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(54) **WRAPPING OF FOOD PRODUCTS**

(57) A machine (1) for wrapping food products (P), e.g. ice cream products, comprises at least one reel holder arrangement (200) for supplying a web (10) of wrapping material from a reel (201) of rolled-up wrapping material. The reel holder arrangement (200) comprises a rotatable reel holder for holding the reel (201) such that reel holder is driven to rotate by the machine (1) drawing the web (10) from the reel (201), and a brake module (202) which operable to apply a brake force to a shaft of

the reel holder. A control unit (20) is arranged to generate, based on a measured or otherwise known web infeed rate (S_{in}) of the machine (1) and a measured rotational speed (ω_m) of the reel holder, a control signal (C1) for operating the brake module (202) to set the brake force so as to control tension in the web (10). The machine (1) may be a multi-lane wrapping machine with a plurality of reel holder arrangements (200).

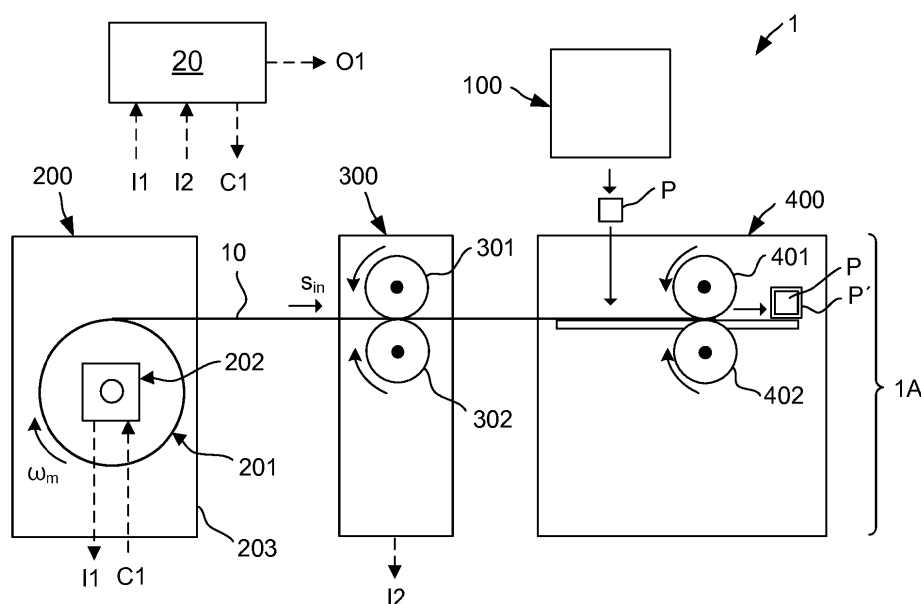


Fig. 1

DescriptionTechnical Field

5 **[0001]** The invention generally relates to wrapping of food products, and in particular to a reel holder arrangement for supplying a web of wrapping material to a food product wrapping machine.

Background Art

10 **[0002]** It is common practice for food product articles to be packaged in a wrapping, either individually or in groups. Such food product articles include frozen confectionary, such as ice cream sticks, bars, cones, sandwiches, etc, as well as other solid and semisolid items that are consumed to provide nutritional support. The wrapping is formed by a wrapping material, which may be made of plastics, paper or a combination thereof.

15 **[0003]** Machines for automated production of wrapped food product articles have been used for a long time in the food industry. Examples of wrapping machines for ice cream products are found in US3834119, US4489536 and GB739807. A food product wrapping machine comprises a wrapping station for receiving the food product articles and a continuous web of wrapping material. The wrapping station is configured to perform a predefined sequence of processing steps on the wrapping material, such as cutting, folding and sealing, so as to produce wrapped food product articles. For increased throughput, it is common to provide a so-called multi-lane wrapping machine, in which a number of continuous webs or
20 lines of wrapping material are conveyed in parallel to a wrapping station.

[0004] Many food product wrapping machines draw the continuous web of wrapping material from a reel that holds the web of wrapping material in rolled-up form. The reel may be arranged on a freely rotatable spindle, so that the spindle and the reel are jointly brought to rotate by the feeding of the web to the wrapping station. This type of reel holder arrangement with a free-spinning reel is e.g. disclosed in the above-mentioned patent documents.

25 **[0005]** While such a reel holder arrangement is simple and robust, the free-spinning reel with its rolled-up wrapping material has a large inertia that may cause undesired variations in the tension of the web of wrapping material as the web is fed to the wrapping station. Such variations in tension may lead to disruptions in the wrapping process in the wrapping station or even cause the web to break. As in all high-volume production, a standstill of a food product wrapping machine is associated with a high cost and malfunctions should be avoided to the extent possible.

30 **[0006]** Further, it may be desirable to include a printing station intermediate the reel holder arrangement and the wrapping station, for printing information onto the web to be visible on each of the wrappings. Such information may include production-specific data, such as production date, expiry date, identification of the production facility, etc. Even small variations in tension of the web as it passes such a printing station may result in poor quality of the print on the wrapping.

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Summary

[0007] It is an object of the invention to at least partly overcome one or more limitations of the prior art. In particular, it is an object to provide an improved technique of controlling the tension in a web of wrapping material that is supplied
40 for wrapping of food products.

[0008] Yet another object is to provide a reel holder arrangement for a food product wrapping machine, where the reel holder arrangement is operable to control tension in the web of wrapping material as supplied to the food product wrapping machine.

45 **[0009]** A further object is to provide such a reel holder arrangement which is of simple and low-cost construction, as well as robust and compact.

[0010] One or more of these objects, as well as further objects that may appear from the description below, are at least partly achieved by a reel holder arrangement, a machine for wrapping food products, and a method of wrapping ice cream products according to one or more of the embodiments described herein.

50 **[0011]** A first aspect of the invention is a reel holder arrangement for supplying a web of wrapping material to a food product wrapping machine that consumes the web of wrapping material at an infeed rate. The reel holder arrangement comprises: a brake module; a shaft rotatably arranged in the brake module, the brake module being operable to apply a brake force on the shaft; and a reel holder combined with the shaft and configured to hold a reel that comprises the web of wrapping material in rolled-up form, such that the reel holder is driven to rotate by the consumption of the web of wrapping material by the food product wrapping machine. The reel holder arrangement further comprises a rotation
55 sensor arranged to sense a parameter indicative of a rotational speed of the shaft, and a control unit configured to receive input signals indicative of the infeed rate and the rotational speed and to generate a control signal for operating the brake module to set the brake force to thereby control tension in the web of wrapping material as supplied to the food product wrapping machine.

[0012] Thus, in the first aspect, the rotation of the reel holder is restrained by the brake force applied by the brake module onto the shaft, and the amount of brake force is set by the control unit based on the rotational speed of the shaft and the infeed rate of the web. By restraining the rotation in this way, it is possible to generate a well-controlled tension in the web of wrapping material. It is thus realized that the first aspect provides a simple and efficient way of controlling the tension in the web of wrapping material that is supplied to the food product wrapping machine. Thereby, the first aspect also enables automated and digital control of the supply of wrapping material to the food product wrapping machine.

[0013] Further, by applying the brake force to the shaft of the reel holder, a well-controlled restriction of the rotation of the reel holder is achieved in a simple, well-defined and robust manner.

[0014] The brake module, which is operable to apply the brake force to the shaft of the reel holder, may be configured as a compact and robust unit of simple construction. In one implementation, an end portion of the shaft is rotatably arranged in the brake module. Such an implementation enables the shaft to be rotatably anchored only in the brake module and thus the reel holder arrangement to have a cantilevered construction. The cantilevered construction may facilitate an operator's access to the reel holder, e.g. for removal of an empty reel and installation of a new reel with rolled-up wrapping material.

