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AUSTRALIA

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NOTICE OF ENTITLEMENT

We, **FARREL CORPORATION** of 25 Main Street, Ansonia, Connecticut 06041-1601, United States of America state the following in connection with Australian Application No. 34514/93:

1. We are the nominated person.

2. The nominated person is the assignee of Farrel Rocksted GmbH who is the assignee of the actual inventor.

3. The nominated person is the assignee of the applicant of the basic application listed in the declaration under Article 8 of the PCT.

4. The basic application is the application first made in a Convention country in respect of the invention.

Dated: 28 July 1994

By **PHILLIPS ORMONDE & FITZPATRICK**
Patent Attorneys for the Applicant
By:

David B Fitzpatrick

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To: The Commissioner of Patents

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MULTI-SHAFT CONTINUOUSLY OPERATING MIXING AND KNEADING MACHINE FOR PLASTICISABLE COMPOUNDS

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(56) Prior Art Documents
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EP 160124
EP 37984

(57) Claim

1. A multi-shaft, continuous mixing and kneading machine including:

a housing assembly including two adjoining and substantially cylindrical housing sections each having an inner wall;

a shaft element disposed within each of said adjoining housing sections such that the shaft elements are axially adjacent each other and rotatable in the same direction about an axis of rotation, each shaft element including a threaded transport screw and a kneading element, said threaded transport screws intermeshing;

each said kneading element disposed within one of said housing sections and including an axially extending polygon having edges and flat surfaces, said edges during rotation circumscribing envelopes with diameters which have a clearance with respect to one another such that the edges of said axially extending adjacent polygons do not overlap while rotating and a clearance is maintained between said polygons, and wherein a distance between the edges and said inner walls of the housing sections is greater than said clearance.

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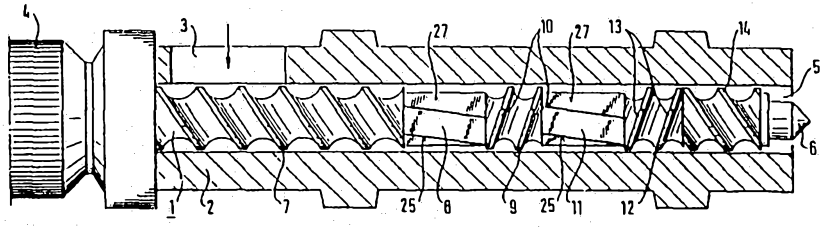
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(54) Title: MULTI-SHAFT CONTINUOUSLY OPERATING MIXING AND KNEADING MACHINE FOR PLASTICISABLE COMPOUNDS

(54) Bezeichnung: MEHRWELLIGE KONTINUIERLICH ARBEITENDE MISCH- UND KNETMASCHINE FÜR PLASTIFIZIERBARE MASSEN

(57) Abstract



A multi-shaft continuously operating mixing and kneading machine for plasticisable compounds with shafts rotating in a housing which pass through a cylindrical housing section surrounding the shaft concerned and have intake and discharge regions and melting, mixing and kneading regions between them. The intake and discharge regions are formed by inter-engaging worms rotating in the same direction and are arranged in the melting, mixing and kneading regions. The kneading components consist of axially extending polygons (8, 11), the surfaces (27) of which are approximately flat and the edges (25) of which pass the peripheries (29, 30) of the other polygon on rotation with a slight clearance and without engagement. The edges of the housing section surrounding them maintain a substantially greater distance than the clearance.

(57) Zusammenfassung

Mehrwellige kontinuierlich arbeitende Misch-Knetmaschine für plastifizierbare Massen mit in einem Gehäuse drehenden Wellen, die jeweils ein die betreffende Welle umgebendes zylindrisches Gehäuseteil durchsetzen und Einzugs- und Austragszonen sowie dazwischen Aufschmelz-, Misch- und Knetzonen aufweisen, wobei die Einzugs- und Austragszonen durch ineinandergreifende gleichsinnig drehende Schnecken gebildet und in den Aufschmelz-, Misch- und Knetzonen Knetelemente angeordnent sind. Die Knetelemente bestehen aus axial gestreckten Polygonen (8, 11), deren Flächen (27) angenähert eben verlaufen und deren Kanten (25) beim Drehen nicht ineinander eingreifend mit geringem Spiel zur Umhüllenden (29, 30) des jeweils anderen Polygons an diesem vorbeilauf'n, wobei die Kanten von dem sie umgebenden Gehäuseteil einen gegenüber dem Spiel wesentlich grösseren Abstand einhalten.

