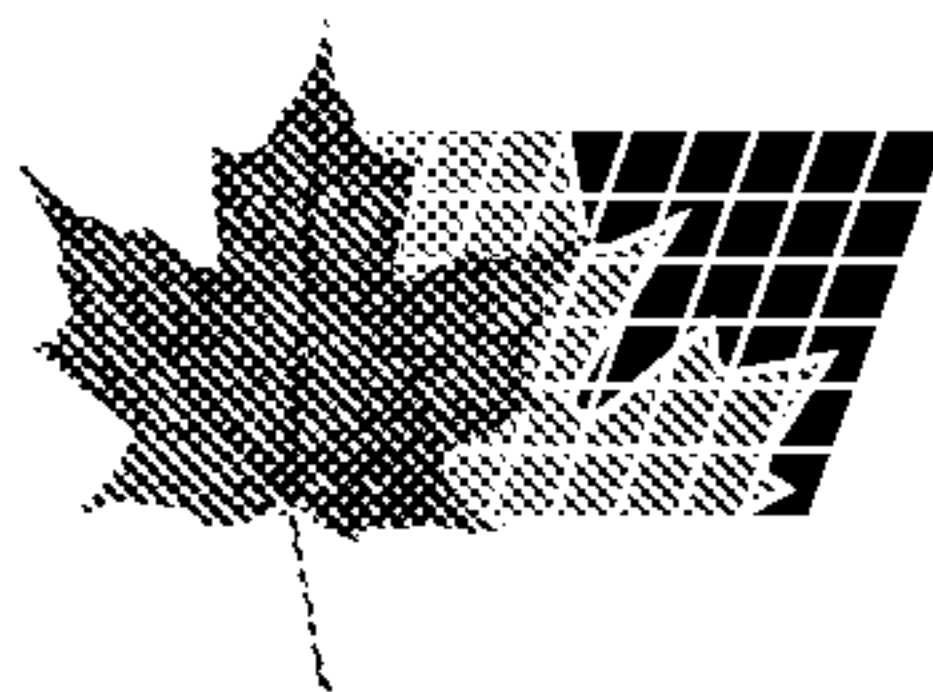




(11) (21) (C) **2,183,996**
(86) 1995/01/31
(87) 1995/10/12
(45) 2000/11/21

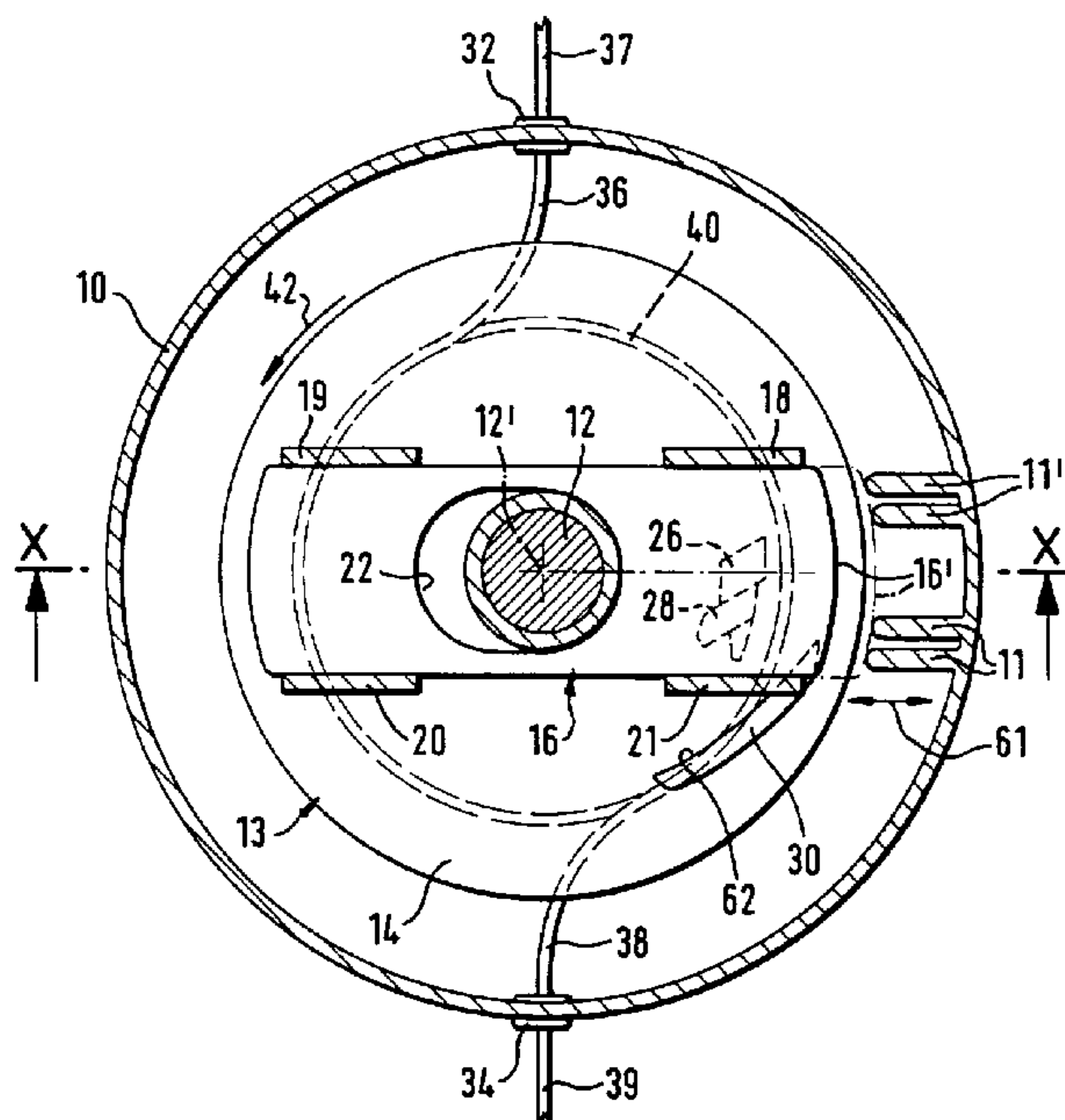
(72) Zilly, Guenter, DE
(72) Hepperle, Wilhelm, DE
(72) Eger, Beate, DE
(72) Ruess, Albert, DE
(72) Schnelle, Klaus-Peter, DE
(72) Houben, Jan P., NL
(72) Jung, Bob, NL
(73) ROBERT BOSCH GmbH, DE

(51) Int.Cl.⁶ A01D 34/73

(30) 1994/03/30 (P 44 11 002.2) DE

(54) **APPAREIL DESTINE A COUPER DES VEGETAUX**

(54) **AN APPARATUS FOR CUTTING PLANTS**



(57) In an apparatus for cutting plants with a cutter filament (36, 38) that spins about an axis of rotation and is wound onto a spool (13), in which a slide (16) locks up the spool (13) by means of a cam (26) so that it cannot rotate but can be released, in which by unlocking the spool (13) the length of the unattached end (37, 39) of the cutter filament (36, 38) can be adjusted, in which the slide (16) is moved into its unlocking position by the centrifugal force resulting from the increased rotational speed of the rotary drive when the cutter filament (36, 38) is shortened, the cutter filament adjustment is simplified and its functionality is improved, in that the slide (16) is held in its locking position relative to the spool (13) only by the equilibrium of forces of the mass supporting forces between it cam (26) and a stop (28) on the spool and can be moved into its unlocking position by centrifugal force, so that the spool (13) can rotate relative to the cup (10), the cam (26) being reset into its locking position by the mass supporting force on a guide surface (62) on the side of the spool, the stop surface (250) of the stop (280) having an increasingly flattened outline as the radial distance from the mid-point (12, 112) of the spool increases.



Abstract

In an apparatus for cutting plants with a cutter filament (36, 38) that spins about an axis of rotation and is wound onto a spool (13), in which a slide (16) locks up the spool (13) by means of a cam (26) so that it cannot rotate but can be released, in which by unlocking the spool (13) the length of the unattached end (37, 39) of the cutter filament (36, 38) can be adjusted, in which the slide (16) is moved into its unlocking position by the centrifugal force resulting from the increased rotational speed of the rotary drive when the cutter filament (36, 38) is shortened, the cutter filament adjustment is simplified and its functionality is improved, in that the slide (16) is held in its locking position relative to the spool (13) only by the equilibrium of forces of the mass supporting forces between it cam (26) and a stop (28) on the spool and can be moved into its unlocking position by centrifugal force, so that the spool (13) can rotate relative to the cup (10), the cam (26) being reset into its locking position by the mass supporting force on a guide surface (62) on the side of the spool, the stop surface (250) of the stop (280) having an increasingly flattened outline as the radial distance from the mid-point (12, 112) of the spool increases.

An Apparatus for Cutting Plants

The present invention relates to an apparatus for cutting plants, of the type according to Claim 1.

5

An apparatus for cutting plants is described in EP 351 989; in this, the length of the cutter filament is controlled by a slide that incorporates cams and is moved by centrifugal force; this takes place when the apparatus or the motor, respectively, is restarted after having been stopped. When the apparatus or the motor is stopped, the cams or the slide is reset into its unlocking, original position by the action of springs. For this reason, when the apparatus is restarted, the spool can rotate within the cup that moves it, and relative to this cup, to the point that a stop on the side of the spool comes to rest against the cams and thus stops this rotation.

The known apparatus works in a reliable fashion, but it is made up of a relatively large number of parts; in addition, as the cutter filament is worn down or lost, the motor has to be switched off and restarted in order to adjust the length of the cutter filament. It is not possible to make up for a loss of fibre length automatically while the apparatus is being operated.

Another apparatus for cutting plants is described in US 4 347 666. In this, a slide with a cam, which can be moved transversely to the axis of rotation, releases or locks stops

for the spool. The length of the cutter filament is adjusted thereby while plants are being cut. The slide, which is controlled by centrifugal force, is held in its locked, original position by a spring, filament adjustment only functioning when the cutter filament is operating, which is to say, when it is cutting plants. Filament adjustment is non-functional when the filament is rotating without coming into contact with material that is to be cut. In the event that the free end of the filament becomes shorter than a specific, critical length as it wears away, i.e, if the cutter filament can no longer reach material that is to be cut, the filament adjustment will not function. The apparatus has to be switched off in order that the length of the filament can be adjusted manually.

US 4 104 796 also describes an apparatus for cutting plants, in which two spring-assisted cams, which are adjusted by centrifugal force, lock up or release a stop on the side of the spool. This brings about automatic adjustment of the cutter filament as a function of the speed of rotation. Because of the springs, the construction of this apparatus is relatively costly. The springs have to be calibrated very precisely and the actual weight must conform exactly with the calculated weight of each cam carrier. Even small variations in the strength of the springs and small differences in weight can so change the adjustment characteristics of the filament adjustment that it will not function within the required speed range. In addition, spring-and-weight systems of this kind

are very prone to failure. Small quantities of dust, moisture, or heat can lead to failure or to premature operation of the filament adjustment system. For this reason, the springs have to be cleaned and readjusted very frequently.

5

Above and beyond this, the resilience properties of the springs change as a function of speed of rotation because of the centrifugal forces that act on the spring. In addition, the springs can have an adverse effect on the centrifugal forces because of their own weight.

10

Advantages of the present invention

The apparatus according to the present invention, which is to cut plants, and which incorporates the distinguishing features set out in Claim 1, has the advantage that makes it possible to dispense with force accumulators or springs as means of control. In place of these, the means of control are realized by the shape of the supporting surfaces between the filament spool and the slide or bolt-like spool locking system. The shape of these depends on filament's mass and centrifugal force.

15

20

25

Because of its simple construction, manufacturing and servicing costs associated with the apparatus are low. The automatic filament adjustment system operates reliably in dusty, damp, and hot environments, and even when the rotational speed of the apparatus varies abruptly; it is far

less prone to failure than filament adjustment systems that use springs.

