



(12) **EUROPEAN PATENT APPLICATION**

(21) Application number : **93304657.5**

(51) Int. Cl.⁵ : **B21K 1/30**

(22) Date of filing : **15.06.93**

(30) Priority : **18.06.92 JP 49165/92**

(43) Date of publication of application :
02.03.94 Bulletin 94/09

(84) Designated Contracting States :
DE FR GB IT

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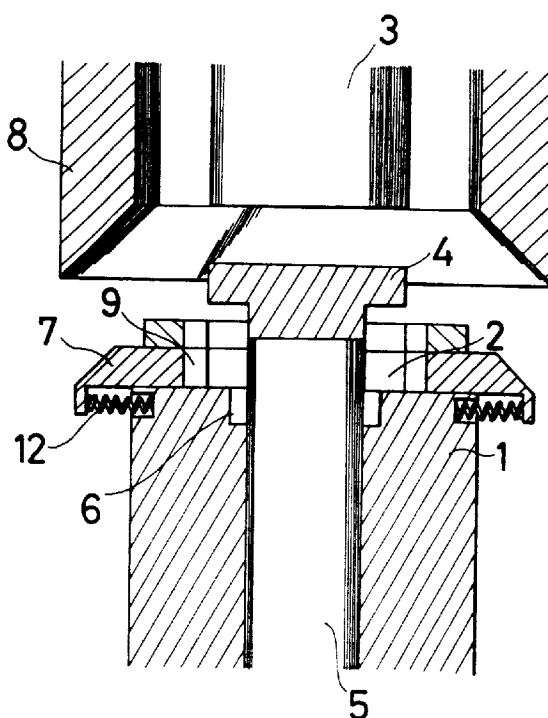
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(54) **Device for forging a helical gear.**

(57) A device for forging a helical gear by plastic working includes a die (1) having a cavity (2) formed on the center thereof for receiving a workpiece (4), a punch assembly (3) disposed above the cavity and movable in a vertical direction, a plurality of helical-tooth punches (7) mounted on a circumference of the cavity (2) and movable in a radial direction towards a center of the cavity, and an extrusion cam (8) disposed above the plurality of helical-tooth punches (7) to be movable in the vertical direction and having a bottom inner surface formed as a cam face constituting a side face of a first truncated cone having predetermined first dimensions and slope. The plurality of helical-tooth punches respectively have sliding faces which together lie in a side face of a second truncated cone for engaging with the cam face of the extrusion cam (8). The second truncated cone has dimensions and slope identical with or corresponding to those of the first truncated cone, and thereby perfectly fits in the first truncated cone. When the extrusion cam (8) is moved down, the plurality of helical-tooth punches (7) are pressed in the radial direction towards the center of the cavity (2) to form rough profiles of helical teeth around a side wall of workpiece (4) set in the cavity (2). The punch assembly (3) is then pressed down to finish the helical teeth roughly formed on the side wall of the workpiece.

F I G . 1



The present invention relates to a device for forging a helical gear by plastic working means, to a method of making a helical gear.

Development of plastic working means allows helical gears to be manufactured by forging in place of conventional machining. A typical example of forged helical gears is disclosed in Japanese Patent Laying-Open Gazette No. 64-22442, wherein helical teeth are formed on a circumference of a work while the work is pressed by a punch into a die.

In such a conventional system, since helical teeth are formed inclining to a central axis of a gear body, the die or the work is to be rotated relative to each other. The relative rotation causes insufficient precision or accuracy in formation of helical teeth as well as undesirably limits an angle of torsion or a module of the forged helical gear.

In another conventional method, a plurality of helical-tooth punches for forming helical teeth are arranged to be movable in radial direction in the same manner as straight teeth formation means as shown in Fig. 10. A plurality of straight-tooth punches 7a,7a (shown by the solid lines in Fig. 10) form straight teeth which are disposed in parallel with a central axis of a gear body. Flat sliding faces of the plurality of straight-tooth punches 7a,7a respectively correspond to and engage with flat cam faces of a plurality of extrusion cams 8a,8a (shown by the one-dot broken lines in Fig. 10) which are movable along the central axis. A plurality of helical-tooth punches 7,7 (shown by the dotted lines in Fig. 10) form helical teeth which are inclined to the central axis of the gear body. Each flat sliding face of the helical-tooth punches 7,7 does not preferably correspond to or engage with each flat cam face of the extrusion cams 8a,8a due to interference of an adjacent extrusion cam 8a. Of course, the sliding faces of the helical-tooth punches can theoretically be arranged in parallel with the central axis of the gear by distorting the helical-tooth punches by respective required angles. This method is, however, not practical because of insufficient pressure resistance of the forged helical teeth. Namely, there is no practical method of mass producing helical gears with high precision by plastic working means.

