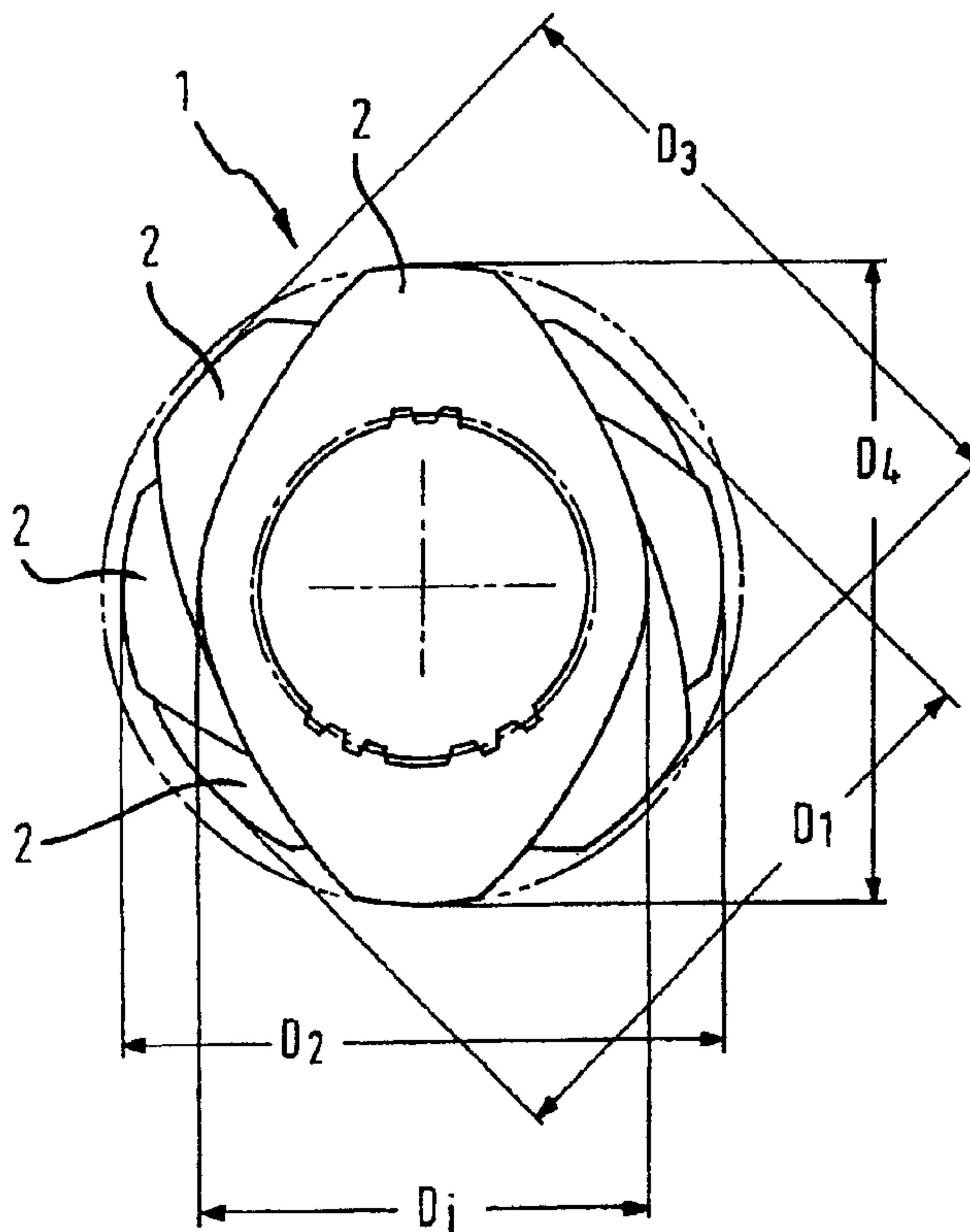




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(57) Abrégé/Abstract:

A screw element, in particular a kneading element (1), to be used with a plasticizing unit, having a screw shaft, includes at least two kneading units, wherein the kneading units can be arranged on a common axis, for example the screw shaft, and wherein the kneading units have a geometry which is designed for attaining particularly good plasticization and reduced mechanical stress in such a way that the geometry of at least two successively arranged kneading units differs.