5 The control action of the filament adjustment system according to the present invention is particularly stable in the face of variations in AC power and vibration of the motor or the apparatus itself. This is because specially shaped inclined support means are arranged between a slide that is fixed to the cup so that it cannot rotate, but can slide, and the
10 cutter filament spool, the slide supporting an eccentric mass.

Equilibrium is established between the force of the eccentric mass of the slide and the centrifugal force of the cutter filament, which generate a torsional moment. If the cutter
15 filament becomes too short, the centrifugal force generated by the cutter filament becomes less, so that the force of the eccentric mass becomes dominant and moves the slide into the unlocking position. In this position, the reduced centrifugal force of the cutter filament is sufficient to rotate the spool
20 relative to the slide, and draw the cutter filament outward, which lengthens the cutter filament, so that its centrifugal forces increases constantly. In order to limit the length of the cutter filament, the rotation of the spool is stopped after a specific amount of rotational travel. To this end,
25 the slide is moved into its locking position by means of the increased centrifugal force of the cutter filament.

22386-2639

Equilibrium of force between the slide and the spool in the locking position is maintained by the inclined support, which is realized in particularly advantageous manner by the concave shape of the stop surface of the spool relative to the cam of the slide. In addition, equilibrium of force between a guide body and the cam of the slide is generated by the shape of the guide surface of the guide body in such a way that sliding friction remains constant without becoming static friction.

Additional advantages of the present invention are described in the secondary claims.

Summary of Invention

In accordance with the present invention, there is provided an apparatus for cutting plants, with at least one cutter filament that spins about an axis of rotation and extends from this, and that is wound onto a spool that is arranged within a rotating, driven cup so as to move with said cup that has at least one opening on its periphery, an unattached end of the cutter filament emerging from this to the outside, a slide that is rotationally fixed and can be displaced radially to the axis of rotation fixes the spool so that it cannot rotate relative to the cup or releases it, so that when the length of the unattached end of the cutter filament is shortened, for example, as it wears away, because of centrifugal force the slide moves from its locking position into its unlocking position, characterized in that the slide is held in its locking position relative to the spool only by the equilibrium of forces of the mass supporting forces between its cam and a stop on the side of the spool, and is moved from this locking position into its unlocking position by centrifugal force and during the released relative rotation of the spool

22386-2639

relative to the cup brought about by this, because of the mass support force between its cam and a guide surface of a guide body it is reset into its locking position.

In accordance with the present invention, there is
5 further provided a spool for an apparatus for cutting plants, with at least one cutter filament that spins about an axis of rotation and extends from this, and that is wound onto the spool that is arranged within a rotating, driven cup so as to move with said cup that has at least one opening on its
10 periphery, an unattached end of the cutter filament emerging from this to the outside, a slide that is rotationally fixed and can be displaced radially to the axis of rotation fixes the spool so that it cannot rotate relative to the cup or releases it, so that when the length of the unattached end of the cutter
15 filament is shortened, for example, as it wears away, because of centrifugal force the slide moves from its locking position into its unlocking position, characterized in that spool has a stop on which the slide rests, its stop surface having an increasingly flattened outline as the radial distance from the
20 mid-point of the coil increases.

Drawings

One embodiment of the present invention is described in greater detail below on the basis of the drawings appended hereto. These drawings show the following:

25 Figure 1: A cross-sectional plan view of the cup with the spool and the slide;

Figure 2: A side view of Figure 1;

Figure 3: A side view of the spool;

Figure 4: A plan view of the spool;

22386-2639

Figure 5: A view of the cam side of the slide;

Figure 6: An enlarged section of the top of the spool as in Figure 4, with the cam in the locking position relative to the stop;

5 Figure 7: A section of the top of the spool as in Figure 6, with the cam moved out of the locking position;

Figure 8: A section as in Figure 6, immediately after the cam has been unlocked;

Figure 9: A section as in Figure 6, with the cam shown shortly after reaching the renewed locking position;

Figure 10: An embodiment of a mathematically/geometrically configured cam, stop, and guide body during a control step to adjust the filament, this step being divided into ten stages;

Figure 11: A slide with a mathematically/geometrically configured cam;

Figure 12: The cam as in Figure 11, as a detail;

Figure 13: A perspective view of a spool as in Figure 10;

Figure 14: A diagrammatic view of the spool with the control forces;

Figure 15: A mathematical curve in the X/Y coordinate system, which corresponds to the shape of the guide surface as in Figures 10 and 13.

20 Description of the embodiment

The plan view at Figure 1, of a cup 10 at the lower end of an apparatus for cutting plants (not shown herein), which is connected rigidly to a drive shaft 12, shows the spool 13 that is arranged centrally therein, with a view of its upper face side 14 that is proximate to the machine and a slide 16 that is supported within the cup. The slide 16 is guided on opposite ends between four slide guides 18, 19, 20, 21, and its radial travel is limited by two pairs of resilient stops

11, 11' that prevent the slide from becoming jammed in its stop position. The stop position of the slide 16 is indicated by a dashed line that is drawn by a parallel to and in front of the face end 16' as indicated by the solid line. The slide
5 16 has a central slot 22 with a smaller diameter 23 and a larger dimension 24. On its right-hand end (as shown in the drawing), on its side that is proximate to the spool, it has a cam 26 that is of rhombic cross section. One side of the cam 26 rests against a stop 28 which, like an elongated guide body
10 30, is arranged on the face side 14 so as to project axially in the direction of an observer.

On the periphery of the cup 10, the opposed, unattached ends
37, 39 of a first and a second cutter filament 36, 38 each
15 emerge axially outward through an bushing 32, 35. As a result of the centrifugal force that is generated by the rotating spool 13 when the apparatus is operating, the edges of the unattached ends 37, 39, act as cutters. When this happens, they are subjected to constant wear that is brought about by
20 pieces of the filament breaking off. This means that the unattached ends 37, 39 are made shorter.

The spool 13 is supported in such a manner that it can rotate about the centre of the spool 12'. When the cam 26 is resting
25 against the stop 28 on the spool 13 this establishes a locking condition in which the spool 13 is prevented from rotating relative to the cup 10. The unlocking position is reached by radial displacement of the cam 26 relative to the stop 28,

when the stop 28 is released. The spool 13 can then rotate relative to the cup 10. The locking and unlocking positions of the cam 26 are established by automatic movement of the slide 16 along the slide guides 18, 19, 20, 21, as is indicated by the double-headed arrow 61.

The spool 13 supports coils of filament 40; these are represented by two circles, indicated by dashed lines, that are concentric with the mid-point of the drive shaft. The unattached ends 37, 39 of the cutter filaments 36, 38 merge into the coils 40 through an arc.

An arrow 42 indicates the direction of rotation of the spool 13 relative to the cup 10 so as to adjust the filament length.

The cross-sectional side view of Figure 1 on the line X-X, which is shown in Figure 2, illustrates the arrangement of the drive shaft 12 relative to the cup 10; the position of the spool 13, which is configured as a double spool, with the cutter filaments 36, 38; and the position of the slide 16 with the cam 26. The arrangement of the slide between the slide guides 18, 19, 20, 21 that are formed by projections from the face side of the cup 10, and the guide body 30, a distance piece 44, and a cover 46 that closes off the cup 10 can be seen in this drawing.

The distance piece 44 provides for an axial space between the spool 13 and the slide 16 that ensures that their face sides,

which are axially opposite, do not touch each other; this is done so as to ensure that the slide 16 can move easily and its function remains unimpaired.

5 The spool 13, shown in Figure 3 as a single component of another embodiment of the present invention, is represented in the form of a part-cross section through a side view, and can be seen to be a double spool that is used to hold two cutter filaments. A collar 15, the stop 28, and the guide body 30
10 can be seen on its upper face side.

In Figure 4, the plan view of the face side 14 of the spool 13 shows that four stops 29, 31, 33, 35 that are identical to the first stop 28 are arranged at equal intervals around a first
15 circle 27; and that four guide bodies 41, 43, 45, 47 that are identical to the first guide body 30 are arranged around a second circle 48, concentrically with the mid-point of the spool, at equal intervals from each other and from the stops 28, 29, 31, 33, 35. On their left-hand sides (as viewed) each
20 of the stops 28, 29, 31, 33, 35 have a stop surface 50, 51, 52, 53, 54, and there are reinforcing ribs 56, 57, 58, 59, 60 on their opposite sides. The guide bodies 30, 41, 43, 45, 47 each have guide surfaces 62, 63, 64, 65, 66 on their sides that face radially inward. A radius line passing through the
25 middle of the stop 28 and through the mid-point of the spool will intersect or touch at least the tip 68 of the guide body 30. The sides of the guide bodies 30, 41, 43, 45, 47 that

are, in each case, opposite their tips 68 - 72, determine their ends 74, 75, 76, 77, 78.

5 The stop surfaces 50 to 54 of the stops 28, 29, 31, 33, 35 extend inclined at an angle of 30° to the radius line 49, rotated about the mid-point of the spool in the direction indicated by the arrow 42.

10 The guide surfaces 62 to 66 run from the tips 68 to 72 as far as the ends 74 to 79, and curve from the larger second circle 48 to the smaller circle 27.

15 The shape of the cam 26 resting against the stop surface 50 of the first stop 28 is indicated by the broken line. This illustrates its position relative to the stop 50 in the locking position, and its inclination by 30° relative to a radius line 49.

20 Figure 5 shows the side of the slide 16 that is proximate to the upper face side 14 of the spool 13; its slot 22 and the cam 26 can be seen clearly. The contact surface 25 of the cam 26, which extends at an angle β of approximately 30° , reference number 55, relative to the mid-line axis of the slide 16, can also be seen.

25 Figure 6 shows a segmental section of the upper face side 14 of the spool 13, with the cam 26 in its locking position relative to the stop 28. The contact surface 25 rests on the

stop surface 50. Both surfaces subtend an angle β of 30° , reference number 55, with the radius line 49. On the left-hand side, spaced apart from the stop 28, there is a stop 35, and on the right-hand side there is a stop 29. In addition, to the left of the stop 28, as viewed by an observer, there is a guide body 47, and to the right of this stop 28 there is the guide body 30. The cam 26 has a radial outer face surface 80 and a radial inner face surface 81. The stop 28 has a radial outer face surface 82 and a radial inner face surface 83.

Figure 7 show how, as a consequence of the increasing centrifugal force brought about by the spool 13 rotating at increasing speed, the slide 16 moves the cam 26 radially outward, whereupon the equilibrium of force between the cam 26 and the stop 28 is changed to the point that the stop 28, and thus the spool 13, are rotated to the right, as viewed. This causes the static friction between the contact surface 25 and the stop surface 50 to become sliding friction. The cam 26 moves radially outward between the end 78 of the guide body 47 and the stop 28, and enters its locked position. Once the cam 26 reaches its end position and has releases the stop 28 completely, this can then move past this, below the cam 26.

Figure 8 shows the cam 26 in its radially outermost unlocking position, its radially outer face surface 80 resting on the guide surface 62 of the guide body 30. The spool 18 has rotated further, as indicated by the arrow 42, since the stop 38 is no longer blocked by the cam 26.

Figure 9 shows the cam 26 shortly before it reaches its new locking position relative to the stop 29, it having been displaced into its radially inner position at the end 74 of the guide body 41 by the guide surface 62.

5

It can be seen from Figures 6 to 9 that the cam 26 or the slide 16, respectively, is moved between its unlocking positions and locking positions not by the force of a spring, but only by inertial forces, and is held on the inclined
10 contact surfaces 25 and one of the stop surfaces 50 of the identical stops 28, 29 31, 33, 35 only by equilibrium of forces.