One object of the invention is to provide a novel device for forging a helical gear by plastic working means.

Another object of the invention is to provide a helical gear forging device including a die which is free from a rotation relative to a workpiece.

The above and other related objects are realized by a device for forging a helical gear. The device includes: a die having a cylindrical cavity formed on the center thereof for receiving a work; a punch assembly disposed above the cavity and movable in a vertical direction; and a plurality of helical-tooth punches for forming rough profiles of helical teeth around the work set in the cavity. The plurality of helical-tooth

punches are mounted on a circumference of the cylindrical cavity and movable in a radial direction towards a center of the cavity. The device further includes an extrusion cam disposed above the plurality of helical-tooth punches and movable in the vertical direction.

The extrusion cam has a bottom inner surface formed as a cam face constituting a side face of a first truncated cone having predetermined first dimensions and a slope. The plurality of helical-tooth punches respectively have sliding faces which are arranged to integrally form a side face of a second truncated cone and engage with the cam face of the extrusion cam. The second truncated cone has predetermined second dimensions and a slope identical with or corresponding to those of the first truncated cone, and thereby perfectly fits in the first truncated cone.

When the extrusion cam goes down in the vertical direction, the cam face of the extrusion cam fittingly engages with and presses against the sliding faces of the helical-tooth punches to move the helical-tooth punches in the radial direction towards the center of the cavity to form rough profiles of helical teeth around a side wall of a work set in the cavity. The punch assembly is then pressed down to finish the helical teeth roughly formed on the side wall of the work.

The above structure of the invention allows the truncated cone-shaped cam face of the extrusion cam to effectively press the sliding faces of the helical-tooth punches in the radial direction towards the center of the cavity. Each helical-tooth punch is partly overlapped with adjacent helical-tooth punches. Since the second truncated cone formed by integrating the sliding faces of the helical-tooth punches perfectly fits in the first truncated cone of the cam face of the extrusion cam, the cam face sufficiently presses all the partly overlapped helical-tooth punches in the radial direction to form rough profiles of helical teeth around a work.

The present invention will now be described in more detail by way of example in the following detailed description, which is to be read in conjunction with the accompanying drawings, in which:

Fig. 1 shows a device for forging a helical gear embodying the invention;

Fig. 2 shows a relationship between a cam face of an extrusion cam and sliding faces of a plurality of helical-tooth punches;

Fig. 3 shows a process for forging a helical gear with the helical gear forging device of Fig. 1;

Fig. 4 shows a process for forging a helical gear with the helical gear forging device of Fig. 1;

Fig. 5 shows a first step for forming helical teeth on a gear;

Fig. 6 shows a second step for forming helical teeth on a gear;

Fig. 7 shows a third step for forming helical teeth on a gear;

Fig. 8 shows a process for forging a helical gear with the helical gear forging device of Fig. 1;

Fig. 9 shows a process for forging a helical gear with the helical gear forging device of Fig. 1; and Fig. 10 shows a relationship between cam faces of a plurality of extrusion cams and sliding faces of a plurality of helical-tooth punches in a prior art structure.

A device for forging a helical gear embodying the invention is described in detail according to the drawings.

As shown in Fig. 1, a helical gear forming device of the embodiment includes a die 1, a punch assembly 3, and an ejector 5. The die 1 includes a disk-shaped cavity 2 formed on its center. The punch assembly 3 is located immediately above the die 1 to be movable in a vertical direction between an upper position and a lower position for pressing a work 4 down into the cavity 2. The work 4 has a larger-diametral element and a smaller-diametral element. The ejector 5, which is also movable in the vertical direction between an upper position and a lower position, goes through a central portion of the cavity 2 to press the work 4 up.