[0015] In one embodiment, the rotation sensor is arranged in the brake module, e.g. to measure the rotational speed of the shaft that is rotatably arranged in the brake module. This embodiment provides a well-defined placement of the rotational sensor and makes it possible to perform a complete functionality test of the brake module, in relation to a control unit, before installation into the reel holder arrangement. A brake module with integrated rotation sensor may also facilitate maintenance and repair, and thereby reduce standstill of the wrapping machine. An operator that identifies a malfunctioning reel holder arrangement need not investigate the origin of the malfunction but may simply replace the brake module.

[0016] One of the input signals for the control unit is indicative of the rotational speed and is thus directly or indirectly obtained from the rotational sensor. Another of the input signals is indicative of the infeed rate, which is the rate at which the web of wrapping material is fed into the food product wrapping machine from the reel holder arrangement. It should be understood that the infeed rate may be time-varying variable that is measured in real time by a sensor in the food product wrapping machine, a fixed value that is entered by an operator, or a fixed value or a time-varying variable that is computed, by the control unit or an external unit, based on one or more operating parameters of the food product wrapping machine.

[0017] All embodiments disclosed herein are applicable to all types of food products that may be provided with a wrapping, either individually or in groups. As used herein, a "food product" comprises any solid or semisolid item that may be consumed by a human or another a mammal for nutritional support. In a specific implementation, the food product is an ice cream product. The wrapping may, but need not, completely enclose the food product. The web of wrapping material denotes a continuous sheet material that may comprise one or more plastic materials, paper or a combination thereof.

[0018] In one embodiment, the control unit is configured to generate the control signal to set the tension in the web of wrapping material within a predetermined tension interval. For example, the control unit may allow an operator to enter a selected tension value that lies within the tension interval, whereupon the control unit operates to at least approximately achieve the selected tension value in the web that is fed into the wrapping machine. The tension interval may be predefined so as to ensure an adequate tension in the web, e.g. well above zero to prevent slacking of the web between the reel holder arrangement and the wrapping machine and well below the breaking tension of the web.

[0019] In one embodiment, the control unit is configured to generate the control signal so as to maintain a consistent tension in the web of wrapping material as supplied to the food product wrapping machine. Such an embodiment will effectively minimize variations in tension, although certain variations are inevitable in a practical situation. As used herein, a "consistent tension" allows for variations in tension of less than $\pm 10\%$, and preferably less than $\pm 5\%$.

[0020] In one embodiment, the control unit is configured to generate the control signal as a function of a required brake force which is computed as a function of the infeed rate, the rotational speed and a desired tension in the web of wrapping material. Such a control unit may be implemented as an open-loop controller. The desired tension may be a predefined value or be entered by an operator. It should be realized that the desired tension may differ depending on the composition and thickness of the wrapping material. The function may be given by a predefined model that relates brake force to infeed rate, rotational speed and desired tension. In one implementation, the required brake pressure is given by: $P_{\text{brake}} = K \cdot S_{\text{in}} \cdot F_t / \omega_m$, wherein S_{in} is the infeed rate of the wrapping material, ω_m is the rotational speed of the shaft, F_t is the desired tension in the web of wrapping material, and K is a constant.

[0021] In one embodiment, the control unit is configured to estimate a diameter of the reel as a function of the rotational speed and the infeed rate and to generate, as a function of the diameter, an output signal for use in controlling the food product wrapping machine. This embodiment provides a simple way of estimating the diameter of the reel by computation only, based on input data that is available to the control unit. Thereby, the need to install a separate measurement device for measuring the reel diameter is obviated. The provision of the output signal makes it possible to take preventive action so as to minimize standstill of the food product wrapping machine, e.g. to indicate an upcoming need to replace a reel

that is running low on wrapping material. The output signal may contain information to be presented to an operator, e.g. on a display. Alternatively or additionally, the output signal may contain information that results in generation of an alarm signal to alert an operator to take action. Alternatively or additionally, the output signal may be generated to enable automatic control of the food product wrapping machine, e.g. to stop the consumption of the web of wrapping material.

[0022] In one embodiment, the output signal comprises any one of: an estimated amount of remaining wrapping material in the reel, an estimate of a time period until a predefined amount of wrapping material remains in the reel, and an indication to stop the consumption of the wrapping material from the reel holder arrangement. The estimated amount of remaining wrapping material may e.g. be given as a remaining number of turns of wrapping material on the reel, or a remaining length of wrapping material on the reel. The time period may be calculated as a function of the remaining length and the infeed rate, and may be given as a time period until the reel is deemed to be empty.

[0023] In one embodiment, the control unit is configured to detect, based on the rotational speed, a rupture of the web of wrapping material. This embodiment provides a simple way of automatically detecting a rupture of the web, i.e. that the web is no longer connected to the wrapping machine. The rupture detection is made by computations only, based on input data that is available to the control unit. Thereby, the need to install a separate rupture detection device is obviated. The rupture detection makes it possible to alert an operator to take corrective measures and/or automatically control the wrapping machine to stop consuming wrapping material from the reel holder arrangement, so as to thereby minimize the impact of the rupture on the operation of the wrapping machine.

[0024] In one embodiment, the control unit is configured to detect the rupture when the rotational speed decreases at a rate that is beyond a threshold level. When the web is ruptured, the driving force for the rotation of the reel is removed, and the rotation speed of the reel will start to decrease. By evaluating the rate of decreasing rotation speed, it is possible to detect a rupture at an early stage and in a simple, robust and efficient manner. In an alternative embodiment, the control unit is configured to detect the rupture when the rotational speed is below a predefined threshold level.

[0025] In one embodiment, the brake module comprises a frictional element arranged to engage a cylindrical surface portion of the shaft, and an actuator arranged to impart a movement of the frictional element towards the shaft. This embodiment provides a simple and robust way of applying the brake force to the shaft.

[0026] In one embodiment, the frictional element is arranged in the brake module to move at right angles to a rotational axis of the shaft. This embodiment ensures a simple structure of the brake module and optimizes the brake force acting of the shaft.

[0027] In one embodiment, the actuator comprises an inflatable element which is arranged to expand towards the shaft when inflated, to thereby impart the movement of the frictional element. This embodiment enables pneumatic control of the brake module in simple, robust and well-controlled manner. For example, the actuator may have a minimum of mechanical components. Further, this type actuator may provide a straightforward relation between supplied pressure to the inflatable element and the force applied by the inflatable element to the frictional element.

[0028] In one embodiment, the frictional element is a cylindrical element with a rear end surface arranged to engage the actuator and a front end surface arranged to engage the cylindrical surface portion of the shaft. This embodiment provides a simple and robust construction of the brake module.

[0029] In one embodiment, the brake module comprises a housing that defines a first channel which extends from a first opening in the housing, and a second channel which extends at right angles to the first channel from a second opening in the housing to the first channel; one or more bearings are fitted in the first channel; the shaft is arranged to extend through the first opening into the first channel in engagement with the one or more bearings so as to be freely rotatable in relation to the housing; the frictional element is arranged for movement along the second channel; and the actuator is fastened at the second opening for engagement with the frictional element. This embodiment provides a compact structure of the brake module. It also enables a cantilevered mount of the shaft of the reel holder in the brake module.

[0030] In one embodiment, the rotation sensor is an inductive proximity sensor which is arranged to face a perimeter of a wheel on the shaft, the wheel comprising radially projecting elements that are uniformly distributed along the perimeter. This embodiment provides a robust measurement of rotational speed, even for a slowly rotating reel holder, e.g. at rotational speeds of 5-50 rpm. The embodiment also allows the rotation sensor to be arranged in the brake module.