Multi-shaft continuous mixing and kneading machine for plasticizable compounds

The invention relates to a multi-shaft, continuous mixing and kneading machine for plasticizable compounds with shafts, which rotate in a housing and which penetrate the cylindrical housing section enclosing the shafts concerned and exhibit feed and discharge zones and intermediate melting, mixing and kneading zones, whereby the feed and discharge zones are formed by intermeshing screws that rotate in the same direction, and kneading elements are disposed in the melting, mixing and kneading zones.

Such a machine is known from the DE-AS 1 679 884. For this machine the kneading elements are designed as intermeshing kneading discs, which are usually provided with two or three axially extending edges. These relatively narrow kneading discs induce severe shear and thus intense development of heat in the material to be processed owing to the intermeshing of the kneading discs. Owing to the high shear concentrating on an axially relatively short region, the result is frequently high temperature peaks, which involve risk of thermal damage to the material concerned, when the operating parameters of the machine are not set and monitored especially accurately and carefully.

It is further known from the DE-AS 24 52 994 a non-continuously working kneading machine which only works batch-wise. It has to be discharged after the kneading process by turning it over. In this known kneading machine all components and zones are missing being necessary for continuously working, particularly also a closed housing. It includes only two kneading elements rotating in opposite directions which are provided with triangular planes inclined against the axial direction, whereby the inclination of the triangular planes alternately runs in opposite directions in order to achieve the effect of an alternate to and back feeding of the kneading material to be treated, which in necessary with this machine.

The present invention is directed to the task of designing the melting, mixing and kneading process in such a manner that high temperature peaks may be minimised.

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According to an aspect of the present invention, there is provided a multi-shaft, continuous mixing and kneading machine including:

a housing assembly including two adjoining and substantially cylindrical housing sections each having an inner wall;

a shaft element disposed within each of said adjoining housing sections such that the shaft elements are axially adjacent each other and rotatable in the same direction about an axis of rotation, each shaft element including a threaded transport screw and a kneading element, said threaded transport screws intermeshing;

each said kneading element disposed within one of said housing sections and including an axially extending polygon having edges and flat surfaces, said edges during rotation circumscribing envelopes with diameters which have a clearance with respect to one another such that the edges of said axially extending adjacent polygons do not overlap while rotating and a clearance is maintained between said polygons, and wherein a distance between the edges and said inner walls of the housing sections is greater than said clearance.

The non-intermeshing, axially extended polygons provide, in interaction with the housing section concerned in the region of the flat surfaces of the polygons, axially extending chambers where an easy kneading effect is produced when one edge of the polygon travels by the adjoining shaft, since the edge penetrates somewhat into the chamber and thus pushes aside the material which is conveyed and contained in the chamber, without the material having to absorb especially high shear forces. To generate the desired kneading effect, the extended polygon is designed suitably long, a feature that does not cause an engineering problem due to its shape. Expediently the length of the polygons is greater than the diameter of their envelopes. The low shear stress of the material is essentially attained in that the polygons do not intermesh and travel by one another with small clearance. Owing to the significantly greater distance of the edges of the polygons from the housing section concerned as compared to the clearance, the result is an adequately large free cross section for the requisite throughput of material in the direction to the discharge zone. Thus, relative to this region, the surface of the housing section is suitably large, a feature that has a

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good effect on the optionally necessary introduction of heat from the housing section.

Compared to the known kneading discs, the shear velocity generated with the effect of the polygons is significantly less, a feature that leads to a correspondingly reduced heat build-up in the material to be processed, when it is conveyed along the polygons. It is achieved in the region of the chambers formed by the polygons with the housing section concerned despite a high mixing effect, since the residence time of the material in these chambers is relatively long; in any case longer than the residence time in the free spaces concerned at the known narrow kneading discs since they leave only relatively small free spaces owing to their intermeshing so that the material to be processed is forced rapidly along the kneading discs. The longer residence time of the material next to the polygons thus leads to a mixing in the chambers concerned that repeats itself often, without resulting in a particularly high build-up of heat, in particular thermal peaks.