The cavity 2 includes a smaller-diametral portion having a straight teeth forging element 6 arranged on a circumference thereof for forming straight teeth on the smaller-diametral element of the work 4, and a larger-diametral portion having a plurality of helical-tooth punches 7,7 mounted on a circumference thereof for forming rough profiles of helical teeth on the larger-diametral element of the work 4. The helical-tooth punches 7,7 are supported on the larger-diametral portion of the cavity 2 to be freely movable in a radial direction between a first radial position and a second radial position. The larger-diametral portion of the cavity 2 also has a helical teeth forging element consisting of a plurality of grooves 9,9 for forming helical teeth around the larger-diametral element of the work 4, in combination with the plurality of helical-tooth punches 7,7.

A cylindrical extrusion cam 8, which is movable in the vertical direction between a first vertical position and a second vertical position, is further disposed above the plurality of helical-tooth punches 7,7. The extrusion cam 8 goes down to the second vertical position to press the helical-tooth punches 7,7 towards the center of the cavity 2 to the second radial position. Each helical-tooth punch 7 is provided with a spring 12 for returning the helical-tooth punch 7, which is pressed to the second radial position by the extrusion cam 8, to the first radial position.

Each helical-tooth punch 7, in combination with an adjacent helical-tooth groove 9 of the cavity 2, roughly forms a helical-tooth profile on the larger-diametral element of the work 4 when being pressed in

the radial direction by the extrusion cam 8. The cylindrical extrusion cam 8 concentrically arranged with the punch assembly 3 has an inner bottom surface formed as a cam face constituting a side face of a first truncated cone having predetermined first dimensions and slope. The helical-tooth punches 7,7 respectively have sliding faces which are arranged to integrally form a side face of a second truncated cone and engage with the cam face of the extrusion cam 8 as clearly seen in Fig. 2. That is, the sliding face of each helical-tooth punch 7 is a curved surface constituting part of the second truncated cone. The second truncated cone has predetermined second dimensions and a slope identical with or corresponding to those of the first truncated cone, and thereby perfectly fits in the first truncated cone. This structure allows any part of the circular cam face of the cylindrical extrusion cam 8 to sufficiently press the helical-tooth punches 7,7 towards the center of the cavity 2.

A process for manufacturing a helical gear with the helical gear forging device thus constructed is described according to the drawings.

The work 4 is placed on an upper surface of the ejector 5 lifted up to its upper position, and then set into the cavity 2 by moving down the ejector 5 to its lower position (see Fig. 3). In a subsequent step, the extrusion cam 8 is lowered to the second vertical position to press the plurality of helical-tooth punches 7,7 towards the center of the cavity 2 to the second radial position as clearly seen in Fig. 4. While the plurality of helical-tooth punches 7,7 are pressed in the radial direction by the extrusion cam 8, each helical-tooth punch 7, in combination with an adjacent helical-tooth groove 9, roughly forms a helical-tooth profile on the larger-diametral element of the work 4 set in the cavity 2 (see Figs. 5 and 6).

The punch assembly 3 is then moved down to its lower position to press the work 4 down as shown in Fig. 8. The work 4 is radially expanded by the pressing force of the punch assembly 3 to fill the straight teeth forging element 6 and the plurality of helical-tooth grooves 9,9. This results in forming straight teeth 10 around the smaller-diametral portion of the work 4 and finishing helical teeth 11 around the larger-diametral portion of the work 4 (see Fig. 7). After formation of the straight teeth 10 and the helical teeth 11 is completed, the plurality of helical-tooth punches 7,7 are returned to the first radial position by means of the plurality of springs 12,12 while the punch assembly 3 is lifted up to its upper position. At a last step, the ejector 5 is lifted up to its upper position to press the work 4 having the straight teeth 10 and the helical teeth 11 out of the cavity 2 as shown in Fig. 9. A through hole for a shaft may be formed in the work 4 after completion of the above forging process, or alternatively formed simultaneously with formation of gear teeth on a ring-shaped work using a mandrel.

