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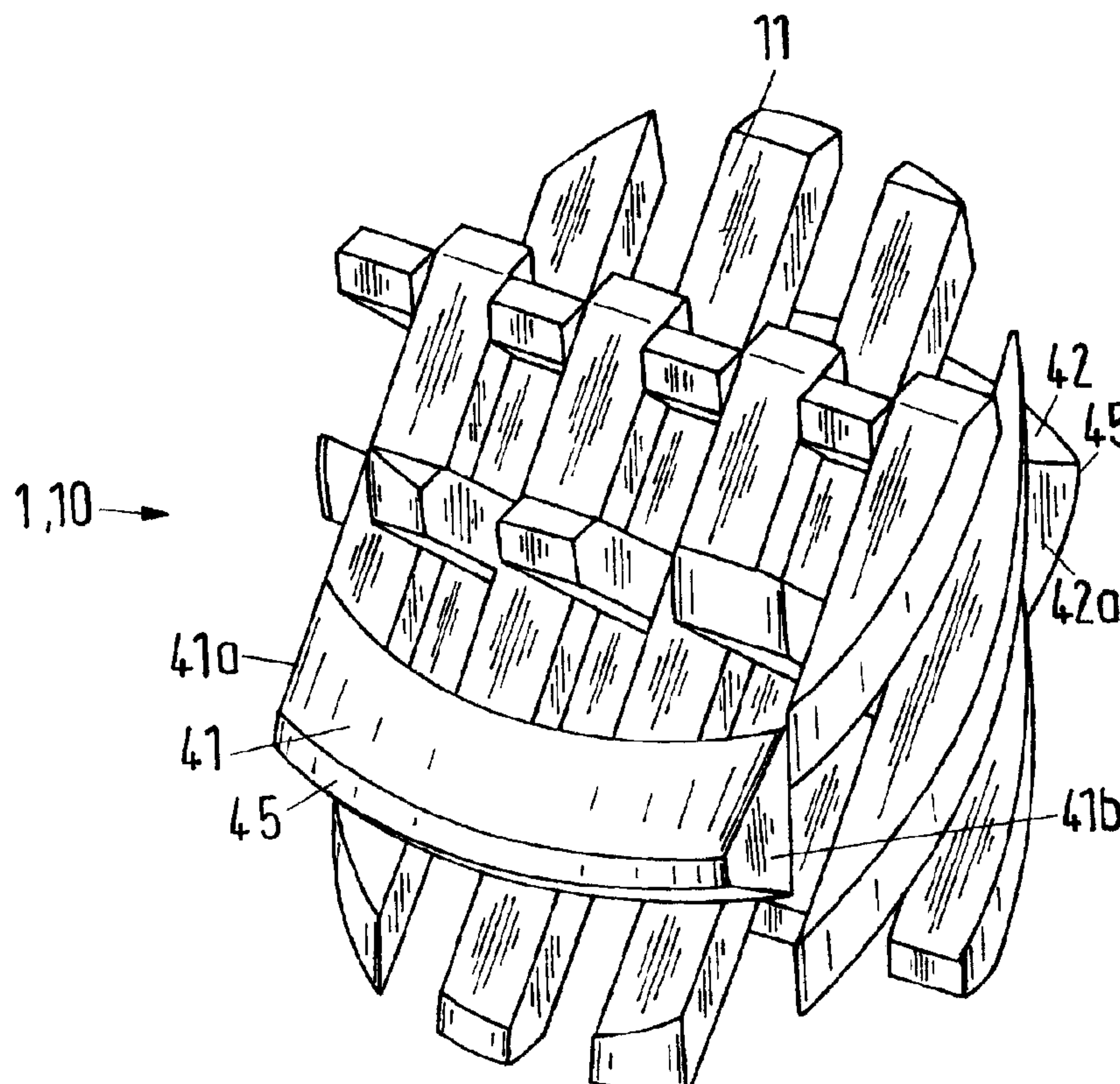
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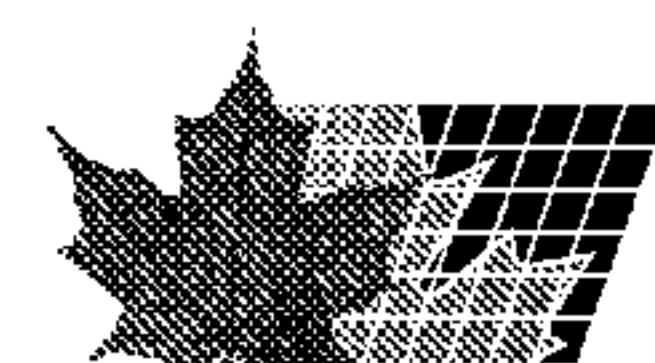
(54) Titre : MELANGEUR STATIQUE POUR MILIEU A VISCOSITE ELEVEE

(54) Title: A STATIC MIXER FOR HIGH-VISCOSITY MEDIA



(57) Abrégé/Abstract:

The static mixer for a high-viscosity flowing fluid includes mixing elements which are made as monoliths and sleeve elements in the form of tube pieces by means of which the mixing elements are positioned as well as a housing into which the sleeve elements are inserted together with the mixing elements. The mixing elements each include a lattice structure of webs that cross. The sleeve elements have two cut-outs in the end faces that receive two ribs of the mixing elements in a shape-matched manner. The ribs are annular segments.