The introduction of heat in the region of the polygons can be obtained in the known manner with heating elements attached to or in the housing. Additional heat introduced thus into the material is more economical to produce than the heat that is generated in the material by high shear and which stems from a correspondingly required power of the drive machine. The resulting torque leads to a corresponding wear. In addition, experience has shown that owing to the temperature peaks, which are produced through high shear, the heat generated thus must be subsequently dissipated through cooling, in order to protect the material against damage. This risk is largely eliminated with the machine according to the invention, since, on one hand, as stated, the heat produced in the material with the kneading effect is relatively low and, on the other hand, the heat introduced from the outside can be readily metered in such a manner that there is no risk of the material being damaged. Thus, for the machine of the invention, in particular when a necessary cooling is taken into consideration, the result is a totally lower energy supply at the same throughput as compared to machines using known kneading discs.

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It should also be pointed out that with respect to a non-intermeshing twin screw extruder it is known from the DE-AS 1 014 735 to provide kneading elements, which comprise per screw coaxial cylindrical rollers with planar flattenings arranged on opposing sides, between the outlet opening of the machine and screws. The diameter of the rollers is smaller than the inner diameter of the screw housing. Due to the non-intermeshing of the screws and the resulting non-overlapping of the walls of the two screw housings that form the inner cylinders (the inner cylinders touch precisely in the central region between the screws) the result of this decrease in the diameter of the rollers with respect to the inner diameter of the screw housing concerned both in the outer region of the screw housing and also in the central region between the rollers is a distance on the outside in the direction of the screw housing and on the inside in the direction of the opposing roller, where in the region between the rollers the distance from flattening to opposing flattening is twice as large as the distance between one flattening and the outer region of the screw housing. This means that in operation the distance between the flattenings of the opposing rollers that travel by one another is particularly large, namely twice as large as the distance of the flattening situated on the outside opposite the screw housing at that time, so that the kneading effect in this region that is especially important for the kneading is decisively reduced and thus its intensity is virtually lost. Apart from this, the cited document also discloses only kneading elements in the usual short length, which is significantly less than the diameter of the screws.

The edges of the extended polygons can be oriented axis-parallel. In this case the result is a component that can be produced in a simple manner from an engineering point of view. However, it is also possible to incline the edges of the extended polygons, namely allow them to extend in particular at such a small angle relative to the axial direction of the screw concerned that the edges extend only over a fraction of a complete course of a thread. If the edges of the adjoining polygons run in the same direction, rotation of the screw produces advancing approaching regions of the opposing edges of the polygons, which produce a shear that travels along the edges, where the material is subjected thus on a longer path to instantaneous shear and thus to a specific mixing effect. Thus, the

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relatively high residence time in the region of the polygons remains preserved, while the material is treated especially uniformly with the travelling shear.

To keep the mixing chambers, formed next to the surfaces of the polygons, constantly filled, baffles are provided expediently directly behind the polygons. Short screws with interrupted reverse feed threads have proven to be especially suitable as baffle elements. Where the thread is interrupted, the material can flow over from one course of the thread into the other course of the thread.

The extended polygons are expediently designed as a radially symmetrical, equilateral polygon, so that each polygon surface behaves in the same manner with respect to the housing wall and the respective other polygon. In so doing, a polygon which is hexagonal in cross section has proven to be especially advantageous, since as regards processing technology this polygon yields good throughput cross-sections for the transport of the material to be processed.

In order to better understand the present invention, preferred embodiments are hereinafter described by way of example with reference to the accompanying drawings, wherein:

Fig. 1 is a side view of a twin-shaft mixing and kneading machine,

Fig. 2 is a top view of the same machine,

Fig. 3 is a cross sectional view of the machine along line III-III of Fig. 2 with both shafts being set at such an angle that the edge of one polygon is opposite the flat of the other polygon,

Fig. 4 is a corresponding (enlarged) sectional view as in Fig. 3, but with both polygons set at different angles,

Figs. 5 to 7 show different embodiments of the polygon.

Fig. 1 shows a twin-shaft mixing and kneading machine, in fact in a side view, so that only the one shaft 1 of the machine can be seen. Shaft 1 is disposed in the schematically illustrated housing 2. Housing 2 has the inlet opening 3 for the supply of the material to be processed. At the left end of the housing 2 the drive unit 4 is shown. At the right end of the housing 2 the outlet 5 is provided, which is penetrated by the shaft tip 6. Thus, it is the conventional design of a twin-shaft mixing and kneading machine.