As described above in detail, the helical gear

forging device of the invention allows formation of helical teeth with high precision without rotating a work or a die relative to each other. The integrally formed extrusion cam of the device has sufficient strength and preferable durability and is applicable to any teeth number, module, and tooth profile.

Since there may be many modifications, alterations, and changes without departing from the scope or spirit of essential characteristics of the invention, it is clearly understood that the above embodiment is only illustrative and not restrictive in any sense. For example, the plurality of helical-tooth punches and the vertically movable punch assembly may be operated simultaneously to form helical teeth on a side wall of a work. Although the smaller-diametral portion of the cavity has the straight teeth forging element in the above embodiment, it may be omitted to form a flat boss on the smaller-diametral element of the work. In another example, the die may have a one-step cavity instead of the two-step cavity of the embodiment.

Claims

1. A device for forging a helical gear, said device comprising:
 - a die (1) having a cylindrical cavity (2) formed on the center thereof for receiving a workpiece (4),
 - a plurality of helical-tooth punches (7) for roughly forming helical teeth (10) around said workpiece set in said cavity (2), said plurality of helical-tooth punches being mounted on a circumference of said cylindrical cavity and movable in a radial direction towards a center of said cavity (2),
 - a punch assembly (3) disposed above said cavity (2) and movable in a vertical direction for finishing helical teeth roughly formed by said plurality of helical-tooth punches (7), and
 - an extrusion cam (8) disposed above said plurality of helical-tooth punches (7) and movable in the vertical direction for pressing said plurality of helical-tooth punches in the radial direction towards the center of said cavity (2),
 - said extrusion cam (8) having a bottom inner surface formed as a cam face constituting a side face of a first truncated cone, and
 - said plurality of helical-tooth punches (7) respectively having sliding faces which are arranged to lie in a side face of a second truncated cone and engage with said cam face of said extrusion cam (8).
2. A device in accordance with claim 1, wherein said first truncated cone has predetermined first dimensions and slope whereas said second truncated

cated cone has predetermined second dimensions and slope identical with or corresponding to those of said first truncated cone, so that said second truncated cone perfectly fits in said first truncated cone.

3. A device in accordance with claim 2, wherein said cavity (2) of said die has a larger-diametral portion and a smaller-diametral portion, and said plurality of helical-tooth punches (7) are mounted on a circumference of said larger-diametral portion.
4. A device in accordance with claim 3, wherein said smaller-diametral portion of said cavity further comprises a straight tooth forging element (6) arranged on a circumference thereof.
5. A device for forging a helical gear, said device comprising:
 - a die (1) having a cylindrical cavity (2) formed on the center thereof for receiving a workpiece (4),
 - ejection means (5) disposed along a vertical axis of said die (1) to be movable in a vertical direction between an up-position and a down-position and pass through a central portion of said cylindrical cavity (2), said ejection means (5) supporting said workpiece and being movable to said up-position to press said workpiece out of said cavity (2),
 - a plurality of helical-tooth punches (7) for roughly forming helical teeth (10) around said workpiece (4) set in said cavity (2), said plurality of helical-tooth punches (7) being mounted on a circumference of said cylindrical cavity and movable in a radial direction between a first radial position and a second radial position,
 - a plurality of helical-tooth grooves (9) formed around said cavity (2) for forming helical teeth around said workpiece, in combination with said plurality of helical-tooth punches (7),
 - a punch assembly (3) disposed above said cavity (2) and movable in a vertical direction between an upper position and a lower position, said punch assembly going down to said lower position to finish helical teeth (10) roughly formed by said plurality of helical-tooth punches (7), and
 - an extrusion cam (8) disposed above said plurality of helical-tooth punches (7) and movable in the vertical direction between a first vertical position and a second vertical position, said extrusion cam being downwardly movable to said second vertical position to press said plurality of helical-tooth punches (7) in the radial direction to said second radial position,
 - said extrusion cam (8) having a bottom inner surface formed as a cam face constituting a

side face of a first truncated cone, and
said plurality of helical-tooth punches (7)
respectively having sliding faces which together
lie in a side face of a second truncated cone and
engage with said cam face of said extrusion cam
(8). 5

6. A device in accordance with claim 5, wherein said
first truncated cone has predetermined first di-
mensions and slope whereas said second trun-
cated cone has predetermined second dimen-
sions and slope identical with or corresponding to
those of said first truncated cone, so that said
second truncated cone perfectly fits in said first
truncated cone. 10 15