[0031] A second aspect of the invention is a machine for wrapping food products. The machine comprises a plurality of a reel holder arrangements of the first aspect, which are arranged to supply a plurality of webs of wrapping material from a plurality of reels containing rolled-up wrapping material; a feeding station arranged to feed the webs of wrapping material at an infeed rate; a supply arrangement arranged to supply the food products; and a wrapping station arranged to receive the food products and the webs of wrapping material and to process the webs of wrapping material into wrappings around the food products.

[0032] The machine for wrapping food products may generate control signals for operating each of the brake modules in the reel holder arrangements individually, to set the brake forces and thereby tensions in the webs of wrapping material individually. The control signals may be generated by a common control unit.

[0033] A third aspect of the invention is a method of wrapping ice cream products. The method comprises: supplying

a plurality of webs of wrapping material from a plurality of reel holder arrangements of the first aspect; feeding the webs of wrapping material at an infeed rate to a wrapping station; supplying the ice cream products to the wrapping station; and processing the webs of wrapping material, at the wrapping station, into wrappings around the ice cream food products.

[0034] The second and third aspects share the advantages of the first aspect. Any one of the above-identified embodiments of the first aspect may be adapted and implemented as an embodiment of the second and third aspects.

[0035] Still other objectives, features, aspects and advantages of the invention will appear from the following detailed description as well as from the drawings.

Brief Description of the Drawings

[0036] Embodiments of the invention will now be described, by way of example, with reference to the accompanying schematic drawings.

Fig. 1 is a schematic side view of a wrapping machine with a reel holder arrangement in accordance with an embodiment.

Fig. 2A is a perspective view of a wrapping machine with a plurality of reel holder arrangements, and Fig. 2B is an enlarged view of the reel holder arrangements in Fig. 2A.

Fig. 3 is a perspective view of a reel holder arrangement in accordance with an embodiment.

Fig. 4 is an exploded view of a brake module included in the reel holder arrangement of Fig. 3.

Fig. 5 is a perspective view of the brake module in Fig. 3, partly in section and viewed in direction A in Fig. 4.

Fig. 6 is a side view of a reel containing a rolled-up web of wrapping material.

Fig. 7 is a flow chart of a process for wrapping ice cream products in accordance with an embodiment.

Detailed Description

[0037] Embodiments of the present invention will now be described more fully hereinafter with reference to the accompanying drawings, in which some, but not all, embodiments of the invention are shown. Indeed, the invention may be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure may satisfy applicable legal requirements. Like numbers refer to like elements throughout.

[0038] Fig. 1 schematically illustrates a food product wrapping machine 1. The machine 1 comprises a supply arrangement 100 for supplying food products P to a wrapping production line 1A, which is operated to supply, feed and process a web 10 of wrapping material into wrappings P' around individual food products P. In the illustrated example, the production line 1A comprises a reel holder arrangement 200, a feeding station 300 and a wrapping station 400. The reel holder arrangement 200, denoted RHA in following, comprises a fixed frame or support 203 which is configured to rotatably hold a reel 201 of wrapping material. The wrapping material is in the form of a continuous web 10 that is rolled-up onto a core of the reel 201. The reel 201 is mounted in the RHA 200 such that it is rotated by the pulling force of the web 10 being fed into the feeding station 300. A brake module 202 is attached to the frame 203 and is operable to selectively restrict the rotation of the reel 201. The feeding station 300 comprises a pair of opposite rollers 301, 302, which are driven to rotate in engagement with the web 10 so as to draw the web 10 from the RHA 200 at a web infeed rate, S_{in} . Typically, one of the rollers 301, 302 is a driven roller and the other is an idler roller. The wrapping station 400 is arranged to receive the web 10 from the feeding station 300. In the illustrated example, a pair of opposite rollers 401, 402 are operated in engagement with the web 10 to feed the web 10 inside the wrapping station 400. The wrapping station 400 is configured to receive the food products P from the supply arrangement 100 and comprises equipment (not shown) for processing the web 10 into a wrapping P' on the respective food products P. Such equipment and its operation is well-known to the person skilled in the art, and any suitable and commercially available feeding station and wrapping station may be used together with the RHA 200.

[0039] A control unit 20 is configured to generate a control signal C1 for the brake module 202 to control the tension in the web 10 that extends from the reel 201 to the feeding station 300. The control unit 20 receives two input signals I1, I2, where input signal I1 is indicative of the rotational speed ω_m of the reel 201 and input signal I2 is indicative of the web infeed rate S_{in} . In the illustrated example, signal I1 is provided by the RHA 200, and signal I2 is provided by the feeding station 300. The control unit 20 is also configured to generate an output signal O1, e.g. to indicate a current or future need for replacement of the reel 201 or to signal a rupture of the web 10.

[0040] The control unit 20 may comprise an MMI (Man Machine Interface), not shown, which is operated to present information to an operator or user about the operation of the machine 1 and accepts input data and control instructions from the operator. The MMI may, e.g., comprise one or more of a display, a touch screen, a mouse, a keyboard, a track pad, buttons, sliders, switches and knobs.

[0041] The control unit 20 may be implemented by hardware components, or a combination of hardware components

and software instructions. The software instructions may be executed by a processor in conjunction with an electronic memory in the control unit 20. The software instructions may be supplied to the control unit 20 on a computer-readable medium, which may be a tangible (non-transitory) product (e.g. magnetic medium, optical disk, read-only memory, flash memory, etc) or a propagating signal. In one embodiment, the control unit 20 is a PLC.

[0042] It should be understood that the control unit 20 may also be configured to control other functions of the wrapping machine 1, such as at least part of the operation of one or more of the supply arrangement 100, the feeding station 300 and the wrapping station 400.

[0043] Figs 2A-2B illustrate a so-called multi-lane wrapping machine 1 that implements the principles of the machine in Fig. 1 in respect of a plurality of RHAs 200 that provide a respective continuous web (lane) 10 of wrapping material to the feeding station 300. In the illustrated example, the machine 1 comprises 24 RHAs and is configured to define 12 lanes of wrapping material. Thus, the machine 1 actively operates 12 RHAs and the remaining 12 RHAs are spares, which may be connected to the feeding station 300 if one or more of the actively operated RHAs malfunction or run out of wrapping material. It is realized that the control unit 20 is configured and connected to control 24 RHAs, specifically the brake module (202 in FIG. 1) in the respective RHA 200. It is thus highly desirable for the control unit 20, and the brake modules, to be simple, cost-effective and robust.

[0044] The lanes 10 may be drawn into the feeding station 300 at the same infeed rate or at different infeed rates, depending on the configuration of the feeding and wrapping stations 300, 400.

[0045] As seen in Fig. 2B, the brake modules 202 are attached in rows to opposite sides of the frame 203. As will be described in detail below, a reel holder (205 in Figs 3-5) is rotatably connected to the respective brake module 202 to define a cantilevered holder for the reels 201 of wrapping material.

[0046] One of the RHAs 200 is shown in more detail in Figs 3-5. The RHA 200 comprises a brake module 202, a reel holder 205 and a spindle or shaft 206. The brake module 202 is defined by a compact housing 204 of metal. The reel holder 205 defines a mounting surface for the reel 201. The reel 201 comprises a core 201' of paper or plastic material, onto which the web 10 of wrapping material is wound. The mounting surface of the reel holder 205 comprises a plurality of elongated locking elements 207 that extend in an axial direction of the reel holder 205 and are movable in a radial direction of the reel holder 205. The locking elements 207 are controllable to retract when a reel 201 is to be installed on the reel holder 205 and to be pushed out for locking engagement with the core 201' of the installed reel 201. In the illustrated example, the locking elements 207 are pneumatically controlled and a connector 209 is attached to an end of the reel holder 205 for fluid connection to a pneumatic pressure source (not shown).

