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(72) Inventors:
• **GLUKHOV, Dmitry Evgenievich**
Ufa, 450103 (RU)
• **GOLUBEV, Vitaly Nikolaevich**
Ufa, 450009 (RU)

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(74) Representative: **Savolainen, Seppo Kalevi**
Oy Kolster Ab,
Iso Roobertinkatu 23,
P.O. Box 148
00121 Helsinki (FI)

(71) Applicant: **Glukhov, Dmitry Evgenievich**
Ufa, 450103 (RU)

(54) **METHOD FOR PRODUCING BLANKS HAVING A FINE-GRAIN STRUCTURE**

(57) The invention relates to plastic working of metals, in particular, to a method of fabricating workpieces of metals and alloys by plastic deformation, including fabrication of long-length workpieces with a conditioned fine-grained structure, in particular, with a submicrocrystalline and nanocrystalline structure. The method enables the production of longitudinally laminated and internally reinforced workpieces, and can be utilized for processing workpieces from powdered metal components to obtain a solid article. The plastic deformation is performed by extrusion in an extrusion container using a shaping tool arranged in an extrusion channel, which directs the flow of metal and creates a combined intensive upsetting/shear/torsional plastic deformation pattern with simultaneous recovery of the workpiece cross-section area without impairing the continuity. The method reduces expenditures for processing workpieces owing to the use of commercially available equipment, e. g. vertical and horizontal hydraulic presses, and allows processing of workpieces from hard-to-deform and low-plastic alloys, powdered metals, composite materials, as it increases the use factor of the workpiece metal.

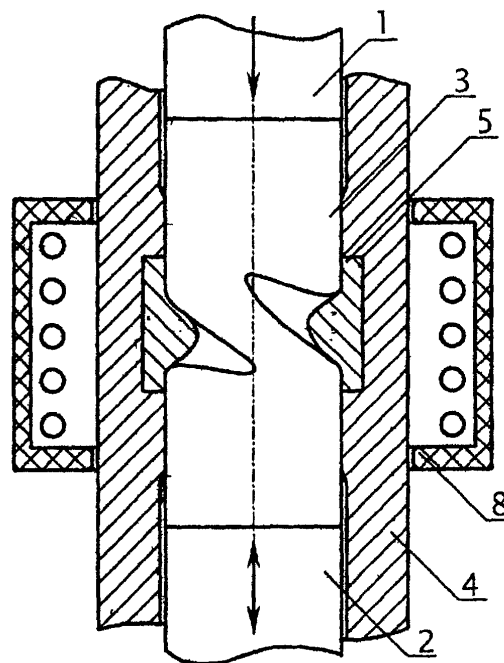


Fig.1

Description

FIELD OF THE INVENTION

[0001] The present invention relates to the field of plastic working of metals, in particular, to a method of fabricating workpieces of metals and alloys by plastic deformation, including fabrication of long-length workpieces with a conditioned fine-grained structure, in particular, with a submicrocrystalline and nanocrystalline structure. The method enables the production of arbitrary laminated and internally reinforced workpieces, and can be utilized for processing workpieces from powdered metal components to obtain a solid article.

BACKGROUND OF THE INVENTION

[0002] A method of deformation processing of materials, mainly metals, by angular extrusion, comprises the steps of: placing a material in a first channel of an apparatus for deformation processing, applying force to move the material to a second channel and impart deformation to the material by angular extrusion in the region of intersection of the channels, and removing the workpiece, wherein the material, when passing through the second channel, undergoes an additional deformation so that the cross-section of the workpiece is changed (RU 2 146 571 20.03.2000, B 21 C 25/00). The angular extrusion method allows multiple extrusions to be carried out without impairing the continuity of the workpiece, but the deformation is non-uniform throughout the cross-section of the workpiece.

[0003] Another method of processing axisymmetric workpieces by applying torsion, comprises the steps of: placing a workpiece into a cavity of a container, applying axial compression force to the workpiece by punch presses adapted to perform a relative axial movement and rotate with predetermined parameters. The workpiece is processed in a sectional container, wherein in the processing the workpiece is forced to move in the axial direction until each cross-section in the height of the workpiece will pass at least once through the parting plane of the container parts, and torsion is applied to the workpiece by rotation of the container parts in the directions corresponding to the directions of rotation of punch presses disposed therein (RU 2 021 064, 15.10.94, B 21 J 5/00). An important disadvantage of the method is that the plastic deformation is non-uniform since the external and internal layers of the metal move with different velocities under the torsion applied to them.