7. A device in accordance with claim 6, wherein
each of said plurality of helical-tooth punches (7)
comprises a spring (12) for returning each said
helical-tooth punch (7), which is pressed to said
second radial position by said extrusion cam (8),
to said first radial position. 20

8. A device in accordance with claim 6, wherein said
cavity (2) of said die (1) has a larger-diametral
portion and a smaller-diametral portion, and said
plurality of helical-tooth punches (7) are mounted
on a circumference of said larger-diametral por-
tion. 25 30

9. A device in accordance with claim 8, wherein said
smaller-diametral portion of said cavity further
comprises a straight tooth forging element (6) ar-
ranged on a circumference thereof. 35

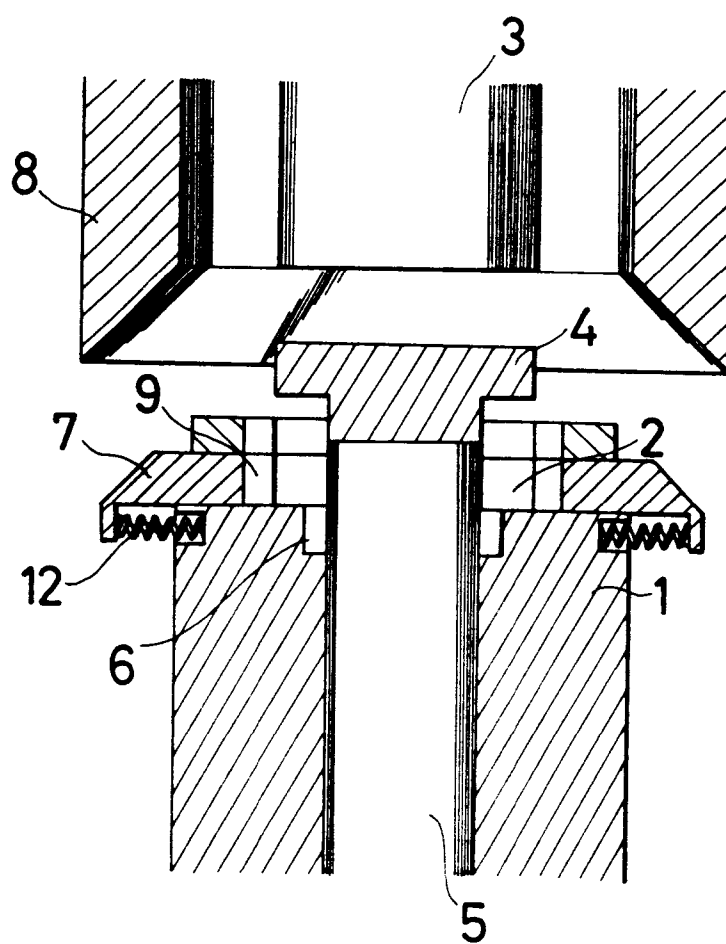
10. Use of a device according to any of claims 1 to 9,
for the manufacture of a helical gear element by
a plastic working, extrusion method, and an ex-
trusion method of making a helical gear element. 40