[0047] The spindle (shaft) 206 projects from the reel holder 205 and is arranged in, attached to, integrated with or otherwise combined with the reel holder 205 in alignment with its geometric center line. Thereby, the spindle 206 forms a unit with the reel holder 205 and defines a rotational axis R1 of the combination of spindle 206 and reel holder 205 (Fig. 5). In one example, the spindle 206 is a rod-like element that extends through and is rigidly connected to the reel holder 205. The spindle 206 comprises an end portion or end hub 208 which is configured for arrangement in the brake module 202.

[0048] The housing 204 defines a first channel 210 (Fig. 5) for receiving the end hub 208 of the spindle 206. The first channel 210 is a through-hole that extends between openings 210A, 210B on opposite sides of the housing 204. Two bearings 211 are mounted in the first channel 210 and configured to snugly receive the end hub 208. Thereby, the spindle 206 is rotatably arranged in the housing 204. The end hub 208 comprises a cylindrical engagement surface 212, which is located inside the first channel 210 intermediate the bearings 211. A sensor wheel 213 with radially projecting teeth 213' is attached to an end surface of the end hub 208, by screws 214 engaged in corresponding holes in the end surface. The teeth 213' are uniformly distributed along the perimeter of the wheel 213.

[0049] The housing 204 further defines a second channel 221 for receiving a brake pad 223 that forms a frictional element for engagement with the engagement surface 212 of the end hub 208. The second channel 221 extends from an opening 221A in the housing 204 into the first channel 210. The second channel 221 is arranged to extend at right angles (perpendicular) to the first channel 210 and thus to the rotation axis R1 of the spindle 206. The brake pad 223 is received in the second channel 221 to be freely moveable along the second channel 221. The brake pad 223 has a cylindrical shape and extends between a front end surface 223A and a rear end surface 223B, where the front end surface 223A has a shape that conforms to the shape of the engagement surface 212. An actuator 224 is arranged for imparting a movement of the brake pad 223 towards the spindle 206 so as to engage the front end surface 223A with the engagement surface 212 and thereby apply a brake force to the spindle 206. The actuator 224 comprises an expandable element 224' for imparting the movement. In the illustrated example, the expandable element 224' comprises an expandable pouch, implemented as a rubber balloon, which is expanded by admission of a gas, i.e. by application of pneumatic pressure. The element 224' may or may not be attached to the rear end surface 223B. The actuator 224 comprises a connector 225 for fluid connection to a pneumatic pressure source (not shown). A cover plate 226 is attached to the housing 204, by screws 227 engaged in corresponding holes, to close the opening 221A and restrict movement of the actuator 224 and the brake pad 223.

[0050] The brake module 202 further comprises a rotation sensor 228, specifically an inductive proximity sensor, which

is mounted in a dedicated hole in alignment with the sensor wheel 213. The rotation sensor 228 is configured to generate a sequence of pulses that each represents the passage of a tooth 213' beneath the sensor 228. It is realized that the number of pulses per unit time represents the rotational speed (angular velocity) ω_m of the spindle 206 and thus the reel 201. The rotation sensor 228 provides the above-mentioned input signal I1 (Fig. 1) that is indicative of the rotational speed ω_m of the reel 201, and a connector 229 is attached to the sensor 228 for electrical connection to the control unit 20.

[0051] The brake module 202 further comprises fasteners 230 (here, holes for receiving screws) for mounting the brake module 202 to the frame 203 (Figs 2A-2B).

[0052] In the following, the operation of the control unit 20 will be exemplified with respect to the RHA 200 in Figs 3-5. As noted above, the control unit 20 is configured to operate the brake module 202, by a control signal C1, to control the tension in the web 10. It should be realized that the required brake force to maintain an essentially consistent tension in the web 10 varies with the diameter of the reel 201. The control unit 20 thus uses a predetermined model to compute a suitable brake force, F_{brake} , at each time point to achieve a desired tension, F_t , in the web 10. The basis for this model is that the current diameter D_c of the reel 201 (Fig. 6) may be computed based on the rotational speed ω_m and the infeed rate S_{in} :

$$D_c = S_{\text{in}} / (\pi \cdot \omega_m) \quad (1)$$

[0053] A target torque T_t on the spindle 206 to achieve the desired tension F_t may be given by:

$$T_t = F_t \cdot D_c / 2 \quad (2)$$

[0054] The required brake force may be given by:

$$F_{\text{brake}} = T_t / (\mu_N \cdot r_{\text{hub}}) \quad (3)$$

where μ_N is the dynamic coefficient of friction for the brake pad 223, and r_{hub} is the radius of the end hub 208 at the engagement surface 212. Entering Eq. (1) and Eq. (2) into Eq. (3) yields:

$$F_{\text{brake}} = K_1 \cdot F_t \cdot S_{\text{in}} / \omega_m \quad (4)$$

where K_1 is a predefined constant for the brake module 202. Other relations for calculating the required brake force are conceivable, but the required brake force is generally a function of the desired tension F_t , the infeed rate S_{in} and the rotational speed ω_m : $F_{\text{brake}} = f_1(F_t, S_{\text{in}}, \omega_m)$. Thus, with respect to achieving the desired tension F_t , the control unit 20 may implement an open-loop controller that computes, based on the function f_1 , a current brake force to be applied by the brake module 202.

[0055] In the specific example of Figs 3-5, the control unit 20 may supply the control signal C1 to operate a pneumatic pressure source (not shown) to generate a target pressure, P_{brake} , in the expandable element 224' that yields the required brake force F_{brake} . The target pressure may be given as:

$$P_{\text{brake}} = K_2 \cdot F_{\text{brake}} / (A_{\text{act}} \cdot E_{\text{act}}) \quad (5)$$

where K_2 is a predefined constant (which may be 1), A_{act} is the contact area between the expandable element 224' and the brake pad 223, and E_{act} is an actuator efficiency value, which may represent a ratio of theoretical pushing force to actual pushing force.

[0056] It should be noted that the rotational speed ω_m is given at each time point by the input signal I1. In the example of Figs 3-5, the input signal I1 comprises a sequence of pulses, and the control unit may compute the current rotational speed as:

$$\omega_m = n_m / n_{\text{rev}} \quad (6)$$

where n_m is the number of pulses in the input signal I1 per unit time, and n_{rev} is the number of pulses per revolution of the spindle 206 and is given by the number of teeth 213' on the wheel 213.

[0057] The infeed rate S_{in} may be obtained from an input signal I2 generated by a sensor in the feeding station 300 or the wrapping station 400. However, if the wrapping machine 1 is operated with a fixed and known infeed rate S_{in} , the input signal I2 may be a value entered by the operator via the above-mentioned MMI. Alternatively, the input signal I2 may be a value computed based on current operating parameters of the wrapping machine 1. In one example, the infeed rate may be computed as $S_{in} = n_P \cdot L_P$, where n_P is the number of products P wrapped per unit time from the web 10 supplied by the RHA 200, and L_P is the length of the wrapping P' for each product.

[0058] The control unit 20 is further configured to monitor the status of the RHA 200 based on the rotational speed ω_m , and to generate the output signal O1 (Fig. 1) to indicate the status. The status given by the output signal O1 may, e.g., be presented to the operator via the above-mentioned MMI.

[0059] In one embodiment, the control unit 20 monitors the rotational speed ω_m for detection of a breakage of the web 10. For example, the control unit 20 may detect and signal a breakage if the rotational speed ω_m is found to decrease rapidly or is at or near zero.