The inclination of the contact 25 or the stop surfaces 50
15 relative to the radius lines 49 at an angle β , 30° , was selected as a function of the diameter of the spool, the mass of the spool, the operating (rotational) speed of the spool, and the possible differences in rotational speed resulting from worn cutter filament, and can, of course, be greater or
20 smaller in an apparatus according to the present invention that is designed using different parameters.

The spacing between the stops 28, 29, 31, 33, 35 on the circle
28 corresponds to the adjustable filament length, by which the
25 shortened cutter filament 36, 38 is automatically lengthened on each occasion.

Usually, any excess length of the cutter filament is removed by a limiting cutting edge that is formed on the housing of the apparatus and lies in the path of movement of the cutter filament, so that the length of the unattached end 37, 39 is automatically kept almost constant.

The travel of the slide 16 is limited by the difference of the larger dimension 24 of the slot 22 relative to the diameter of the drive shaft 12, and by the resilient stops 11, 11' against which the face side of the slide 16 comes to rest when it is at its maximal travel. The left-hand side (as viewed) of the slide 16 in Figure 1 is lighter than the right-hand side (as viewed) with its cam 26.

The difference in the mass of the two sides is so calculated that at a specific rotational speed of the cup 10, and in particular at a specific cutter filament length, the force that moves the slide 16 radially is greater than the opposite radial component between the contact surface 25 of the cam 26 and the stop surface 50 of the stop 28 or, accordingly, the other stops 29, 31, 33, 35.

Figure 10 shows a cam 126 on its path, which is divided into ten separate stages, between the stop 128, along the guide body 30, to the adjacent stop 129.

The path has been divided into ten stages, with the cam 126 being distinguished in its particular position 1 to 10 by the

numbers 1 to 10. The cam 126 is shown without its supporting slide. In principle, this is shaped like the slide 16 that is shown in Figure 1.

5 The cam 126 is of kidney-shaped cross section. Its lower end (as viewed) has a first, curved sliding surface 125. This serves as a supporting surface on the contact edge 128" and on the concave, flattening surface 150 of the stop 128. At its upper end, the cam 126 has a second sliding surface 125' to
10 slide along the concave guide surface 162 of a guide body 130.

The stop 128 has a hook-shaped cross section. A straight arm 128' of the stop 128 that is inclined relative to the radius line forms the contact edge 128" that is proximate to the cam
15 126 and this extends radially outward to become the stop surface 150. The concave stop surface 150 has an inclination β relative to a straight line G" that is parallel to the straight line G. Thus, the straight line G corresponds to the axis of symmetry of the slide (not shown herein) that supports
20 the cam 126 and determines its path of movement x. The angle β becomes larger as the distance from the stop surface 150 from the mid-point of the spool 112' becomes greater. This results in the flattening of the shape of the stop surface
25 150.

The shape of the stop surface 150 of the stop 128 essentially follows the curve plotted by the following mathematically

defined dependency of the angle β on the path x followed by the cam 126 as it moves along the straight line G:

$$\frac{\cos\beta - \mu\sin\beta}{\sin\beta + \mu\cos\beta} = \frac{K_{\text{schalt}}}{m_s(e_s+x)(r_k+x)}$$

5 In the preceding formula, r_k stands for the distance from the axis of rotation to the point of contact given a path of movement x for the cam equal to 0, i.e., if the sliding surface 125 of the cam 126 lies on both the stop surface 150 and on the contact edge 128" of the stop 128; m_s stands for the
10 mass of the slide, e_s stands for the eccentricity and K_{schalt} stands for the quotient of the unlocking moment M_{schalt} and the square of the angular velocity ω , a mathematical value. The slip coefficient of the contact is μ . The unlocking moment M_{schalt} is the result of the minimal filament centrifugal force
15 and its effective arm, which is determined from the winding radius.

Six points of the shape of the stop surface 150 in Figure 10 result from inserting the following values in the above
20 formula: $m_s = 6.3 \text{ g}$, $e_s = 5 \text{ mm}$, $r_k = 20.5 \text{ mm}$, $K_{\text{schalt}} = 883.4 \text{ g} \times \text{mm}^2$, $\mu = 0.2$, with the following result:

$x(\text{mm})$	0	1	2	3	4	5
25 $\frac{\cos\beta - \mu\sin\beta}{\sin\beta + \mu\cos\beta}$	1.368	1.087	0.89	0.746	0.636	0.55
$\beta(^{\circ})$	24.8	31.3	37.0	42.0	46.2	49.0

30 The guide body 130 has a guide surface 162 on which the cam 126 slides on its second sliding surfaces 125' on the path into its locked position to the adjacent stop 129. The guide

surface 162 of the guide body 130 ends at a radial distance from the mid-point of the spool 112' that is smaller than the radial distance of the stop surface 150 of the stop 128 from the mid-point of the spool 112'.

5

The movement sequence for the cam 126 starts in position 1, in which the cam 126 is in its locking position with a displacement travel = null, or at r_k and its sliding surface 125 is resting both on the contact edge 128" or on the stop surface 150 of the stop 128, respectively.

10

At stage 2, the sliding edge 125 of the cam 126 has reached the end of the stop surface 150 of stop 128, and thus at the end of the locking position, and because of its radial movement it has moved the stop 128 and with it the whole of the spool 113 to the right as viewed since, because of a shortened cutter filament, its centrifugal force is smaller than the centrifugal force of the slide that supports the cam 126. Because of this, the cam 126 is able to move further outward radially into the unlocking position that is numbered 3. This position is determined by stops that limit the slide's travel, as discussed with reference to the slide 16 and the stops 11 in Figure 1.

15

20

25

Cam 126 number 4 is unable to move any further outward radially outward from the unlocking position, but it or its sliding surface 125' slides along the guide surface 162 of the guide body 130, whereupon the spool 113 rotates about the mid-

point 112' of the spool to the left as viewed. When this takes place, increasing larger portions of the surface of the sliding surface 125' of the cam 126 numbered 5, 6, 7 lie against the guide surface 162, so that the cam 126 is moved
5 radially inward.

As it is guided along the guide surface 162--by additional rotation of the spool 113 as a consequence of the cutter filament growing increasingly longer with this relative
10 movement, and its increasing centrifugal force--the cam 126 number 8 has moved radially inward into its end position.

The sliding surface 126 of the cam 126 number 9 is lying on the contact edge 129" of the stop 129, where it occupies a
15 position that is the innermost relative to the mid-point 112' of the spool. The cam 126 number 10 is once again moving radially outward in order to take up the same position as cam 126 number 1 relative to the stop 128.

20 This ends the regulating step for adjusting the filament. Additional regulating steps take place as soon as the filament becomes too short.

Figure 11 is a view of the side of the slide 116 that is
25 proximate to the spool 113, with the cam 126 as in Figure 10, and it shows the position of the sliding surfaces 125, 125' relative to the slot 122, which corresponds to the slot 22 in Figure 5.

Figure 12 shows the cam 126 as in Figure 11, as a detail, in plan view. This drawing shows the sliding edges 125, 125'.

5 Figure 13 is an overall perspective drawing of the spool 113 as in Figure 10, with the stops 128, 129, 131, 133, 135 and the guide bodies 130, 141, 143, 145, 147.

10 Figure 14 is a diagram showing the spool 13, 113 with the emergent cutter filaments 36, 38; 136, 138, and the dynamic forces acting on these components. The spool moment M that acts about the mid-point 12'; 112' is the product of the centrifugal force of the rotating filaments F_F and the winding radius r_F . The centrifugal force F_F is the product of the filament mass m_1 (from the mid-point 12'; 112' of the coil as
15 measured on the line of the filament), from the centre of gravity interval r_1 of the filament and from the square of the angular velocity ω .

The spool moment and the centrifugal force are held in
20 equilibrium by the shape of the slide or the geometry of the cam 126, of the stop 128, and of the guide body 130 such that adjustment of the filament cannot be initiated unintentionally, but only if the length of the cutter filament falls below a specific minimum length, and it has to be
25 adjusted, the cam 126 once again arriving in a locking position that is the same as the original one at the end of the filament adjustment process, from which it can be set in the unlocking position as often as required, so that the

filament adjustment can be repeated as in the first adjustment stage until such time as no more cutter filament is left.

Figure 15 shows a curve that corresponds to the shape of the outline of the guide surface 162 as in Figure 10 and that is represented or determined by polar coordinates, i.e., it is possible to determine the associated values for r_1 to r_2 for angular positions from Φ_1 to Φ_2 of the point of engagement of the sliding surface 125' relative to the sliding surface 162.

In order that the cam 126, as described on the basis of Figure 10, is actually reset into its position that corresponds to the previous position, the outline of the guide surface 162 of the guide body 130 is so configured that it follows the mathematical equation:

$$\frac{dr}{d\varphi} = r \cdot \frac{Z(\varphi)r \cdot \mu + (\mu^2 - 1)M(\varphi)}{Z(\varphi)r + 2\mu M(\varphi)} = F(r, \varphi)$$

wherein, according to the above formula, r stands for the distance between the guide surface 162 and the mid-point 112' of the spool; dr stands for an infinitesimally smaller part of r , with Φ_1 to Φ_2 being the angle between a reference radius line r_0 that passes through the left-hand (as viewed) end of the guide body 130, and the radius line of the first or last point of engagement, respectively, of the sliding surface 125' of the cam 126 on the sliding surface 162 of the guide body 130, with Z standing for the centrifugal force on the cam 126,

and μ standing for the coefficient of friction between the surface 125' and the outline 162, and M standing for the spool moment that results from the centrifugal force of the filament and its effective arm about the mid-point 112' of the spool, the arm being determined from the winding radius of the cutter filament.

This equation does not contain the angular velocity. This means that the equilibrium of forces can be adjusted without reference to the angular velocity of the spool 113. The outline of the guide surface 162 of the guide body 130 as in Figure 10 and 13, or corresponding to the shape of the curve in the x-y coordinate system as in Figure 15, which corresponds to the surface of the spool width, is configured by plotting the equation numerically, with the intersection of the x-y axes corresponding to the mid-point 112' of the coil.

The mathematical equation that forms the basis of the shape of this curve determines a shape for the guide surface 162 through which equilibrium of forces is set up at each point between the cam 126 and the guide surface 162, at which for a given coefficient of friction μ , sliding friction is always close to the limit of static friction. The tip and the end of the guide surface 162 are determined by a circular sector that is established according to the minimum filament adjustment length. The arrangement of the stop 128 relative to the guide body 130 is also determined by this circular sector.

The shape of the outline of the guide curve 162 ensures that even in the event of a greater coefficient of friction between the cam 26; 126, and the guide surface 62; 162, the cam 26, 126 does not bind on the guide surface 62; 162. Thus, the
5 system must be of somewhat easier action than is calculated according to the ideal mathematical model.

Practice shows that at coefficients of friction $\mu = 0.1$ to 0.15, resetting the cam 126 by having it slide along the guide
10 surface 162 functions without any problem. In particular, the stick-and-slip effect that is familiar during movement in the boundary area between static and sliding friction is avoided.

The embodiment for the shape of the guide surface 162 as in
15 Figure 15 was based on the following values:

2183996

	Filament density	0.023 g/mm
	Housing radius r_g	45 mm
	Initial filament length l_0	95 mm
	Winding radius r_f	20 mm
5	Mass of slide m	6.3 g
	Centre of gravity interval r_1	19.1 mm
	Initial point of the guide surface 162	$r_1 = 32.1$ mm at $\phi_1 =$ 0.1262 rad
	End point of the guide surface 162	$r_2 = 20.9$ mm at $\phi_2 = 0.986$ rad

Patent Claims

1. An apparatus for cutting plants, with at least one cutter filament (36, 38) that spins about an axis of rotation (12; 112) and extends from this, and that is wound onto a spool (13, 113) that is arranged within a rotating, driven cup (10) so as to move with said cup that has at least one opening on its periphery, an unattached end (37, 39) of the cutter filament (36, 38) emerging from this to the outside, a slide (16; 116) that is rotationally fixed and can be displaced radially to the axis of rotation (12; 112) fixes the spool (13; 113) so that it cannot rotate relative to the cup (10) or releases it, so that when the length of the unattached end (37, 39) of the cutter filament (36, 38) is shortened, for example, as it wears away, because of centrifugal force the slide (16; 116) moves from its locking position into its unlocking position, characterized in that the slide (16; 116) is held in its locking position relative to the spool (13; 113) only by the equilibrium of forces of the mass supporting forces between its cam (26; 126) and a stop (28, 128) on the side of the spool, and is moved from this locking position into its unlocking position by centrifugal force and during the released relative rotation of the spool (13; 113) relative to the cup (10) brought about by this, because of the mass support force between its cam (26; 126) and a guide surface (62; 162) of a guide body (130) it is reset into its locking position.