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ABSTRACT

The static mixer for a high-viscosity flowing fluid includes mixing elements which are made as monoliths and sleeve elements in the form of tube pieces by means of which the mixing elements are positioned as well as a housing into which the sleeve elements are inserted together with the mixing elements. The mixing elements each include a lattice structure of webs that cross. The sleeve elements have two cut-outs in the end faces that receive two ribs of the mixing elements in a shape-matched manner. The ribs are annular segments.

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A static mixer for high-viscosity media

10 The invention relates to a static mixer for high-viscosity media in accordance with the preamble of claim 1 and to a mixing element for this mixer.

15 A static mixer is known from EP-A 0 646 408 with which high-viscosity polymer melts can be homogenised. This mixer can be used as a mixing head in the nozzle of an injection moulding machine or as a melt mixer subsequent to the screw of an extruder. It has a cylindrical shape and consists of a plurality of mixing elements as well as of sleeves which are inserted into the cylindrical hollow space of a housing. The mixing elements are cast bodies. They contain structures, for example lattice structures, which bring about a mixing process in a melt flowing through. The mixer structures shown in EP-A 0646 408 are built up of layers formed by webs. These layers are aligned in parallel in the direction of the longitudinal axis of the housing. The webs of adjacent layers cross. In a preferred embodiment, the sleeves form a tubular jacket together with flange-like rings of the mixer structures and the mixer structures are arranged successively in said jacket. In adjacent mixer structures, the orientations of the layers are each offset with respect to one another by a predetermined angle, preferably by 90°.

30 In injection moulding machines, polymer melts are injected into moulds (the tools) at high pressure and in a pulsating manner. Injection moulding

machines have been further developed in a manner such that the throughputs and the injection pressures can be increased. Load peaks occur as a result of high alternating stresses which put a larger mechanical stress on the installed mixing elements.

The static mixer for a high-viscosity flowing fluid includes mixing elements, which are designed as monoliths, and sleeve elements in the form of tube pieces by means of which the mixing elements are positioned, as well as a housing into which the sleeve elements are inserted together with the mixing elements. The mixing elements each have a lattice structure. Webs of this lattice structure cross at crossing positions which are arranged on bar-like regions transversely to a main flow direction of the fluid, with the main flow direction being set by a longitudinal axis of the housing. The sleeve elements are in contact at their ends via abutment surfaces. Cut-outs are present at these ends into which two ribs of the mixing elements are laid in a shape-matching manner – in a shape complementary to the cut-outs. The ribs are made in the form of annular segments. Two end surfaces of each rib are arranged such that centres of the end faces can each be connected by lines which are at least approximately aligned like the bar-like regions of the crossing positions. These bar-like regions have cross-sectional surfaces which are not larger than radial cross-sectional surfaces of the ribs.

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In accordance with one aspect of this invention, there is provided a static mixer for a high-viscosity flowing fluid with mixing elements which are made as monoliths, with sleeve elements in the form of tube pieces by means of which the mixing elements are positioned, and with a housing into which the sleeve elements are inserted together with the mixing elements, with the mixing elements each including a lattice structure, webs of this lattice structure crossing at crossing positions which are arranged at bar-like region transversely to a main flow direction of the fluid, and the main flow direction being given by a longitudinal axis of the housing, characterised in that the sleeve elements are in contact at their ends via abutment surfaces; in that cut-outs exist at these ends into which two annular segments of the mixing elements are inserted in a shape-matched manner to the cut-outs; in that two end surfaces of each segment are each arranged such that centers of the end surfaces can each be connected by lines which are aligned at least approximately the same as the bar-like regions of the crossing positions; and in that these bar-like regions have cross-sectional surfaces which are not larger than radial cross-sectional surfaces of the ribs.

In accordance with another aspect of this invention, there is provided a one-piece body forming a mixing element for a static mixer, said body having a first plurality of ribs disposed in spaced apart parallel layers angularly of a longitudinal axis; a second plurality of ribs disposed in spaced apart parallel layers and in crossing relation to said first plurality of ribs, said ribs of said first plurality of ribs and said ribs of said second plurality of ribs forming bar-like regions transverse to said longitudinal axis; and a pair of annular segments disposed on and projecting from opposite sides of said body, said

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segments being peripherally spaced apart to define gaps therebetween.

In accordance with a further aspect of this invention, there is provided a static mixer comprising a plurality of mixing elements, each element comprising a one-piece body having a first plurality of ribs disposed in spaced apart parallel layers angularly of a longitudinal axis; a second plurality of ribs disposed in spaced apart parallel layers and in crossing relation to said first plurality of ribs, said ribs of said first plurality of ribs and said ribs of said second plurality of ribs forming bar-like regions transverse to said longitudinal axis; and a pair of annular segments disposed on and projecting from opposite sides of said body; and a plurality of sleeve elements disposed in alternating relation with said mixing elements along said longitudinal axis, each said sleeve element having a pair of oppositely disposed recesses in each side thereof receiving said annular segments of an adjacent mixing element, each said sleeve being in contact with an adjacent sleeve.

The invention will be explained in the following with reference to the drawings. There are shown:

5 Fig. 1 a known mixing element;

Fig. 2 a nozzle with mixing head shown in part;

10 Fig. 3 a longitudinal section through the mixing element of Fig. 1
and a sleeve element;

Fig. 4 a first mixing element in accordance with the invention;

15 Fig. 5 a second mixing element in accordance with the invention;

Fig. 6 a further modified embodiment; and

Fig. 7 a sleeve element for the mixing element of Fig. 6.

