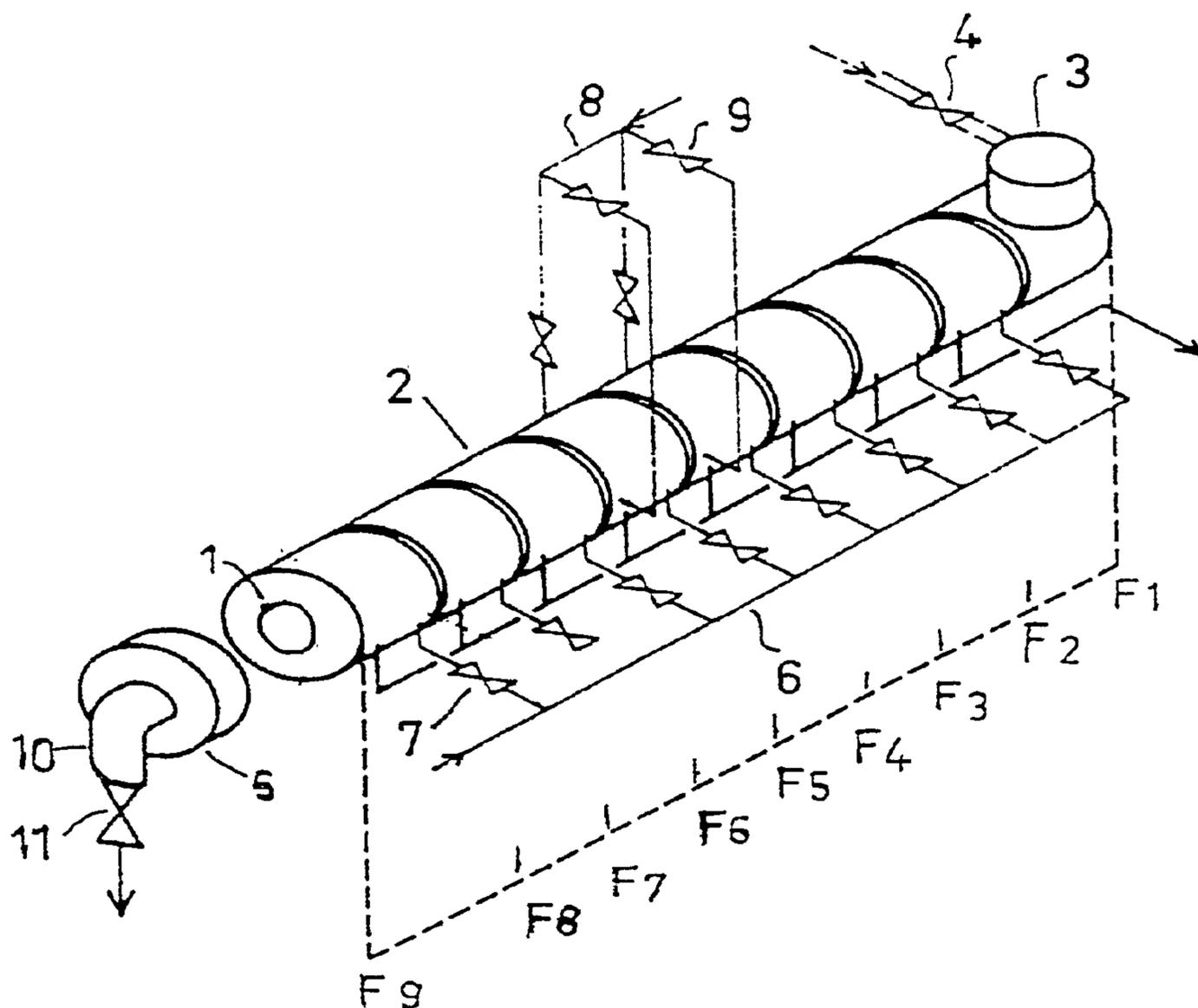




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 (54) Title: METHOD AND DEVICE FOR MANUFACTURING AERATED FROZEN PRODUCTS



(57) Abrégé/Abstract:

The invention discloses a device for manufacturing aerated frozen products comprising a worm screw located in a sheath (7) equipped at one of its ends with a die (5) and at the other with feed means for the composition to be frozen and, in an intermediate part, air supplying means (8, 9), the sheath being provided with a sleeve tube where refrigerating fluids flow.