2. An apparatus as defined in Claim 1, characterized in that the cam (26; 126) has a side contact surface (25) or slide surfaces (125, 125'), with which it rests on a stop surface (50; 150) of the stop (28; 128), the contact surface (25) or the sliding surfaces (125, 125') and the stop surface (50; 150) being arranged so as to be inclined, preferably by 30°, relative to the direction of displacement of the cam (26; 126).
3. An apparatus as defined in Claim 1 or Claim 2, characterized in that as the radial distance from the drive shaft (12; 112) increases, the stop surface (150) of the stop (128) has an increasingly flatter outline.
4. An apparatus as defined in Claim 3, characterized in that the outline of the stop surface (150) is curved concavely.
5. An apparatus as defined in Claim 3 or Claim 4, characterized in that the outline of the stop surface (150) is predetermined in the following manner by the angle of rise β and the displacement travel x of the cam (126), as expressed in the following mathematical relationship:

$$\frac{\cos\beta - \mu\sin\beta}{\sin\beta + \mu\cos\beta} = \frac{K_{\text{schalt}}}{m_s(e_s+x)(r_k+x)}$$

$$\sin\beta + \mu\cos\beta \quad m_s(e_s+x)(r_k+x)$$

wherein r_k stands for the distance from the axis of rotation to the point $x = 0$, m_s stands for the mass of the slide, e_s stands for the eccentricity and K_{schalt} stands for a mathematical value of the quotient of the unlocking

Moment M_{schalt} and the square of the angular velocity ω of the spool (113).

6. An apparatus as defined in one of the Claims 1 to 5, characterized in that the stops (28, 29, 31, 33, 35) have reinforcing ribs (56, 57, 58, 59, 60) on their back faces.
7. An apparatus as defined in one of the Claims 1 to 6, characterized in that the spool (13) supports the stops (28, 29, 31, 33, 35) that are space equidistantly about a smaller circle (27) and the guide bodies (30, 41, 43, 45, 47) that are spaced equidistantly about a larger circle (48).
8. An apparatus as defined in Claim 7, characterized in that the distance between the two circles (27, 48) is greater than the greatest radial width of the cam (26).
9. An apparatus as defined in one of the preceding claims, characterized in that the cup (10) has at least one resilient stop (11) that limits the radial displacement of the slide (16).
10. A spool for an apparatus for cutting plants, with at least one cutter filament (36, 38) that spins about an axis of rotation (12; 112) and extends from this, and that is wound onto the spool (13, 113) that is arranged within a rotating, driven cup (10) so as to move with said cup that has at least one opening on its periphery, an unattached end (37, 39) of the cutter filament (36, 38) emerging from this to the outside, a slide (16; 116) that is rotationally fixed and can be displaced radially to the axis of rotation (12; 112) fixes the spool (13; 113) so that it cannot rotate relative to the cup (10) or releases it, so that when the length of the

unattached end (37, 39) of the cutter filament (36, 38) is shortened, for example, as it wears away, because of centrifugal force the slide (16; 116) moves from its locking position into its unlocking position, characterized in that spool has a stop (128) on which the slide (116) rests, its stop surface (150) having an increasingly flattened outline as the radial distance from the mid-point (112') of the coil increases.

11. A spool as defined in Claim 10, characterized in that the outline of the stop surface (150) is curved, in particular concavely, relative to the cam (126).
12. A spool as defined in Claim 10 or Claim 11, characterized in that the outline of the stop surface (150) is

determined in the following manner by the angle of rise β and the displacement travel x , as linked in the following mathematical equation:

$$\frac{\cos\beta - \mu\sin\beta}{\sin\beta + \mu\cos\beta} = \frac{K_{s\text{chalt}}}{m_s(e_s+x)(r_k+x)}$$

$$\sin\beta + \mu\cos\beta \quad m_s(e_s+x)(r_k+x)$$

wherein r_k stands for the distance from the mid-point (112') of the spool to the point $x = 0$, μ is the coefficient of friction, m_s stands for the mass of the slide, e_s stands for the eccentricity and $K_{s\text{chalt}}$ stands for a mathematical value of the quotient of the unlocking moment $M_{s\text{chalt}}$ and the square of the angular velocity ω of the spool (113).

13. A spool as defined in Claim 10, characterized in that the outline of the stop surface (150) is determined by two straight lines that converge to subtend an angle.
14. A spool as defined in one of the preceding claims, characterized in that the outline of the guide surface (62; 162) of the guide body (130) is determined in the following manner by the angle of rise β relative to the radius line R that passes through the mid-point (12'; 112') of the coil, as expressed in the following mathematical formula:

$$\frac{dr}{d\varphi} = r \cdot \frac{Z(\varphi)r \cdot \mu + (\mu^2 - 1)M(\varphi)}{Z(\varphi)r + 2\mu M(\varphi)} = F(r, \varphi)$$

wherein r stands for the distance between the guide surface (162) and the mid-point (112') of the spool; dr stands for an infinitesimally small part of r ;

ϕ stands for the angle of the guide surface (162) measured on the radius line from the point of contact, through the mid-point of the spool (112') and a reference diagonal;

Z stands for the centrifugal force on the cam 126;

μ stands for the coefficient of friction between the surface (125') and the outline of the guide surface (162);

M stands for the spool moment.