20 A static mixer which is provided for the homogenising of a high-viscosity fluid flow includes a housing into which the mixing elements are inserted together with sleeve elements in the form of tube pieces. The mixing elements are positioned with the sleeve elements. In Figures 1 and 3, a known mixing element 1 is shown which is made as a monolith and which
25 can be produced, for example, by mean of precision casting. In this method, a casting mould is formed with a wax body, application of a ceramic shell to the wax body, subsequent removal of the wax and firing of the ceramic shell. The fluid to be homogenised, a polymer melt 20, flows through a static mixer in a housing 3 – see Fig. 2 – in a main flow direction 30 which is defined by a longitudinal axis of the housing 3.

A structure effective for mixing – namely the lattice-like mixer structure 10 – and a ring 4 form the mixing element 1 in the form of a monolithic body. The mixer structure 10 is made up of webs 11 arranged in layers. The
5 webs 11 each have a rectangular or square cross-section. The layers are oriented parallel to one another in the main flow direction 30. The webs 11 of adjacent layers cross and enclose a uniform angle of 45° with respect to the main flow direction 30. This angle can have a value between 10° and 70° . The webs 1 of the mixer structure 10 cross at crossing positions 12
10 which are arranged at bar-like regions 13 transversely to the main flow direction 30.

In Fig. 2, the housing 3 is shown with the static mixer 2, namely a nozzle 31 with a mixing head such as is used in injection moulding machines. In
15 the static mixer 2, sleeves – the sleeve elements 5 – and rings 4 of the mixing elements 1 can be recognised. The static mixer 2 has an outer diameter with which it fits in a shape-matched manner into the cylindrical inner space of the housing 3.

20 Fig. 3 shows a longitudinal section through the mixing element 1 of Fig. 1 and through a part of a sleeve element 5. The outline of an adjacent mixing element 1' is shown – in part – in a chain dotted manner. The sectional area of this longitudinal section lies along the border between two adjacent layers. In this section, the bar-like regions 13 of the crossing positions 12 can be recognised as cross-sections. In the following, these re-
25 gions are called "cross bars 13" in brief.

On the use of the static mixer 2 in an injection moulding machine, the mixing element 1 is exposed to a load which results in an anisotropic
30 stretching behaviour: due to the high pressure at which the polymer melt

20 has to be transported, the volume of the housing inner space increases. The mixing element 1 yields to the volume change in the direction transverse to the cross bar 13 (arrows 24a, 24b in Fig. 1). Deformation is substantially lower perpendicular to this direction, i.e. in the direction of the cross bar 13. A pulsation of the pressure results in a periodic change in shape of the mixing element 10 which is associated with high local stresses in the ring 4.

Fig. 4 shows a first mixing element 1 in accordance with the invention in which substantially lower load peaks occur. Whereas the known mixing element has a peripheral ring 4, in the new mixing element two annular segments or ribs 41 and 42 are now present. This new geometry allows a stretching behaviour which – compared to that of the known mixing element 1 shown in Fig. 1 – is much more even so that lower maximum stresses occur. The polymer melt 20 transported in a pulsating manner therefore exerts a less high material load with an increasing and decreasing pressure.

The sleeve elements 5 are in contact at their ends via abutment positions. Cut-outs exist at these ends into which two ribs 41, 42 of the mixing elements 1 are inserted in a shape-matched manner – in a shape complementary to the cut-outs – (cf. Figures 8 and 7). The ribs 41, 41 are substantially parallel to the cross bars 13: two end surfaces 41a, 41b or 42a, 42b respectively of the ribs 41, 42 are each arranged such that centres of these end surfaces can be connected by lines which are aligned at least approximately the same as the cross bars 13. Radial cross-sectional surfaces of the ribs 41, 42 are formed with larger cross-sectional surfaces than with the cross bars 13 for reasons of strength.

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Fig. 6 shows the mixing element 1 of Fig. 5 in an embodiment in which corners are formed, on the one hand, at the crossing positions 12 of the webs 11 and, on the other hand, at the connection positions of the webs 11 to the ribs 41, 42 as continuously curved transitions: in surrounding regions of these transitions, surface elements 111 and 112 standing transversely to one another are connected by round surface sections 110. The radii of curvature of these surface sections 110 are larger than around 10% of a diagonal web diameter. Stress peaks form in operation in the notch-like corners of the embodiment shown in Fig. 5. These stress peaks are substantially reduced by the rounding of the corners.

Fig. 7 shows a sleeve element 5 for the mixing element 1 of Fig. 6. Wedge-shaped cut-outs 54 for the ribs 41, 42 are restricted to regions which do not extend up to the inner wall of the housing 3. A small ridge 53 at the outer surface of the sleeve element 5 screens the apex 45 of the wedge-shaped ribs 41, 42 from contact with the housing 3. This is advantageous on the pushing in or pulling out of the mixer 2 into or out of the housing 3 since a jamming can no longer occur and thus an installation of the mixer is made substantially simpler. Only one half of the wedge-like ribs 41, 42 in each case comes to rest in the cut-outs 54 of the sleeve element 5. The other halves are received by adjacent sleeve elements (not shown). Adjacent sleeve elements 5 are in contact at their ends via planar abutment surfaces 50.

In addition to the aforesaid measures with which the mechanical stability of the mixing element 1 is improved (namely ribs and rounded corners), the choice of an ideal material is also a further means towards the same purpose.

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INCONEL*, in particular IN 718*, is advantageously used as a casting material for the mixing elements 1. The sleeve elements 5 can be produced to exact dimensions from a heat-treatable steel.