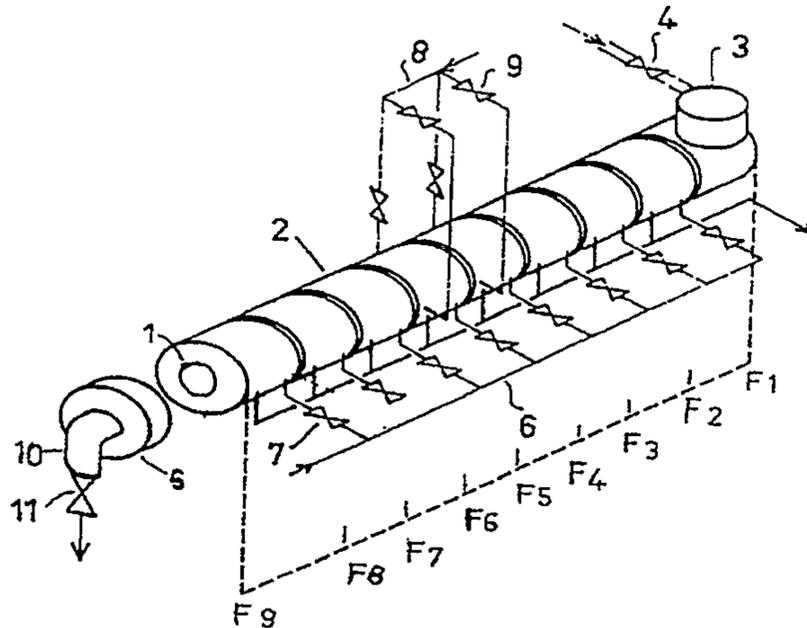


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(57) Abstract

The invention discloses a device for manufacturing aerated frozen products comprising a worm screw located in a sheath (7) equipped at one of its ends with a die (5) and at the other with feed means for the composition to be frozen and, in an intermediate part, air supplying means (8, 9), the sheath being provided with a sleeve tube where refrigerating fluids flow.

(57) Abrégé

Le dispositif de fabrication de produits congelés aérés comprend une vis sans fin, placée dans un fourreau (7) muni à l'une de ses extrémités d'une filière (5) et à l'autre de moyens d'alimentation en composition à glacer et, dans une zone intermédiaire, de moyens d'alimentation en air (8, 9), le fourreau étant pourvu d'un manchon où circulent des fluides frigorigènes.

Process and device for manufacturing aerated
frozen products

The invention concerns the manufacture of aerated frozen
5 products and a device for putting the process into
practice.

A conventional process for manufacturing aerated frozen
products, in particular ice cream, comprises the operations
10 of blending, homogenizing, pasteurizing, freezing and
hardening the mixture to be frozen. Aeration of the mixture
or expansion is carried out during the freezing step in a
proportion such that the volume increases by 70 to 120 %.
On leaving the freezer, the temperature of the aerated mass
15 is typically -5 to -6°C. The mass is then hardened at -40 to
-45°C in a hardening chamber, until the temperature of the
product reaches -18°C or lower at the core for bulk products
or -30°C for products extruded as bars.

20 An attempt has been made to reduce the temperature of the
mass leaving the freezer for reasons of energy saving and
with the object of improving the texture, for example in
the direction of improved oiliness. Insurmountable problems
have however been encountered with conventional equipment
25 with the high viscosity of the ice cream mass at
temperatures below -7 to -8°C. These problems have been
partially resolved by using two freezers with a scraped
surface in series, the first conventional one delivering
aerated ice cream at approximately -7°C, and the second
30 specially designed to treat the highly viscous material so
as to lower its temperature to approximately -10°C.

Within the same type of ideas, EP-A-0 561 118 describes a
three-step process for producing ice cream at a low
35 temperature, down to -20°C. This is an exit temperature
where the hardening step may be entirely dispensed with for
bulk products, and considerably shortened for extruded

products. In the first step, the so-called pre-expansion step, air is incorporated into the mixture to be frozen at a positive temperature. In the second step, the aerated mass is cooled in a scraped surface exchanger and leaves at
5 approximately -6°C . During the third step, a screw device cools the mass to approximately -20°C .