etherington & Co
Colum, Canada
Patent Agents

FIG. 1

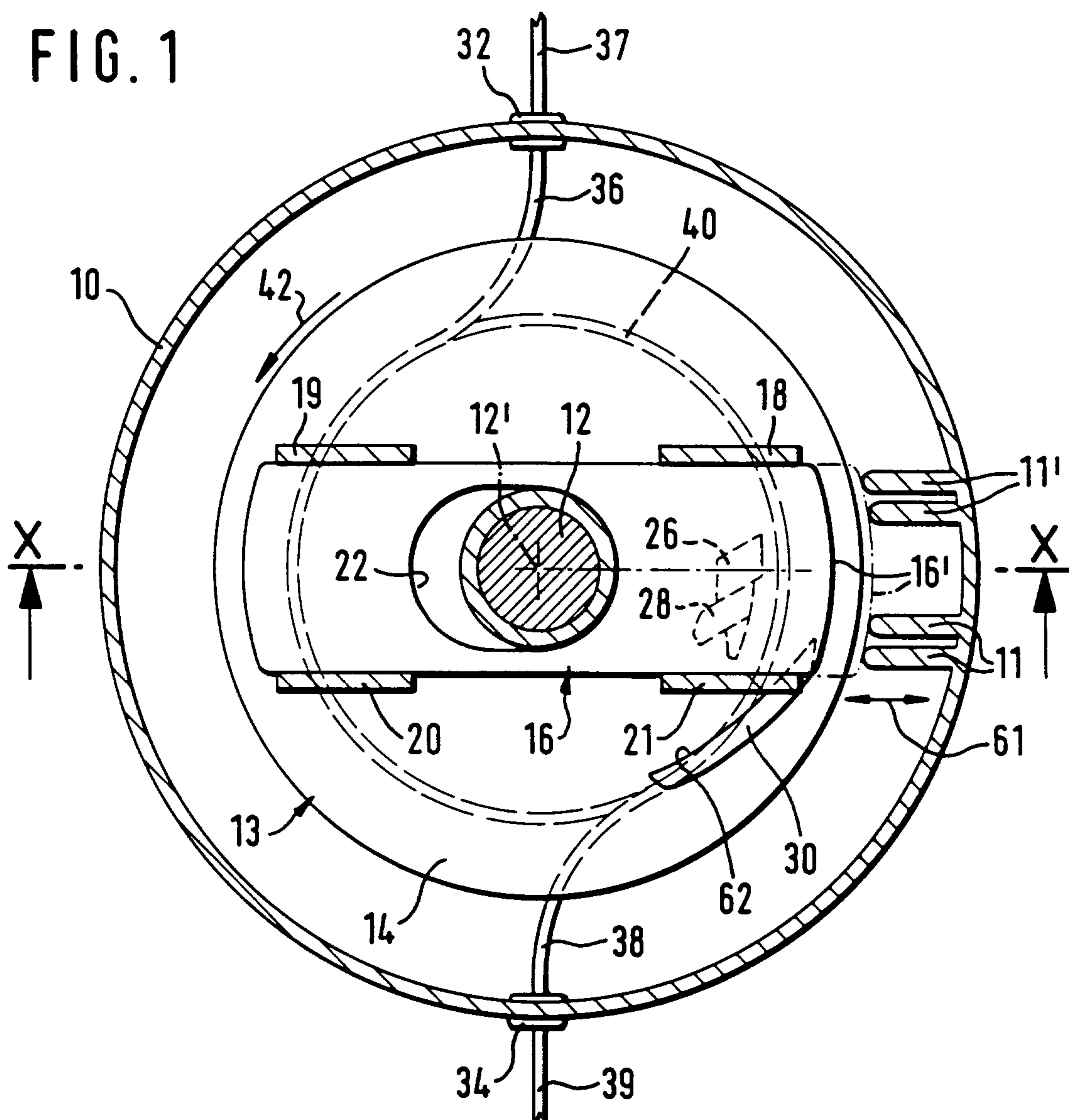


FIG. 2

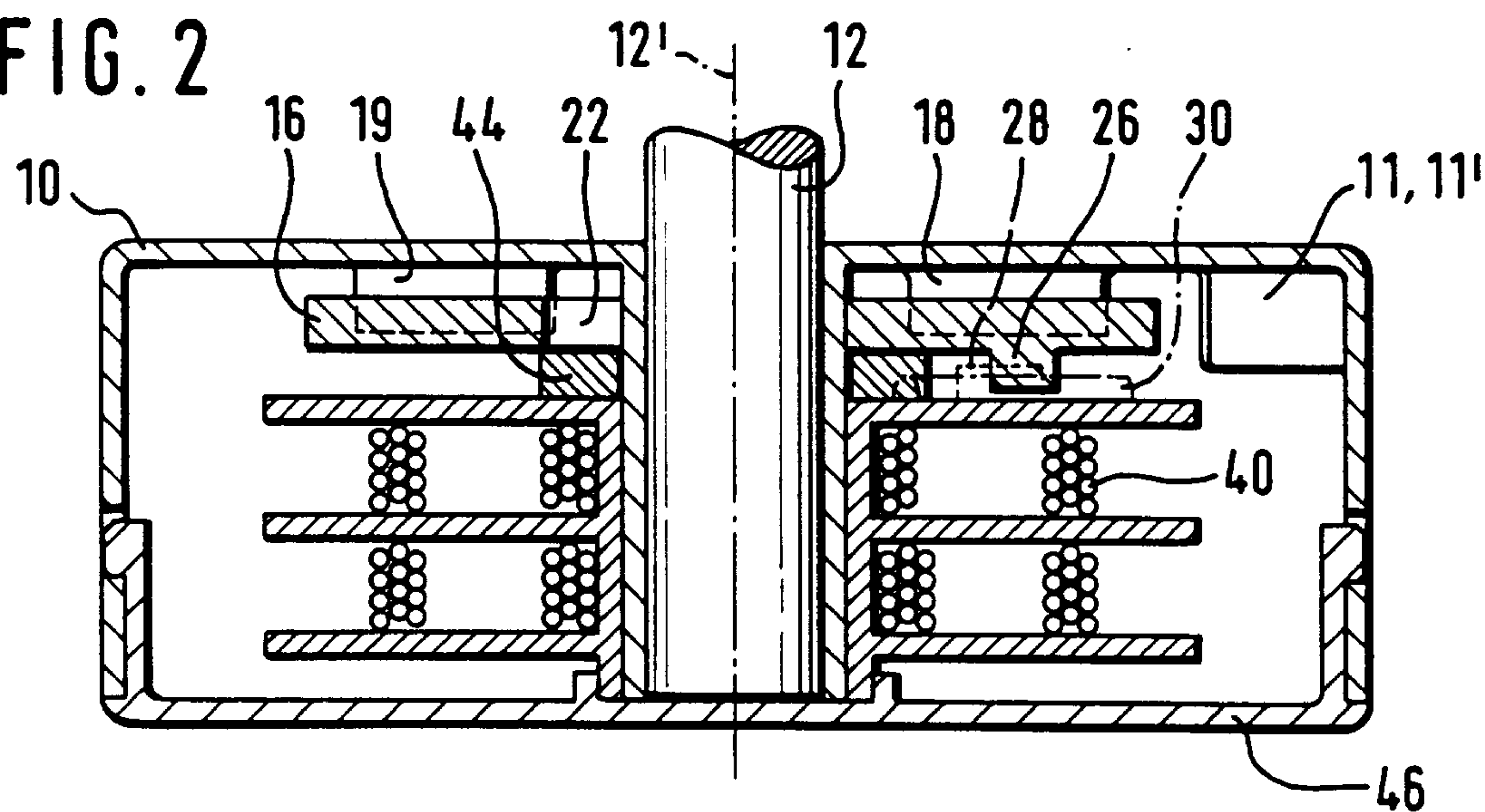


FIG. 3

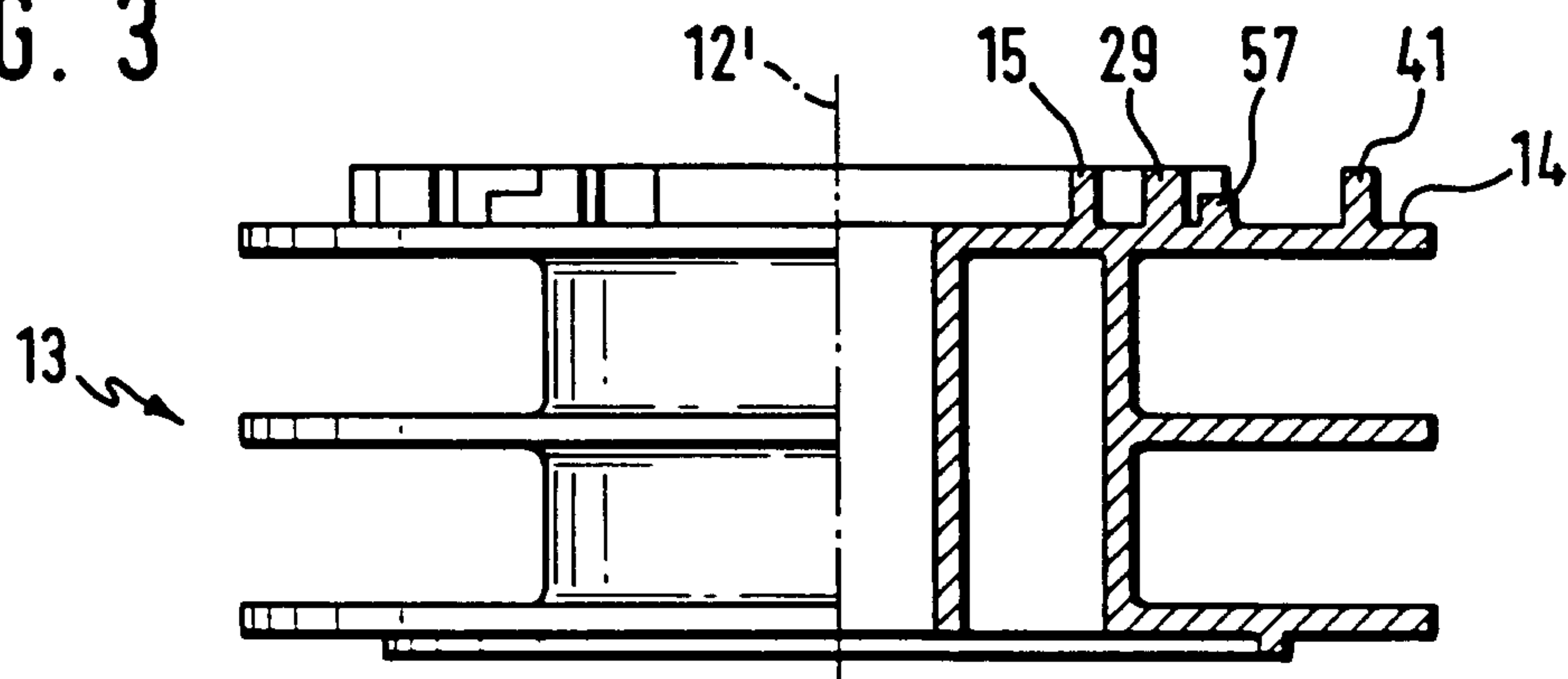