WO 2007/112861

PCT/EP2007/002482

Abstract

A screw element, in particular a kneading element (1), to be used with a plasticizing unit, having a screw shaft, includes at least two kneading units, wherein the kneading units can be arranged on a common axis, for example the screw shaft, and wherein the kneading units have a geometry which is designed for attaining particularly good plasticization and reduced mechanical stress in such a way that the geometry of at least two successively arranged kneading units differs.

31254-51

Description

Screw Element

The invention relates to a screw element, in particular a kneading element for use in a plasticizing unit.

When processing plastics in a plasticizing unit, as carried out in extruders or injection molding machines, a widest variety of processes are applied. One such process involves compounding, i.e. admixture of filling or reinforcing agents, incorporating dyes or pigments, blending various materials, like e.g. plastics or elastomers, reactive processes, or the like. Common to all these processes is their implementation by two extruders including two or more shafts and having screws that rotate in a same direction or in opposite direction. Shear energy for melting the plastic materials is introduced into the material by these screws. The screws have so-called screw elements which oftentimes have multi-threaded configuration.

A special screw element is the so-called kneading element, also called kneading block in the art. Such a kneading block is made of spiral-shaped screw parts or several kneading units disposed behind one another in processing direction and having a certain geometry. Known kneading elements have kneading units of a geometry which is the same especially as far as their width and their outer and inner diameters are concerned and is selected in accordance with the size of the plasticizing unit, i.e. the plasticizing unit of the extruder or the injection molding machine.

Dissipation of mechanical energy, introduced via the drive, via the gear train, and via the screw shaft, is determined by the type of used screw structure besides for example in dependence on the enthalpy of the plastic being processed. The type of the used screw structure is also called configuration. The configuration varies for example by the type and number of kneading blocks and the other screw elements.

WO 2007/112861

PCT/EP2007/002482

The main conversion of energy is primarily realized directly anteriorly as well as over the first kneading element(s) in dependence of the geometry of the screw elements. The main conversion of the energy is realized by shearing. Primarily determinative are hereby the rotation speed of the screw and thus the (angular) speed of the kneading units, the gap between the kneading unit and the extruder barrel as well as the kneading units in the gusset zone and the flight land area of the kneading element, when twin-screw extruders are involved. The shear rate as well as the shear stress can be calculated accordingly from these variables. Melting of the material to be plasticized can be established on the basis of the shear stress. The highest mechanical stress on the screw element and its shaft/hub connection is encountered during melting.

Such a kneading element is disclosed in the recorded documents of German utility model 82 32 585. The screw element shown there includes individual kneading units which can be plugged together separately. The kneading units have hereby the same geometry.

DE 100 50 295 A1 describes a multi-shaft extruder for preparing and/or processing elastomer containing filler material, having two shafts which, when viewed in transport direction, include a filling zone, a masticating zone, and a dispersing zone. The masticating and dispersing zones may hereby include kneading disks whose maximum diameter increases or decreases in production direction.

The summary of JP 2004202871 describes a kneading screw having between two conveying sections a kneading section whose kneading disks have a continuously increasing diameter in conveying direction.

DE 199 50 917 A1 is directed to a twin-screw extruder having particular screw elements and exhibiting a good dispersive mixing action to attain a smallest possible dissipative temperature increase. The introductory part of the specification relates

31254-51

only in general terms to the possibility to provide screw elements with continuous helix angle (revolutions) or also to provide disks of variable width and infinite pitch (no revolution) or arranged at angular offset (so-called kneading blocks).

Some embodiments of the invention may provide a screw element of the afore-stated
5 type to allow good plasticization of the material to be processed while reducing the mechanical stress on the screw elements.

According to one embodiment of the invention there is provided a kneading element for use in a plasticizing unit with a screw shaft, having at least three kneading units (2), wherein the kneading units (2) can be arranged on a common axis for example
10 the screw shaft, characterized in that the width (b) of the kneading units (2) increases overall in processing direction, wherein the width of successively arranged kneading units (2) may be partly the same.