US-A-5 024 066 concerns a two-step system. Pre-expansion takes place in the first step during which air is added to
10 the mass to be frozen at a positive temperature. In the second step the aerated mass is cooled by means of an archimedean screw with a rough surface provided with scraping knives at its periphery, to a negative temperature sufficiently low to ensure a stable texture of the frozen
15 mass, which enables the products to be stored directly in a cold chamber.

The present invention seeks to carry out expansion and cooling operations on the mass in a single
20 step in a single apparatus, which is easier to control and is less bulky than known devices, as well as to simplify the freezing process at a low temperature while deriving from this the previously mentioned advantages regarding energy and texture.

25 The invention concerns a process for manufacturing aerated frozen products, wherein a composition to be frozen is mixed, aerated, frozen and cooled to a temperature lower than or equal to -8°C and is passed through a die,
30 characterized in that the operations take place in a single step in a single mono-screw extrusion device situated in a barrel provided with means for aeration and cooling.

2a

According to the present invention there is provided a process for manufacturing a frozen aerated composition comprising (i) introducing an unfrozen composition suitable for being frozen for preparing a frozen aerated composition into an extrusion apparatus which consists essentially of a barrel which is cooled and of a single screw which is contained in the barrel and configured for transporting, mixing, shearing and compressing the composition and of a product exit die and rotating the screw for (a) transporting the composition through the apparatus to and then through the exit die and for (b) during transport of the composition through the apparatus, mixing, shearing and compressing the composition and (ii) during the transport of the composition through the apparatus, cooling the composition and injecting air into the composition to obtain, from the exit die, a compressed, aerated, cooled composition which has a temperature of equal to or lower than -8°C .

It has been found surprisingly that it is possible to aerate, mix, cool and extrude a composition to be frozen in a single step whilst obtaining a frozen aerated product at

a low temperature having an improved and stable texture when it would have been feared that the texture of the frozen composition would be damaged during treatment in a mono-screw extrusion device. This does not necessarily
5 follow, since known processes provide for aeration to take place prior to cooling in a separate device, and cooling leading to freezing is carried out, at least partially, in a device provided with scraper knives.

10 In order to put the process into practice, there is prepared in a conventional manner a composition for ice cream, low-fat ice cream or sorbet, based, according to the recipe, on milk, skimmed milk, cream, concentrated milk, powdered milk or butter oil, to which are added sucrose,
15 glucose, fruit dextrose, fruit pulp and stabilizing hydrocolloids such as, for example, carragheenates, alginates, carob gum, emulsifiers such as, for example, partial glycerides and flavourings. After intimately mixing the ingredients in the proportions dictated by the
20 recipe, the mixture is pasteurized, cooled and then may optionally be homogenized, preferably hot, under stringent conditions enabling the mean size of the fat globules to be reduced to around 8-20 micron. After cooling and
homogenizing at a low temperature, close to 0°C, the
25 composition may be allowed to ripen for a certain length of time at this temperature. Homogenization and maturing are optional steps.

This mass, optionally homogenized and ripened, is
30 hereinafter designated as the "mass to be frozen". It is introduced, preferably at approximately 2-7°C into a mono-screw freezer which will be described later in greater detail, in which it is conveyed to an air injection zone where it is expanded to 0-150 %, strongly cooled to -8
35 to -20°C, and then forced through a die.

Work in the mono-screw device is carried out surprisingly without excessive shear, so that the increase in pressure does not exceed approximately 50 bar in the region of the die. The emerging product is characterized by a mean ice
5 crystal diameter of 10 to 30 micron, which is appreciably less than that which can be obtained with conventional freezers. The result is an improved texture in the sense of better oiliness and better creaminess.

10 The invention also concerns a device for putting the process into practice, comprising an endless screw, placed in a barrel provided at one of its ends with an extrusion die and at the other end with means for feeding the composition to be frozen and, in an intermediate zone,
15 means for feeding in air, the barrel being provided with a sleeve through which cooling fluids flow.

The endless screw may have successive segments where its form varies from one segment to another, from the point of
20 view of the orientation of the threads and their pitch. The configuration of the screw is chosen so as to carry out operations for transporting, mixing, shearing and compressing the mass through the die and to encourage, optionally, the incorporation of gas so as to obtain good
25 expansion. Zones can be provided for mixing, for example by mono-lobe or bi-lobe discs with a positive orientation, having a transporting effect or with a negative orientation having a return effect or having a segment with an inverse screw pitch inducing a return.