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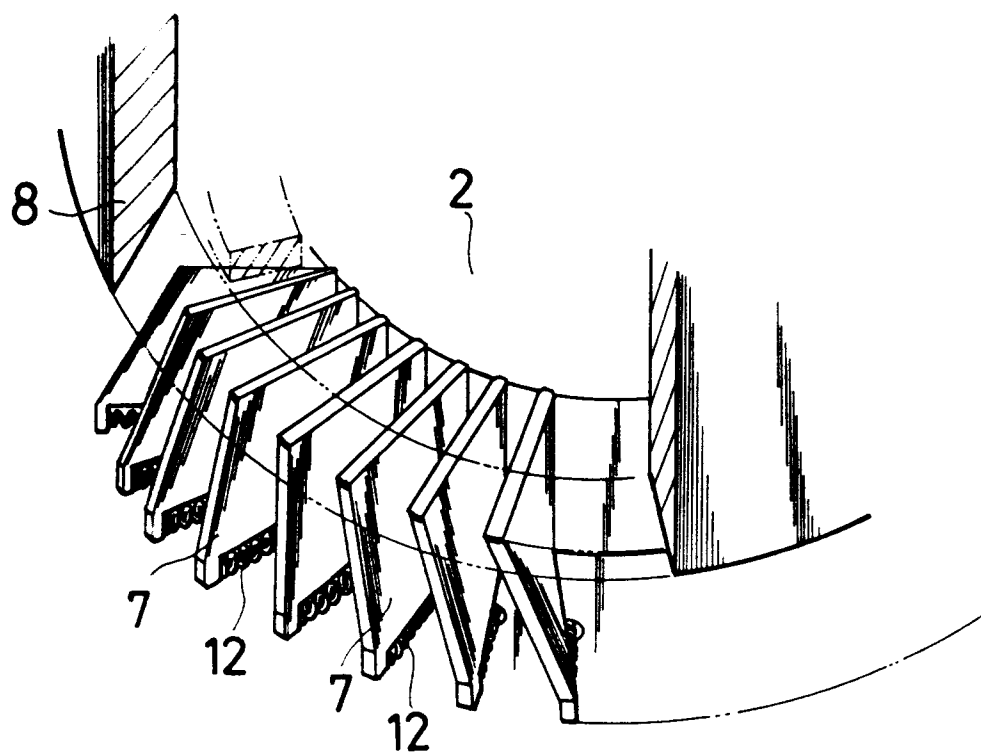
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F I G. 1