According to another embodiment of the invention, there is provided a kneading element for use in a plasticizing unit with a screw shaft, having at least three
15 kneading units, wherein the kneading units are arranged on a common axis wherein the width of the kneading units increases overall in a processing direction, and wherein the width of each successively arranged kneading unit is the same as or greater than the width of a preceding kneading unit.

As a result, the screw element involved here is constructed and improved in such a
20 way that the geometry of at least two kneading units arranged in succession is different, with the width of the kneading units increasing in processing direction.

The width of at least two kneading units may thus vary. As a result, the shearing clearance would be influenced in such a manner that the shearing area changes. This may also be implemented within one or more successive screw elements like -
25 as will be explained hereinafter - when the diameter of the kneading unit changes. The kneading units or screw parts have throughout no same width across the width of the screw element. Moreover, the kneading units or screw part sections may have also no same diameter throughout. The screw elements can be irrespective of the

31254-51

number of elements in the screw. Thus, the disk-land width variability may extend over several screw elements. The screw elements can thus be length-independent.

The width of the kneading units increases overall in processing direction. As a result, also shearing of the material to be plasticized increases in processing direction.

- 5 Processing direction is thus defined as the direction of the plasticizing unit in which the material to be plasticized and/or the plasticized material is transported. The

WO 2007/112861

PCT/EP2007/002482

progression of the variability of the width of the kneading units does not have to increase steadily however, but may also be partly the same.

In summary, it has been recognized that good plasticization can be realized while reducing the mechanical stress on the screw element by deviating from the conventional shape of same geometry of the kneading units. Selecting different geometries, namely different widths, of the kneading units enables control of the shear introduction and the mechanical stress and optimization of the respective process.

The use of the screw elements according to the invention is possible for a number of plasticizing units and widest variety of processes. The kneading elements according to the invention are applicable for two-shaft or multi-shaft plasticizing units which rotate in a same direction or in opposite direction. It is also possible to design the screw elements single-threaded or multi-threaded, to configure them of spiral-shaped screw parts or integral or to make them of loosely interconnected kneading units. The kneading units are selected in dependence on the size of the plasticizing unit and the respective process task. The configuration of the screw element in accordance with the invention is thus independent of the machine size and the diameter of the screw element. Further, the screw elements are independent of the type of the shaft/hub connection as well as number of threads of the screw element. The screw elements can further be used for any type of material to be plasticized and are independent of the DA/D_i ratio as well as rotation direction of the screws.

Especially advantageous is the configuration of the geometry in such a manner as to attain a continuous increase of shear of the material to be plasticized. This would have the particular advantage that shear is introduced not massively and suddenly but smoothly, for example steadily increasing. Such a configuration would be mechanically especially advantageous as the element is under stress also

WO 2007/112861

PCT/EP2007/002482

increasingly dynamic over a longer path rather than locally harshly in a narrow restricted region.

As stated already, also the diameter of at least two kneading units may differ. As a result, the shearing clearance formed between the kneading unit and the extruder barrel would be designed greater or smaller in processing direction. According to a preferred configuration, the diameters of the individual kneading units or sections may increase in processing direction. The kneading units as well as kneading elements arranged in succession may hereby have throughout different diameters.

The progression of the diameter does not necessarily have to steadily increase but may partly also be the same or decrease. Depending on the process task, all possible variations of the diameter are conceivable. The diameter variability may hereby extend over various screw elements.

When the diameter of the kneading units increases in processing direction, the element would be exposed to mechanical stress in an increasingly dynamic manner over a longer path. The progression of the variability of the diameter of the kneading units does not necessarily have to increase steadily, rather it may also partly be the same or decrease.

The variability of the geometry has thus a direct influence on the development of the shear rate and the shear stress anteriorly of and in the screw element as well as on the development of the mechanical stress on the elements. Further, the D_a/D_i ratio of the kneading units may be constant or vary for the screw element according to the invention.