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In the region of the inlet opening 3, the shaft 1 has the transport screw 7, followed by the axially extended polygon 8. Polygon 8 is followed by a relatively short screw 9 with its screw thread, disposed opposite to that of screw 7, so that the screw 9 acts as a baffle element. Both illustrated thread courses of screw 9 have the two interruptions 10, in order to allow the necessary throughput in the region of the screw 9 despite its baffle effect. Screw 9 is followed by another polygon 11, followed by (as provided after polygon 8) screw 12, acting as a baffle element with opposite directed thread and with interruptions 13, so that both polygon 8 and polygon 11 work against the effect of screws 9 and 12. The discharge screw 14, which feeds the processed material conveyed to it to the outlet 5, forms the end of shaft 1.

Fig. 2 is a top view of the twin-shaft mixing and kneading machine according to Fig. 1. Next to the shaft 1 is the second shaft 15, which is driven together with shaft 1 in the same direction of rotation by the drive unit 4. The shaft 15, constructed in the same manner as shaft 1, is provided in the region of the inlet opening 3 (not visible in Fig. 2) with the transport screw 17, which meshes with the threads of the transport screw 7 and vice versa. Thus, it involves known intermeshing screws 7 and 17, which are driven in the same direction and which owing to their intrinsic function transport the material, fed via the inlet opening 3, from left to right. In so doing, the material is conveyed into the region of polygons 8 and 18, further to the baffles 9 and 19, further to the polygons 11 and 21 and finally via the discharge screws 14 and 24 to the outlet 5.

In the region of polygons 8 and 18 as well as 11 and 21 the material transported in by the transport screws 7/17 is thoroughly kneaded along edges 25, since during the rotation of the shafts 1 and 15 the edges 25 travel past the surfaces 27 or edges 25 of the opposing polygon and thus the supplied material is thoroughly kneaded in the manner already described above. This will be further described in conjunction with the accompanying Figs. 3 and 4. The polygons 8/18 and 11/21 extend over a relatively long length within the entire machine, so that the heat generated in the material to be processed during kneading is distributed over a suitable length and thus thermal peaks generated in a narrow space are avoided. Additionally required heat may be supplied by the

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bores 26, which convey a suitable heat transfer medium and which are provided in the housing 2.

Figs. 3 and 4 are cross sectional views along line III-III from Fig. 2, where for the presentation in Fig. 3 the setting of the two shafts 1 and 15 is selected at such an angle relative to each other that during rotation of the two shafts one edge 25 travels past one polygon flat surface 27. In the arrangement according to Fig. 4, this setting of the two shafts 1 and 15 relative to each other is selected differently, namely in such a manner that here two edges 25 of both opposing polygons approach one another. In so doing, in both the arrangements according to Fig. 3 and Fig. 4, the envelopes 29/30 of the two polygons 8 and 18 maintain a clearance with respect to each other that is significantly less than the distance of the edges 25 from the inner wall 28 of the housing 2.

In both the arrangement according to Fig. 3 and that according to Fig. 4 there is in the region between the two polygons 8 and 18 a pronounced kneading effect on the material situated between them, where, however, this kneading effect extends along the polygons over a relatively large distance (see Fig. 2), so that the kneading operation proceeds relatively gently for the material to be processed. If the edges 25 of the polygons are at a small angle to the respective axial direction, as shown in Fig. 2, the result is a kneading effect travelling along the respective polygon as a consequence of the axial shifting of the approach region of the respective edge 25, which at this time is opposite the other polygon. The kneading effect is thus generated along the material put through, a feature that has a particularly good effect on the mixing of various materials supplied.

The kneading operation shall be explained once again in the following. It is apparent from Figs. 3 and 4 that the two envelopes 29 and 30 of the two polygons 8 and 18 do not overlap, thus providing that a relatively small clearance, in which the kneading operation essentially takes place, remains between edge 25 and the polygon surface 27. In so doing, the material to be processed is subjected, according to the drawn arrows, to a certain shear, which stems from the rotation of the two polygons 8 and 18 in the same direction, although in the region of the clearance existing between the two polygons the respective opposing edges 25 or polygon flat surfaces 27 travel by one another in the opposite direction relative to each other.

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Figs. 5 to 7 show different designs of the polygon.

According to Fig. 5, the edges 31 of the polygon are oriented parallel to the axis. Figs. 6 and 7 show edges 32 and 33 extending at a small angle with respect to polygon axis, while the edges 32 and 33 are inclined in opposite directions. The incline is so slight that the edges 32 and 33 extend only over a fraction of the course of a thread, which would result in an especially large pitch as edges 32 and 33 were to continue.

It has turned out that a design of the polygons with edges 25, as shown in Fig. 2, has an optimal effect, i.e. where the edges 25 are inclined in the same direction, since in this case the aforementioned effect of the travelling of the kneading operation is especially pronounced when one edge is placed opposite the respective other polygon.