*Trade-mark

The ribs 41, 42 of the cast mixing element 1 can be reworked by grinding at their surfaces. The purpose of such a rework is to obtain an exact shape match in the cut-outs of the sleeve elements 5.

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CLAIMS:

1. A static mixer for a high-viscosity flowing fluid with mixing elements which are made as monoliths, with sleeve elements in the form of tube pieces by means of which
5 the mixing elements are positioned, and with a housing into which the sleeve elements are inserted together with the mixing elements, with the mixing elements each including a lattice structure, webs of this lattice structure crossing at crossing positions which are arranged at bar-like region
10 transversely to a main flow direction of the fluid, and the main flow direction being given by a longitudinal axis of the housing,

characterised in that the sleeve elements are in contact at their ends via abutment surfaces; in that cut-
15 outs exist at these ends into which two annular segments of the mixing elements are inserted in a shape-matched manner to the cut-outs; in that two end surfaces of each segment are each arranged such that centers of the end surfaces can each be connected by lines which are aligned at least
20 approximately the same as the bar-like regions of the crossing positions; and in that these bar-like regions have cross-sectional surfaces which are not larger than radial cross-sectional surfaces of the ribs.

2. A mixer in accordance with claim 1, characterised
25 in that the webs each have a rectangular cross-section; in that transitions are formed at the crossing positions of the webs and at the connection positions of the webs to the ribs such that surface elements standing transversely to one another are connected by rounded surface sections in
30 surrounding regions of the transitions; and in that the radii of curvature of these surface sections are larger than 10% of a diagonal diameter of the webs.

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3. A mixer in accordance with claim 1, characterised in that radial cross-sectional surfaces of the ribs are wedge-shaped, with an apex of the wedge shape being directed to the outside.

5 4. A mixer in accordance with claim 1 characterised in that the cut-outs for the segments are restricted to regions which do not extend up to an inner wall of the housing.

5. A mixing element for a mixer in accordance with
10 claim 1.

6. A mixing element in accordance with claim 5, characterised in that the segments of the mixing element are reworked by grinding at their surfaces for the purpose of producing a precise shape match in the cut-outs of the
15 sleeve elements.

7. A one-piece body forming a mixing element for a static mixer, said body having

a first plurality of ribs disposed in spaced apart parallel layers angularly of a longitudinal axis;

20 a second plurality of ribs disposed in spaced apart parallel layers and in crossing relation to said first plurality of ribs, said ribs of said first plurality of ribs and said ribs of said second plurality of ribs forming bar-like regions transverse to said longitudinal axis; and

25 a pair of annular segments disposed on and projecting from opposite sides of said body, said segments being peripherally spaced apart to define gaps therebetween.

8. A one-piece body as set forth in claim 7 wherein

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said body is a cast body made of INCONEL IN 718*.

9. A one-piece body as set forth in claim 7 wherein each rib has a rectangular cross-section and wherein said body has rounded transitions connecting adjacent ribs.

5 10. A one-piece body as set forth in claim 7 wherein each annular segment has a wedge-shaped cross-section.

11. A static mixer comprising

a plurality of mixing elements, each element comprising a one-piece body having a first plurality of ribs
10 disposed in spaced apart parallel layers angularly of a longitudinal axis; a second plurality of ribs disposed in spaced apart parallel layers and in crossing relation to said first plurality of ribs, said ribs of said first plurality of ribs and said ribs of said second plurality of
15 ribs forming bar-like regions transverse to said longitudinal axis; and a pair of annular segments disposed on and projecting from opposite sides of said body; and

a plurality of sleeve elements disposed in alternating relation with said mixing elements along said
20 longitudinal axis, each said sleeve element having a pair of oppositely disposed recesses in each side thereof receiving said annular segments of an adjacent mixing element, each said sleeve being in contact with an adjacent sleeve.

12. A static mixer as set forth in claim 11 wherein
25 each rib has a rectangular cross-section and wherein said mixing element has rounded transitions connecting adjacent ribs.

*Trade-mark

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13. A one-piece body as set forth in claim 11 wherein each annular segment has a wedge-shaped cross-section.

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PATENT AGENTS

OTTAWA, CANADA

Fig.1
(PRIOR ART)