According to an advantageous configuration, the diameter and the width of at least two kneading units may be different. This would allow an especially great variability of

31254-51

the shearing clearance. A screw element designed in this way could also be best suited to a widest variety of process tasks.

In the context of attaining an especially good shear introduction and with respect to a balanced stress of the shear element, the diameter as well as also the width of the kneading units may increase in processing direction.

There are various possibilities to advantageously configure and improve the teaching of the present invention. Reference is made to the following description of preferred exemplary embodiments of the screw element according to the invention with reference to the drawing. In combination with the description of the preferred exemplary embodiments of the screw element according to the invention with reference to the drawing, generally preferred configurations and further improvements of the teaching are also explained. The drawings show in:

Fig. 1 a schematic plan view of an exemplary embodiment of a screw element with variable diameter,

Fig. 2 a schematic side view of the exemplary embodiment of a screw element with variable diameter, shown in Fig. 1,

Fig. 3 a schematic plan view of an exemplary embodiment of a screw element according to the invention with variable width of the kneading unit, and

Fig. 4 a schematic side view of the exemplary embodiment of a screw element according to the invention, shown in Fig. 3, with variable width of the kneading unit.

WO 2007/112861

PCT/EP2007/002482

The shown exemplary embodiments involve a kneading element 1 as the screw element for use in an unillustrated plasticizing unit with a screw shaft which is also not shown.

The kneading element 1 is comprised of kneading units 2 which are firmly connected to one another in this exemplary embodiment. The kneading units 2 can be arranged on a common axis. The kneading units 2 have hereby a toothed surface which is engageable with a toothed surface of the screw shaft so that the kneading element is secured on the screw shaft in substantial fixed rotative engagement. The kneading units 2 have a geometry which is determined by two diameters D_i and D_a , i.e. the diameters D_1 and D_2 , D_3 , or D_4 .

The geometry of two kneading units arranged in succession varies hereby. The kneading element shown in Fig. 1 is configured such that the outer diameter D_a increases in processing direction. This means that the kneading unit 2 with the smallest diameter D_1 is arranged in this exemplary embodiment closest in direction of the feeding zone, and the kneading unit 2 with the smallest diameter D_4 is arranged farthest in direction of the discharge zone. Thus, in the exemplary embodiment shown here, D_4 is greater than D_3 , and D_3 is greater than D_2 . D_1 is again smaller than D_2 , i.e. $D_1 < D_2 < D_3 < D_4$. The inner diameter D_i of the kneading element 1 remains hereby constant. For each configuration, it is conceivable to vary the inner diameter D_i in correspondence to or differently than the outer diameter D_a ,

Fig. 2 shows a schematic side view of the kneading element 1 shown in Fig. 1. The kneading element 1 of this exemplary embodiment has a total width B . The kneading units 2 in turn have a width b .

Fig. 3 shows a kneading element according to the invention with variable land width, i.e. the kneading units 2 have different widths b . The diameter ratio D_a/D_i is constant in this exemplary embodiment. It should further be taken into account that the outer

WO 2007/112861

PCT/EP2007/002482

diameter D_a is also constant. The width b of the kneading units 2 increases in processing direction. As a result, the material shear is higher across the width B of the kneading element 1. In this actual exemplary embodiment, the width b_1 of the kneading unit 2, disposed closest in direction feeding zone for this kneading element 1, is smaller than the width b_2 . The width b_2 is again smaller than the width b_3 . The width b_4 of the next kneading unit 2 is again greater than the width b_3 of the preceding kneading unit 2. Further, the width b_5 of the kneading unit 2, which in relation to this kneading element 2 is arranged farthest in direction discharge zone, is greater than the width b_4 , i.e. $b_1 < b_2 < b_3 < b_4$.

With respect to further details, reference is made to the general description to avoid repetitions.

Finally, it should be expressly noted that the afore-described exemplary embodiments serve only for explanation of the claimed teaching which is not to be restricted however to these exemplary embodiments.

