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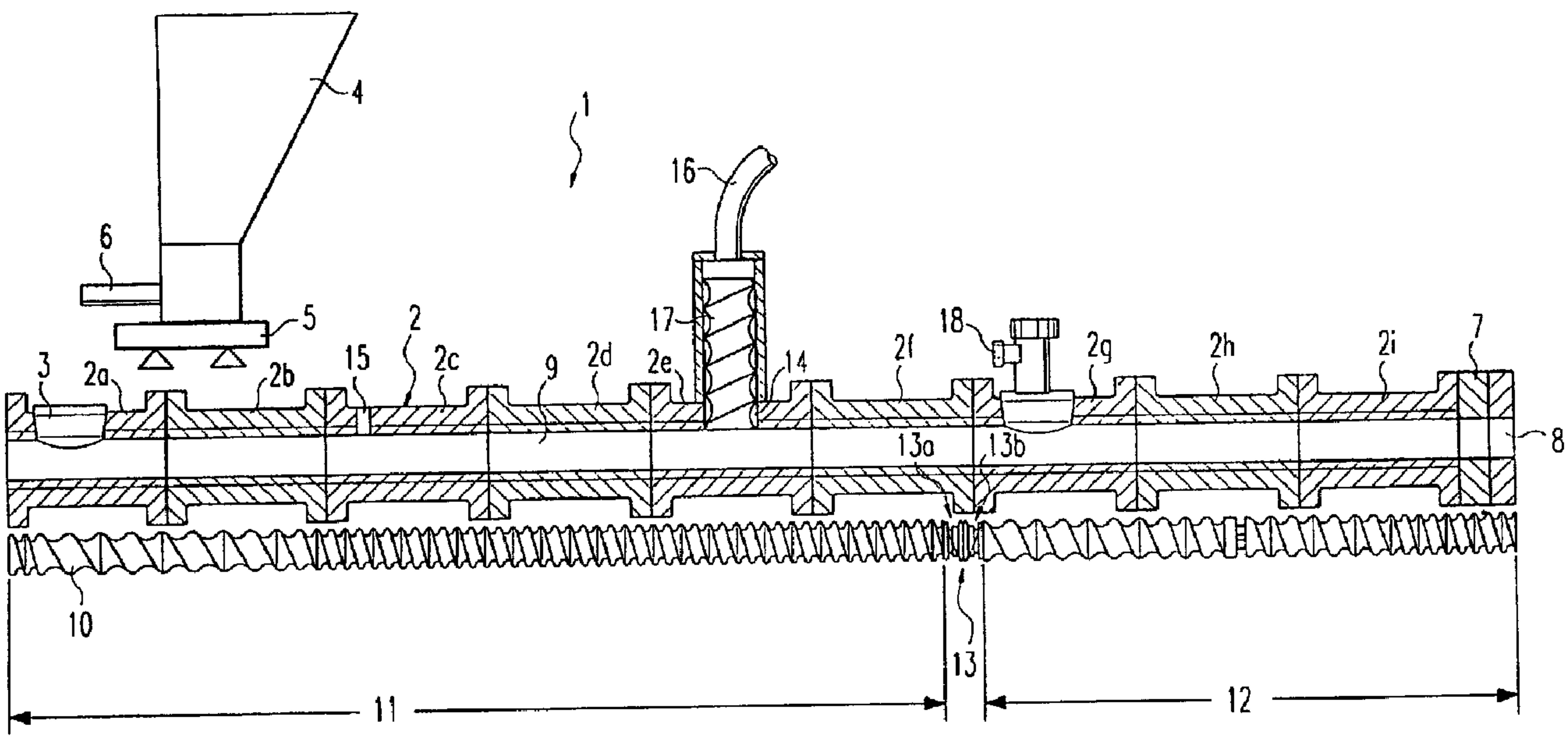
(54) Titre : PROCEDE ET DISPOSITIF POUR LE TRAITEMENT D'UN POLYCONDENSAT THERMOPLASTIQUE
(54) Title: METHOD AND DEVICE FOR PROCESSING A THERMOPLASTIC CONDENSATION POLYMER



(57) **Abrégé/Abstract:**
The invention relates to a method for processing a thermoplastic condensation polymer which comprises the following process steps: introduction of the condensation polymer into an extruder (1) in the solid state; heating of the condensation polymer to a temperature below the melting point; degassing and/or drying of the condensation polymer and subsequent melting thereof. According to the invention the condensation polymer is degassed and/or dried in the solid state at a pressure below atmospheric pressure and/or an inert gas is added.

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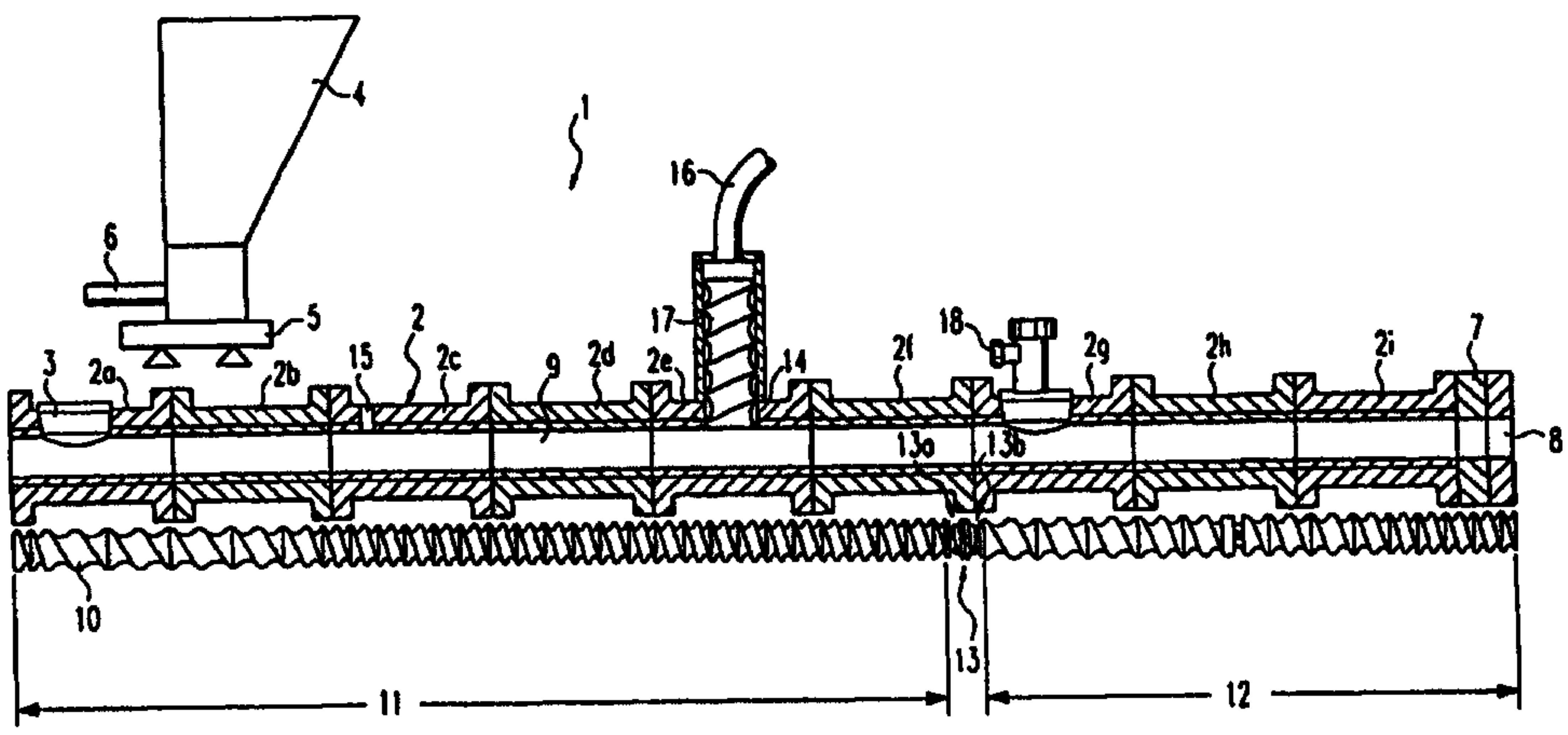
(54) Title: METHOD AND DEVICE FOR PROCESSING A THERMOPLASTIC CONDENSATION POLYMER