[0060] In a further embodiment, the control unit 20 computes a parameter indicative of a fill status of the reel 201. The fill status may be signaled to the operator, by the output signal O1, to indicate a need to replace the reel 201, e.g. by switching to a spare RHA 200 in the wrapping machine (cf. Figs 2A-2B).

[0061] The computation of various fill status parameters is exemplified below, with reference to input values indicated in Fig. 6, which shows a reel 201 at a current time point during consumption. The reel 201 is associated with a current diameter D_c , a starting diameter D_1 when full (indicated by dashed lines), and a core diameter D_0 when empty.

[0062] In a first example, the control unit 20 computes and signals the current number of turns of web 10 left on the reel 201, e.g. given by:

$$N_c = (D_c - D_0) / (2 \cdot h) \quad (7)$$

[0063] where h is the actual thickness of the web 10 when rolled onto the reel 201. Generally, this means that N_c is given by a function $f_2(S_{in}, \omega_m)$.

[0064] The actual thickness h may be either predefined or computed based on design data for the reel 201. It should be noted that the actual thickness h may differ from the nominal or rated thickness of the web 10. In one example, the actual thickness may be computed as:

$$h = \pi \cdot (D_1^2 - D_0^2) / (2 \cdot (\pi \cdot D_1 - \pi \cdot D_0 + 2 \cdot L_1)) \quad (8)$$

where L_1 is the length of the web on the reel 201 when full.

[0065] In a second example, the control unit 20 computes and signals the remaining web length on the reel 201, e.g. given by:

$$L_c = \pi \cdot N_c \cdot (D_0 + h \cdot (N_c - 1)) \quad (9)$$

[0066] Generally, the means that L_c is given by a function $f_3(S_{in}, \omega_m)$.

[0067] In a third example, the control unit 20 computes and signals the remaining time until the reel 201 is empty, e.g. given by:

$$\Delta t_c = L_c / S_{in} \quad (10)$$

[0068] Generally, this means that Δt_c is given by a function $f_4(S_{in}, \omega_m)$.

[0069] It should be understood that certain input data for the control unit 20 may be predefined for the brake module 202 and stored in a memory of the control unit 20, e.g. μ_N , r_{hub} , K_1 , K_2 , A_{act} , E_{act} , n_{rev} , and that other input data may be fixed and entered by the operator prior to starting the wrapping machine, e.g. F_t , n_P , L_P , D_0 , D_1 , L_1 , and that at least the rotational speed ω_m is given as a measured input variable, possibly together with the infeed rate S_{in} .

[0070] Fig. 7 illustrates a method 700 of operating the multi-lane wrapping machine 1 as depicted in Figs 2A-2B, for wrapping of ice cream products. In step 701, a plurality of webs 10 of wrapping material are supplied from the RHAs 200. In step 702, the webs 10 are fed from the RHAs 200 to a wrapping station 400 at an infeed rate S_{in} . In step 703, the ice cream products P are supplied to the wrapping station 400. In step 704, the webs 10 are processed at the wrapping station 400 into wrappings P' around the ice cream products P. During these steps 701-704, the brake modules 202 in the RHAs 200 are operated, by the control unit 20, to control tension in the web 20 as supplied from the RHAs 200.

Claims

1. A reel holder arrangement for supplying a web (10) of wrapping material to a food product wrapping machine (1) that consumes the web (10) of wrapping material at an infeed rate (S_{in}), the reel holder arrangement comprising:
 - a brake module (202),
 - a shaft (206) rotatably arranged in the brake module (202), the brake module (202) being operable to apply a brake force on the shaft (206), and
 - a reel holder (205) combined with the shaft (206) and configured to hold a reel (201) that comprises the web (10) of wrapping material in rolled-up form, such that the reel holder (205) is driven to rotate by the consumption of the web (10) of wrapping material by the food product wrapping machine (1), wherein
 - a rotation sensor (228) is arranged to sense a parameter indicative of a rotational speed (ω_m) of the shaft (206), and
 - the reel holder arrangement comprises a control unit (20) configured to receive input signals (I1, I2) indicative of the infeed rate (S_{in}) and the rotational speed (ω_m) and to generate a control signal (C1) for operating the brake module (202) to set the brake force to thereby control tension in the web (10) of wrapping material as supplied to the food product wrapping machine (1).
2. The reel holder arrangement of claim 1, wherein the control unit (20) is configured to generate the control signal (C1) to set the tension in the web (10) of wrapping material within a predetermined tension interval.
3. The reel holder arrangement of claim 1 or 2, wherein the control unit (20) is configured to generate the control signal (C1) as a function of a required brake force (F_{brake}) which is computed as a function of the infeed rate (ω_m), the rotational speed (ω_m) and a desired tension in the web (10) of wrapping material.
4. The reel holder arrangement of any preceding claim, wherein the control unit (20) is configured to estimate a diameter (D1) of the reel (201) as a function of the rotational speed (ω_m) and the infeed rate (S_{in}) and to generate, as a function of the diameter (D1), an output signal (O1) for use in controlling the food product wrapping machine (1).
5. The reel holder arrangement of claim 4, wherein the output signal (O1) comprises any one of
 - an estimated amount of remaining wrapping material in the reel (201),
 - an estimate of a time period until a predefined amount of wrapping material remains in the reel (201), and
 - an indication to stop the consumption of the wrapping material from the reel holder arrangement.
6. The reel holder arrangement of any preceding claim, wherein the control unit (20) is configured to detect, based on the rotational speed (ω_m), a rupture of the web (10) of wrapping material.
7. The reel holder arrangement of claim 6, wherein the control unit (20) is configured to detect the rupture when the rotational speed (ω_m) decreases at a rate that is beyond a threshold level.
8. The reel holder arrangement of any preceding claim, wherein the brake module (202) comprises a frictional element (223) arranged to engage a cylindrical surface portion (212) of the shaft (206), and an actuator (224) arranged to impart a movement of the frictional element (223) towards the shaft (206).
9. The reel holder arrangement of claim 8, wherein the frictional element (223) is arranged in the brake module (202) to move at right angles to a rotational axis (R1) of the shaft (206).
10. The reel holder arrangement of claim 8 or 9, wherein the actuator (224) comprises an inflatable element (224') which is arranged to expand towards the shaft (206) when inflated, to thereby impart the movement of the frictional element (223).
11. The reel holder arrangement of any one of claims 8-10, wherein the frictional element (223) is a cylindrical element with a rear end surface (223B) arranged to engage the actuator (224) and a front end surface (223A) arranged to engage the cylindrical surface portion (212) of the shaft (206).
12. The reel holder arrangement of any one of claims 8-11, wherein
 - the brake module (202) comprises a housing (204) that defines a first channel (210) which extends from a first opening (210A) in the housing (204), and a second channel (221) which extends at right angles to the first channel

(210) from a second opening (221A) in the housing (204) to the first channel (210),
 one or more bearings (211) are fitted in the first channel (210),
 the shaft (206) is arranged to extend through the first opening (210A) into the first channel (210) in engagement with
 the one or more bearings (211) so as to be freely rotatable in relation to the housing (204),
 the frictional element (223) is arranged for movement along the second channel (221), and
 the actuator (224) is fastened at the second opening (221 A) for engagement with the frictional element (223).

13. The reel holder arrangement of any preceding claim, wherein the rotation sensor (228) is an inductive proximity
 sensor which is arranged to face a perimeter of a wheel (213) on the shaft (206), the wheel (213) comprising radially
 projecting elements (213') that are uniformly distributed along the perimeter.