WO 2007/112861

PCT/EP2007/002482

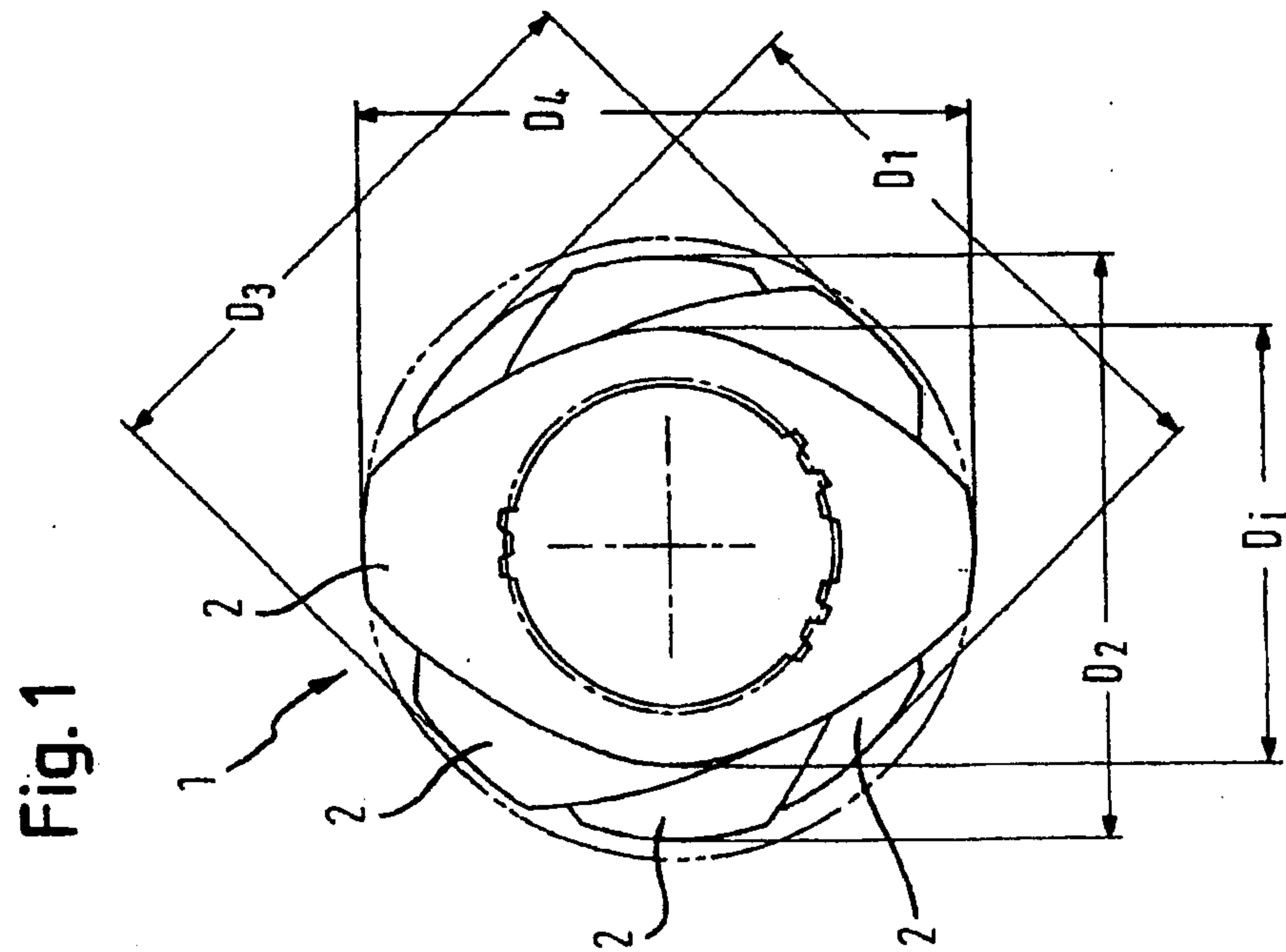