FIG. 4

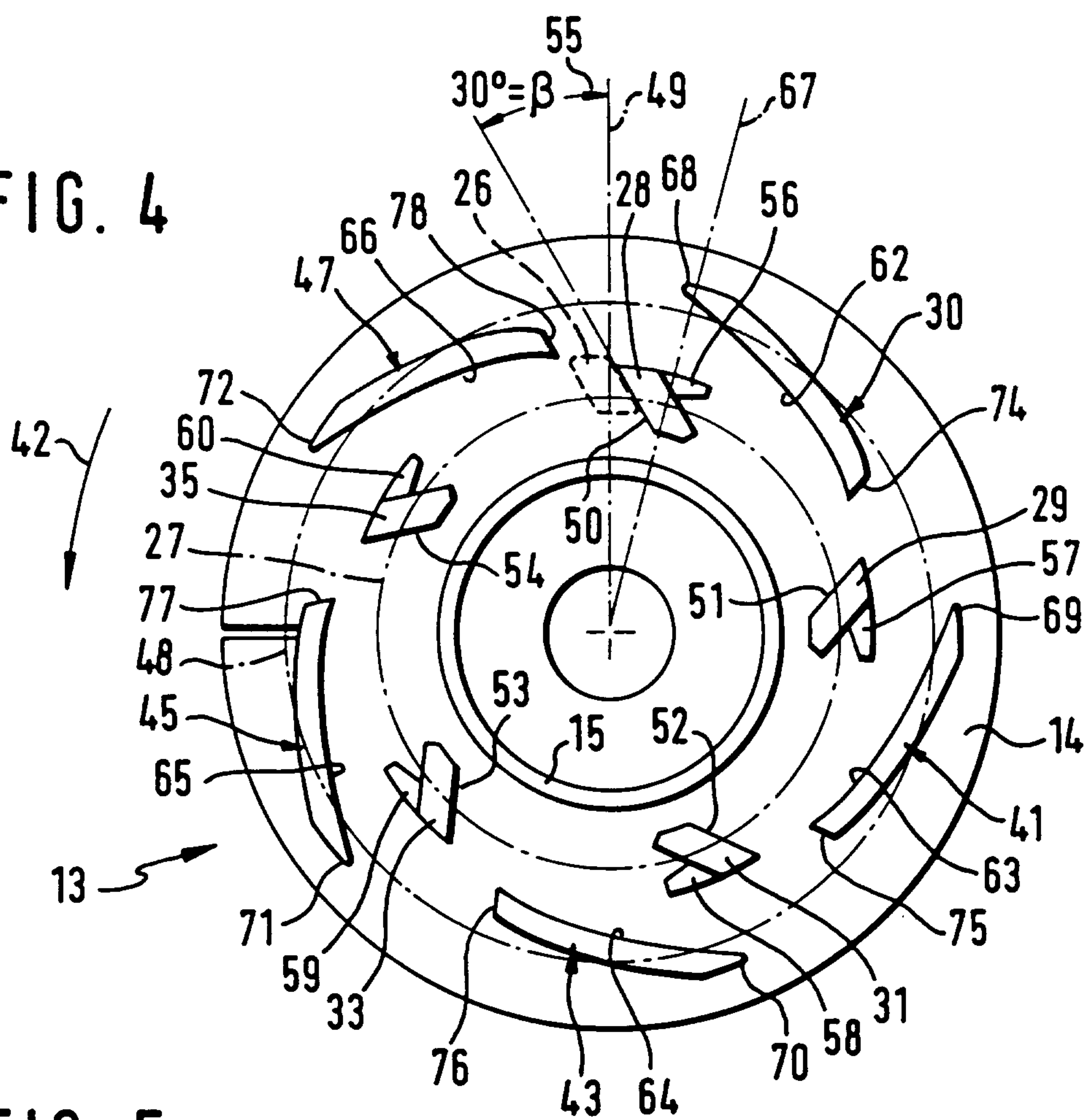


FIG. 5

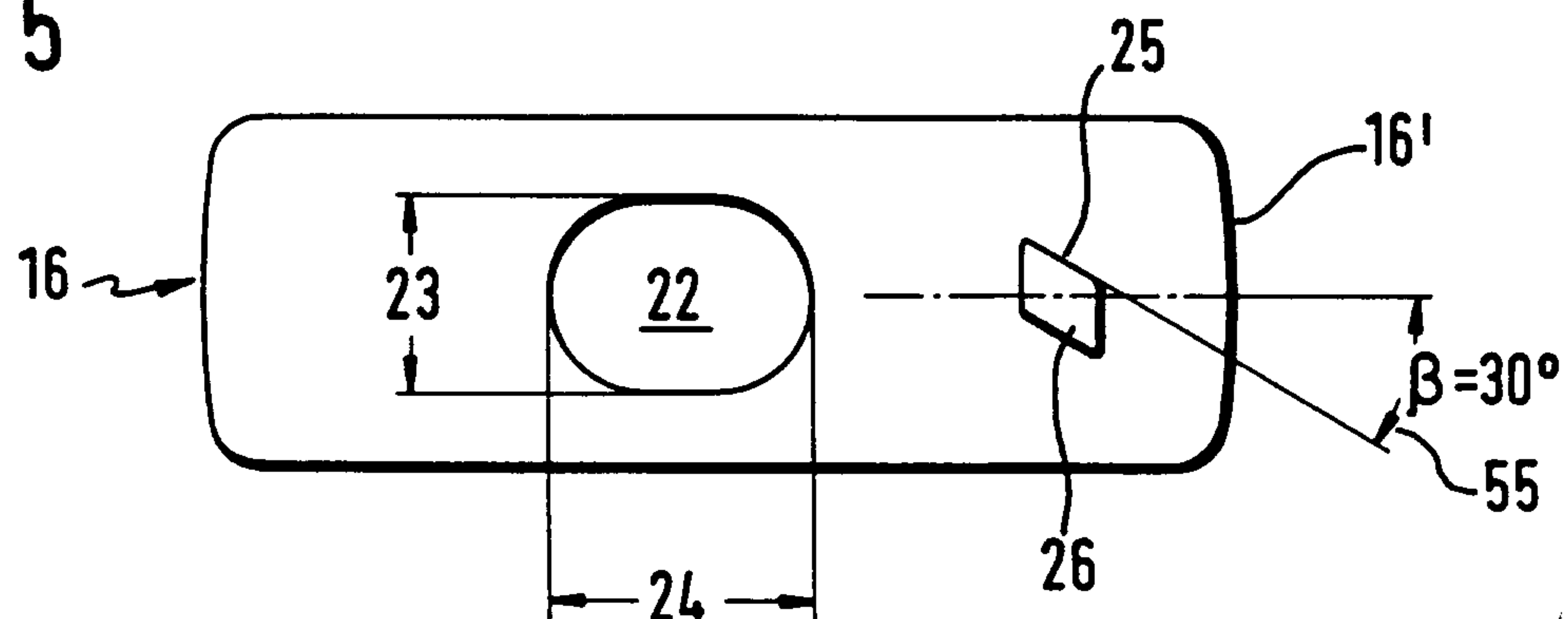


FIG. 6

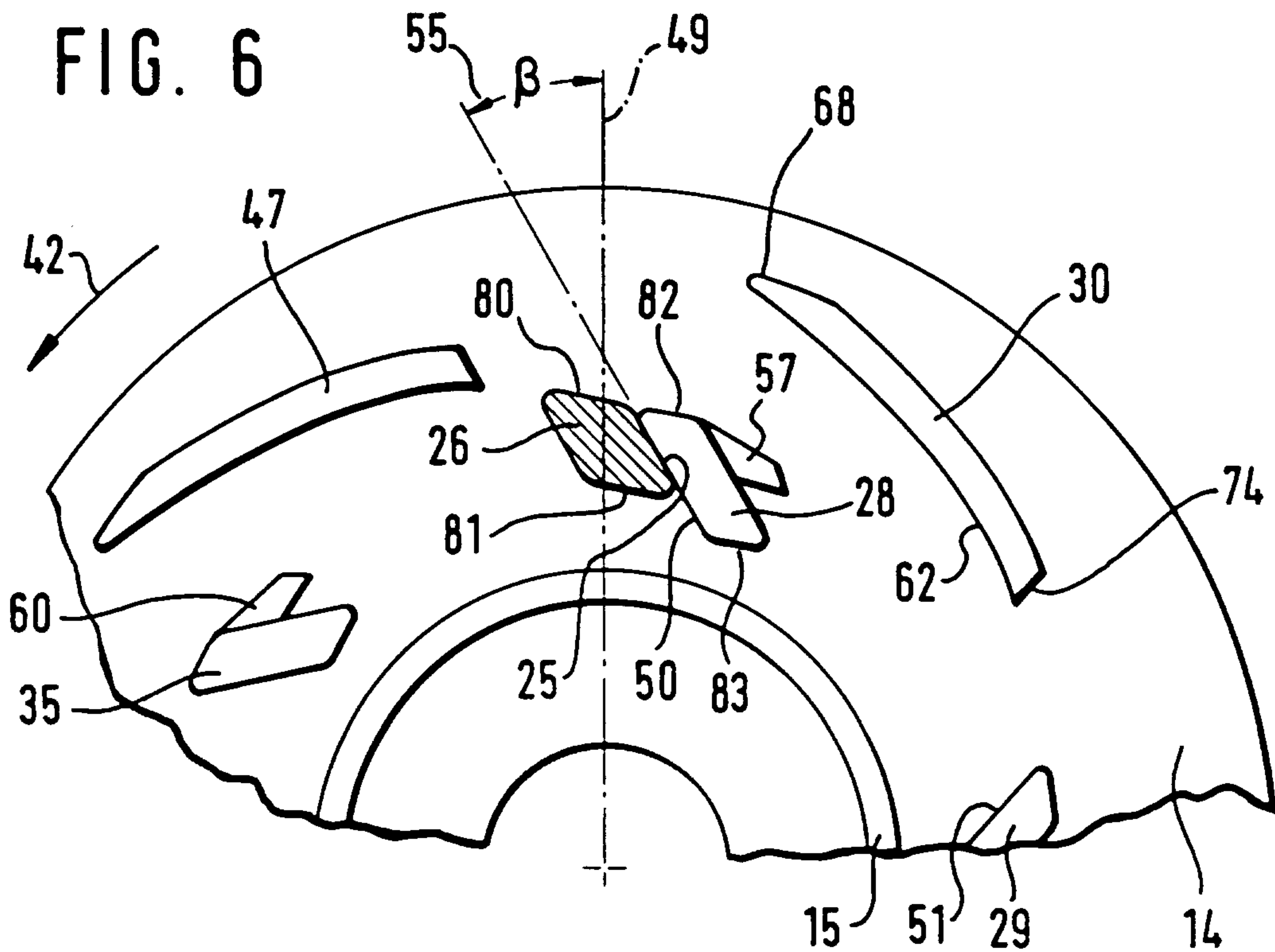


FIG. 7

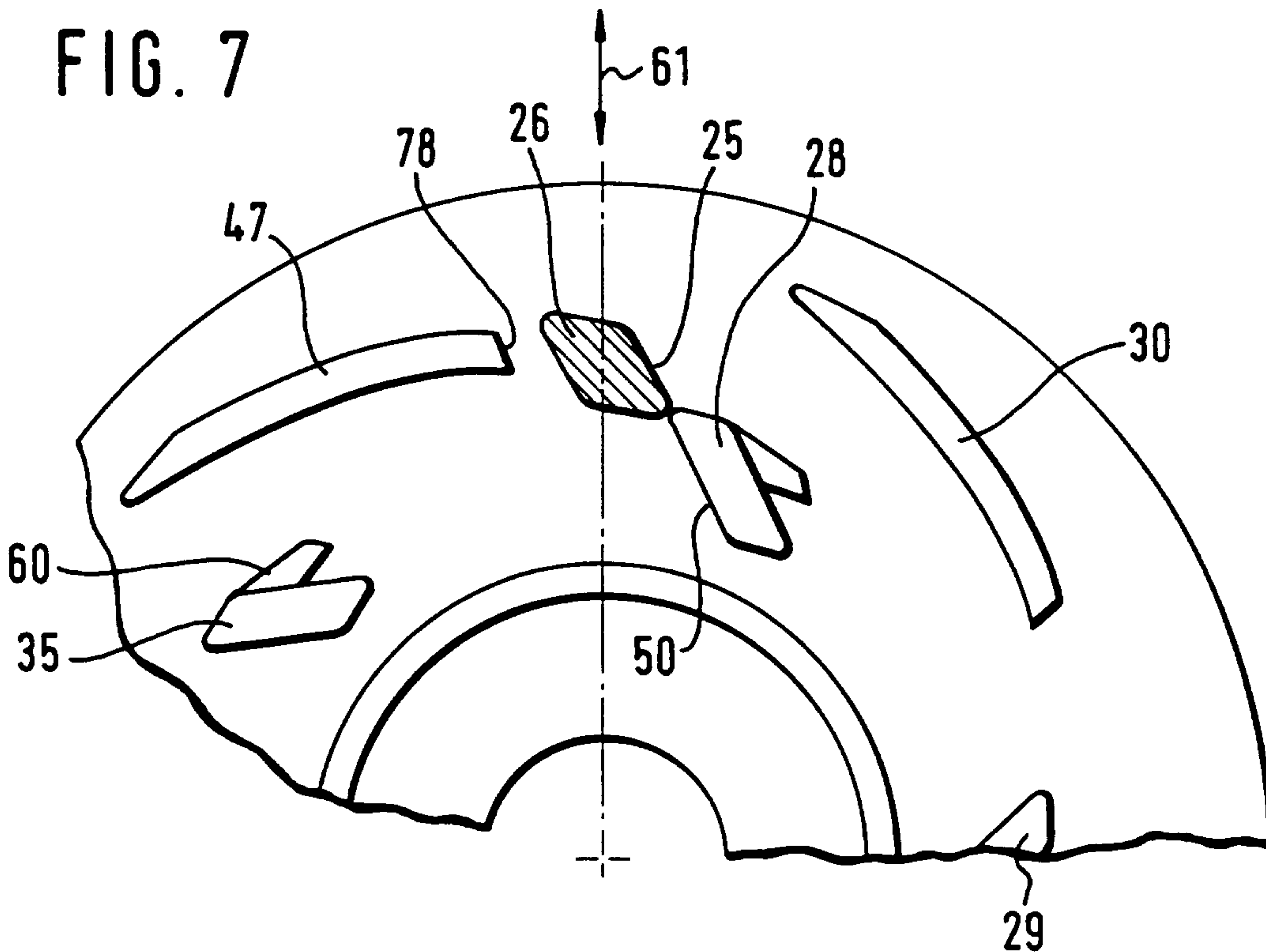