[0004] Another method of processing workpieces, mainly long-length rods, comprises deformation according to different patterns, including that leading to reduction in the cross-section. The workpiece is disposed on at least two seats, and the reduction is accomplished by a tool adapted to move longitudinally and transversely relative to the workpiece axis, with relative rolling of the surface, e.g. by a roll (RU 2 159 162, 20.11.200, C21C

37/04). To process a workpiece by the method, dedicated machinery is required, this raising the cost of application of the method in industry. Another disadvantage of the method is an inferior quality of the workpiece surface after the processing and the presence of scale layer on the surface, because it is formed in a free state in a furnace under the effect of rolls, therefore, an additional mechanical working is needed, which reduces the metal use factor. The method is unsuitable for processing workpieces from hard-to-deform and low-plastic metals, such as tungsten-niobium-tantalum and niobium-zirconium alloys.

[0005] The object of the invention is to provide a method for thermo-mechanical processing of workpieces having different shape and dimensions and a fine-grained structure, which increases the metal use factor and reduces equipment costs owing to the possibility to use commercially available equipment, and can be employed for processing workpieces from hard-to-deform and low-plastic alloys, powdered metals and composite materials.

SUMMARY OF THE INVENTION

[0006] The object of the invention is accomplished in a method for fabricating workpieces with a fine-grained structure, including plastic deformation of workpieces of metals and alloys in predetermined thermo-mechanical conditions, wherein said plastic deformation of a workpiece comprises subjecting the workpiece to extrusion in an extrusion container through a shaping tool arranged in an extrusion channel to direct the flow of metal and create a combined upsetting/shear/torsional plastic deformation pattern without impairing the continuity of the workpiece. The processing in accordance with the invention involves a profound exposure of the metal structure throughout the cross-section of the processed workpiece with forming different patterns of plastic deformation of a portion, including upsetting, shear and torsion, and allows the direction of preferred development of deformation to be changed. According to a preferred embodiment of the method, the extrusion can be repeated many times in the same or reversed direction.

[0007] The deformation is localized in a certain portion of the workpiece, and in a preferred embodiment it is provided by the use of at least one shaping tool that locally narrows the extrusion channel and has a working surface with a geometry which creates a combined plastic deformation pattern in the extrusion process. The workpiece can have recesses into which the shaping tool is inserted before the extrusion. To provide full or partial recovery of the workpiece cross-section area without impairing the continuity, the workpiece undergoes the extrusion at a predetermined back pressure, and the workpiece is arranged in a closed volume defined by a pair of punch presses. In the extrusion process, the workpiece disposed between the pair of punch presses is forced to move relative to the shaping tool

disposed in the container, or the container is moved together with the shaping tool relative to the workpiece disposed between a pair of fixed punch presses.

[0008] According to another preferred embodiment, the closed volume can be provided by a frame which holds its shape in the extrusion process and accommodates the workpiece. The extrusion container can be a sectional container with at least one parting plane.

[0009] To produce a longitudinally laminated workpiece, a workpiece can be coated with one or more layers of different materials before the extrusion. In addition, internally reinforced workpieces can be produced, in that case a pre-reinforced workpiece is used. A workpiece being processed can undergo deformation at a temperature needed to obtain a desired structure and desired mechanical properties. To this end, extrusion can be carried out in a furnace or an induction chamber or with passing electric current through the workpiece. Selection of a particular temperature for heating the workpiece depends on the material or the desired microstructure to be obtained in the extrusion.

[0010] The shaping tool can be cooled in the course of extrusion as may be required. In extrusion of a long-length workpiece, a local heating can be provided only at a portion of the workpiece, the deformation being localized due to thermal softening of the material in the portion heated. When a workpiece or an extrusion container is of a highly oxidable metal, the extrusion can be carried out in a shielding atmosphere or vacuum.

[0011] For high-temperature extrusion of a workpiece with the use of a frame it is preferable that the materials of the frame and the workpiece have different thermal expansion coefficients.

[0012] In extrusion of a workpiece from hard-to-deform refractory alloys, it is recommended to use a short time reversal of the direction of extrusion.