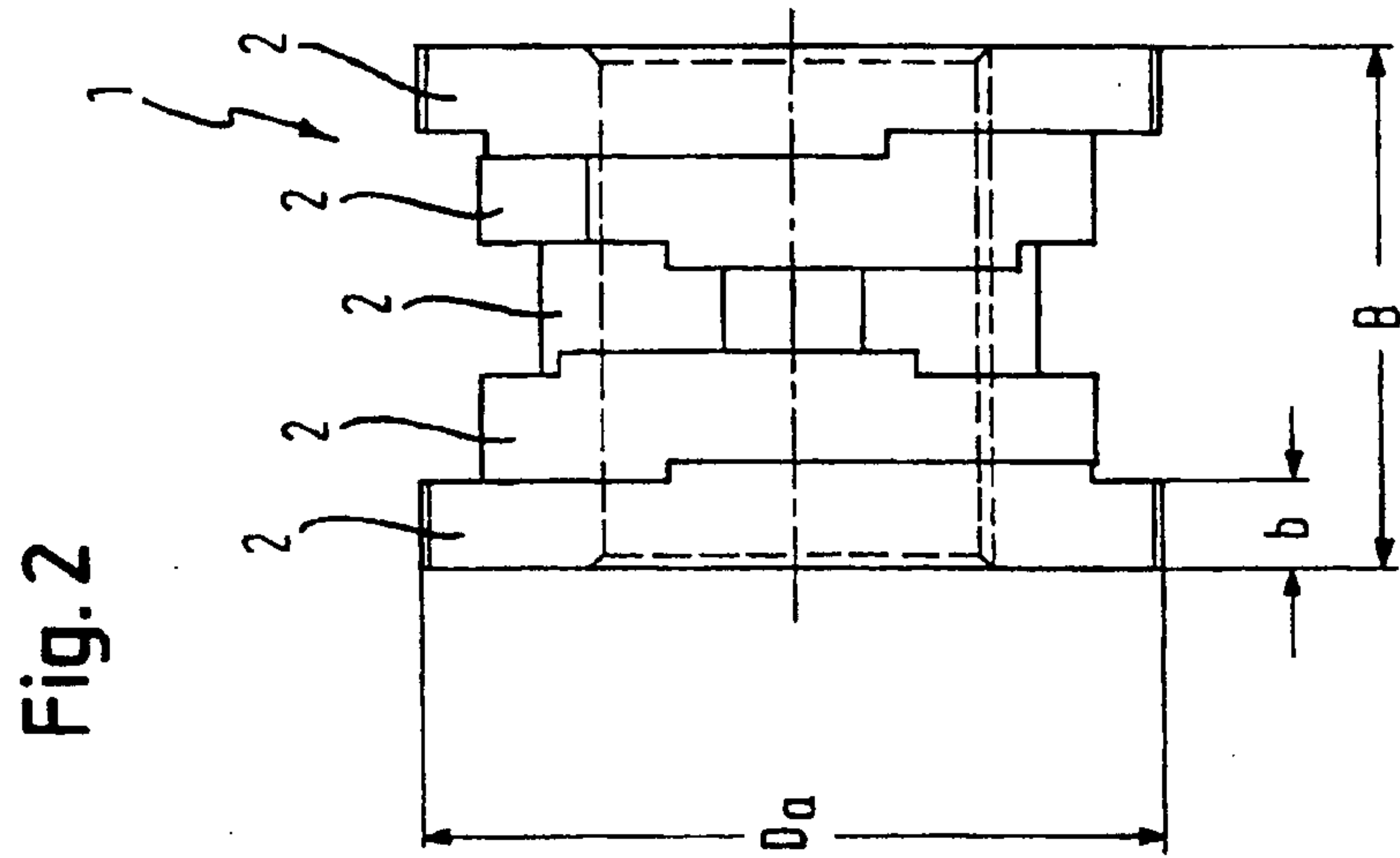
List of Reference Signs