(54) Bezeichnung: VERFAHREN UND VORRICHTUNG ZUR AUFBEREITUNG EINES THERMOPLASTISCHEN POLYKONDENSATS



(57) Abstract

The invention relates to a method for processing a thermoplastic condensation polymer which comprises the following process steps: introduction of the condensation polymer into an extruder (1) in the solid state; heating of the condensation polymer to a temperature below the melting point; degassing and/or drying of the condensation polymer and subsequent melting thereof. According to the invention the condensation polymer is degassed and/or dried in the solid state at a pressure below atmospheric pressure and/or an inert gas is added.

Method and Device For Processing A Thermoplastic Condensation Polymer

The invention relates to a process and a device in the form of an extruder for processing a thermoplastic polycondensate. The method according to the invention and the extruder according to the invention are in particular used for recycling thermoplastic polycondensates such as polyethylene therephthalate, polyester or polyamide.

From DE 42 08 099 A1 a process and an extruder are known in which for processing a thermoplastic polycondensate the comminuted polycondensate is fed to an extruder, still in its solid, non-melted state. The extruder is a two-shaft extruder with two tightly intermeshing worm shafts arranged parallel in respect of each other in a housing. In a first processing zone, the polycondensate which is still in its solid state, is heated to a temperature below the melt point, so that low-molecular components, in particular water, can at least partly escape via a degassing aperture provided in the housing. Then the polycondensate is processed by means of kneading elements and melted. In a subsequent processing zone the polycondensate melt is subjected to reduced pressure so that a further fraction of low-molecular components, in particular water, which remain in the melt, can escape via a discharge aperture. The polycondensate melt is then fed to a mixing container in which the melt is agitated by mixing tools. At the surface which is continuously renewing itself as a result of the mixing process, further outgassing of the low-molecular components can take place, with said components being able to escape from the mixing container by way of a degassing aperture.

This known process is disadvantageous in that degassing and drying of the polycondensate in the still solid state is incomplete because only a part of the low-molecular components which are being released during heating can escape, all the more so since the design size of the degassing aperture cannot be selected at will. Consequently, in the processing zone in which, for degassing and drying, the polycondensate to be processed is heated to a temperature below the melting point, a thermodynamic equilibrium occurs between the vapour phase of the low-molecular components and the low-molecular components bound in the polycondensate. The effectiveness of degassing and drying is limited due to the limited escape of the vapour phase from the degassing aperture.

From DE 42 31 231 C1 a multi-shaft extruder with several worm shafts arranged in a ring shape between an interior housing and an exterior housing, for degassing of a polycondensate melt, is known in principle. In the method known from this printed publication, the polycondensate is fed to the extruder in the melted state, and no degassing in the still solid state takes place. The effectiveness of this method is thus also limited. Furthermore, melting of the polycondensate takes place in a device which is separate from the multi-shaft extruder, thus leading to greater expenditure. This method is thus only conditionally suitable for recycling thermoplastic polycondensates.

EP 0 336 520 A1 discloses a method for processing a thermoplastic polycondensate, in particular in the form of comminuted PET bottles, with the particles being supplied to the extruder at a particle size below 2 mm. This small particle size is considered necessary to prevent excessive IV decomposition of the polycondensate during processing, in that due to the high degree of comminution of the polycondensate to be processed and the resulting high ratio of surface-to-volume, degassing of the polycondensate is facilitated. In particular, water vapour is removed, so as to largely prevent hydrolysis of the polycondensate and the resulting IV decomposition.

EP 0 861 717 A1 relates to a worm extrusion device, in particular a two-shaft extruder, for processing strongly outgassing materials whose content of volatile components can be in excess of 10 % and in extreme cases up to 90 %. In view of the large quantities of gas arising, it is proposed that removal of the gas take place by means of branching out the gas stream into at least three partial streams, with each of the branch lines being provided with a return conveyor device for the polycondensate.

EP 0 788 867 A1 relates to a ring extruder in which several shafts comprising interacting processing elements are arranged in a ring-shape or collar shape so that in each instance a processing space is determined inside the ring or collar and outside the ring or collar. So as to prevent a situation where one or the other of these spaces is full of material to be processed, while the respective other space is empty, there is a connection between the space situated inside the collar and the space situated outside the collar, so as to make it possible for material to enter from one space to the other. Thus a degassing aperture which would directly have to be provided either in the space situated inside the collar, and/or in the space situated outside the collar, would necessarily establish contact with the material to be degassed and would also require a return conveyor device in order to convey back to the extruder polycondensate escaping via the degassing aperture.

It is the object of the present invention to create a method and an extruder for processing a thermoplastic polycondensate in which degassing and or drying of the polycondensate in the still solid state is improved.

In regard to the method, this object is met by the characterising features of claim 1, while in regard to an extruder suitable for implementing this method, the object is met by the characterising features of claim 19 or claim 25, in each instance in connection with the generic features.

The invention is based on the recognition that effectiveness of degassing and/or drying the polycondensate in the still solid state can be improved in that the polycondensate is subjected to reduced pressure below atmospheric pressure and/or in that an inert gas is added. As a result of lowering the pressure, the steam pressure of the low-molecular components is reduced so that these components evaporate more easily from the still solid polycondensate. In the thermodynamic equilibrium, the addition of an inert gas causes a lowering of the partial pressure of the undesired low-molecular components, in particular of the water components bound in the still solid polycondensate. Due to the reduced partial pressure, these undesirable low-molecular components can also evaporate more easily from the polycondensate. In this context the term inert gas means that said inert gas does not concentrate or concentrates only to a small extent in the polycondensate and thus does not modify the characteristics of the polycondensate in an undesirable manner. The measures of the pressure reduction and the addition of the inert gas can also be combined, thus increasing their effectiveness.

The invention is further based on the recognition that an extruder suitable for implementing the above-mentioned method has to be modified compared to a known extruder, so that the still solid polycondensate cannot escape via the degassing aperture. The polycondensate is supplied to the extruder in the solid state, as a rule in the form of flakes or a granulate which are for example obtained from the recycled products, for example single-use plastic bottles, by cutting or other comminution methods. Such polycondensate flakes or the granulate are relatively light; as a result of the pressure gradient which exists in that location, said flakes or granulate can escape through the degassing aperture to which a reduced pressure has to be applied for the method according to invention, or through which degassing aperture the inert gas flows. A sieve or filter arranged at the degassing aperture would wear quickly and is thus not suitable. In line with the solution according to claim 19, the invention proposes that with a dual-shaft or multi-shaft extruder a conveyor device be provided at the degassing aperture, said device returning to the extruder any polycondensate which has escaped via the degassing aperture. The said conveyor device can clean itself on the worm shafts of the extruder. As an alternative, according to the solution according to claim 25, the use of a multi-shaft extruder is proposed in which between an interior housing and the worm shafts arranged in a ring shape, an interior space is formed, and between an exterior housing and the worm shafts an exterior space separated from the interior space is formed. The polycondensate which is still in the solid state can then either be located in the interior space and the degassing aperture can be connected to the exterior space, or conversely the polycondensate which is still in the solid state can be in the exterior space and the degassing aperture can be connected to the interior space. The tightly intermeshing worm shafts in any case prevent the solid polycondensate flakes from advancing to the degassing aperture. Thus any escape of the polycondensate flakes via the degassing aperture is prevented.