It must also be pointed out that several polygon stages may be provided in succession along a multi-shaft mixing and kneading machine, i.e. more than the two stages, as shown in Figs. 1 and 2. The number of polygon stages depends substantially on the material to be processed, in particular on the amount of heat to be generated thereby. It is also possible to shorten the polygons as compared to the drawing in Figs. 1 and 2 and to provide instead a larger number of polygon stages in succession. However, it has been shown that within one individual polygon stage an adequate kneading effect can be obtained only if the length of the polygons is greater than the diameter of their envelopes.

It must also be pointed out that, for example, triple-shaft mixing and kneading machines with the axially extended polygons can also be provided. In Figs. 5 to 7 the polygons are shown as hollow shafts. In the actual construction, however, the cavity is filled by an anchor, which penetrates the respective entire shaft and transfers the drive torque.

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The claims defining the invention are as follows:

1. A multi-shaft, continuous mixing and kneading machine including:

a housing assembly including two adjoining and substantially cylindrical housing sections each having an inner wall;

a shaft element disposed within each of said adjoining housing sections such that the shaft elements are axially adjacent each other and rotatable in the same direction about an axis of rotation, each shaft element including a threaded transport screw and a kneading element, said threaded transport screws intermeshing;

each said kneading element disposed within one of said housing sections and including an axially extending polygon having edges and flat surfaces, said edges during rotation circumscribing envelopes with diameters which have a clearance with respect to one another such that the edges of said axially extending adjacent polygons do not overlap while rotating and a clearance is maintained between said polygons, and wherein a distance between the edges and said inner walls of the housing sections is greater than said clearance.

2. A machine as claimed in Claim 1 further including:

an inlet opening in said housing for feed of material to be mixed and kneaded and an outlet opening in said housing for discharge of said material;

each shaft element also including a threaded discharge screw, with said threaded discharge screws intermeshing, and

wherein said threaded transport screws are disposed adjacent said inlet opening, said threaded discharge screws are disposed adjacent said outlet opening, and said kneading elements are disposed axially between said threaded transport screws and said threaded discharge screws.

3. A machine as claimed in Claim 1 or Claim 2 wherein said polygons have an axial length which is greater than the diameter of the circumscribed envelopes.

4. A machine as claimed in Claim 3 wherein each of said shaft elements further include baffle elements disposed axially adjacent said kneading elements on a side of the kneading elements opposite the threaded transport screws.

5. A machine as claimed in Claim 4 wherein said baffle elements include screws having an interrupted thread, the threads of said baffle elements being of opposite hand relative to said threaded transport screw.

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6. A machine as claimed in Claim 5 wherein the baffle screws have an axial length which is shorter than the axial length of the threaded transport screws.

7. A machine as claimed in Claim 6 wherein each shaft element has two kneading elements.

8. A machine as claimed in Claim 7 wherein each shaft element has two baffle elements, one baffle element disposed axially adjacent each of the two kneading elements on a side of the kneading elements opposite the threaded transport screw.

9. A machine as claimed in any one of Claims 1 to 8 wherein said edges of said polygons extend parallel to the axis of rotation of said shaft elements.

10. A machine as claimed in any one of Claims 1 to 8 wherein the edges of said polygons extend axially at an angle relative to the axis of rotation of said shaft elements such that the edges extend over only a fraction of a complete course of rotation of a thread.

11. A machine as claimed in Claim 10 wherein for adjacent polygons the edges of said polygons extend axially at angles in the same direction in reference to a plane through their axis of rotation.

12. A machine as claimed in any one of the preceding claims wherein for adjacent polygons the edges of said polygons extend parallel to each other in reference to a plane through their axis of rotation.

13. A machine as claimed in any one of the preceding claims wherein a cross-section of said polygons taken perpendicular to their axis of rotation is an equilateral polygon.

14. A machine as claimed in Claim 13 wherein said equilateral polygon is an hexagon.

15. A machine as claimed in any one of the preceding claims wherein said axially extending polygons include hollow shafts disposed about an anchor portion of said shaft elements.

16. A machine as claimed in Claim 4 or Claim 5 wherein said baffle elements include screws which have an axial length which is shorter than the axial length of the threaded transport screws, and

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the edges of said polygons extend axially at an angle in the same direction relative to the axis of rotation of said shaft elements such that the edges extend over only a fraction of a complete course of rotation of a thread.