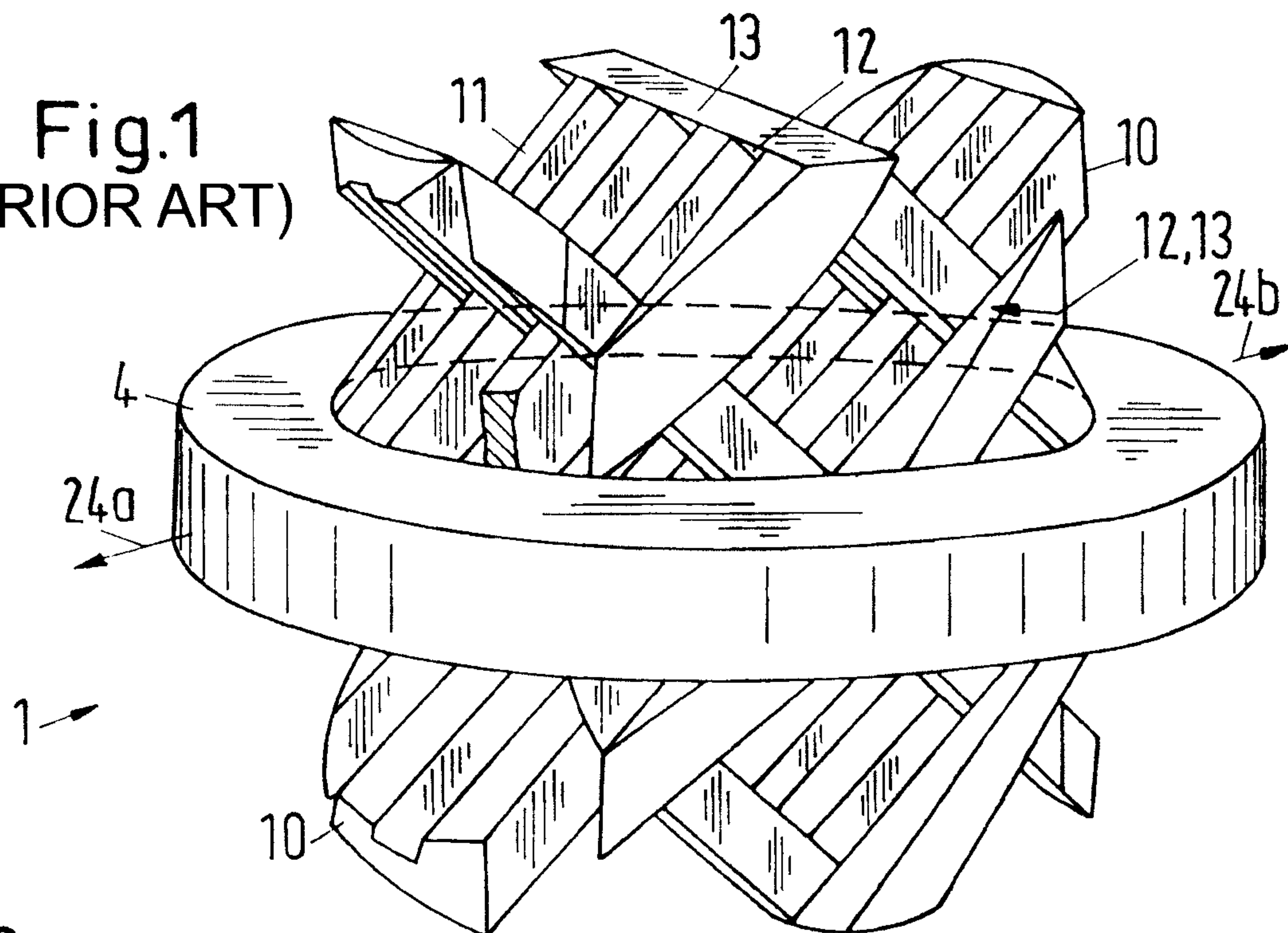


Fig.2
(PRIOR ART)