FIG. 8

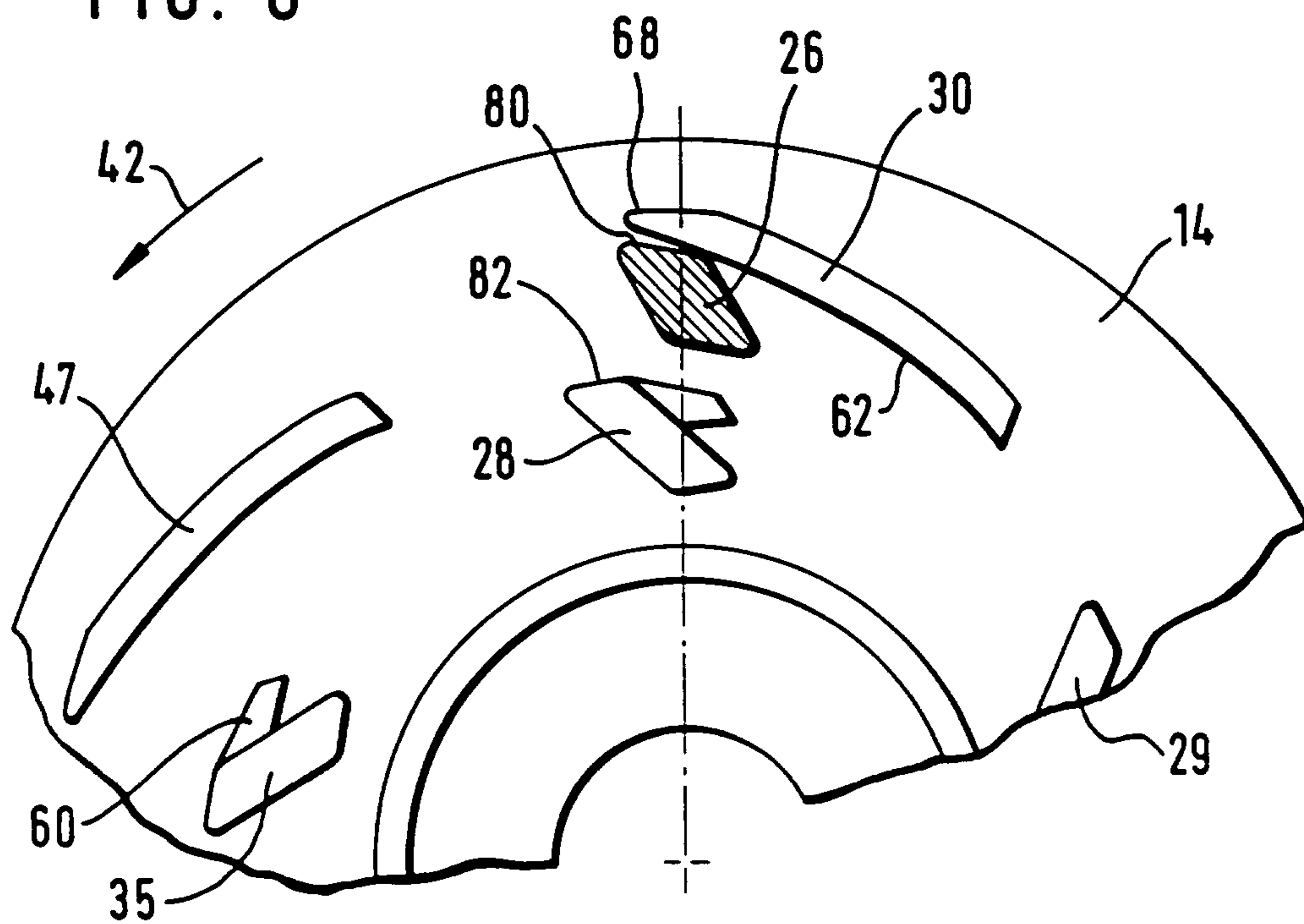


FIG. 9

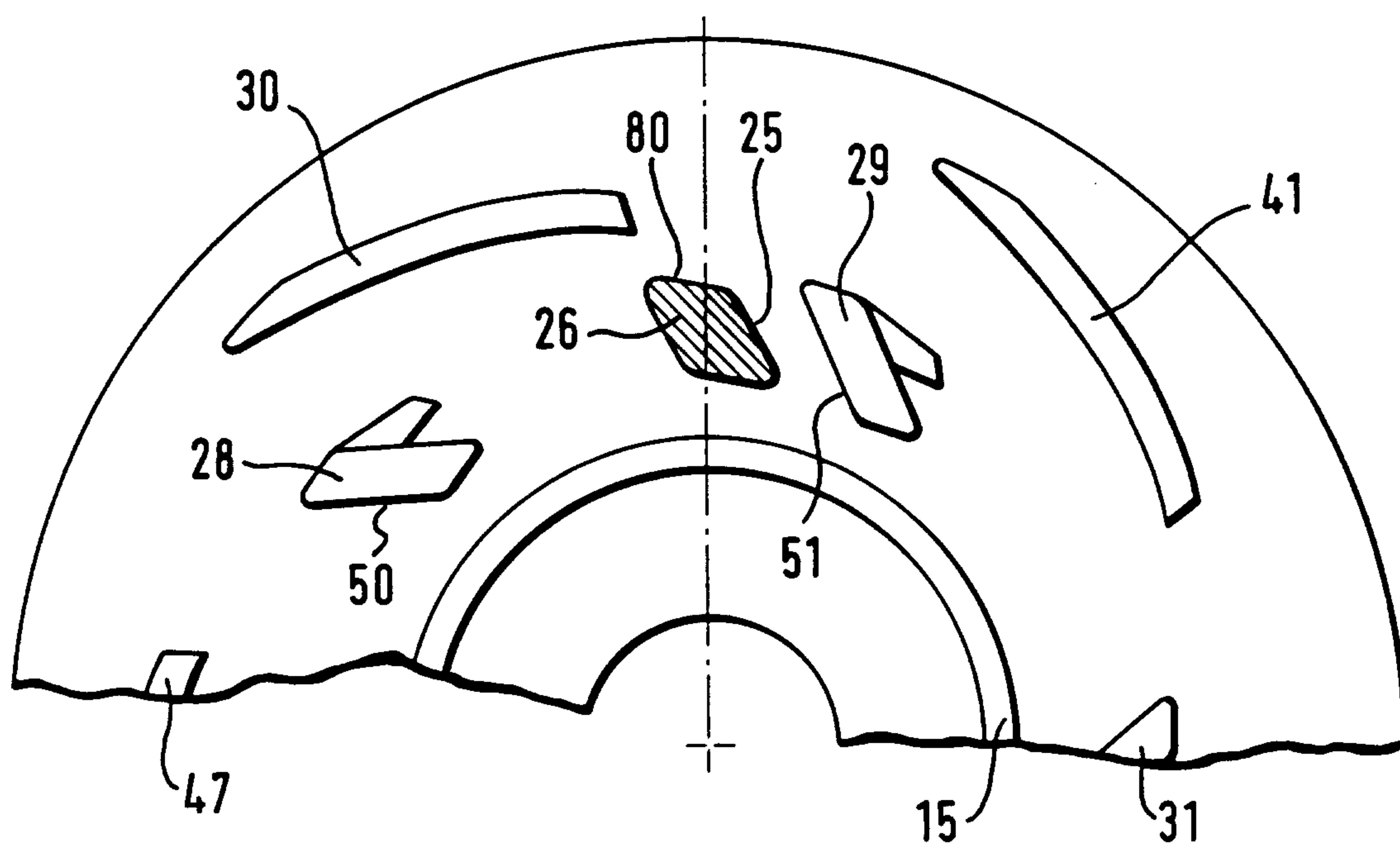


FIG. 10

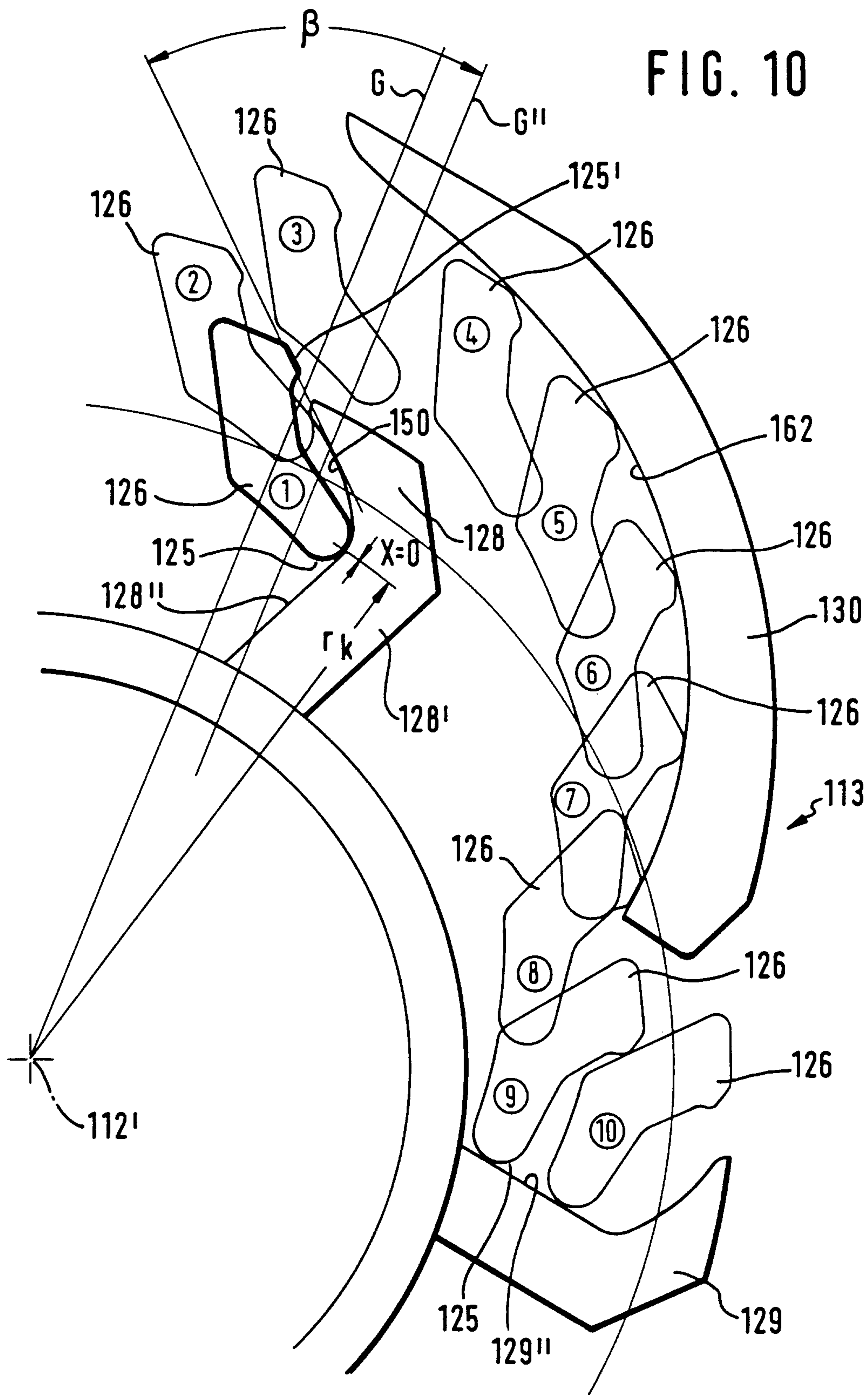


FIG. 11