Claims 2 to 18 describe advantageous improvements of the method according to the invention.

The method according to the invention is in particular, but by no means exclusively, suitable for recycling of polyester, in particular polyethylene therephthalate and polyamide. Preferably the polycondensate is fed to the extruder in the form of flakes whose thickness on average is less than 2 mm and whose largest expansion on average is less than 20 mm. In order to further enhance the effectiveness of the method, it is advantageous if the polycondensate is subjected to a pressure below atmospheric and/or is subjected to the inert gas already prior to feeding said polycondensate to the extruder. But the polycondensate can also be heated to a temperature below the melt temperature of the polycondensate, prior to it being fed to the extruder.

After melting the polycondensate, further degassing of the polycondensate melt can take place. To this effect, an inert gas, preferably in condensed form and at increased pressure, can be added to the polycondensate melt. Due to foaming, this results in an increase in the surface at the phase limit. Here too, the inert gas reduces the partial pressure of the undesirable low-molecular components in the polycondensate melt, thus facilitating outgassing. In particular nitrogen, carbon dioxide or dried air are suitable inert gases.

It is advantageous if the polycondensate melt passes through at least one melt filter. Melt filters can be connected to the conveying zone of the extruder, after the kneading elements or behind the extruder. The use of melt filters imparts a constant and high product quality to plastic melts prior to further processing. Melt particles with a size of 20 - 50 μm which have not been eliminated in the region of the first conveying zone in which the polycondensate is still present in the solid state, can be separated from the melt flow during filtration. For plastic processing (polycondensates such as PA, PET, etc.) a wire mesh filter is used with minimum grades of filtration between 5 and 100 μm.

Claims 20 to 24 and 26 to 29 comprise advantageous embodiments of the extruder according to the invention.

The conveyor devices can be conveyor worms, in particular two tightly intermeshing conveyor worms. It is advantageous if the conveyor devices or the surrounding housing are heatable. This prevents condensation on the conveyor device, of the outgassing low-molecular components, and their return to the extruder. If required, the degassing aperture can coincide with the inlet aperture for supplying polycondensate to the extruder and the conveyor device provided at that location can at the same time be used for the dosed supply of the polycondensate to the extruder.

Furthermore it is advantageous if the housing in the region of the first conveying zone in which the polycondensate is still present in the solid state, is heatable so as to ensure fast and even heating of the polycondensate.

Below, the invention is described in more detail by means of exemplary embodiments, with reference to the drawing, as follows:

Fig. 1 is a longitudinal view of a first exemplary embodiment of an extruder according to the invention;

Fig. 2 is a longitudinal view of a second exemplary embodiment of an extruder according to the invention; and

Fig. 3 is a cross section of a third embodiment of an extruder according to the invention.

Figure 4 shows a sectioned longitudinal half-representation of an extruder corresponding to the exemplary embodiment represented in Figure 3; and

Figure 5 shows a sectioned longitudinal half-representation of an extruder corresponding to an exemplary embodiment modified with respect to Figure 4.

Figure 1 shows a first exemplary embodiment of an extruder 1 according to the invention. The extruder 1 represented in Figure 1 is designed as a twin-screw extruder. The extruder 1 comprises a barrel 2, which is constructed in a modular manner from a plurality of part-barrels 2a - 2i. The part-barrels 2a - 2i are flanged to one another. The first part-barrel 2a has an inlet opening 3, via which the polycondensate to be reprocessed is fed to the extruder 1 in a still solid state, preferably in the form of flakes. The polycondensate is located in a silo 4 and is metered in via a metering system 5 and a conveying device 6. At the end of the last part-barrel 2i is the output flange 7, with an outlet opening 8, at which the reprocessed polycondensate melt emerges.

Two longitudinal bores, which are arranged offset with respect to one another and only one of which, bore 9, can be seen in Figure 1, are provided in the barrel 2. Inserted in each of the two longitudinal bores there is in each case a screw shank 10, which in Figure 1 is drawn outside the associated longitudinal bore 1 for reasons of improved representation. The screw shanks 10 extend from the inlet opening 3 to the outlet opening 8. The two screw shanks 10 intermesh closely with one another and are driven in the same direction of rotation.

The screw shanks 10 are divided roughly into a first conveying zone 11, for conveying the polycondensate in the solid state, and a second conveying zone 12, for conveying the polycondensate in the molten state. Between the first conveying zone 11 and the second conveying zone 12 there are kneading elements 13. While the conveying screw 10 initially has a relatively great pitch in its first conveying zone 11, in the region of the inlet opening 3, the pitch is reduced in the direction of the outlet opening 8, as a result of which the polycondensate is drawn in relatively quickly at the inlet opening 3. The dwell time or dwell time spectrum of the polycondensate in the first conveying zone 11 is relatively long, so that the polycondensate can heat up to a temperature below the melting point. For this purpose, the barrel 2 is heated in the region of the first conveying zone 11 by heating elements (not represented). As a result, low-molecular-weight constituents of the polycondensate, in particular water, can outgas from the polycondensate in the still solid state and escape via a degassing opening 14. To improve the effectiveness of the outgassing of the low-molecular-weight constituents, the first conveying zone 11 of the extruder 1 is subjected to a reduced pressure in comparison with atmospheric pressure or it is flushed with an inert gas. By reducing the pressure in the barrel 2, the vapor pressure of the undesired low-molecular-weight constituents is reduced, so that these low-molecular-weight constituents outgas more easily. The adding of the inert gas brings about a reduction in the partial pressure of these low-molecular-weight constituents, so that the effectiveness of the outgassing is likewise improved. If an inert gas is used, it can be added via an inert-gas inlet opening 15. Nitrogen, carbon dioxide or dried air are suitable in particular as the inert gas. In principle, noble gases are also suitable. The inert gas escaping via the degassing opening 14 can be filtered and fed again to the extruder 1 in a cleaned state via the inert-gas inlet opening 15 in a closed cycle.

A line 16, which is connected to the degassing opening 14, serves for generating a negative pressure in the longitudinal bores 9 or for carrying away the inert gas. According to the invention, a conveying device 17, designed as a conveying screw, is provided at the degassing opening 14 in order to convey polycondensate flakes escaping via the degassing opening 14, due to the negative pressure or the inert gas flowing away, back into the extruder 1 and consequently prevent polycondensate flakes from being able to escape from the extruder 1. The conveying device 17 may also be made up of two closely intermeshing conveying screws arranged next to one another. It is advantageous if the conveying device 17 is heatable. This avoids condensation of the degassing low-molecular-weight constituents, in particular the water vapor, at the conveying device 17 and consequently conveying back of these condensed constituents into the extruder 1.

The kneading elements 13 adjoining the first conveying zone 11 have both distributive and dispersive properties and lead to melting of the polycondensate in a heating region which is kept very short. The melting takes place in a process length of preferably 1 L/D to 2 L/D. The kneading elements are preferably made up of conveying kneading elements 13a and conveying-back kneading elements 13b, in order to increase the dwell time spectrum of the polycondensates at the kneading elements 13 and consequently keep the melting region short. The polycondensates are heated up as close as possible to the melting temperature already in the first conveying zone 11, by the barrel 2 being heated, so that the melting enthalpy to be transferred from the kneading elements 13 to the polycondensates is low.