F I G . 2



F I G . 3

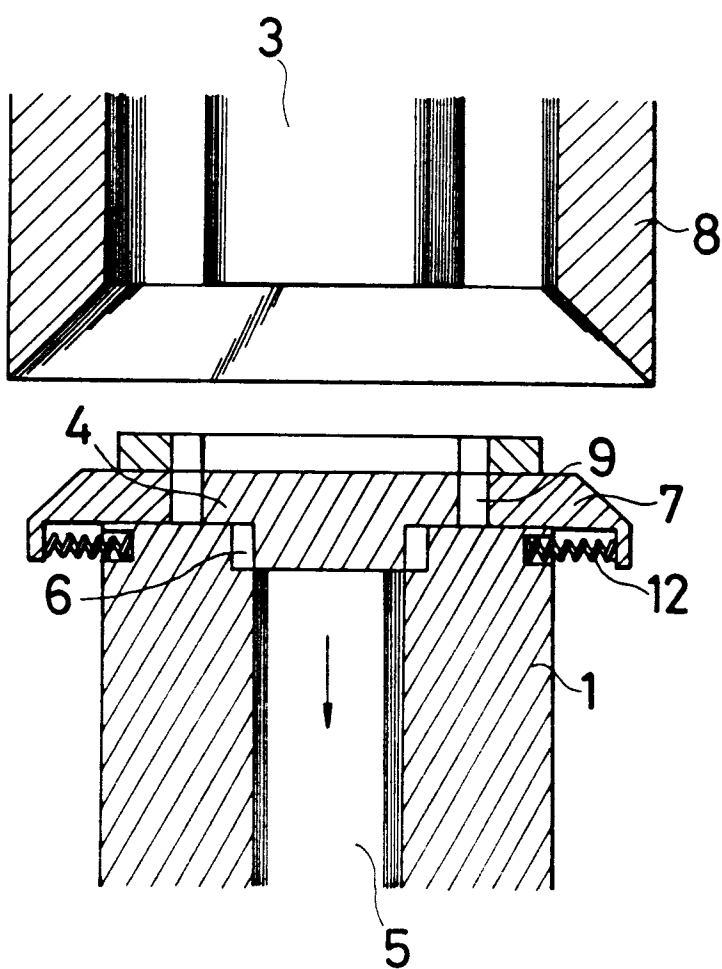
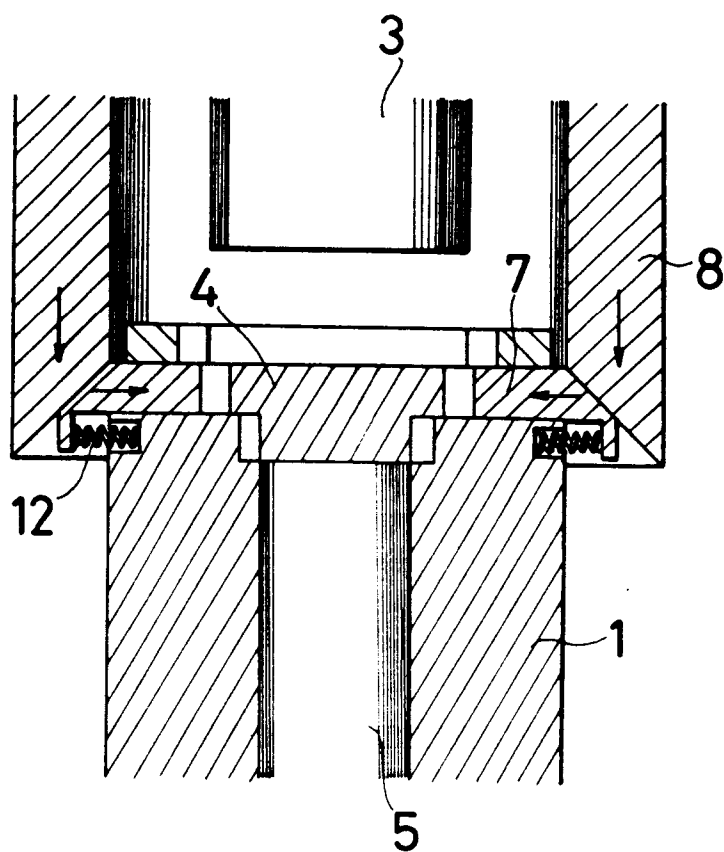
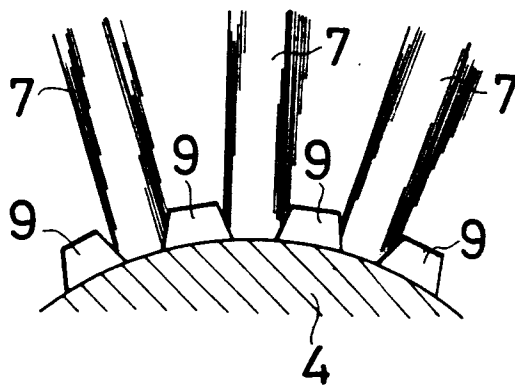