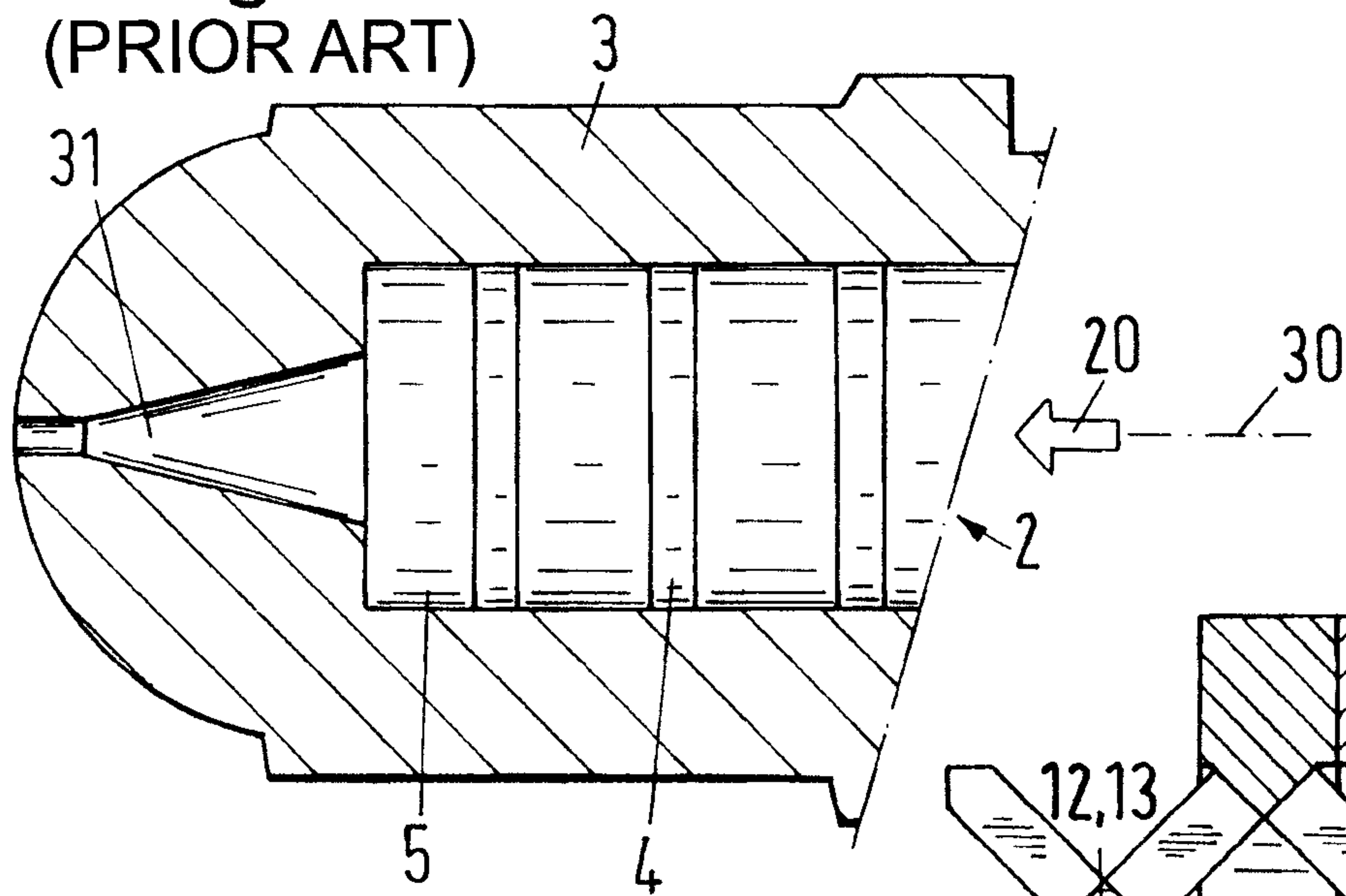


Fig.3
(PRIOR ART)