In the second conveying zone 12, adjoining the kneading elements, the polycondensate melt is conveyed in the direction of the outlet opening 8. Here, too, the pitch of the screw shanks 10 is reduced in the direction of the outlet opening 8. A further degassing of the polycondensate melt preferably takes place in this region. Here, too, the degassing may take place as a result of a reduction in the operating pressure or else additionally as a result of the adding of an inert gas, in particular nitrogen. The adding of the inert gas preferably takes place in a condensed state, the polycondensate melt being subjected to an increased pressure when the gas is added. During a subsequent reduction in pressure of the polycondensate melt, the inert gas and the undesired low-molecular-weight constituents outgas from the polycondensate melt and can leave via a further degassing opening 18.

It is advantageous to expose the polycondensate in the silo 4 already to an inert gas atmosphere and/or a reduced pressure and subject it to an increased temperature, in order to increase the effectiveness of the method and reduce the heating-up time in the first conveying zone 11.

The kneading elements are preferably located at the end of a part-barrel 2f. This has the advantage that the melt zone lies at the end of the part-barrel 2f, so that the further processing in the adjoining part-barrel 2g can be configured in an optimum way.

The method according to the invention is also suitable for a reactive extrusion based on the reaction principle of polyaddition with the aid of additives and/or polycondensation. In this case, the additives are optimally mixed by the kneading elements 13 at the same time as the melting. A possibly necessary increase in the dwell time spectrum is preferably realized by toothed elements. The incorporation of additional substances, in particular glass or pigments, is also possible. These substances are preferably metered in shortly after the melting and are incorporated by means of narrow kneading elements directly after the melting.

In a way corresponding to patent claim 15 [sic], suitable as additional substances (additives, color pigments, fillers, processing aids, stabilizers, reactive substances etc.), which are introduced into the extruder along with the polycondensate [sic]. The use of additional substances ensures that a constant melt viscosity of the polycondensate melt is achieved.

Figure 2 shows an exemplary embodiment of an extruder 1 according to the invention modified with respect to Figure 1. Elements already described on the basis of Figure 1 are provided with the same reference numerals, so that to this extent there is no need for the description to be repeated.

The difference between the exemplary embodiment represented in Figure 2 and the exemplary embodiment already described on the basis of Figure 1 is that the polycondensate is fed in the solid state to the inlet opening 3 of the extruder 1 from the silo 4 via a conveying device 20 designed as a conveying screw or as two closely intermeshing conveying screws. The inert gas can be fed in at the same time via the stub 21, the polycondensate stored in the silo 4 already being kept under an inert-gas atmosphere before the feeding into the extruder.

It is conversely also possible to carry the inert gas away via the stub 21 and the silo 4, the conveying device 20 then conveying counter to the direction of flow of the inert gas. The conveying device 17 and the degassing opening 14 can then also be omitted. The same applies if flushing with an inert gas is not carried out, but instead the extruder 1 is kept at a negative pressure in the first conveying region 11. The vacuum connection necessary for this may be provided directly at the silo 4, the polycondensate being charged into the silo 4 via a suitable air lock. Here, too, the inlet opening 3 may serve at the same time as a degassing opening and the conveying device 17 can be omitted. If the inert-gas inlet opening 15 is arranged in the vicinity of the kneading elements 13, this has the advantage that the direction of flow in the extruder 1 runs counter to the conveying direction and therefore the flushing is particularly effective.

Figures 3 and 4 show a completely differently configured extruder 1, which is likewise suitable for carrying out the method according to the invention. In this case, Figure 3 shows a cross section through the extruder 1 and Figure 4 shows a longitudinal half-section up to the center axis 30. Elements already described are denoted by the same reference numerals.

In contrast to the twin-screw extruders represented in Figures 1 and 2, the extruder 1 represented in Figures 3 and 4 is a multi-screw extruder, in which a plurality of screw shanks, twelve in the exemplary embodiment, 10a - 10l are arranged in an annular form between an inner barrel 31 and an outer barrel 32. The screw shanks 10a - 10l are also designed in a closely intermeshing manner in the case of the multi-screw extruder represented in Figures 3 and 4, so that the screw shanks 10a - 10l arranged in an annular form separate an inner space 33, formed between the inner barrel 31 and the screw shanks 10a - 10l, from an outer space 34, formed between the outer barrel 32 and the screw shanks 10a - 10l. In a subregion of the first conveying zone 11 of the extruder 1, which is still to be described in more detail and in which the polycondensate is conveyed in the solid state, the polycondensate is located in the inner space 33, which is indicated in the drawing by cross hatching. The outer space 34, on the other hand, is connected in the exemplary embodiment to a plurality of degassing openings 14, via which evaporating low-molecular-weight constituents of the polycondensate to be reprocessed can escape.

In the first conveying zone 11, in which the polycondensate is in the solid state, the barrel 2, in particular the inner barrel 31, is heated, in order to heat up the polycondensate as far as possible to just below the melting point, and in this way bring about effective outgassing of the low-molecular-weight constituents. In addition, in a way corresponding to the method according to the invention already described, either a negative pressure is generated in the extruder 1 and/or an inert gas, in particular nitrogen, is added for flushing purposes via the outgassing openings 14. The inert gas may in this case enter the inner space 33, in which the polycondensate is located, via inert-gas inlet openings (not represented), pass through between the closely intermeshing screw shanks 10a - 10l and escape via the degassing openings 14, which is illustrated by corresponding arrows.

What is important is that, in this configuration, conveying elements are not necessary at the degassing openings 14, because the polycondensate is already prevented from leaving from the degassing openings 14 by means of the closely intermeshing screw shanks 10a - 10l.

Nevertheless, if need be, a conveying direction [sic] 17 may be provided at or in the input opening 14 [sic].

The configuration of the screw shanks 10a - 10l can be better seen from the longitudinal half-section represented in Figure 4. A screw shank 10a is represented in the associated longitudinal bore 9, which is formed between the inner barrel 31 and the outer barrel 32. In this case, the inner space 33, formed between the screw shank 10a and the inner barrel 31, and the outer space 34, formed between the screw shank 10a and the outer barrel 32, can likewise be seen. The polycondensate to be processed is fed to the extruder 1 via one or more inlet openings 3 in the solid state, for example in the form of flakes. The screw shanks 10a - 10l are divided roughly into a first conveying zone 11, in which the polycondensate is conveyed in the solid state, and a second conveying zone 12, in which the polycondensate melt is conveyed. Between the first conveying zone 11 and the second conveying zone 12 there are kneading elements 13 for the melting of the polycondensate.

The first conveying zone 11 is subdivided into a drawing-in zone 35 and a degassing zone 36. In the drawing-in zone 35, the polycondensate is drawn in, the polycondensate being distributed essentially uniformly in the inner space 33 and the outer space 34. At the end of the drawing-in zone 35 there is a first barrier comprising a conveying-back portion 38, arranged after a spacer ring 37. Provided on the inner barrel 31, but not on the outer barrel 32, is a groove 39, which reaches over the conveying-back region 38. The polycondensate can therefore pass over from the drawing-in zone 35 into the degassing zone 36 only in the region of the inner space 33, so that it is ensured that the polycondensate in the degassing zone 36 is located virtually exclusively in the inner space 33. The barrel 2 is heated in the region of the first zone 11, so that the polycondensate is heated up to just below the melting temperature. At the same time, a negative pressure is generated and/or flushing with an inert gas is carried out. In this way, effective degassing is achieved. At the end of the degassing zone 36 there are kneading elements 13, which have distributive and dispersive properties. The polycondensate is melted very quickly in this region and is subsequently in the form of a melt.

A second barrier, comprising a conveying-back portion 41 arranged after a spacer ring 40, in conjunction with a groove 42 provided on the inner barrel 31, has the effect of ensuring that the polycondensate melt is located with preference in the inner space 33. A second degassing opening 43, which permits additional degassing of the polycondensate melt, opens out in the outer space 34. The melt is distributed relatively uniformly on the surface of the screw shanks 10a - 10l, the closely intermeshing screw shanks 10a - 10l causing a steady new stretching-out of the melts, whereby constantly new surfaces are produced. As a result, the degassing operation is significantly speeded up. The degassing operation can be promoted by applying a negative pressure to the degassing opening 43, in order to reduce the vapor pressure of the low-molecular-weight constituents, in particular the water content.