14. A machine for wrapping food products (P), comprising:

a plurality of a reel holder arrangements (200) according to any one of claims 1-13, which are arranged to supply
 a plurality of webs (10) of wrapping material from a plurality of reels (201) containing rolled-up wrapping material,
 a feeding station (300) arranged to feed the webs (10) of wrapping material at an infeed rate (S_{in}),
 a supply arrangement (100) arranged to supply the food products (P), and
 a wrapping station (400) arranged to receive the food products (P) and the webs (10) of wrapping material and
 to process the webs (10) of wrapping material into wrappings (P') around the food products (P).

15. A method of wrapping ice cream products (P), comprising:

supplying (701) a plurality of webs (10) of wrapping material from a plurality of reel holder arrangements (200)
 according to any one of claims 1-13,
 feeding (702) the webs (10) of wrapping material at an infeed rate (S_{in}) to a wrapping station (400),
 supplying (703) the ice cream products (P) to the wrapping station (400), and
 processing (704) the webs (10) of wrapping material, at the wrapping station (400), into wrappings (P') around
 the ice cream food products (P).

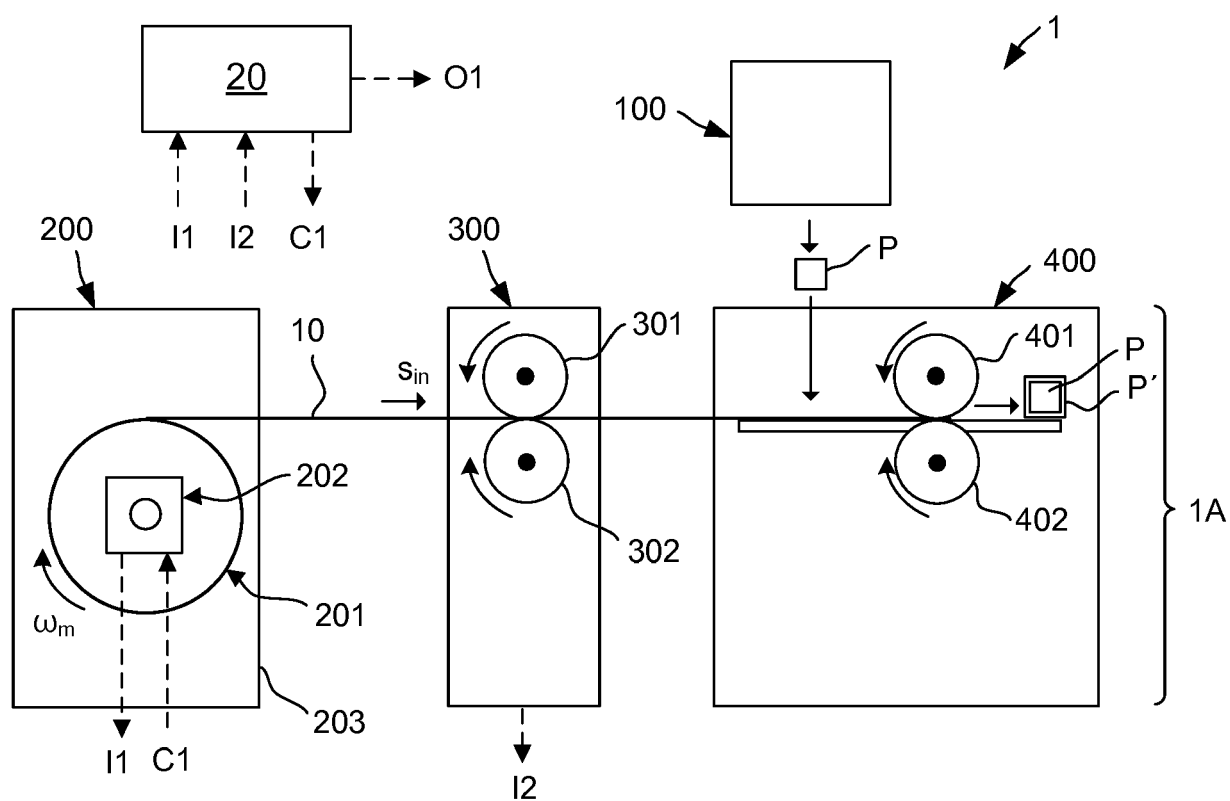


Fig. 1

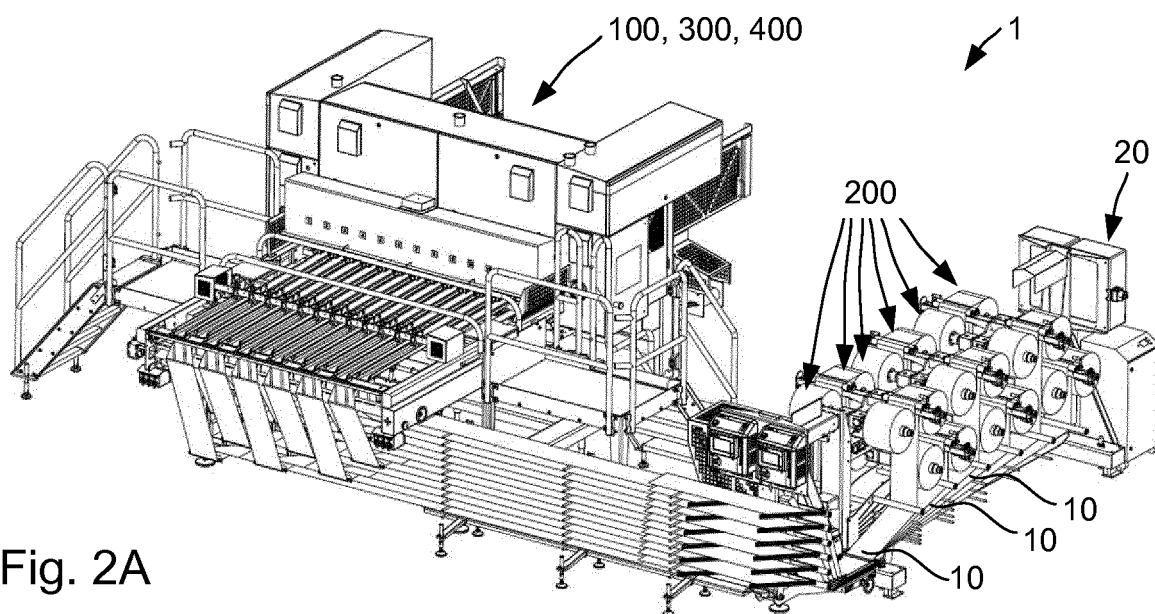


Fig. 2A

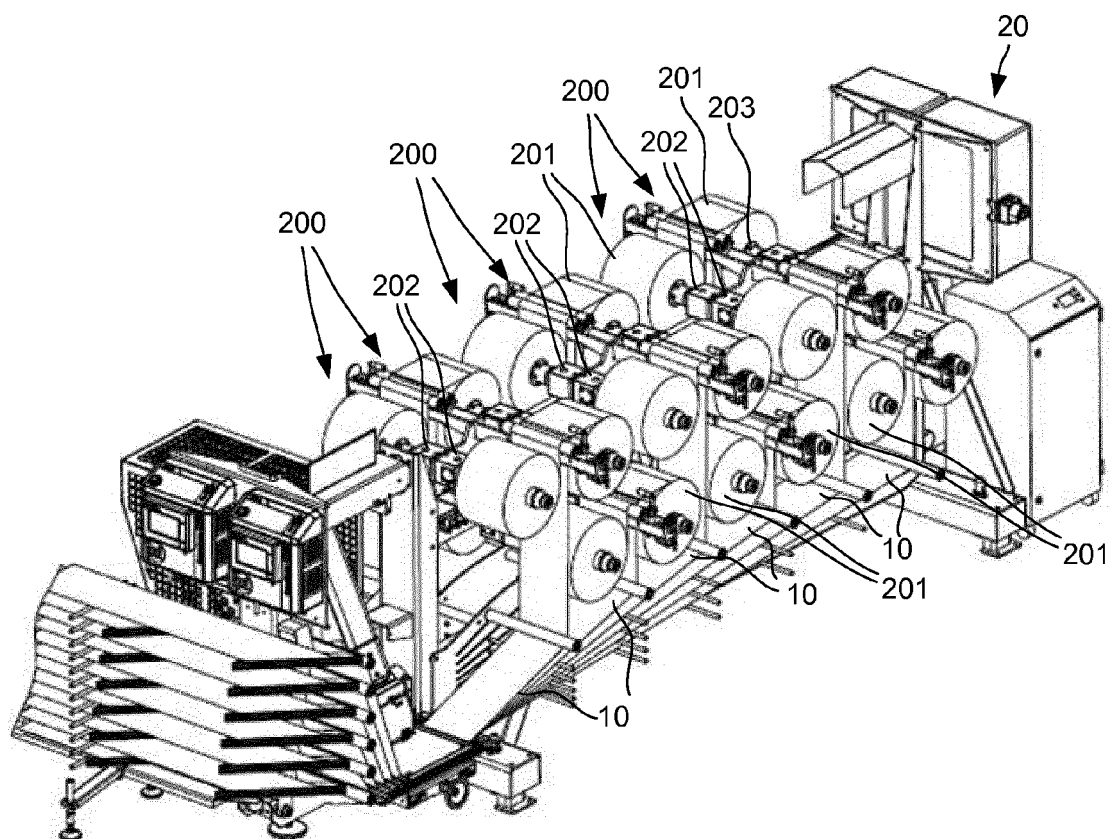


Fig. 2B

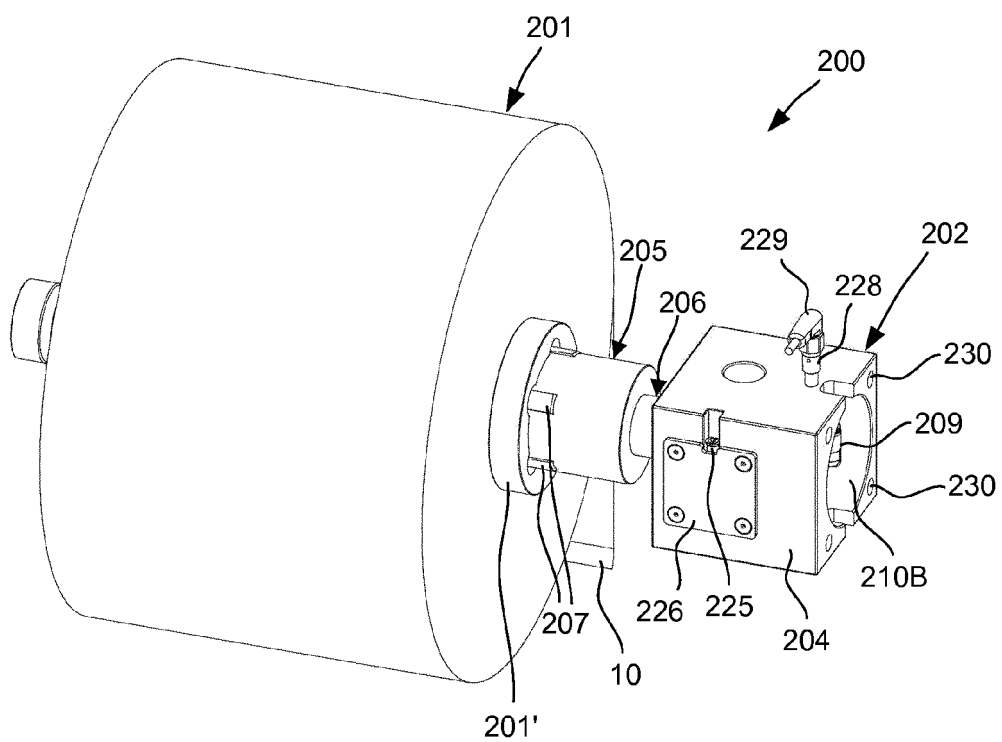


Fig. 3

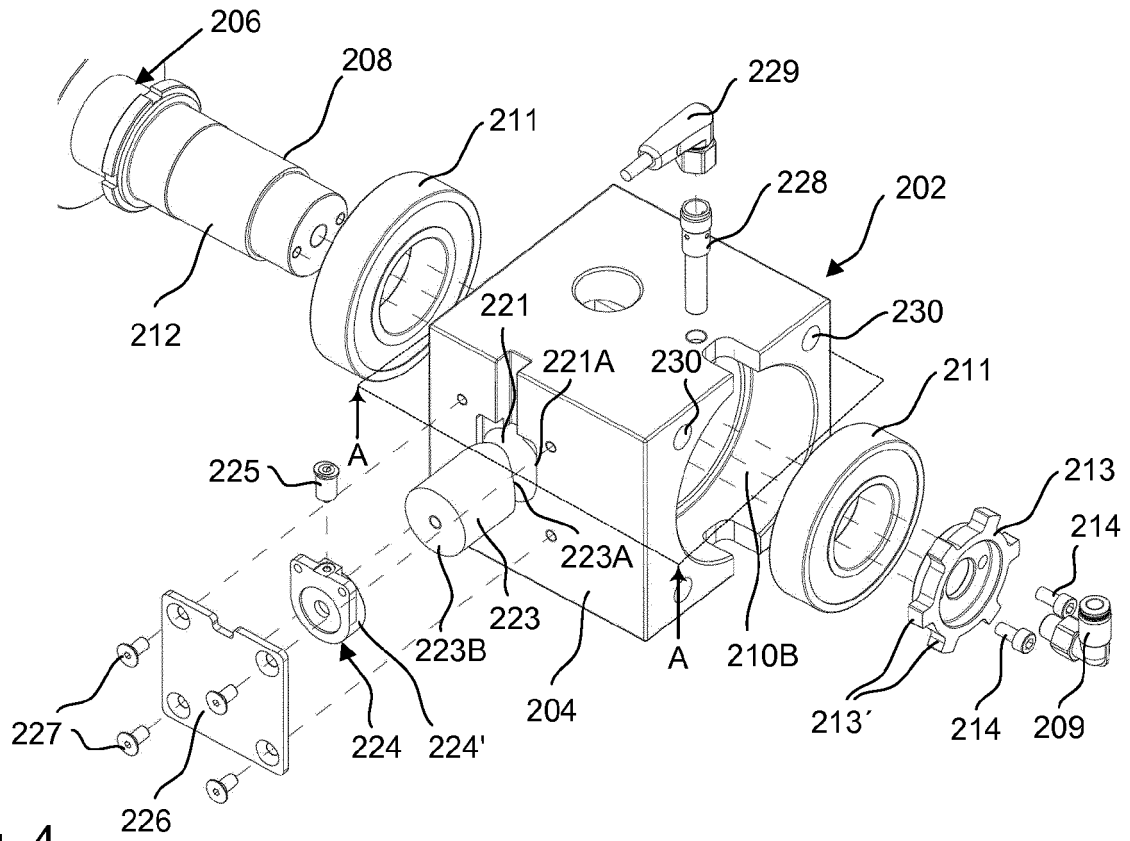


Fig. 4

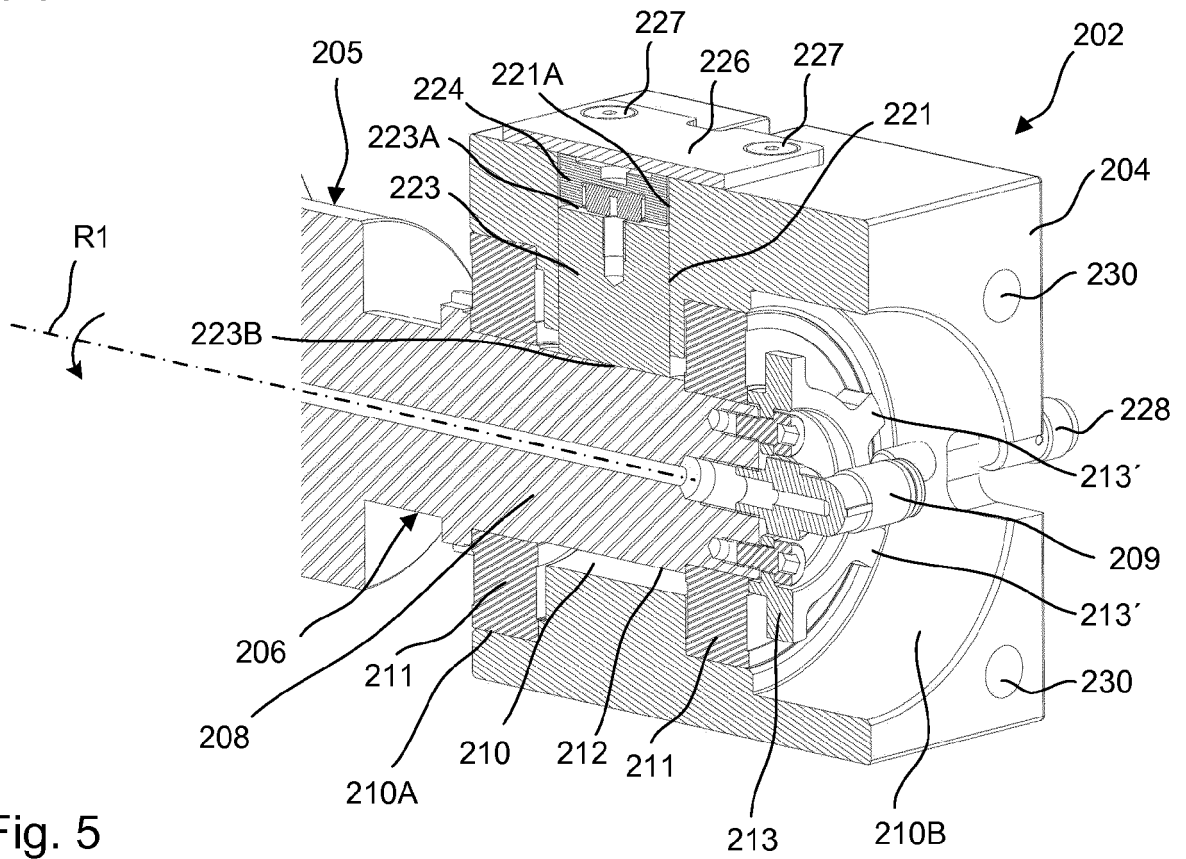


Fig. 5

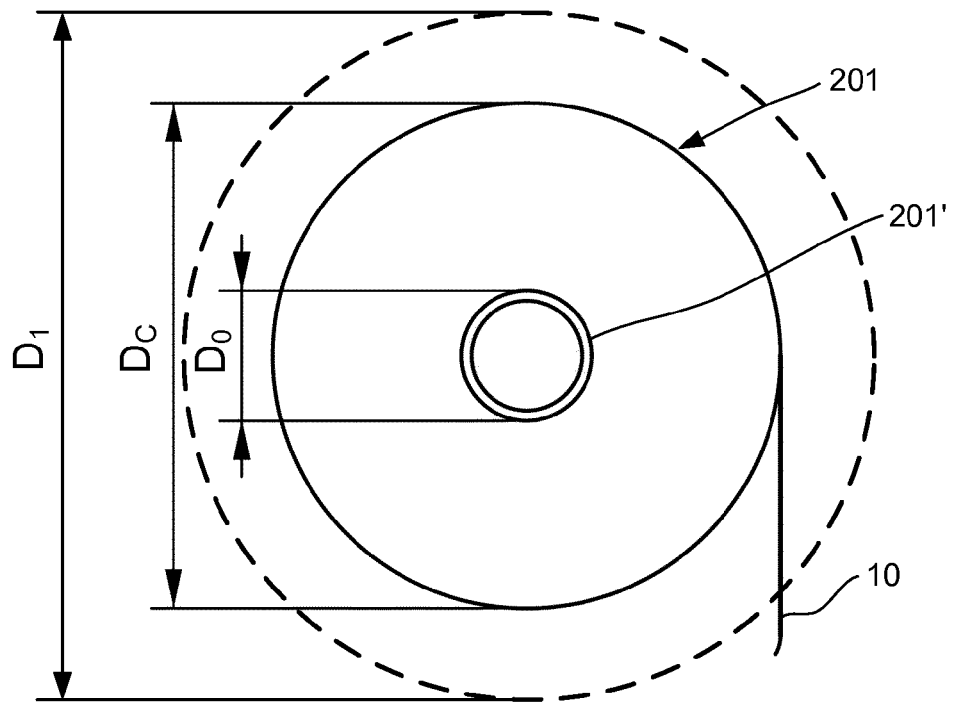


Fig. 6

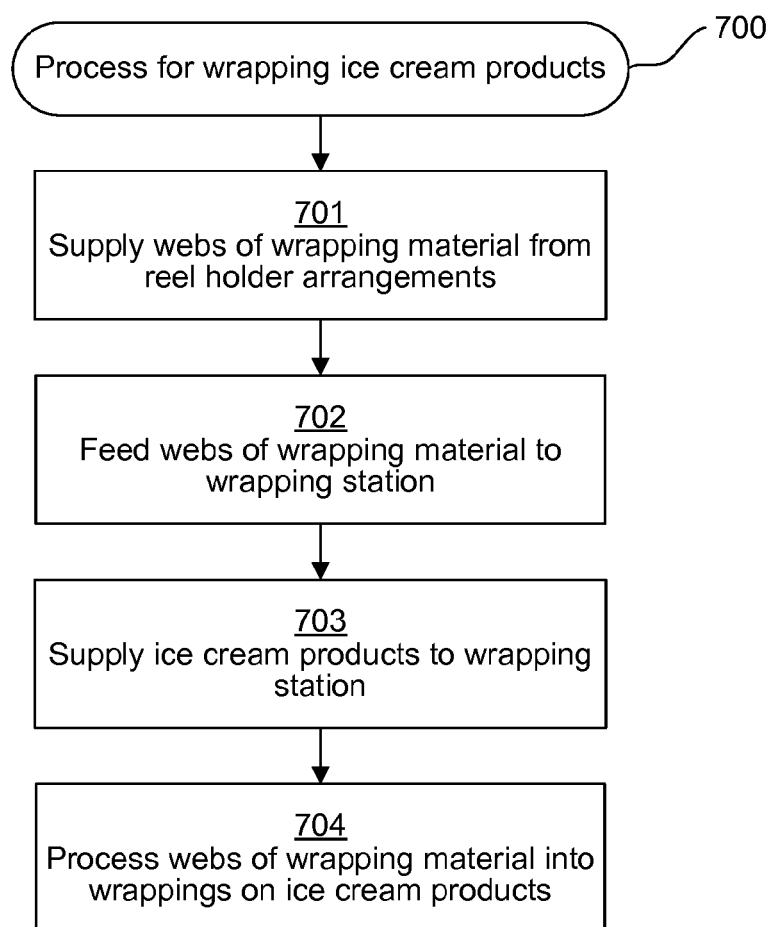


Fig. 7



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