30 The barrel is provided with means for cooling consisting of a jacket with, preferably, one self-contained cooling circuit per segment, with valves controlling the flow rate of cooling agent which enables the temperature of each
35 segment to be regulated individually. The screw may also have an internal cooling circuit.

Air may be injected by means of flow meters through pipes at different regions of the barrel, preferably in the second half of its length, preferably from either side thereof. In this way, it is possible to achieve 0 to 150 %
5 and preferably 30 to 120 % expansion.

The die may have a horizontal or vertical outlet. The geometry and dimensions of the die or, as the case may be, the diameter and length of the outlet pipe which may be
10 associated therewith are designed to ensure a counter-pressure of the order of 4 to 50 bar and preferably 4 to 25 bar. The counter-pressure may be regulated by means, for example, of a ball valve downstream from the pipe in question, for example in the case of an outlet temperature
15 for the product close to the lower limit, in which case the diameter of the outlet pipe should be increased to compensate for the fall in pressure due to the loss of charge caused by the increase in viscosity when the temperature of the mass falls. The die may preferably be
20 cooled, for example by means of a sleeve through which a cooling fluid flows.

Ice crystal size may be determined by one of ordinary
25 skill in the art, using a dispersion of ice crystals in mineral oil at -10°C , for example, by the method of optical microscopy disclosed in "Determination of ice crystal size distributions in frozen desserts" by D.P. Donhowe et al., J. Dairy Sci., 74: 3334-3344 (1991),
30 using $D_{1,0}$ as the arithmetic mean of measurements of equivalent diameter, as the diameter of a circle that has an equivalent surface area as the surface of the crystal, taken on several ice crystals, about 1000-1500 ice crystals being automatically measured from about 10
35 views. The mean fat globule diameter, $D_{v0.5}$ was measured by laser scattering using the Malvern MastersizerTM technique.

5a

The device according to the invention is described below in greater detail with reference to the accompanying drawing, given by way of example, in which :

- 5 Figure 1 is an exploded diagrammatic view in perspective of the device.

As will be seen in figure 1, the device comprises an extrusion screw 1, which can move in rotation about its
10 axis and is driven by a motor (not shown). The screw is mounted in a barrel (2) which has at its beginning a pipe 3 for feeding a composition to be frozen provided with a non-return valve 4 for ensuring air tightness and which ends in a die 5 in the form of a plate.

The barrel comprises nine segments F1 to F9, 100 mm in length, which are modulable from the point of view of the configuration of the screw with which are associated individual cooling circuits 6 corresponding to the sleeves 5 through which a water-alcohol mixture flows, with individual flow rate regulation by means of the valves 7. Aeration takes place through the air inlet 8, on either side of the barrel and air is injected by a piston provided with a mass flow meter. The air flow rate is regulated 10 individually by the valves 9.

In a variant (not shown) the die 5 is provided with a sleeve through which a cooling fluid also flows of which the flow rate may be regulated individually. 15

A pipe 10 at the end of the outlet from the barrel 2 and the die 5, acts as a pre-expansion zone. The pipe 10 is provided with a ball valve 11 for controlling the counter-pressure and the dwell time of the mass in the barrel. 20

If L is the total length of the segments of the screw which represent the active length of this screw and D is its diameter, the ratio L/D is of the order of 30 to 60.

25 The process according to the invention is described in greater detail in the following examples given by way of illustration. Percentages and parts are by weight, except where indicated to the contrary.

Example 1

A composition to be frozen was prepared having a low freezing point containing 8.5 % of milk fats (in the form of cream with 35 % fats), 11 % of non-fat milk solids, 12 % sucrose, 6.4 % glucose syrup (dextrose equivalent 40), 1 % dextrose, 0.47 % partial glycerides as stabilizers/emulsifiers and 0.4 % of vanilla flavouring. The total solids content of the composition was 39.15 %, the remainder being represented by water. The mixture was subjected to homogenization in two steps at 135 bar, and then 35 bar, and was pasteurized at 86°C for 30 s, cooled to 4°C and stored 24 h at this temperature. This composition was introduced into the device under the operating conditions given below :

- Configuration of screw

Segments	F1	F2	F3	F4	F5	F6	F7	F8	F9
Type of screw	T	T/M	T/M	M/C	T	CO	M/CO	M/CO	CO

Where T: Transport, M: Mixing, C: Shear and CO: Compression

- Flow rate of product entering 8 kg/h, at 6°C
 - Air injection: in 9 from both sides in F5 and F6, i.e. through 4 pipes with a flow rate of 15 g/h.
 - Rate of rotation of screws: 300 rpm.
 - Cooling of zones F2 to F9 with a cooling fluid at -26°C (inlet temperature)/-24.4°C (outlet temperature), at a flow rate of 17 litres/min.
 - Diameter of outlet die: 12 mm
- The outlet temperature of the product was -10.4°C and expansion was 40 %.