A variation of the exemplary embodiment represented in Figures 3 and 4 is represented in Figure 5. In this case, Figure 5 shows, in a way similar to Figure 4, a longitudinal half-section through an extruder 1 designed as a multi-screw extruder.

The difference in comparison with the exemplary embodiment represented in Figure 4 is that an inert gas in a preferably condensed form is added to the polycondensate melt via an inert-gas inlet opening 44. Both the inert gas and the undesired low-molecular-weight constituents of the polycondensate to be reprocessed, in particular the still remaining water content, leave the extruder 1 via the degassing opening 43. It may be more favorable to feed the inert gas in via the opening 43 and let it out via the opening 44.

The invention is not restricted to the exemplary embodiments represented. In particular, the multi-screw extruder represented in Figures 3 to 5 can also be configured in such a way that, in the degassing zone 36, the polycondensate is located in the outer space 34 and the degassing openings 14 are connected to the inner space 33. For this purpose, the groove 39 is to be formed not on the inner barrel 31 but on the outer barrel 32.

Furthermore, the multi-screw extruder represented is not restricted to the twelve-screw shank [sic] represented only by way of example in Figure 3.

WHAT IS CLAIMED IS:

1. A method for the reprocessing of a thermoplastic polycondensate, having the following method steps:

introducing the polycondensate into an extruder in a solid state,

heating the polycondensate to a temperature below the melting point and degassing and/or drying the polycondensate,

using a conveying device at a degassing opening in order to convey polycondensate escaping via the degassing opening back into the extruder,

melting the polycondensate,

wherein the degassing and/or drying of the polycondensate takes place in the solid state at a pressure below atmospheric pressure and/or with an inert gas being added, and the polycondensate is introduced into the extruder in the form of flakes or powder, the thickness of the flakes being on average less than 2 mm and the greatest extent being on average less than 20 mm.

2. Method according to claim 1, wherein the thermoplastic polycondensate is polyester, in particular polyethylene terephthalate, or polyamide.

3. Method according to one of claims 1 or 2, wherein the polycondensate is flushed with the inert gas in the solid state.

4. Method according to any one of claims 1 to 3, wherein the polycondensate is subjected to a pressure below atmospheric pressure and/or the inert gas already before it is introduced into the extruder.

5. Method according to any one of claims 1 to 4, wherein the polycondensate is heated to a temperature below the melting temperature of the polycondensate already before it is introduced into the extruder.

6. Method according to any one of claims 1 to 5, wherein the inert gas is added at a temperature of 60°C. to 250°C.

7. Method according to any one of claims 1 to 6, wherein, after the melting of the polycondensate, further degassing of the polycondensate melt takes place.

8. Method according to claim 7, wherein the degassing of the polycondensate melt takes place with an inert gas being added beforehand.

9. Method according to claim 8, wherein the inert gas is added in a condensed state to the polycondensate melt at an increased; pressure and, subsequently, the pressure of the polycondensate melt is lowered, so that the inert gas escapes from the polycondensate melt.

10. Method according to any one of claims 1, 3, 4, 6, 8 or 9 wherein the inert gas is nitrogen, dried air, carbon dioxide or a noble gas.

11. Method according to any one of claims 7, 8 or 9 wherein the polycondensate melt is passed through at least one melt pump.

12. Method according to any one of claims 7, 8, 9 or 11, wherein the polycondensate melt is passed through at least one melt filter.

13. Method according to claim 12, wherein the use of melt filters may take place in the conveying direction of the polycondensate, after melting of the polycondensate.

14. Method according to claim 12 or 13, wherein, following the melt filter, further degassing of the polycondensate may take place.

15. Method according to any one of claims 1 to 14, wherein one or more of additional substances are selected from the group consisting of color pigments, fillers, processing aids, stabilizers, and substances reacting with the polycondensate, which are introduced into the extruder along with the polycondensate.

16. Method according to claim 15, wherein the melt viscosity and/or melt elasticity of the polycondensate melt is modified by the use of a substance reacting with the polycondensate.

17. Method according to claim 16, wherein the substance reacting with the polycondensate increases the melt viscosity and/or melt elasticity of the polycondensate by a chain-extending and/or chain-crosslinking reaction with the polycondensate.

18. Method according to any one of claims 1 to 17, wherein further polycondensation of the polycondensate melt takes place under vacuum conditions.

19. The method according to claim 13, after the step of melting the polycondensate, further comprising using melt filters downstream of the extruder in the conveying direction of the polycondensate.

20. Method according to claim 1, wherein the inert gas is added at a temperature of 100°C. to 160°C.

21. A method for processing a thermoplastic polycondensate with the following procedural steps:

incorporating the polycondensate in a solid state in the form of flakes into an extruder with:

screw shanks arranged in a casing, which extend from an inlet opening in the direction toward an outlet opening;

a first conveying zone for conveying the polycondensate in a solid state;

a second conveying zone for conveying the polycondensate in a melted state; and

at least one degassing opening provided in the area of the first conveying zone in the casing;

heating the polycondensate to a temperature under the melting point and degassing and/or

drying the polycondensate in a solid state at a pressure of below atmospheric pressure;

melting the polycondensate between the first conveying zone and the second conveying zone;

characterized in that the screw shanks of the extruder are tightly intermeshing; that the polycondensate flakes are prevented from escaping the extruder by means of a first conveying device provided at the degassing opening and designed as a conveying screw, that the polycondensate in the extruder are metered in as flakes by means of another conveying device, wherein the flakes average less than 2 mm in thickness, expanding at most to less than 20 mm.

22. The method according to claim 21, characterized in that the polycondensate is melted between the first conveying zone and the second conveying zone using kneading elements.

23. The method according to claim 21 or 22, characterized in that the polycondensate is degassed and/or dried with the addition of an inert gas.

24. The method according to any one of claims 21 to 23, characterized in that the thermoplastic polycondensate is a polyester, in particular polyethylene terephthalate, or polyamide.

25. The method according to any one of claims 21 to 24, characterized in that polycondensate is rinsed with the insert gas in a solid state.

26. The method according to any one of claims 21 to 25, characterized in that the polycondensate is already exposed to a pressure below the atmospheric pressure and/or the inert gas before introduced into the extruder.

27. The method according to any one of claims 21 to 26, characterized in that the polycondensate is already heated to a temperature below the melting point of the polycondensate before introduced into the extruder.

28. The method according to any one of claims 21 to 27, characterized in that the inert gas is added at a temperature of 60°c to 250°C.

29. The method according to any one of claims 21 to 28, characterized in that the polycondensate melt is further degassed after the polycondensate has been melted.

30. The method according to claim 29, characterized in that an inert gas is first added before degassing the polycondensate.

31. The method according to claim 30, characterized in that the polycondensate melt is introduced in the condensed state under an elevated pressure, after which the pressure of the polycondensate melt is lowered, so that the inert gas escapes from the polycondensate melt.

32. The method according to any one of claims 23 to 31, characterized in that the inert gas is nitrogen, dried air, carbon dioxide or a noble gas.

33. The method according to any one of claims 29 to 31, characterized in that the polycondensate melt is passed through at least one melt pump.

34. The method according to any one of claims 29 to 31 or according to claim 33, characterized in that the polycondensate melt is passed through at least one melt filter.

35. The method according to claim 34, characterized in that melt filters are used in the conveying direction of the polycondensate after the polycondensate has been melted.