[0013] Owing to the simultaneous use of several plastic deformation patterns, the resulting structure is more uniform throughout the cross-section, and a high degree of accumulated deformation is provided as needed to substantially reduce grains and obtain physico-mechanical properties corresponding to the fine-grained state of the material. In extrusion, the cross-section area of the workpiece is fully or partly recovered without impairing the continuity of the material. When workpieces from powdered or composite materials are processed, great deformation rates destroy oxide layers of components in the workpiece and intensify diffusion processes, this improving the continuity and homogeneity of the material.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] For a more complete understanding of the present invention, reference is now made to the following description of preferred embodiments taken in conjunction with the accompanying drawings, in which:

Fig.1 is an apparatus for processing a workpiece in a variable cross-section channel with the use of local heating;

Figs 2, 3 are different embodiments of a workpiece to be subjected to plastic deformation;

Fig.4 is an apparatus for processing a workpiece by a method in accordance with the invention, where punch presses creating back pressure P move relative to a fixed extrusion container;

Fig.5 is another embodiment of an apparatus for processing a workpiece by a method in accordance with the present invention, where a container moves relative to the workpiece and punch presses creating back pressure P;

Fig.6 is an apparatus for processing a workpiece, using a frame;

Fig.7 is a frame for implementing the method illustrated in Fig.6;

Fig.8 is an apparatus for processing a pipe-shaped workpiece in a closed volume;

Fig.9 is a part which creates a closed volume for processing the pipe shown in Fig.8.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0015] Fig.1 shows an apparatus for implementing a method of fabricating a workpiece with a fine-grained structure in accordance with the present invention, comprising an extrusion container 4 having a variable cross-section channel and a shaping tool 5 accommodated in the channel. A workpiece 3 having pre-formed recesses that match the geometry of the shaping tool 5 is placed in the channel of the container. A local heating device 8, such as an induction furnace, is arranged on the outside of the extrusion container 4. The workpiece is clamped between two punch presses 1 and 2 and subjected to extrusion through the shaping tool 5.

[0016] In a preferred embodiment, the extrusion can be repeated many times in the same or reversed direction.

[0017] Fig.5 shows an apparatus for implementing the method in accordance with the present invention, comprising a pair of punch presses between which a workpiece is clamped, and an extrusion container 4 movable relative to the punch presses. As the container moves relative to the fixed punch presses, the workpiece undergoes deformation by the shaping tool.

[0018] In an apparatus shown in Fig. 6, a workpiece 3 is disposed in a frame 6. The frame with the workpiece is put into an extrusion container 4 having a tool 5 arranged therein. A punch press 1 forces the frame with the workpiece to move through the extrusion channel.

[0019] Fig.8 shows an apparatus for processing a pipe-shaped workpiece 3, where an auxiliary device is used, such as a cylindrical core with end discs for retaining the ends of the workpiece as it is forced to move through the extrusion channel under the effect of the

punch press. Workpieces are processed in the following fashion.

[0020] As shown in Fig. 1, a shaping tool 5 was inserted into a rod-shaped workpiece made of a tool steel and having recesses that match the geometry of the shaping tool 5, the assembled unit was put into a sectional extrusion container 4, heated to the phase transformation temperature of 830°C, clamped between punch presses 1, 2 and subjected to extrusion while being forced to move through the shaping tool 5 at a deformation rate of $0.8 \cdot 10^{-3} \text{ s}^{-1}$. Upon reaching the lower point, the punch presses were removed from the extrusion channel, the container was turned over and the extrusion was repeated. After processing of the workpiece twelve times with reversal of the extrusion direction, a fine-grained structure was obtained with uniform distribution of carbides throughout the workpiece volume, where the severity of carbide inhomogeneity changed from Class 4A to Class 2A according to the standard scale.

[0021] As shown in Fig. 6, a rod-shaped aluminum workpiece 3 having recesses matching the geometry of a shaping tool 5 was placed in a frame 6. The shaping tool 5 comprised of two half parts was inserted into the workpiece recesses and the assembled unit was put into an extrusion container 4. The frame with the workpiece was forced to move through an extrusion channel relative to the tool 5 by a punch press 1. Upon reaching the lower point, the punch press was removed from the extrusion channel, the container was turned up, and the extrusion step was repeated. After repeating the extrusion twenty times, a nanocrystalline structure was obtained with a grain diameter of from 0.8 to 1.0 μm .