17. A multi-shaft, continuous mixing and kneading machine substantially as herein described with reference to any one of the embodiments illustrated in the accompanying drawings.

DATED: 25 October, 1995

PHILLIPS ORMONDE & FITZPATRICK
Attorneys for:
FARREL CORPORATION

David B Fitzpatrick

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Fig. 1

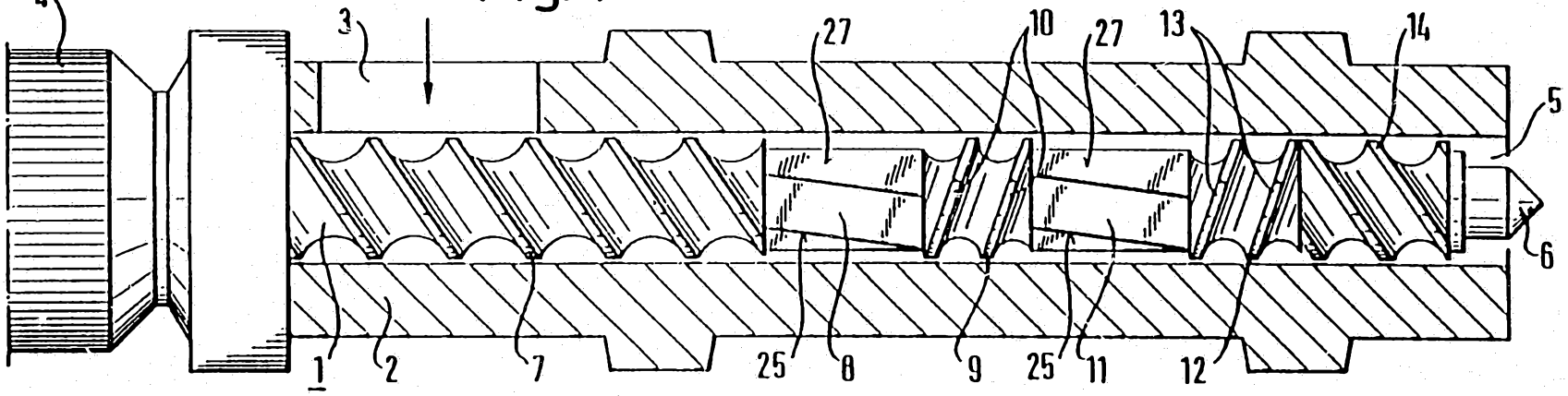
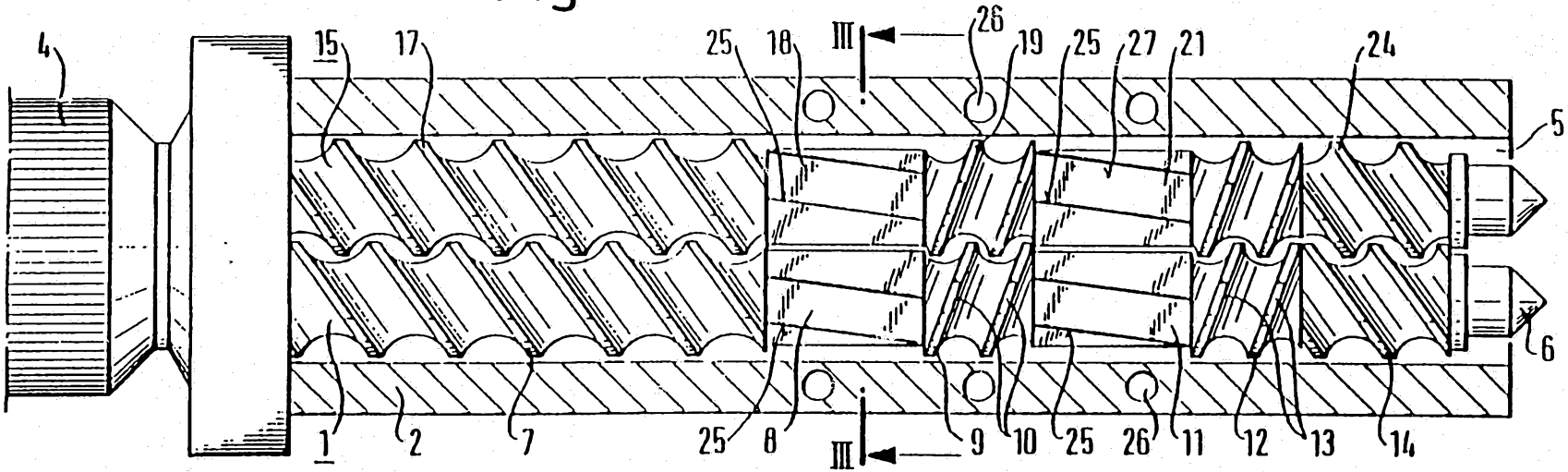