36. The method according to claim 34 or 35, characterized in that the polycondensate is subjected to further degassing after the melt filter.

37. The method according to any one of claims 21 to 36, characterized in that additives, such as dye pigments, fillers, processing aids, stabilizers, substances that react with polycondensate, etc., are introduced into the extruder in addition to the polycondensate.

38. The method according to claim 37, characterized in that the melt viscosity and/or melt elasticity of the polycondensate melt is modified by using a substance that reacts with the polycondensate.

39. The method according to claim 38, characterized in that the substance that reacts with the polycondensate increases the melt viscosity and/or melt elasticity of the polycondensate as the result of a chain-lengthening and/or chain-crosslinking reaction with the polycondensate.

40. A method according to one of claims 21 to 39, characterized in that further polycondensation of the polycondensation melt takes place under a vacuum.

41. The method according to any one of claims 21 to 40, characterized in that an extruder is used with an inlet opening for incorporating the polycondensate to be prepared in a solid state, an outlet opening for discharging the polycondensate in a melted state, more than two tightly intermeshing screw shanks arranged in the casing, wherein the degassing opening is the location of the first conveying device, which encompasses at least one conveying screw, in order to convey the polycondensate that can escape via the degassing opening back into the extruder, and wherein the casing is divided into an inner casing and an outer casing, and the screw shanks are annularly arranged between the inner casing and the outer casing, wherein the screw shanks separate an outer space formed between the outer casing and the screw shanks from an inner space formed between the inner casing and the screw shanks, and, in the first conveying zone, the polycondensate is processed while located either in the inner space and the degassing opening is connected with the outer space, or the polycondensate is processed while located in the outer space and the degassing opening is connected with the inner space, and wherein the polycondensate is metered into the extruder by means of a conveying device located at the inlet opening.

42. The method according to claim 41, characterized in that the conveying device has two or more tightly intermeshing conveying screws.

43. The method according to claim 41 or 42, characterized in that the conveying device and/or the casings enveloping the conveying device is/are heated.

44. The method according to any one of claims 41 to 43, characterized in that the inlet opening is simultaneously used as a degassing opening.

45. The method according to one of claims 41 to 44, characterized in that the degassing opening is placed under a vacuum and/or an inert gas with a rinsing function is discharged via the degassing opening.

46. The method according to claim 45, characterized in that the casing has at least one opening in the area of the first conveying zone via which the inert gas is supplied.

47. The method according to one of claims 41 to 46, characterized in that the used kneading elements have an overall length L, wherein the L/D ratio for the overall length L of the kneading elements to the diameter D of the screw shanks lies between 1 and 2.

48. The method according to any one of claims 21 to 27, characterized in that the inert gas is added at a temperature of 100°C to 160°C.

49. The method according to claim 34, characterized in that melt filters are used in the conveying direction of the polycondensate after the polycondensate has been melted, behind the extruder.

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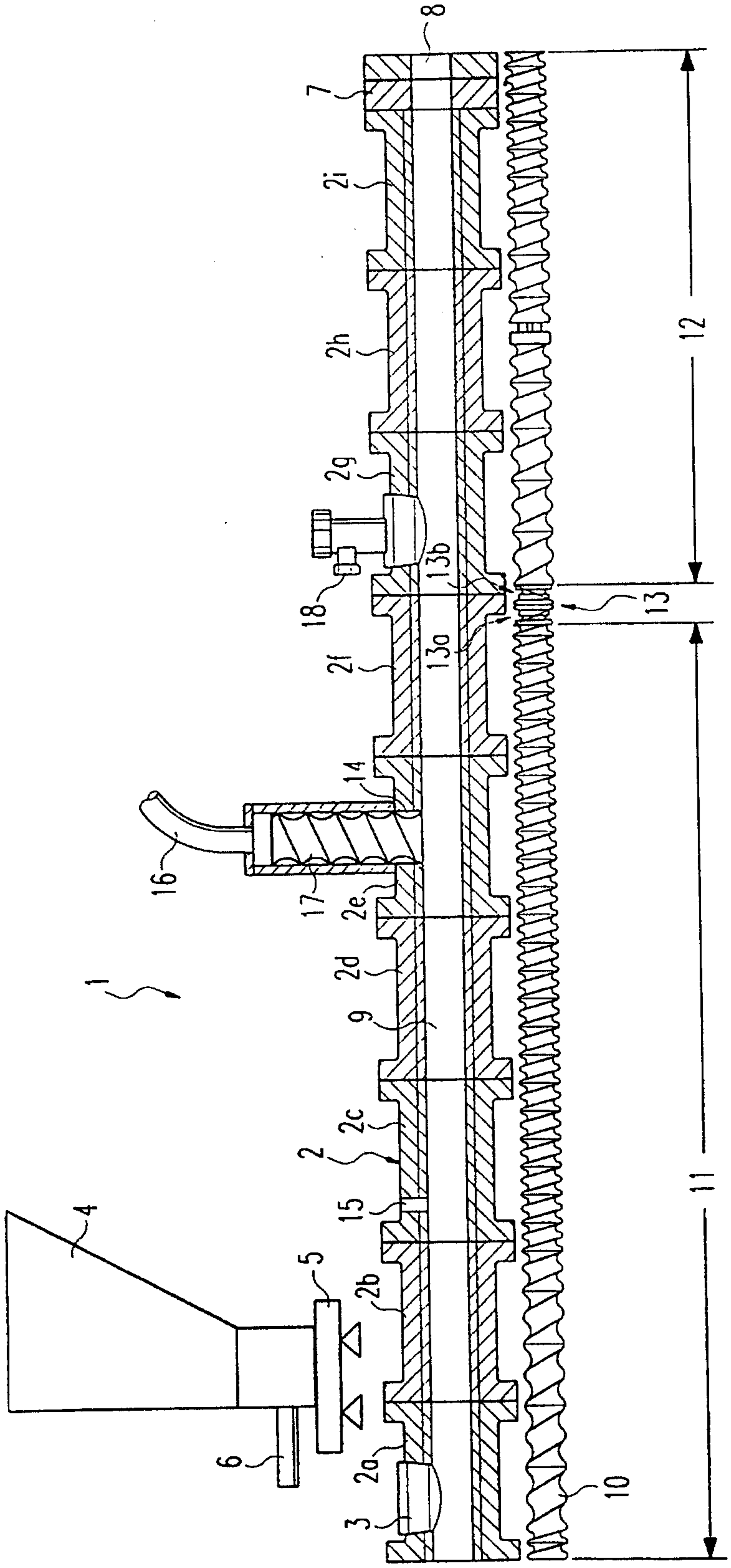
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Fig. 1