The products obtained had an oilier and creamier texture than products manufactured in a conventional manner as a reference.

The mean ice crystal diameter measured by optical microscopy at -10°C was $D_{1,0}:30.25$ micron.

5

Example 2

In this example, compositions for a sorbet were prepared in the following manner: 29 % of sugar, 10 % of glucose syrup and 35 % unsweetened raspberry puree, a colorant and a
10 raspberry flavouring were added to a mixture of 0.8% stabilizers (gelatine, carob gum) at 60°C , as well as a food quality acid to give a pH of 3.2-3.4. The solids content of the composition was 30.30 %, the rest being represented by water. The mixture was homogenized at 72°C in one step
15 at a pressure of 50 bar, and was then pasteurized at 85°C for 30 min, cooled to 4°C and allowed to stand for at least 4 h at this temperature.

This composition to be frozen was introduced into the
20 device with the same configuration of the screws as that in example 1. The operating conditions were the same as in example 1, except for the following:

- Air injection: in 9, from both sides in F5 and F6, i.e.
25 through 4 pipes with a flow rate of 15g/h.

The outlet temperature of the product was -10.4°C and expansion was 40 %.

30 In the preceding examples, the process and the apparatus have been described with reference to the manufacture of a frozen composition without specifying that it is possible to treat at the same time several ice creams or sorbets having different flavours and colours, by co-extrusion, and

thus to obtain composite products, for example marbled products, optionally containing inclusions.

The process is of course applicable to the manufacture of
5 frozen products of the mousse, cream and sweetened type or
salted spreading paste type, for example with cheese,
vegetable, meat or fish, or sauces or salad dressings. In
these cases, the flexibility of the process makes it
possible to adjust the amount of air incorporated in the
10 composition to be frozen according to the varying degree of
expansion desired in relation to the characteristics of the
types of products aimed at.

CLAIMS:

1. A process for manufacturing a frozen aerated composition comprising (i) introducing an unfrozen composition suitable for being frozen for preparing a frozen aerated composition into an extrusion apparatus which consists essentially of a barrel which is cooled and of a single screw which is contained in the barrel and configured for transporting, mixing, shearing and compressing the composition and of a product exit die and rotating the screw for (a) transporting the composition through the apparatus to and then through the exit die and for (b) during transport of the composition through the apparatus, mixing, shearing and compressing the composition and (ii) during the transport of the composition through the apparatus, cooling the composition and injecting air into the composition to obtain, from the exit die, a compressed, aerated, cooled composition which has a temperature of equal to or lower than -8°C .
2. A process according to claim 1 wherein the unfrozen composition introduced into the extrusion apparatus has a temperature of from approximately 2°C . to 7°C .
3. A process according to claim 1 or 2 wherein the composition in the extruder is cooled to a temperature of from -8°C . to -20°C . for transport through the die.
4. A process according to any one of claims 1 to 3 wherein the transporting, mixing, shearing, compression and air injection are carried out so that pressure in the extrusion apparatus does not exceed approximately 50 bar.
5. A process according to any one of claims 1 to 3 wherein the transporting, mixing, shearing, compression and air injection are carried out so that the pressure in the extrusion apparatus is on an order of from 4 bar to 50 bar.

6. A process according to any one of claims 1 to 3 wherein the transporting, mixing, shearing, compression and air injection are carried out so that the pressure in the extrusion apparatus is on an order of from 4 bar to 25 bar.

7. A process according to any one of claims 1 to 6 wherein the screw is revolved at a rate of from 100 rpm to 600 rpm.

8. A process according to any one of claims 1 to 7 wherein the air is injected in a zone of the extrusion apparatus at a position intermediate to a zone whereat the composition is introduced into the extrusion apparatus and to a zone prior to the die.

9. A process according to any one of claims 1 to 8 wherein, after the introduction of the composition into the extrusion apparatus, the composition transported is mixed and then the air is injected and then the aerated composition is mixed and compressed.