[0022] Fig. 8 shows an apparatus for implementing a method of plastic deformation of tubular workpieces. A pipe-shaped workpiece 3 made of a cast refractory alloy and having recesses matching the geometry of a shaping tool was inserted into a part 7 creating a closed volume, and disposed in an extrusion container 4 with a shaping tool 6. Then, the assembly was heated in a furnace to the temperature of 1075°C. After reaching the desired temperature, the workpiece was subjected to extrusion at the deformation rate of 10^{-3} s^{-1} . The process was repeated nine times with reversal of the direction of extrusion. As the result, an equilibrium fine-grained structure of micro-duplex type with a grain size of 2-5 μm was obtained.

[0023] A method in accordance with the present invention reduces expenditures for processing workpieces as compared to conventional methods owing to the use of commercially available equipment, such as vertical or horizontal hydraulic presses, depending on the length of the workpiece processed. Furthermore, the method suits well for processing of workpieces from hard-to-deform, highly oxidable and low-plastic alloys, powdered metals, composite materials, as it increases the use factor of the workpiece metal.

Claims

1. A method of fabricating workpieces with a fine-grained structure, comprising plastic deformation of workpieces of metals and alloys in predetermined thermo-mechanical conditions, wherein said plastic deformation of a workpiece comprises subjecting the workpiece to extrusion in an extrusion container through a shaping tool arranged in an extrusion channel to direct the flow of metal and create a combined upsetting/shear/torsional plastic deformation pattern without impairing the continuity of the workpiece.
2. The method according to claim 1, **characterized in that** said extrusion is performed many times in the same or reversed direction.
3. The method according to claim 1, **characterized in that** at least one shaping tool is used, said shaping tool locally narrowing the extrusion channel and having a working surface with a geometry which directs the flow of metal of the workpiece.
4. The method according to claim 1, **characterized in that** said workpiece has recesses and said shaping tool is inserted into the recesses before the extrusion.
5. The method according to claim 1, **characterized in that** said extrusion of a workpiece is performed at a predetermined back pressure.
6. The method according to claim 1, **characterized in that** said extrusion of a workpiece is performed in a closed volume.
7. The method according to claim 6, **characterized in that** said closed volume is created by a pair of punch presses, the workpiece being disposed between the punch presses, wherein the punch presses and the workpiece are forced to move in the channel relative to the extrusion container, or the extrusion container with the shaping tool disposed therein are forced to move relative to the punch presses and the workpiece.
8. The method according to claim 6, **characterized in that** said closed volume is created by a frame which holds its shape in the extrusion process and accommodates the workpiece.
9. The method according to claim 1, **characterized in that** said extrusion container is a sectional container with at least one parting plane.
10. The method according to claim 1, **characterized in that** to fabricate a longitudinally laminated work-

piece, the workpiece is coated with one or more layers of different materials and subjected to joint extrusion.

11. The method according to claim 1, **characterized in that** to fabricate an internally reinforced workpiece, a pre-reinforced workpiece is used. 5
12. The method according to claim 1, **characterized in that** said extrusion is carried out in a furnace or an induction chamber, or with passing electrical current through the workpiece. 10
13. The method according to claim 12, **characterized in that** said shaping tool is cooled in the course of extrusion. 15
14. The method according to claim 12, **characterized in that** when a workpiece or a container of a strongly oxidable metal is used, said extrusion is carried out in a shielding atmosphere or in vacuum. 20
15. The method according to claim 1, **characterized in that** a long-length workpiece is subjected to extrusion in a variable cross-section extrusion channel and to local heating. 25
16. The method according to claim 8, **characterized in that** at a high-temperature extrusion of a workpiece, materials with different thermal expansion coefficients are used for the workpiece and the frame. 30
17. The method according to claim 1, **characterized in that** workpieces of hard-to-deform refractory alloys are subjected to extrusion with a short time reversal of the direction of extrusion. 35