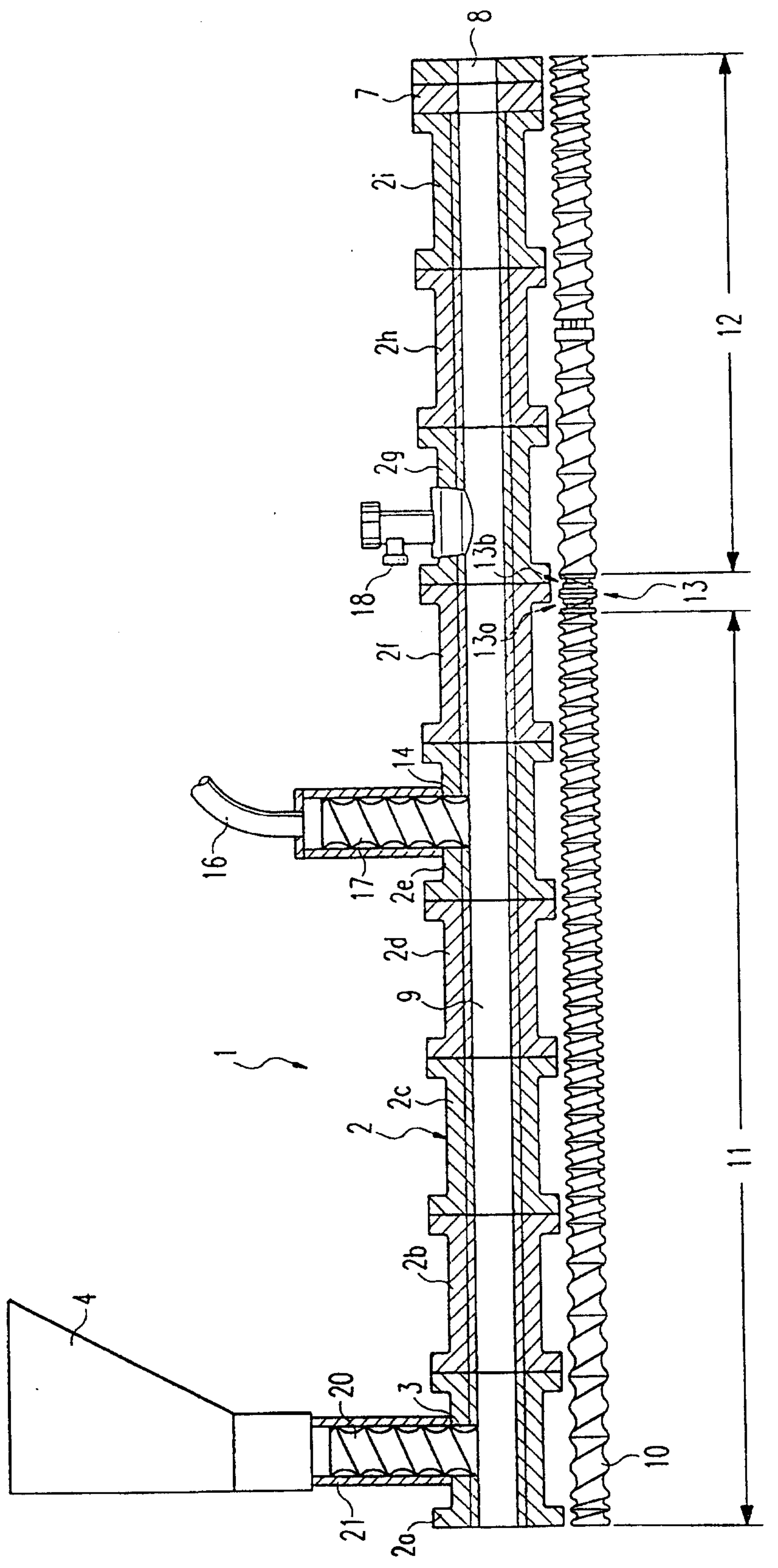
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Fig. 2

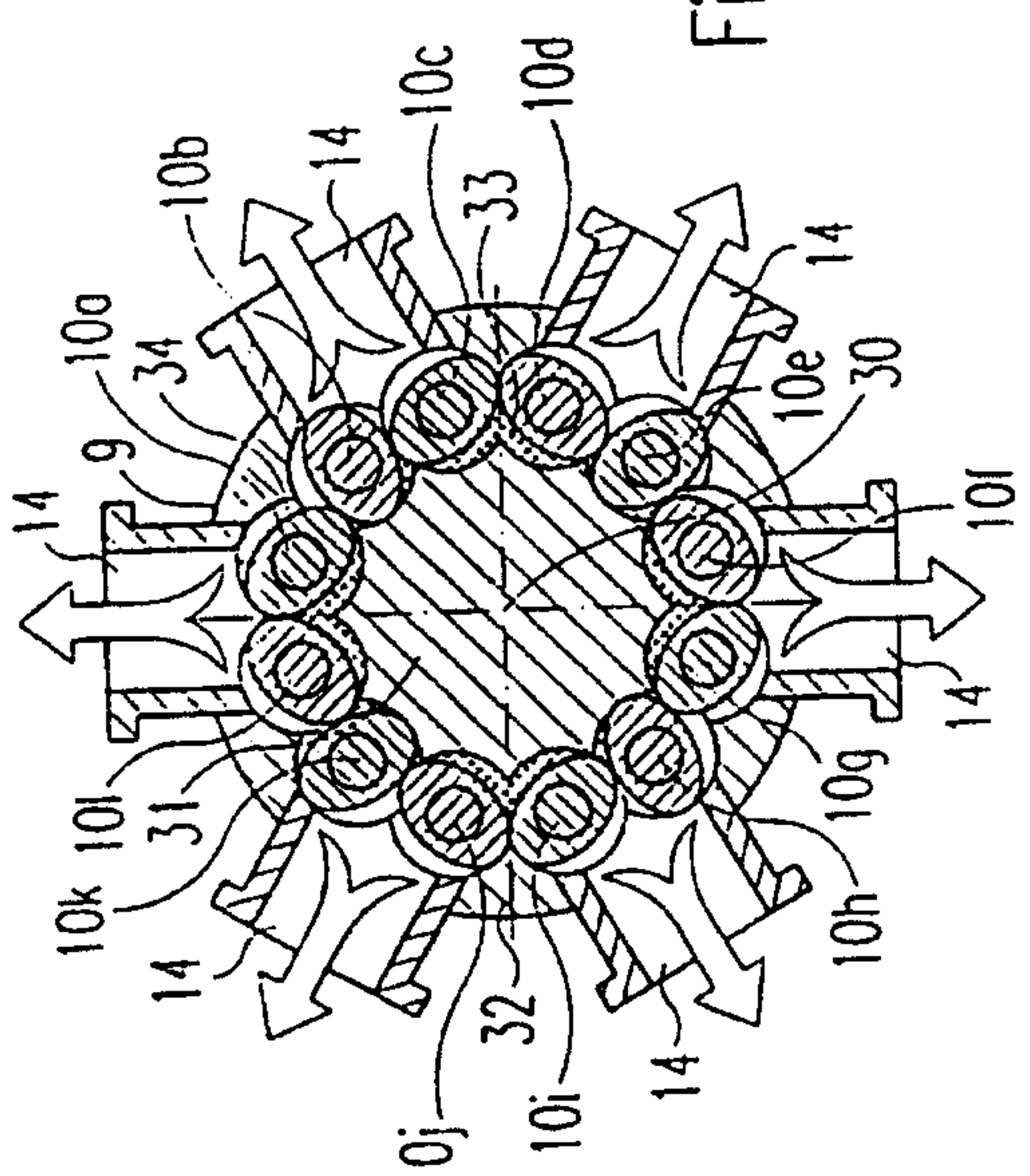
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Fig. 3

