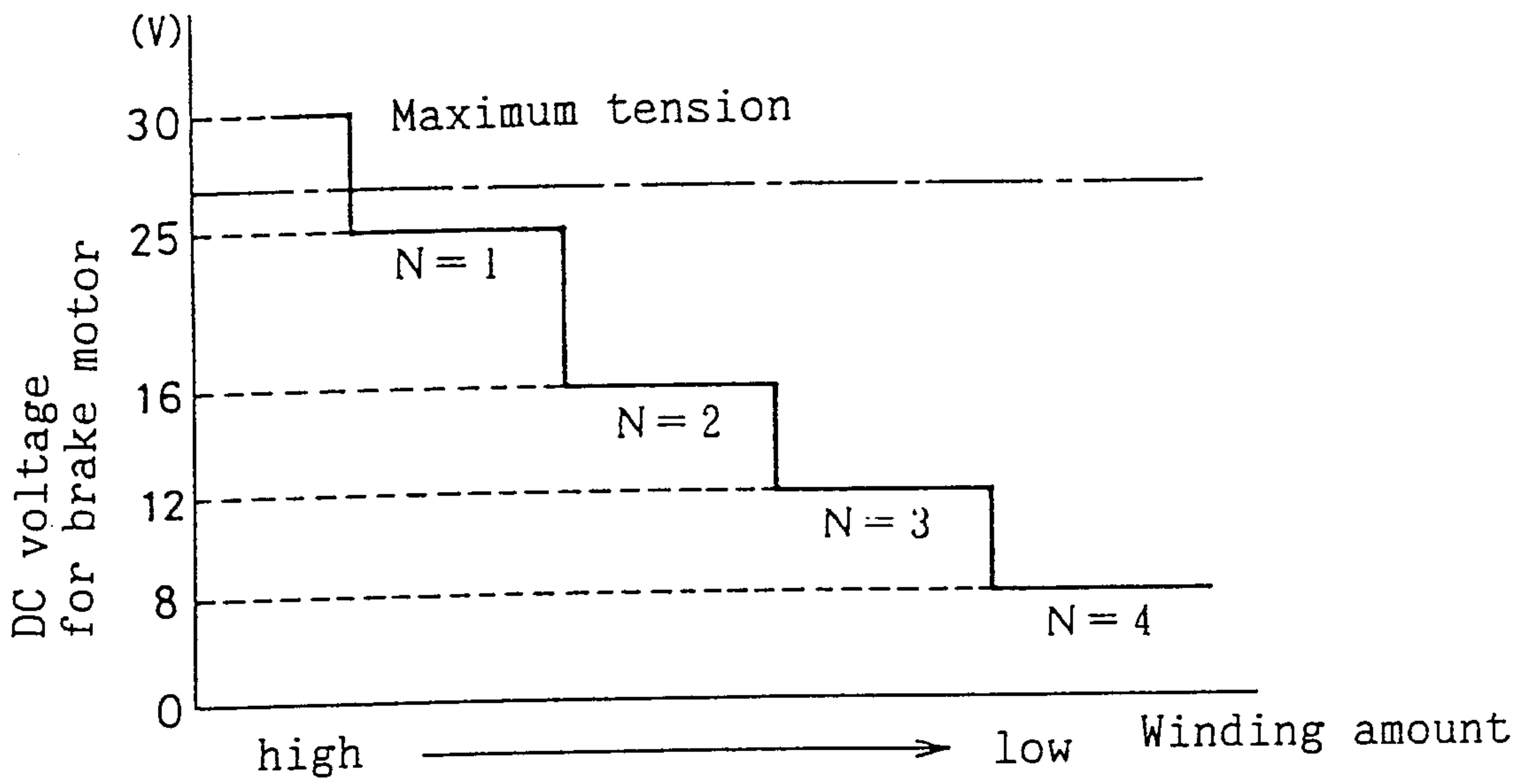


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FIG. 12

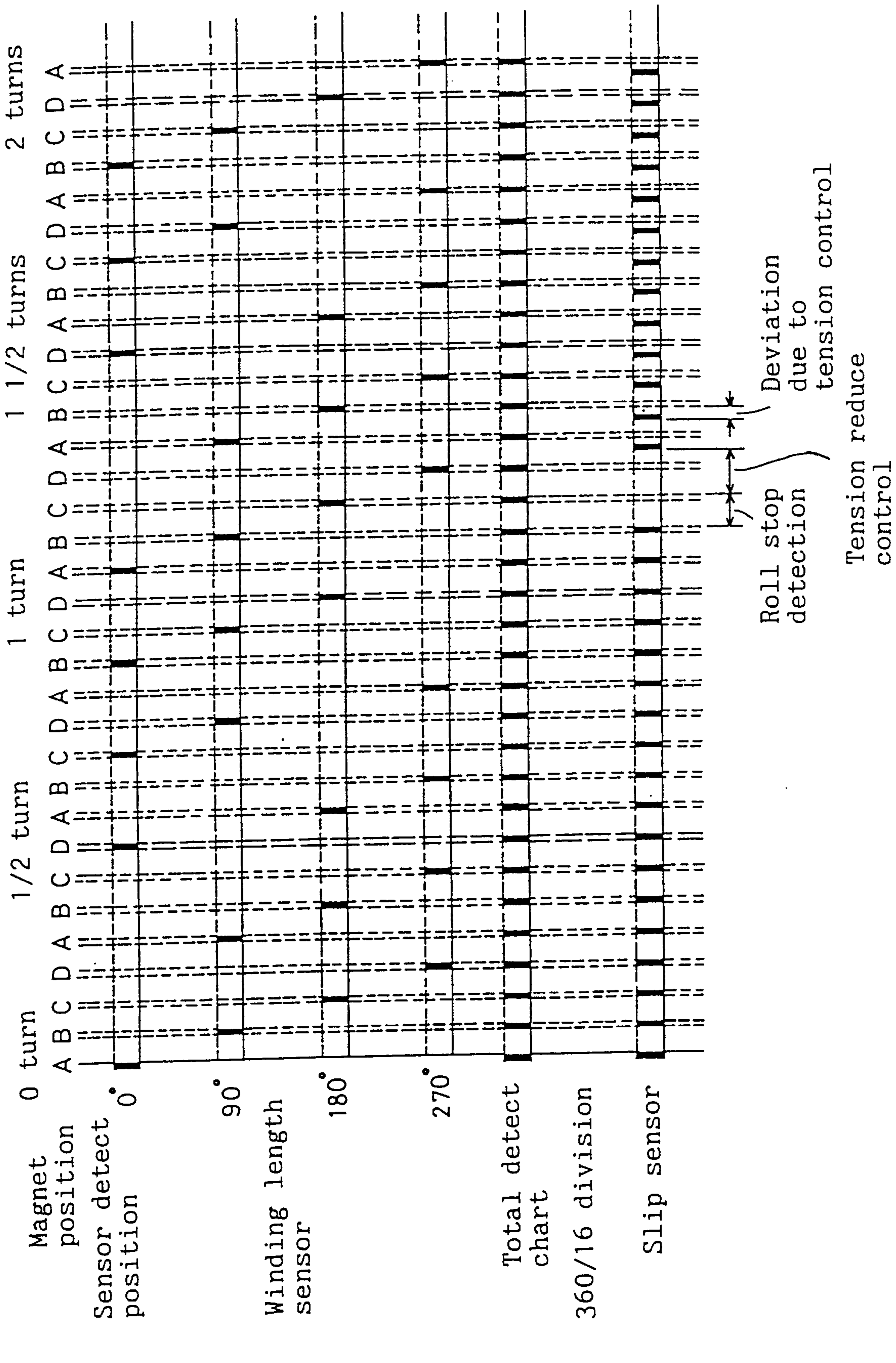

Magnet position
Sensor detect position
Winding length sensor
Total detect chart
360/16 division
Slip sensor
0 turn
1/2 turn
1 turn
1 1/2 turns
2 turns
A B C D
0°
90°
180°
270°
Roll stop detection
Tension control
Deviation due to tension control
Tension reduce control