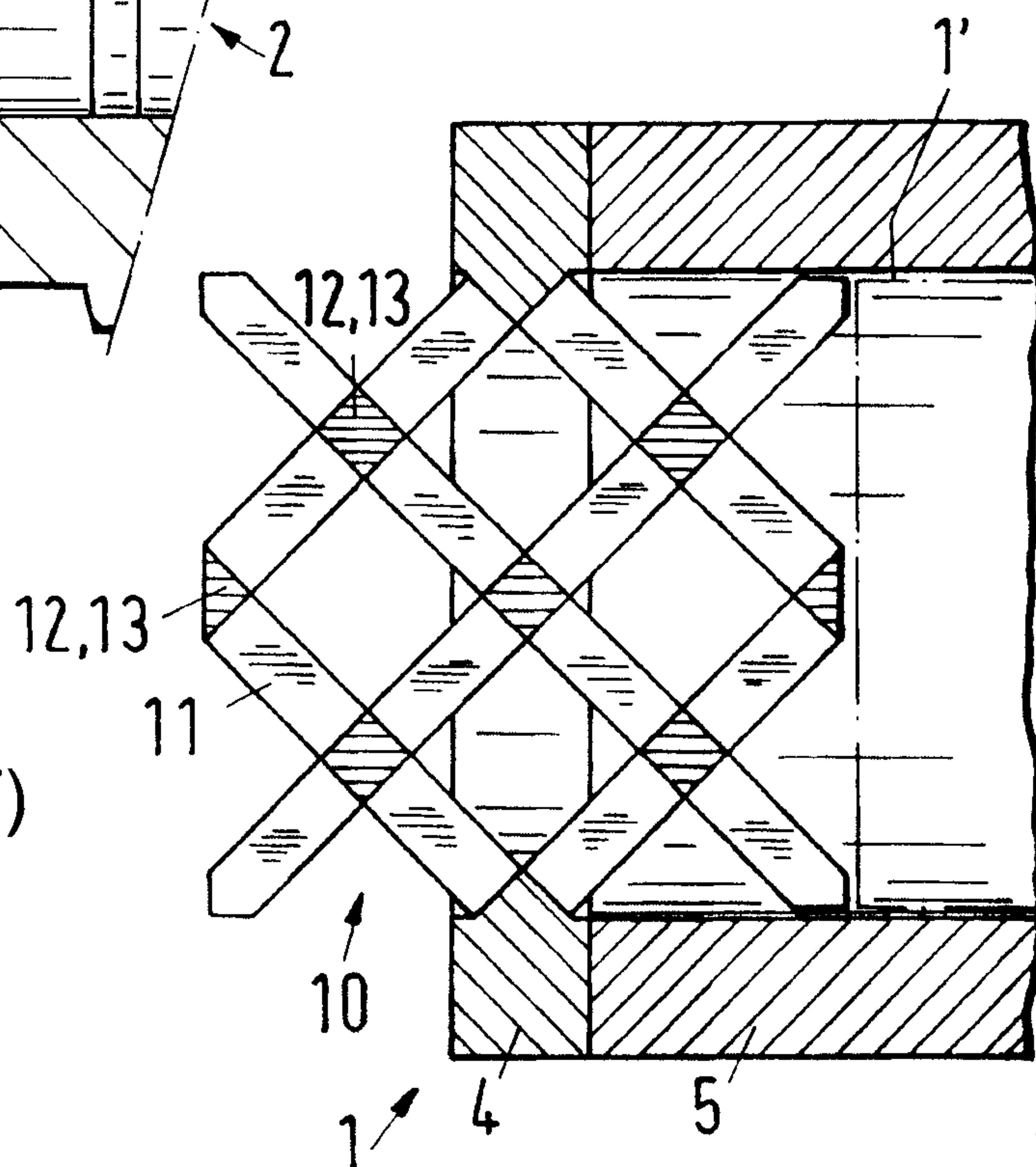


Fig.4

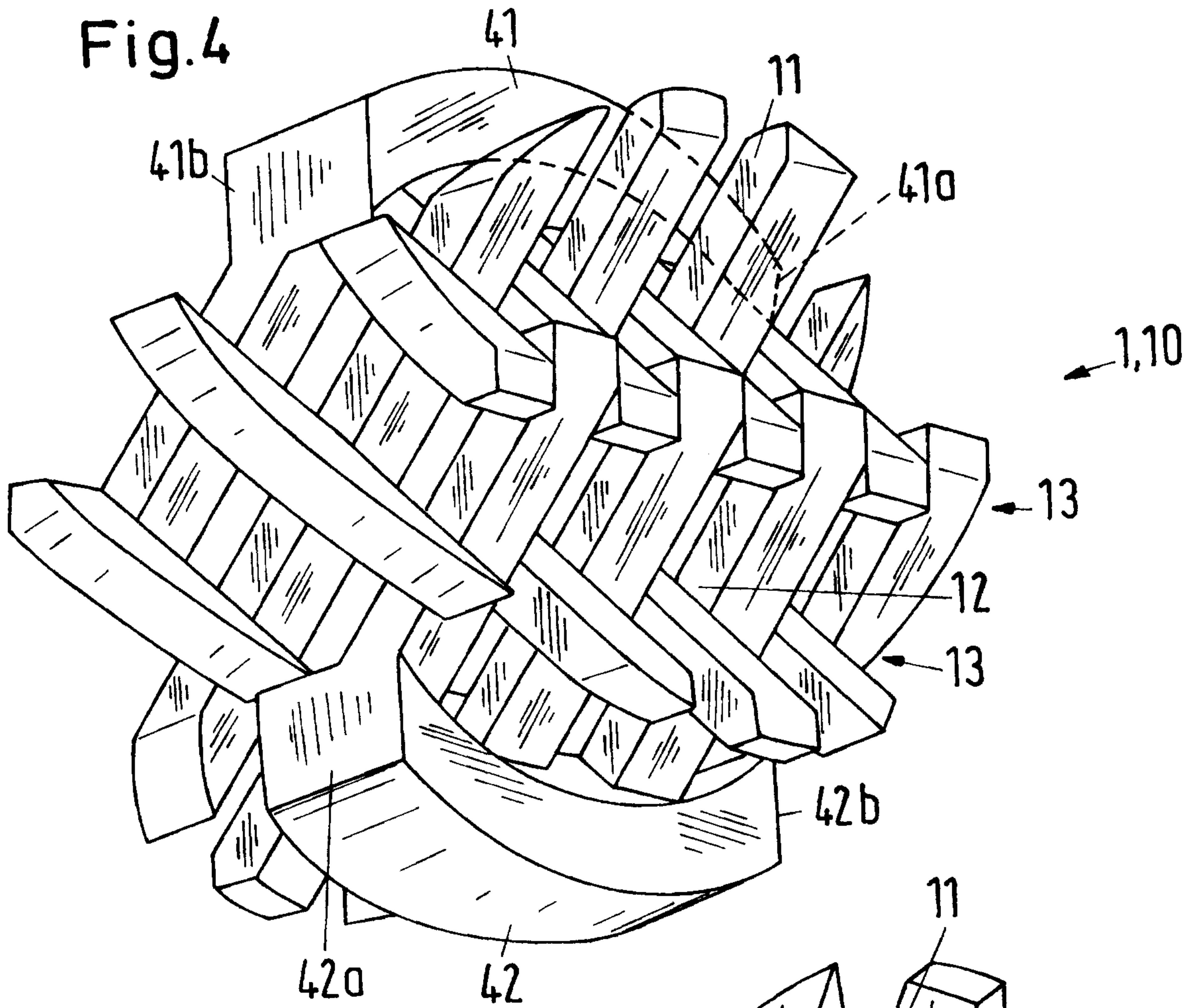
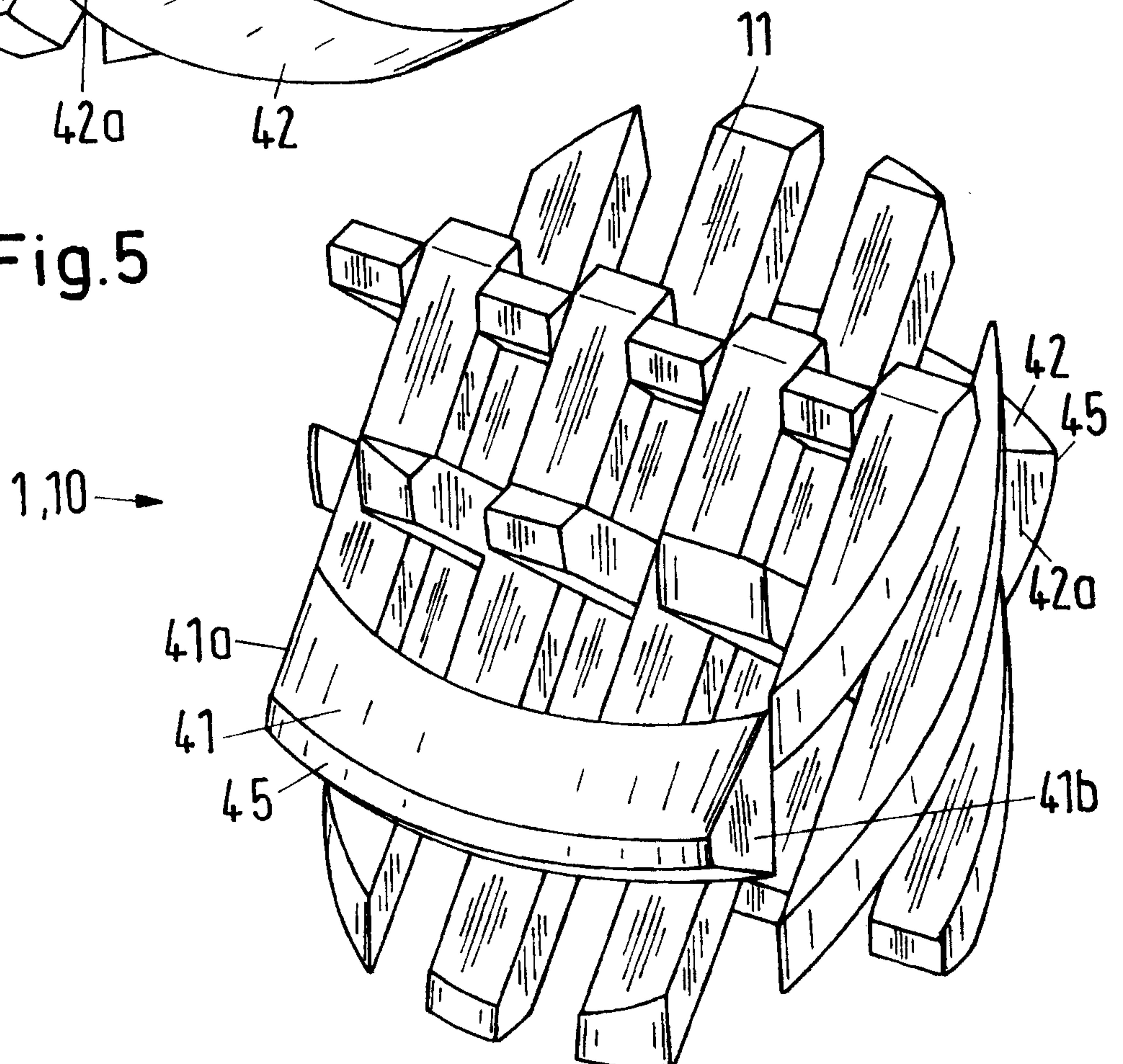