1	kneading element
2	kneading unit
D_a, D_1, D_2, D_3, D_4	outer diameter
D_i	inner diameter
b	width of the kneading unit
B	width of the kneading element

31254-51

CLAIMS:

1. Kneading element for use in a plasticizing unit with a screw shaft, having at least three kneading units, wherein the kneading units are arranged on a common axis
- 5 wherein
the width of the kneading units increases overall in a processing direction, and wherein the width of each successively arranged kneading unit is the same as or greater than the width of a preceding kneading unit.
2. Kneading element according to claim 1, wherein the common axis is
10 defined by the screw shaft.
3. Kneading element according to claim 1 or 2, wherein
the diameter of at least two kneading units varies.
4. Kneading element according to claim 3, wherein
the diameter of the two kneading units increases in processing direction.



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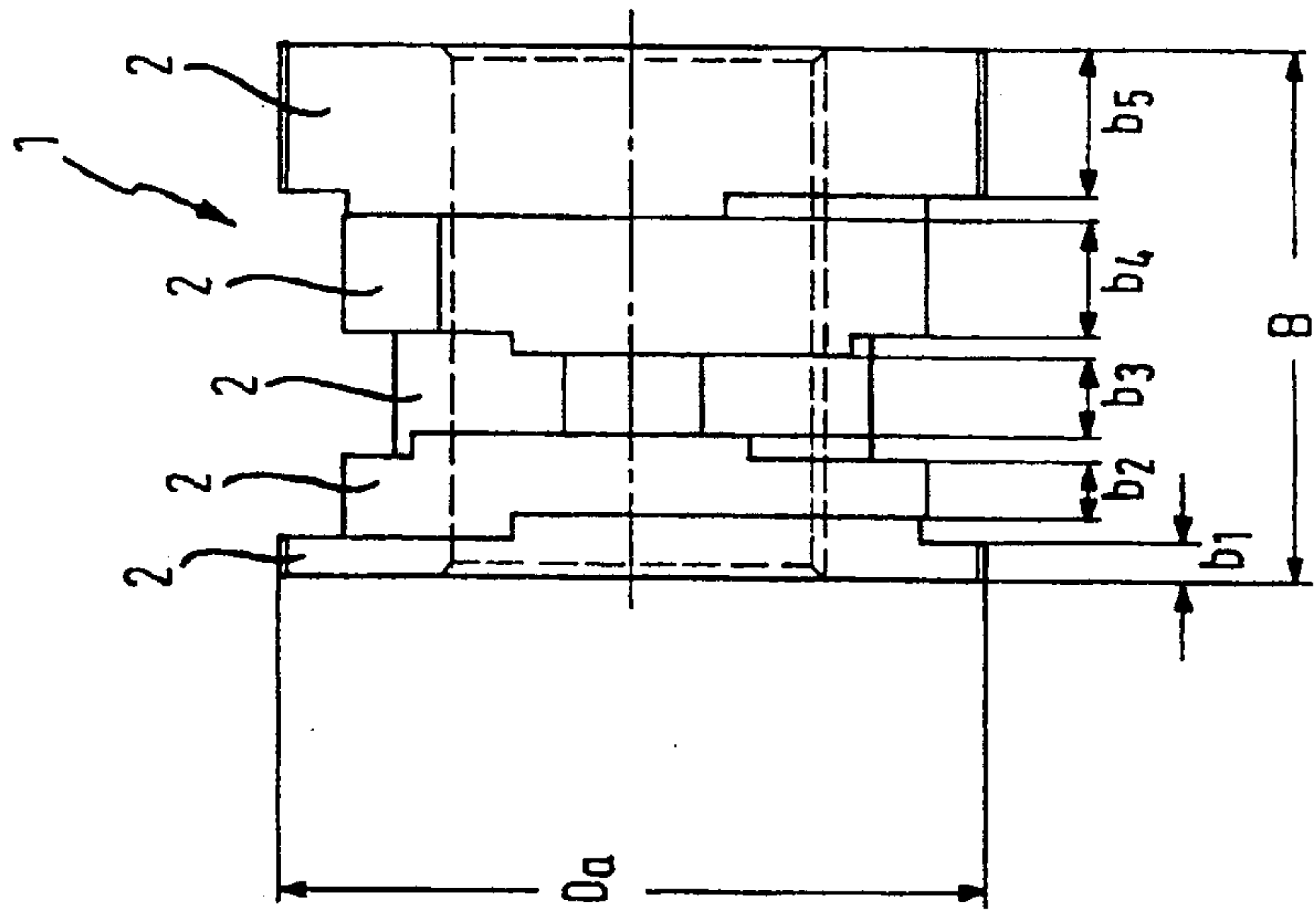