Fig. 2



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Fig. 3

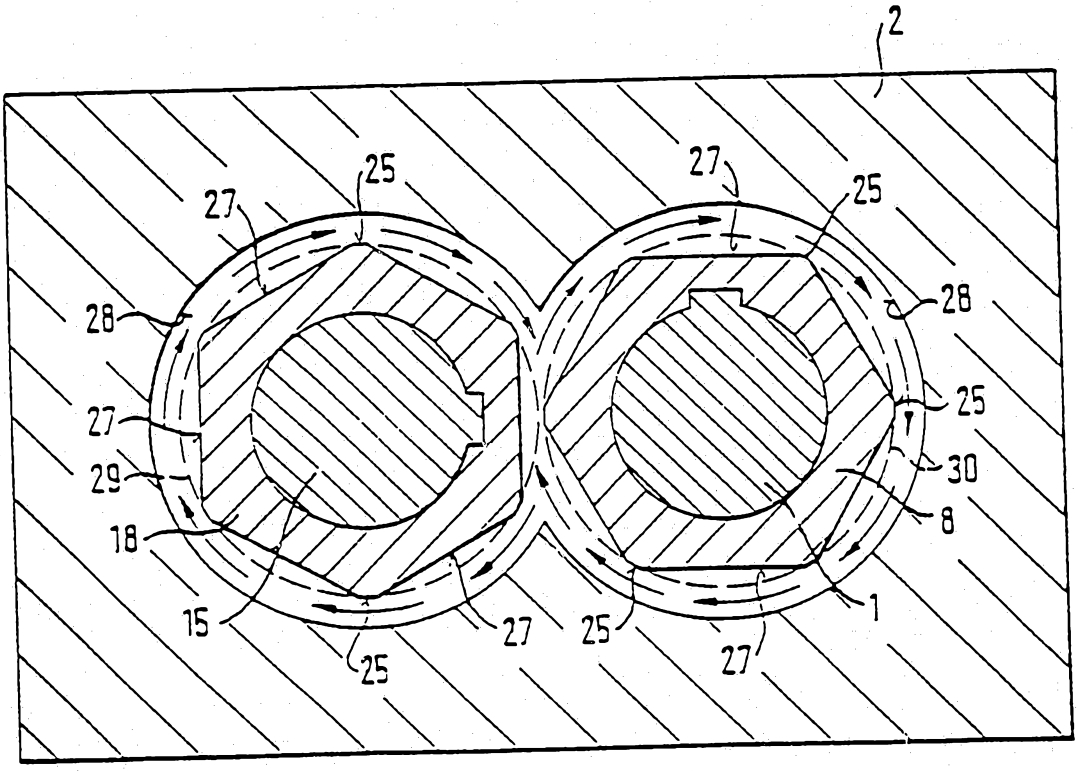


Fig. 4