Fig.5



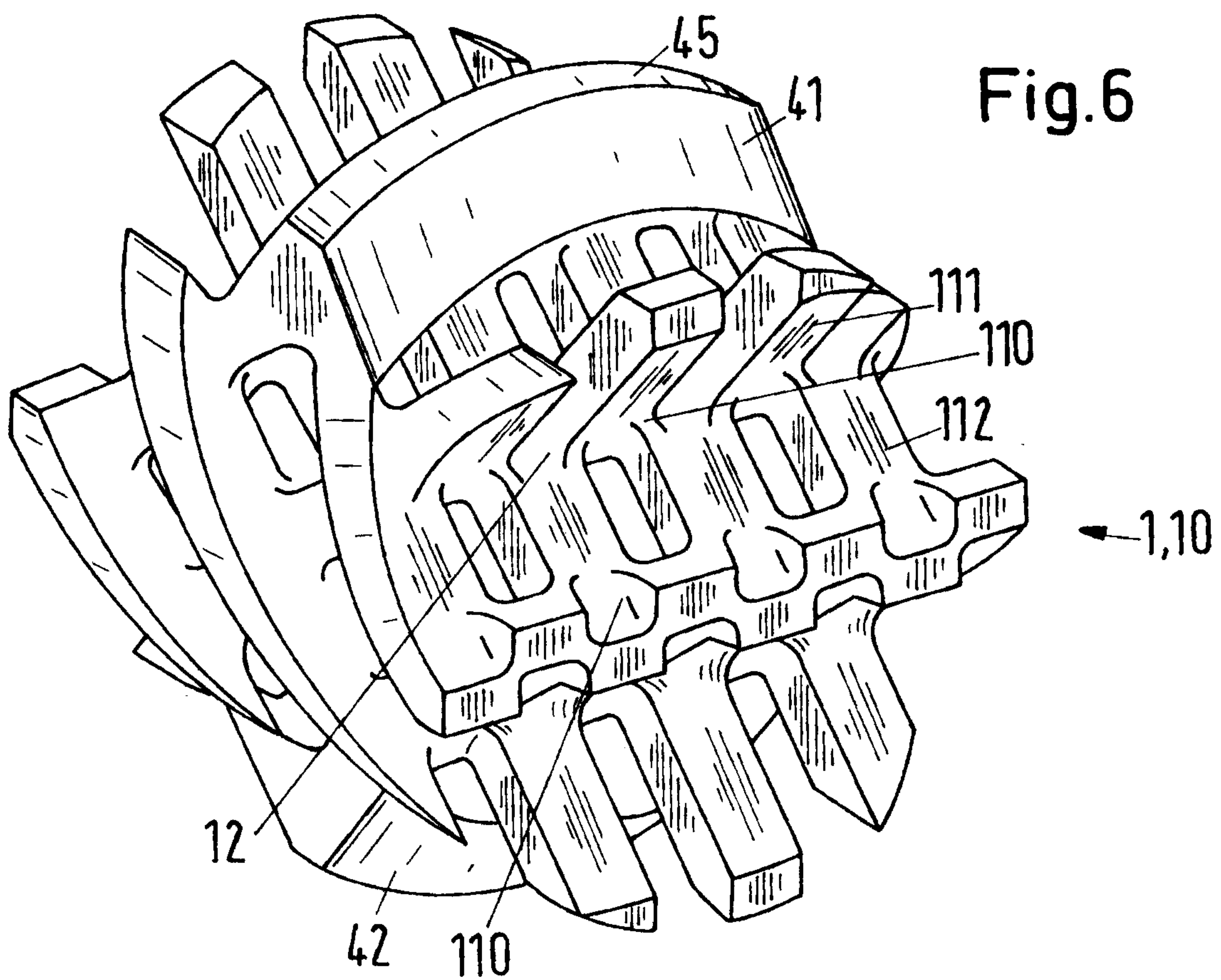


Fig.7