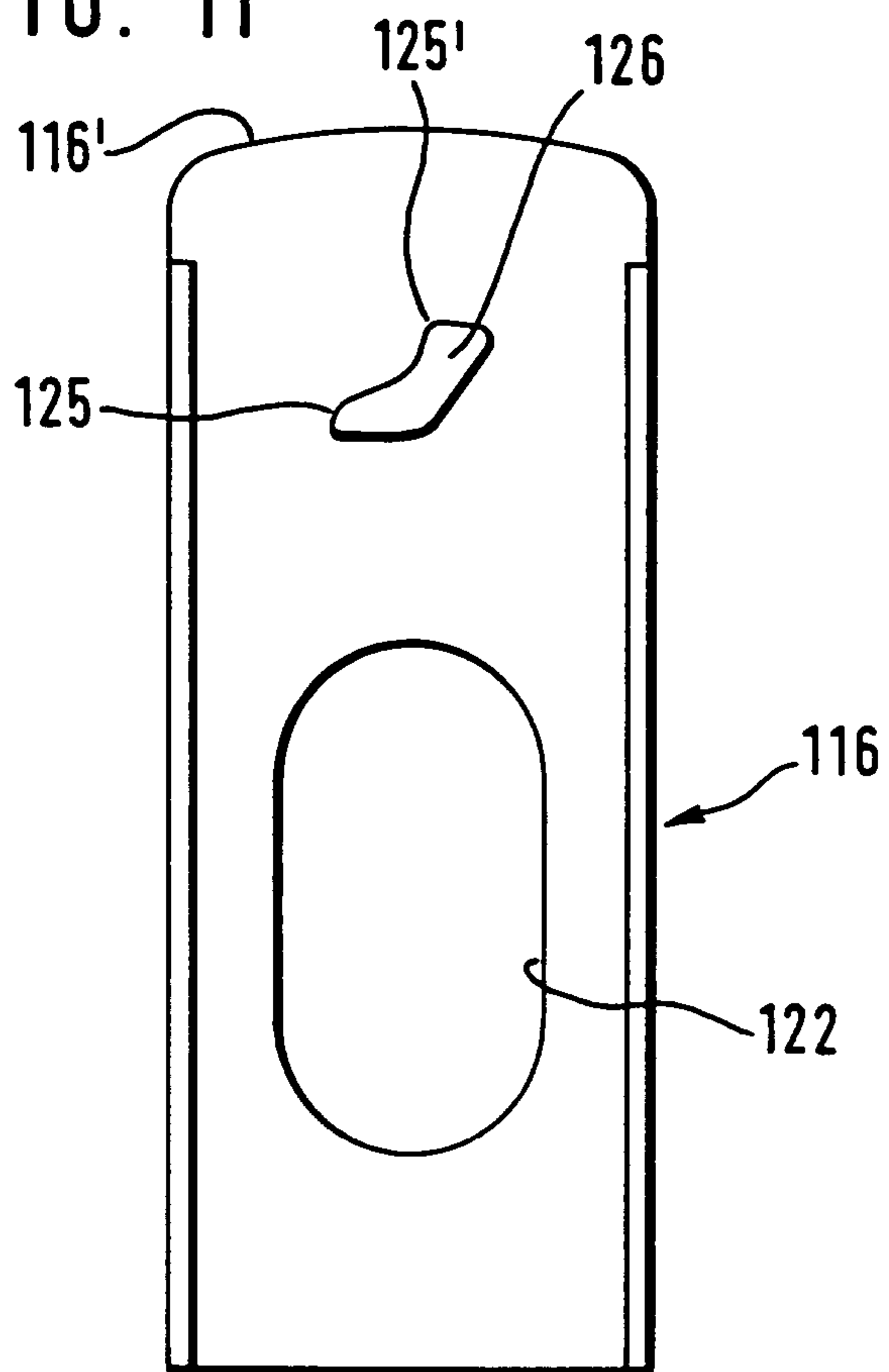


FIG. 12

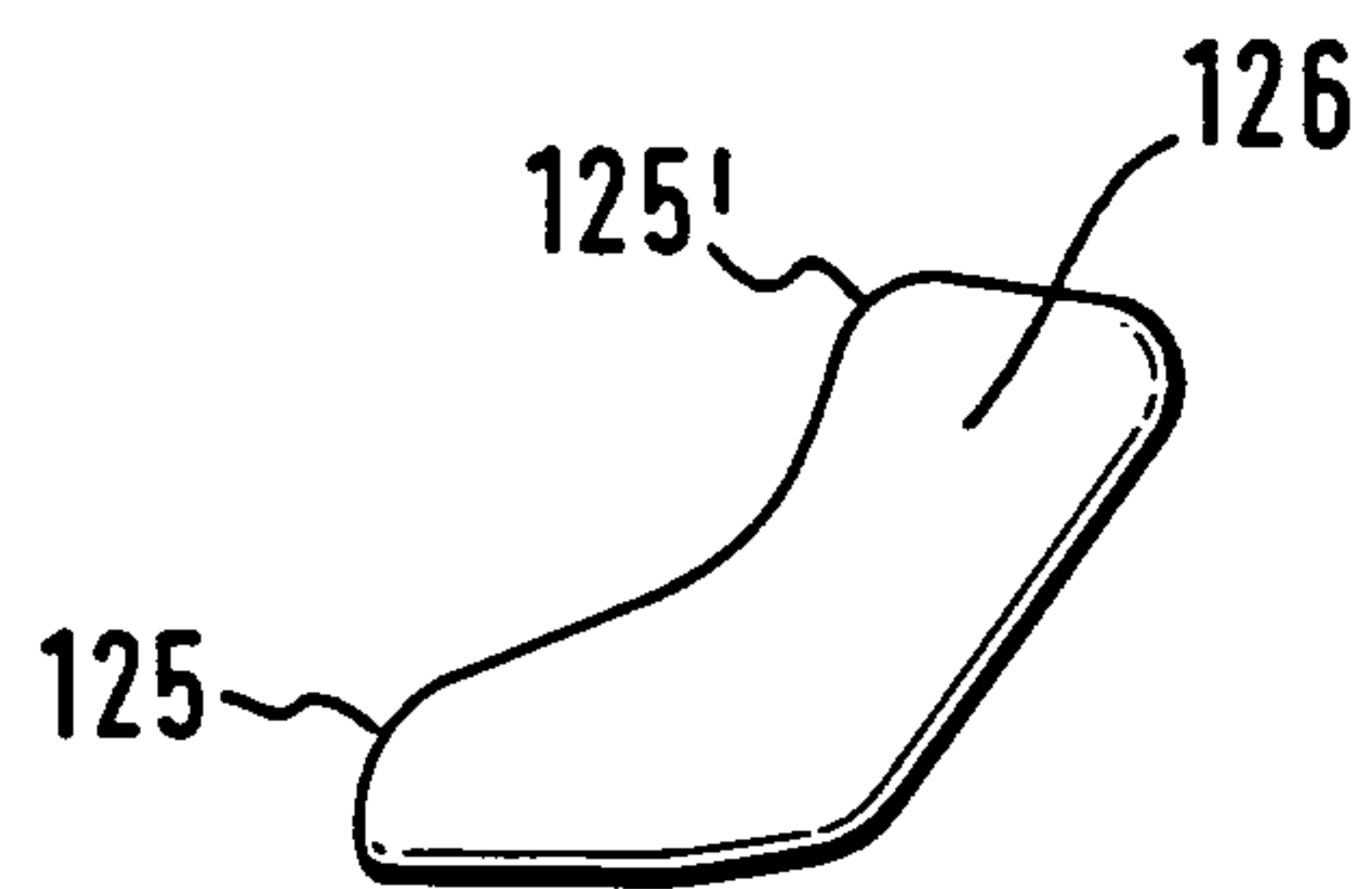


FIG. 13

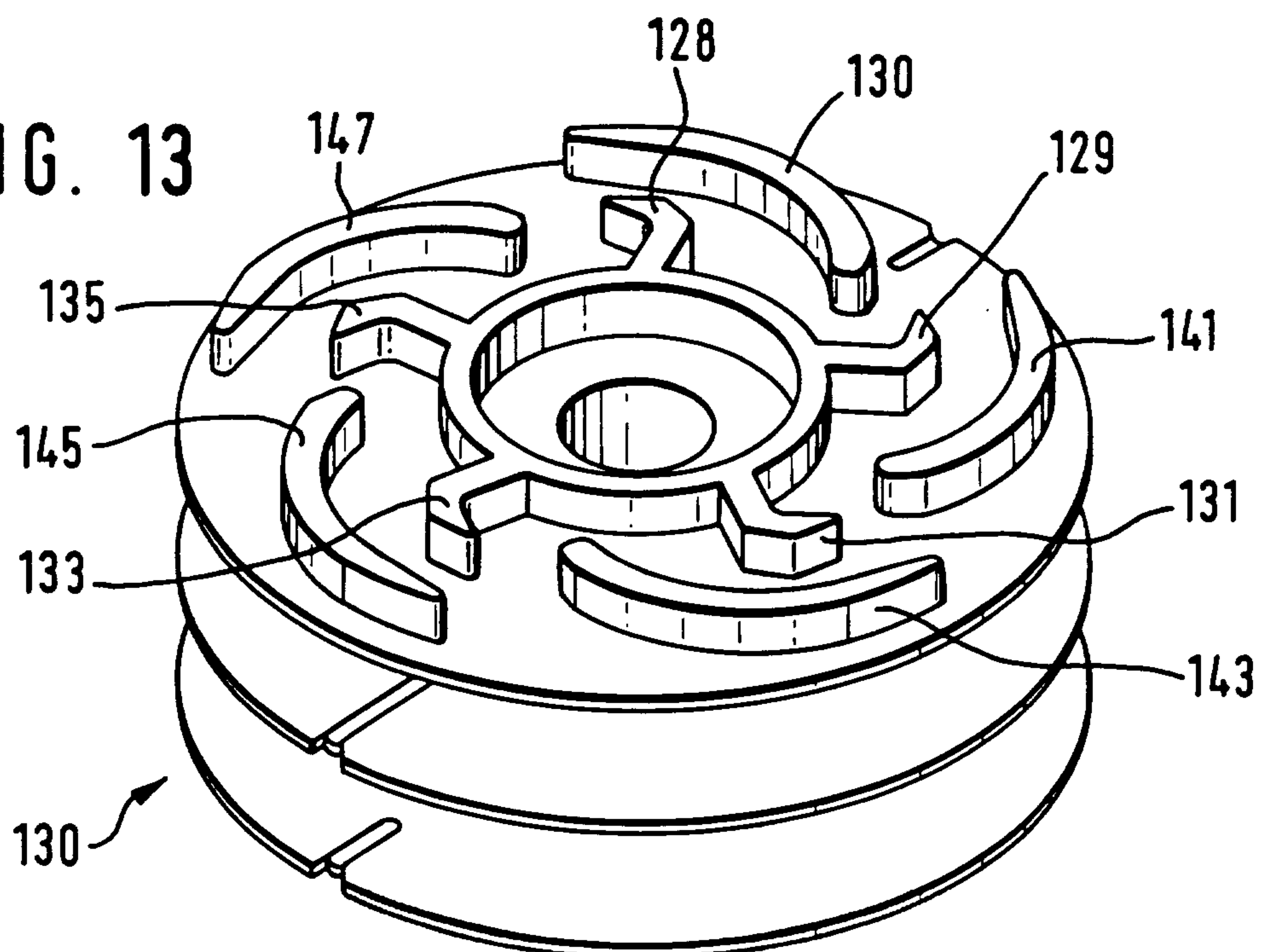


FIG. 14

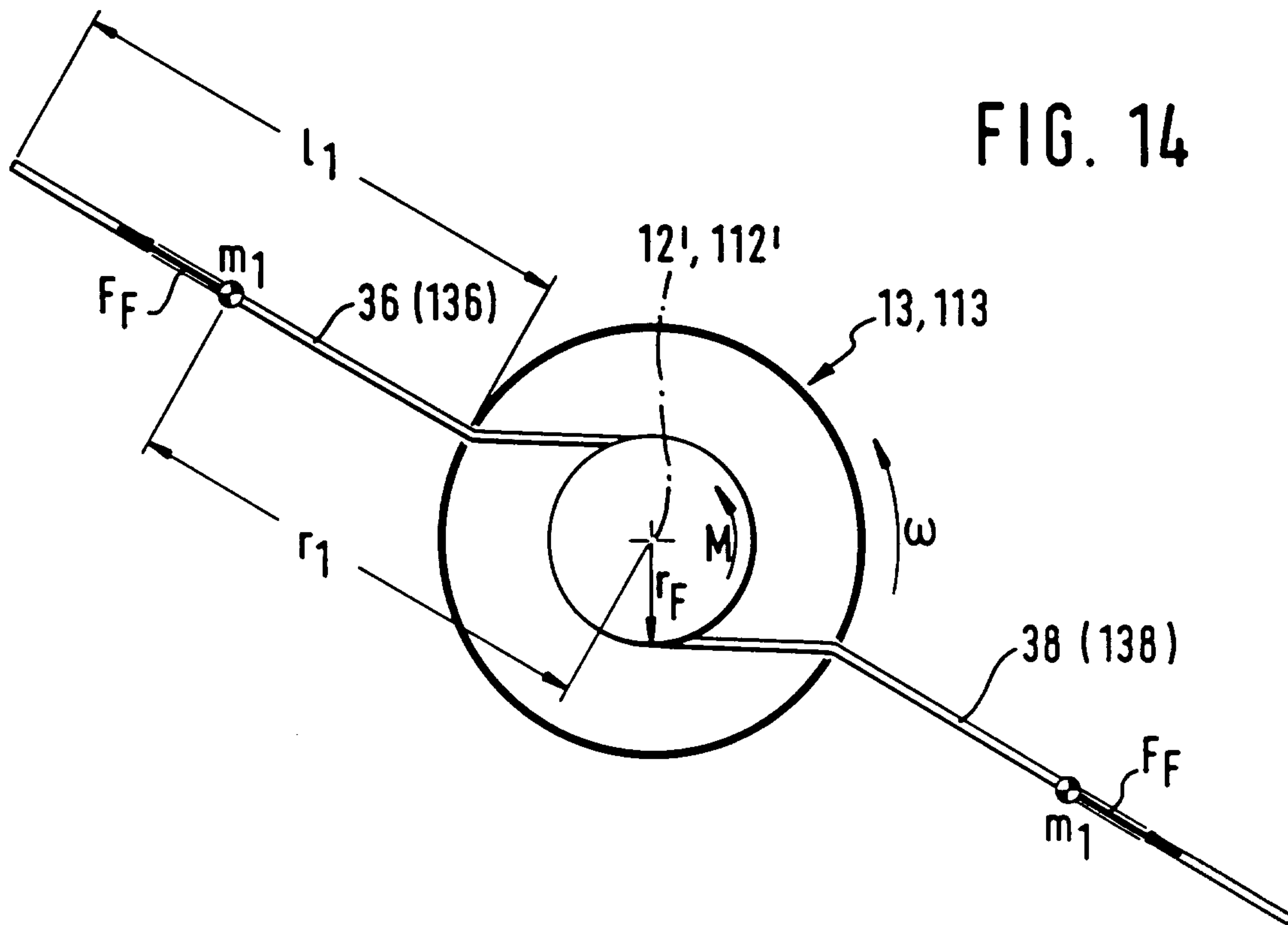


FIG. 15