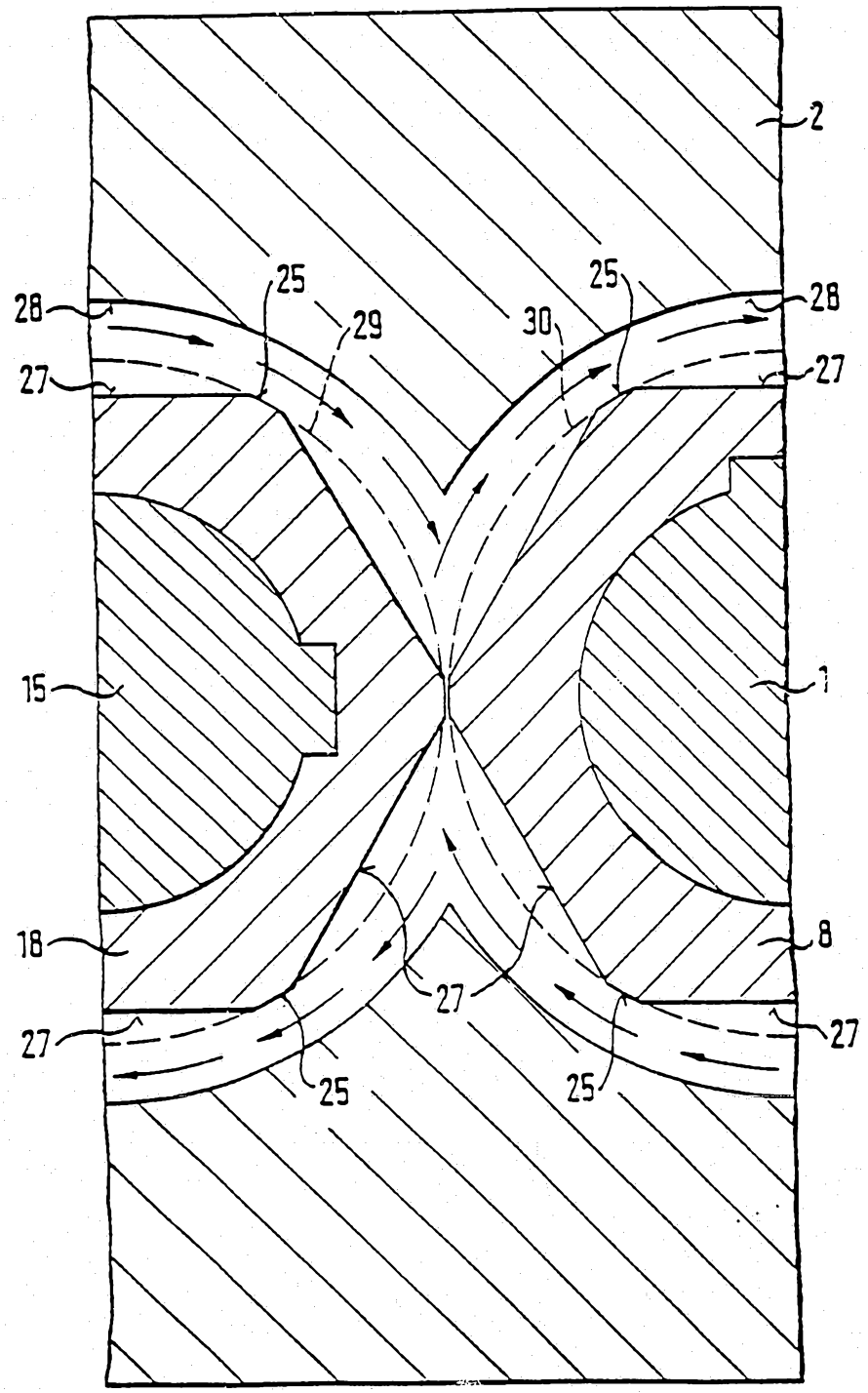


Fig. 5

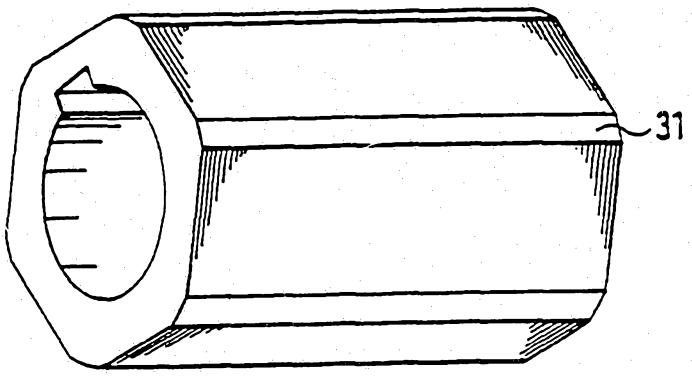


Fig. 6

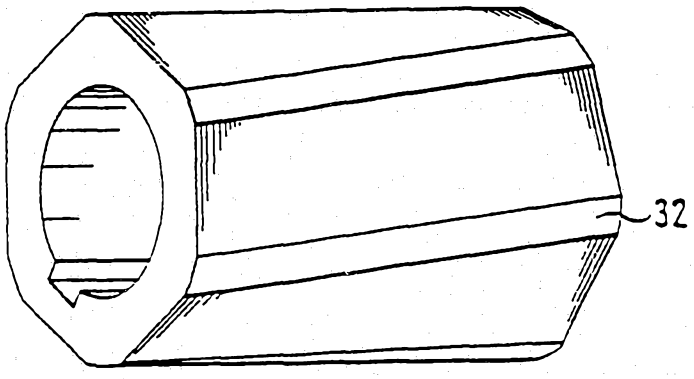


Fig. 7