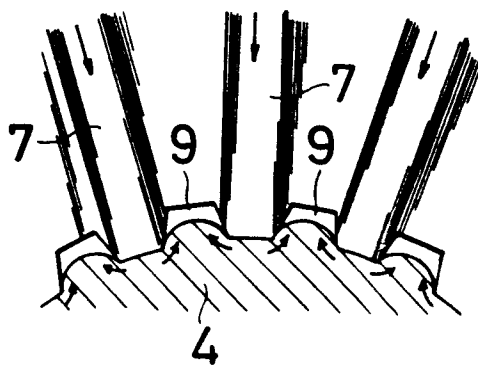
FIG. 4



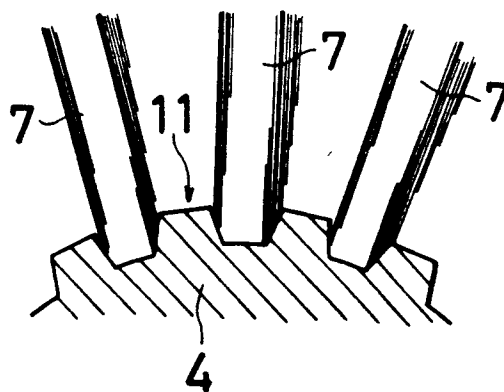
F I G . 5



F I G . 6



F I G . 7



F I G . 8

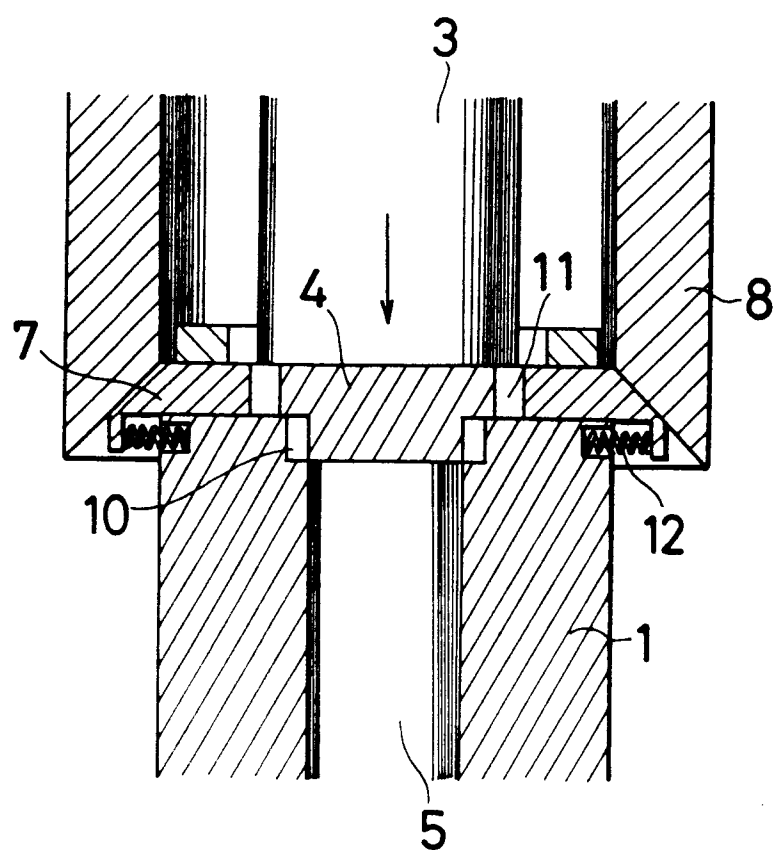
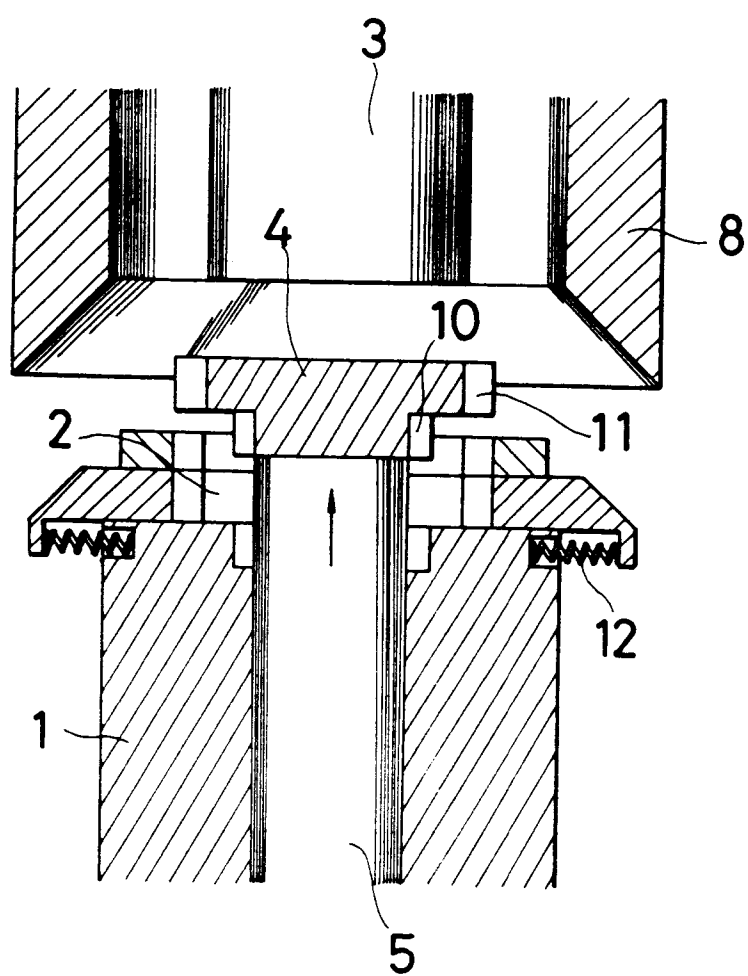


FIG. 9



F I G.10 PRIOR ART