FIG. 13

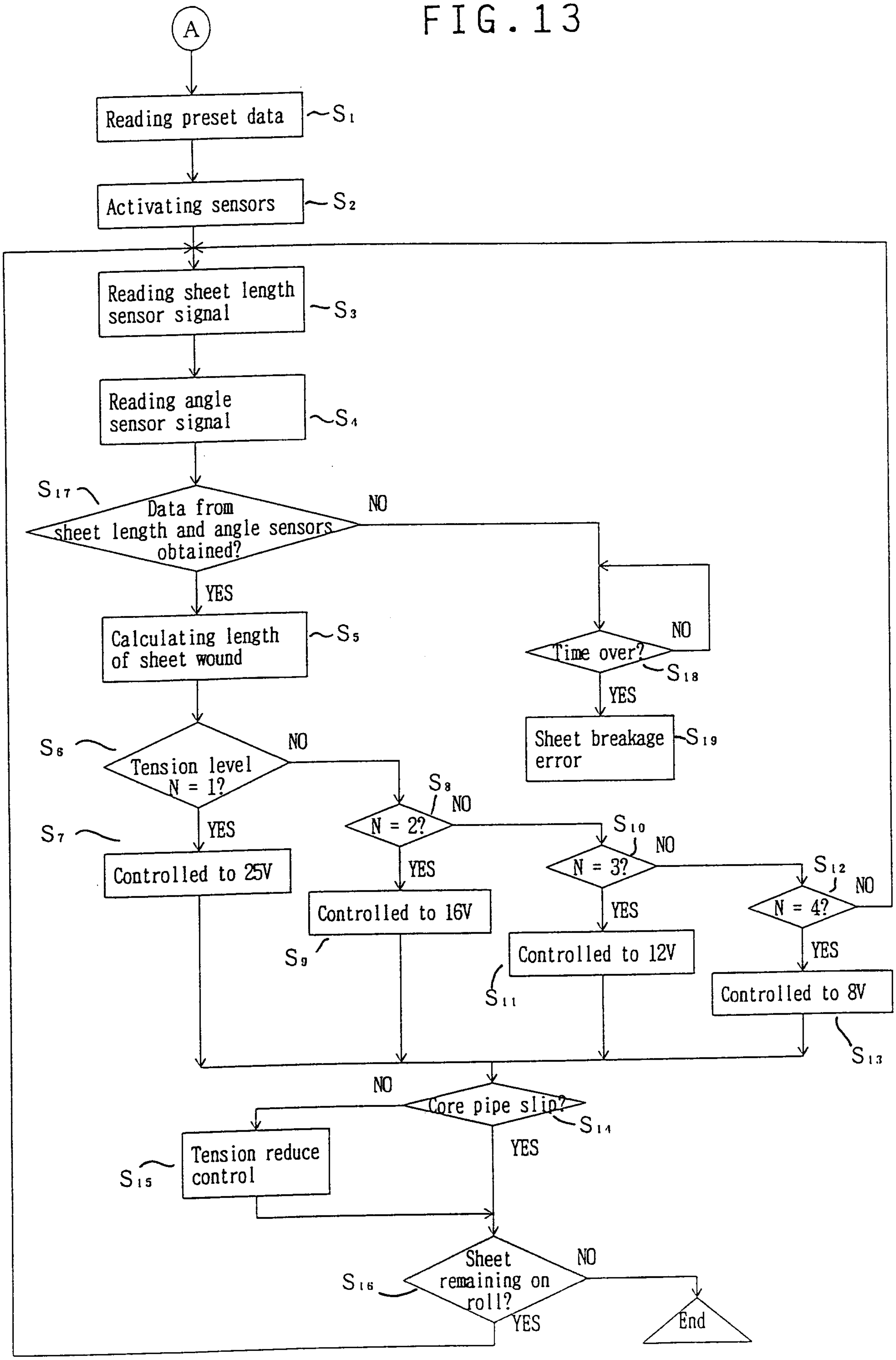
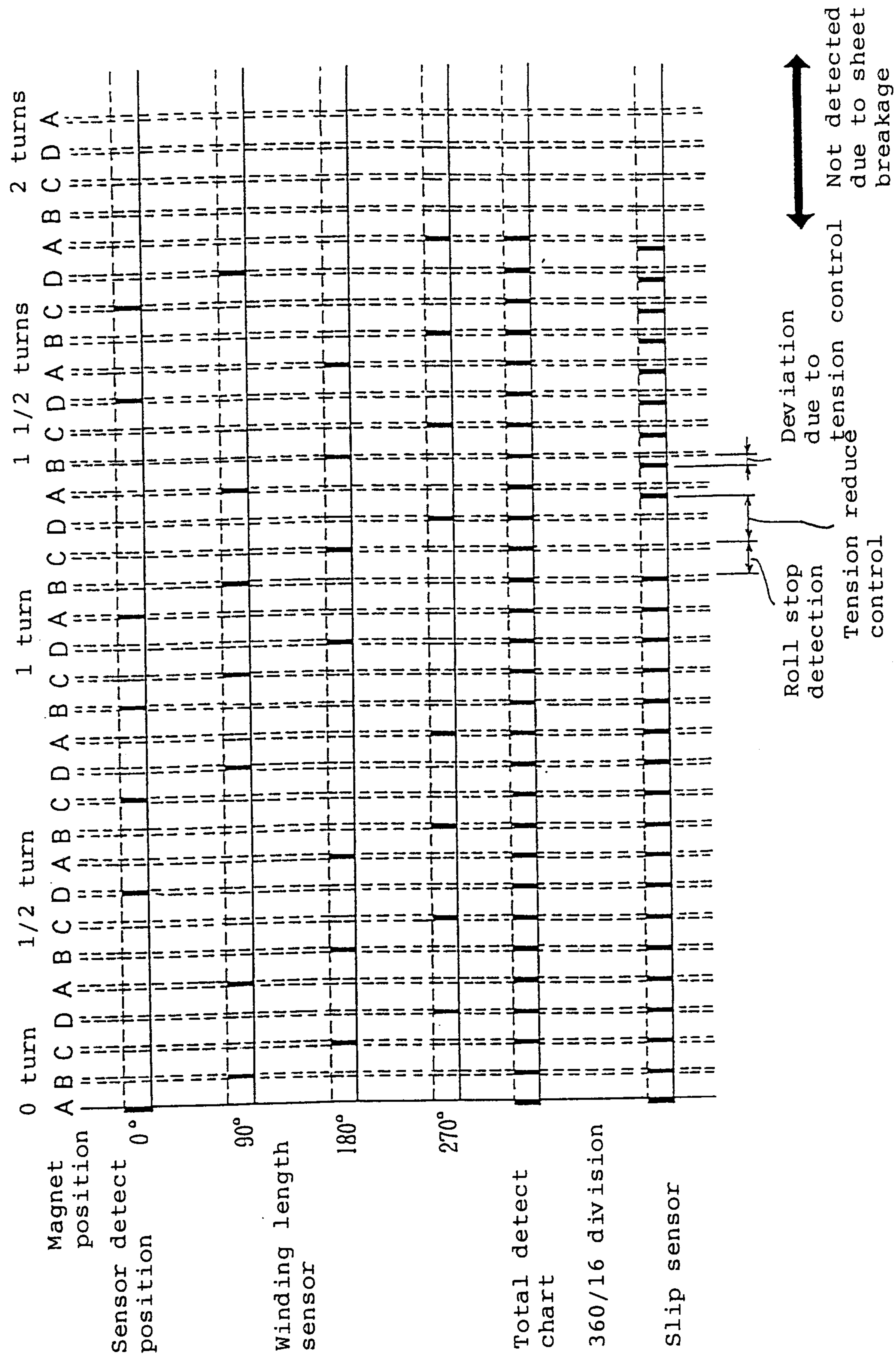
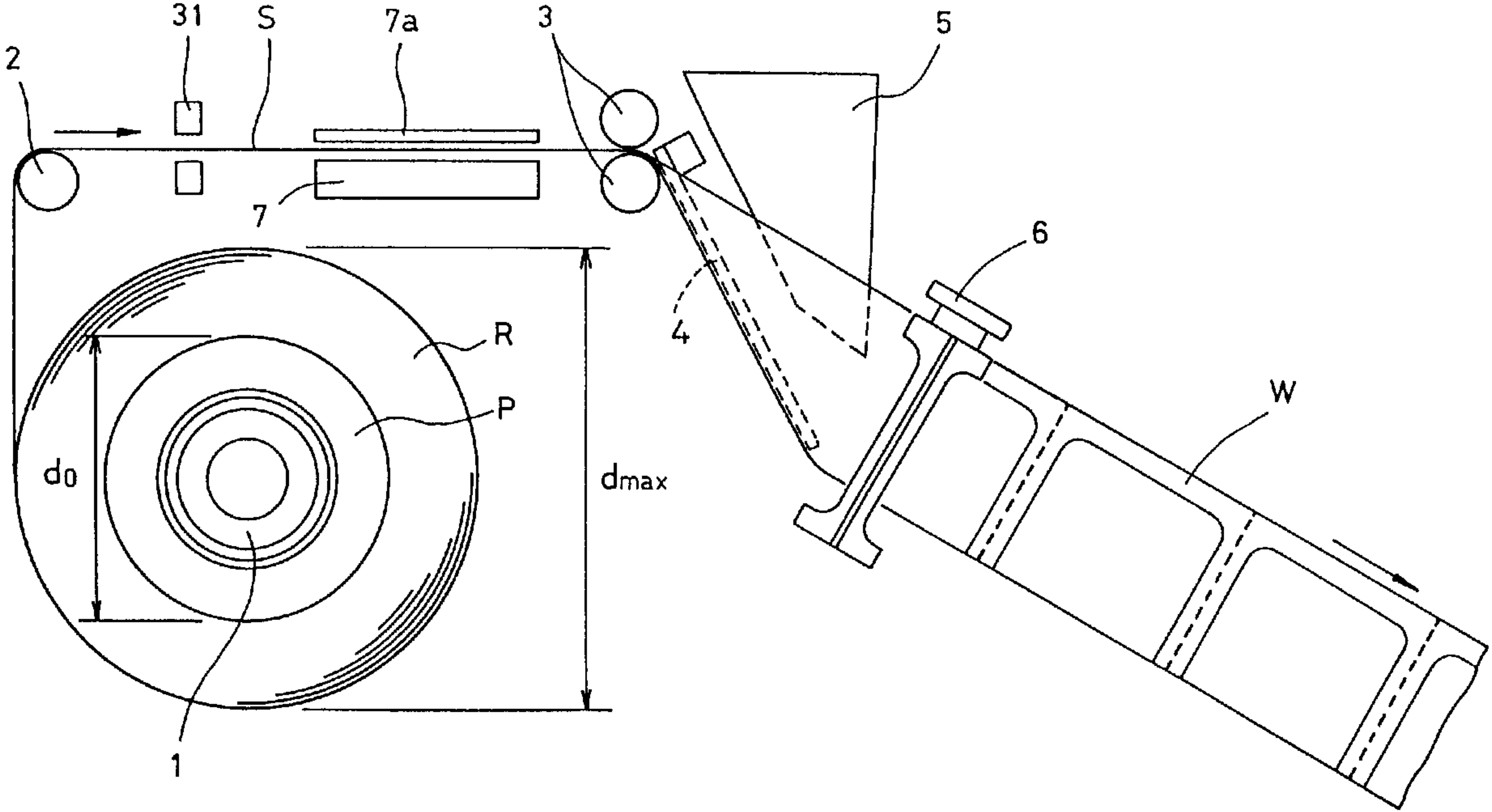

A
Reading preset data
S1
Activating sensors
S2
Reading sheet length sensor signal
S3
Reading angle sensor signal
S4
S17
Data from sheet length and angle sensors obtained?
NO
YES
Calculating length of sheet wound
S5
Time over?
NO
S18
YES
Sheet breakage error
S19
S6
Tension level N = 1?
NO
S8
NO
S7
YES
Controlled to 25V
N = 2?
S10
NO
YES
N = 3?
S12
NO
Controlled to 16V
S9
YES
N = 4?
Controlled to 12V
S11
YES
Controlled to 8V
S13
NO
Core pipe slip?
S14
Tension reduce control
S15
YES
Sheet remaining on roll?
NO
S16
YES
End

FIG.14


Magnet position
Sensor detect position
0°
90°
180°
270°
Winding length sensor
Total detect chart
360/16 division
Slip sensor
0 turn
1/2 turn
1 turn
1 1/2 turns
2 turns
A B C D A B C D A B C D A B C D A B C D A B C D A B C D A B C D A
Roll stop detection
Tension control
Tension reduce control
Deviation due to tension control
Not detected due to sheet breakage


31
S
7a
3
5
2
7
6
4
R
P
W
d0
dmax
1