10. A process according to any one of claims 1 to 9 wherein the air is injected into the composition for expanding the composition in an amount of up to 150%.

11. A process according to any one of claims 1 to 10 wherein temperatures of segments of the extrusion apparatus are regulated individually for the cooling and freezing.

12. A process according to any one of claims 1 to 11 wherein the extrusion apparatus screw and barrel both are cooled.

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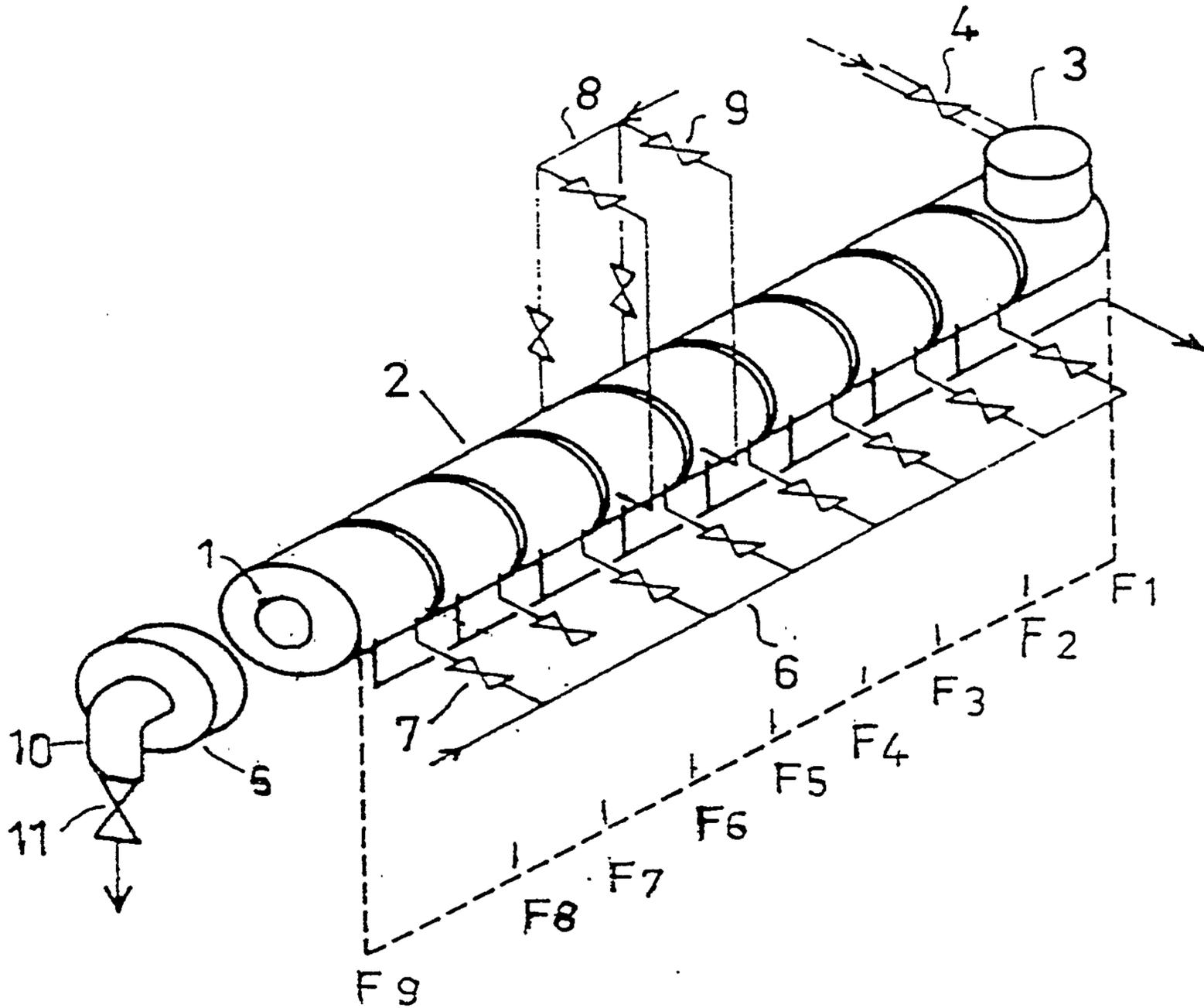


FIG. 1