Fig. 4

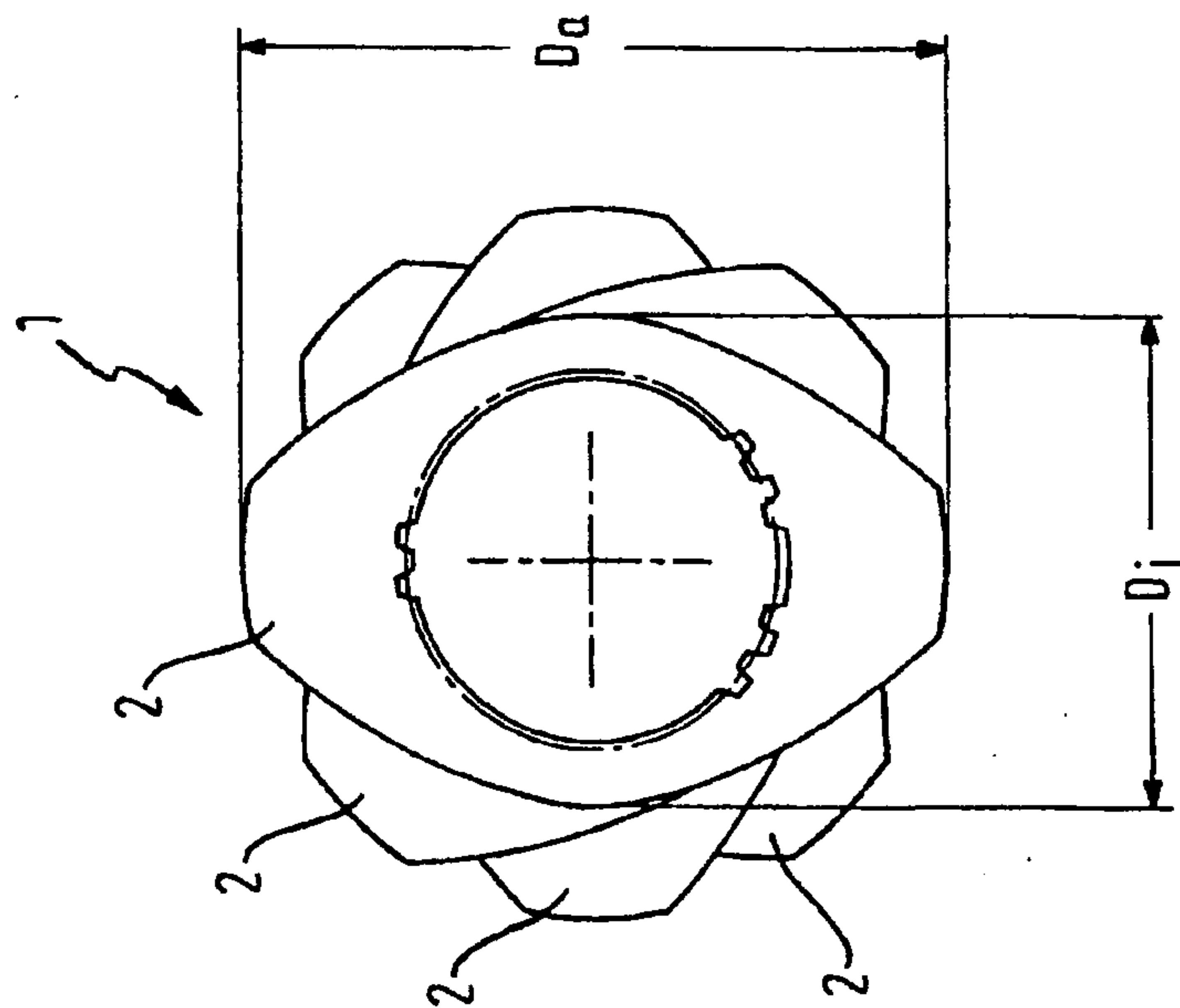


Fig. 3