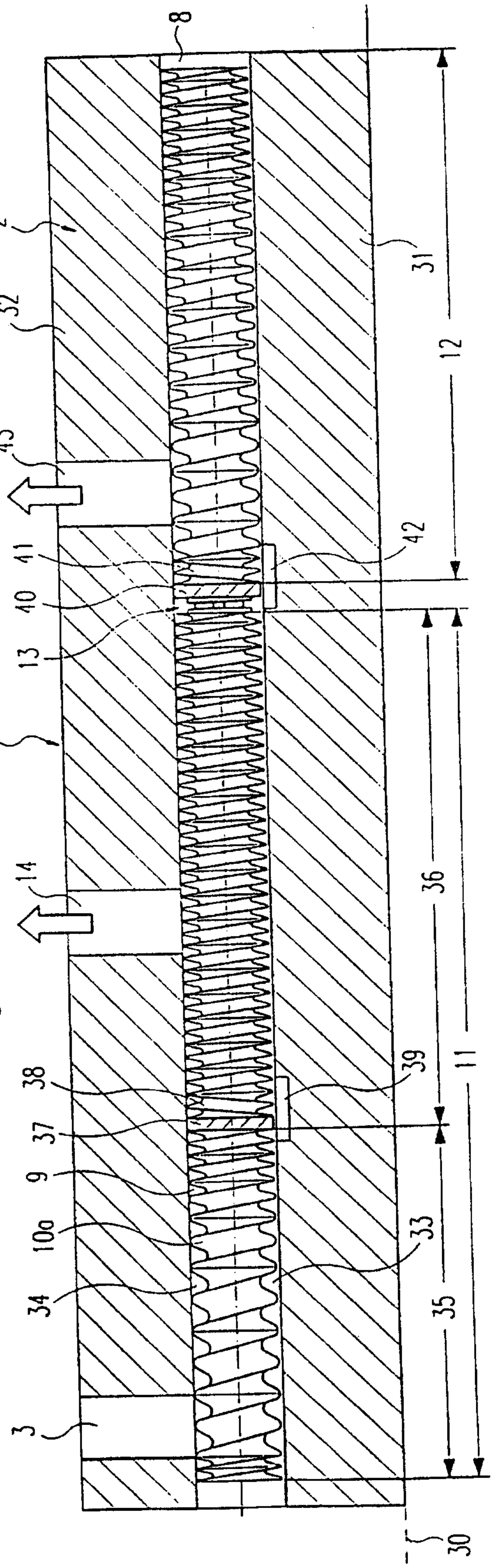
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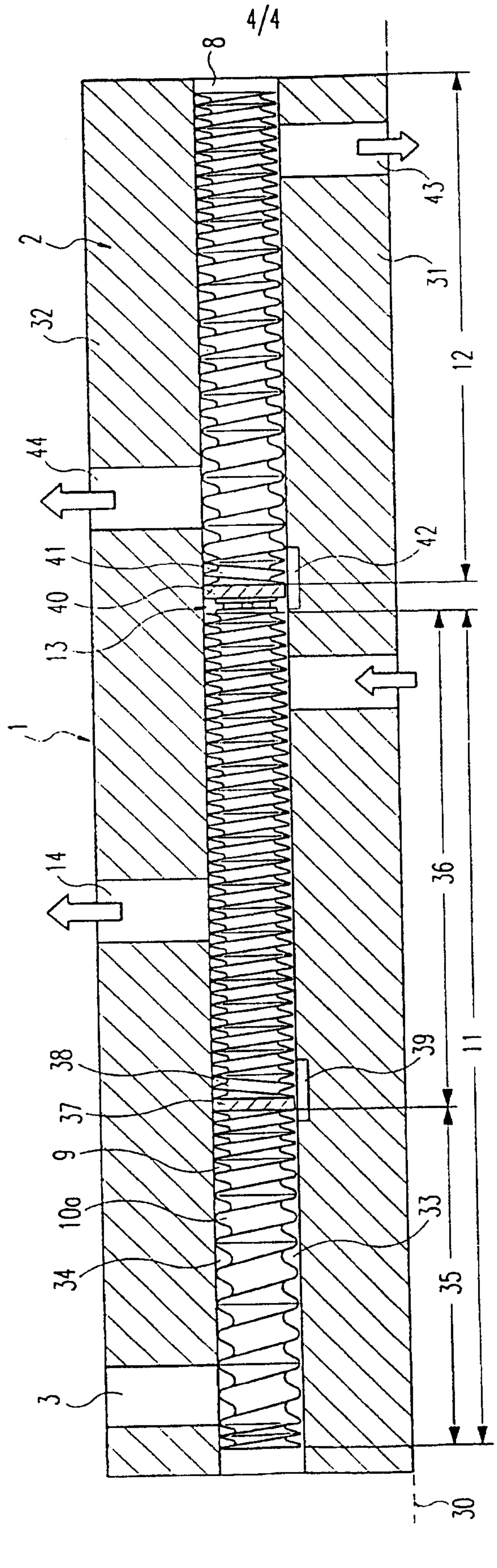
Fig. 4



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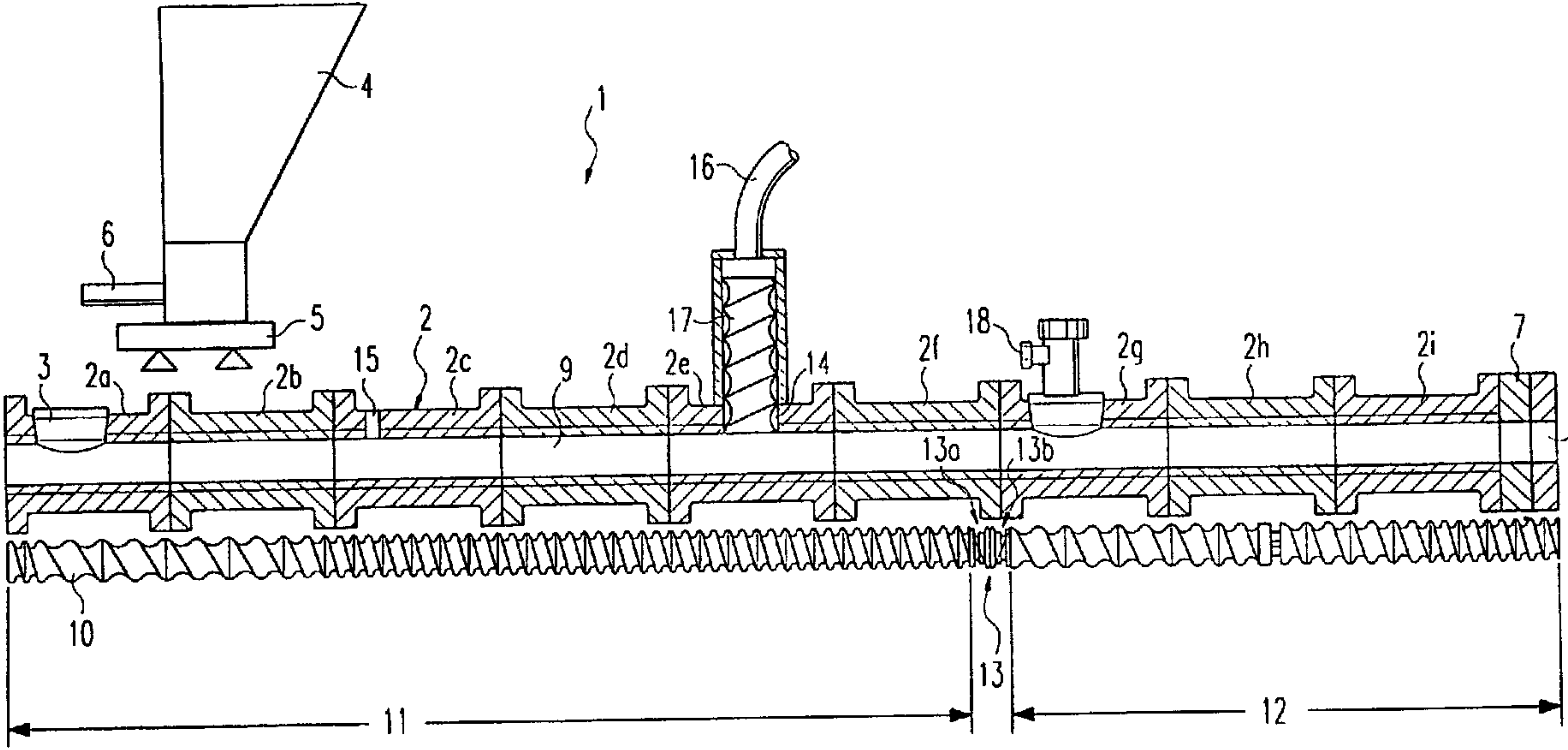
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