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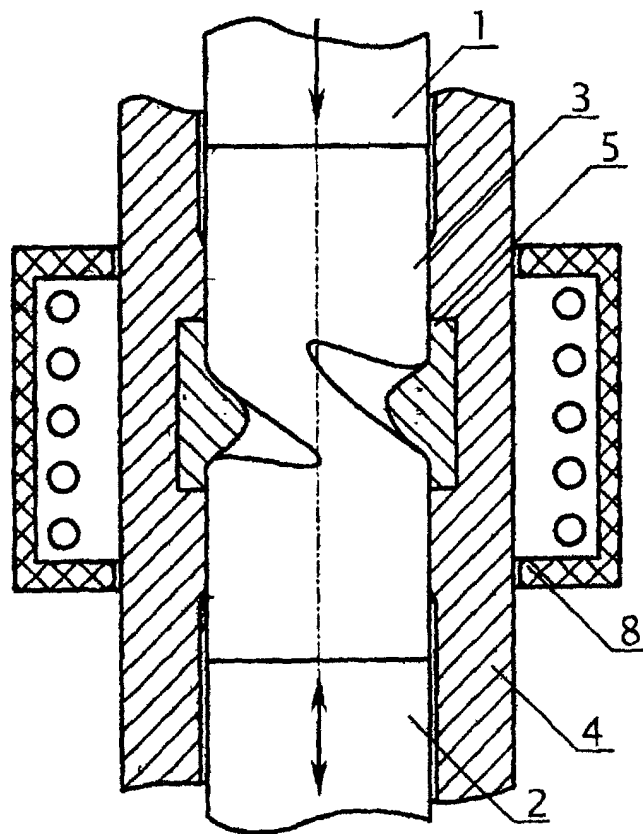


Fig.1

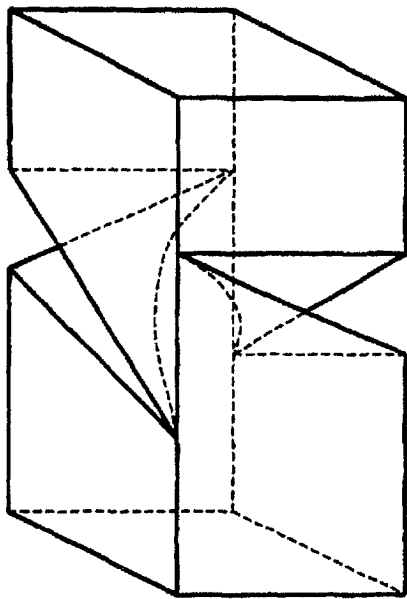


Fig. 2

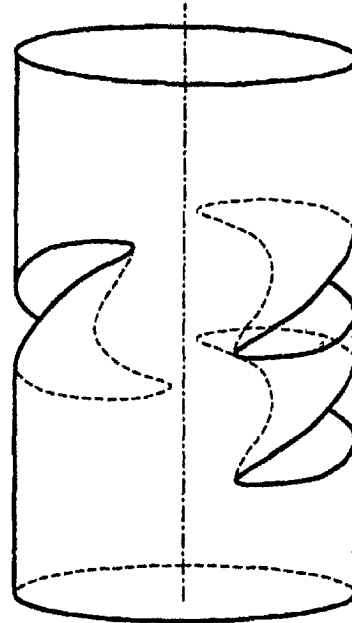


Fig. 3

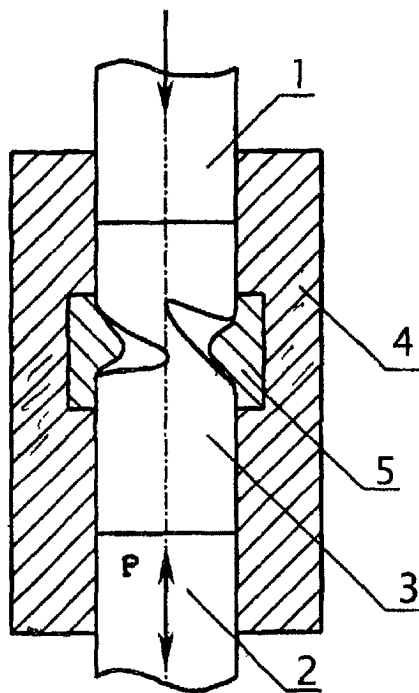


Fig. 4

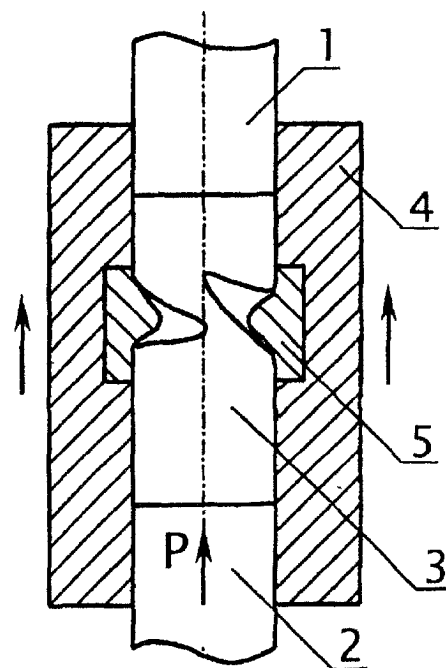


Fig. 5

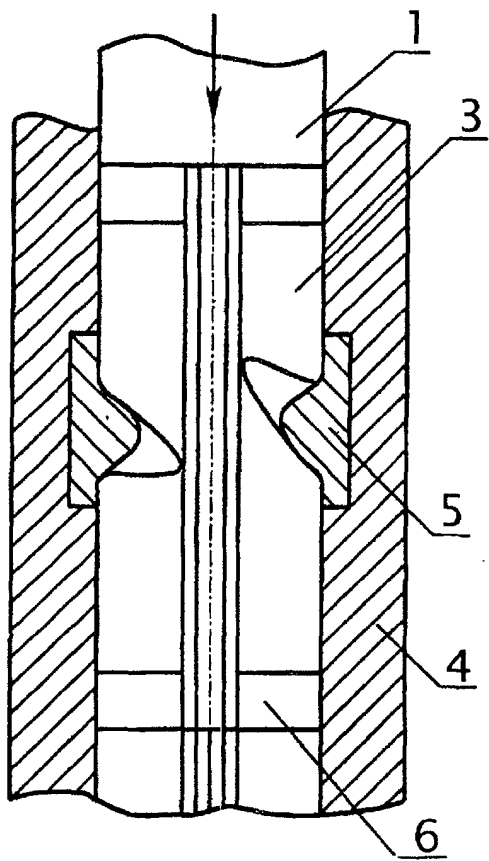


Fig. 6

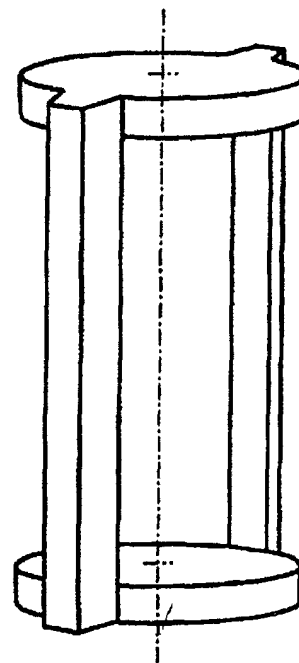


Fig. 7

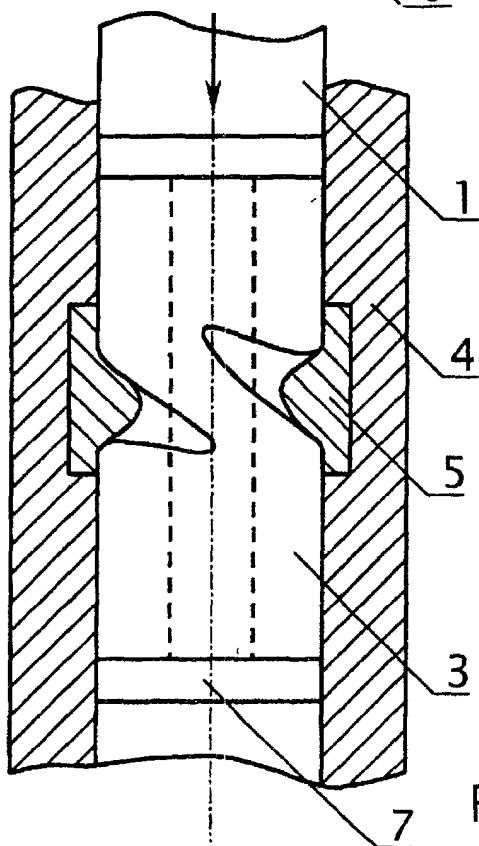


Fig. 8

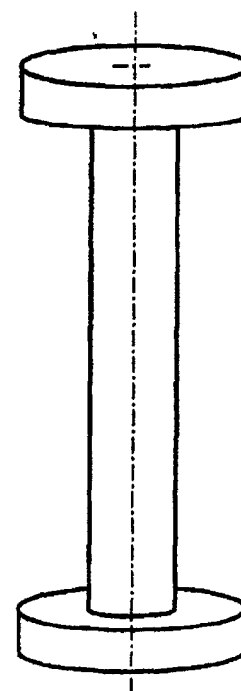


Fig. 9