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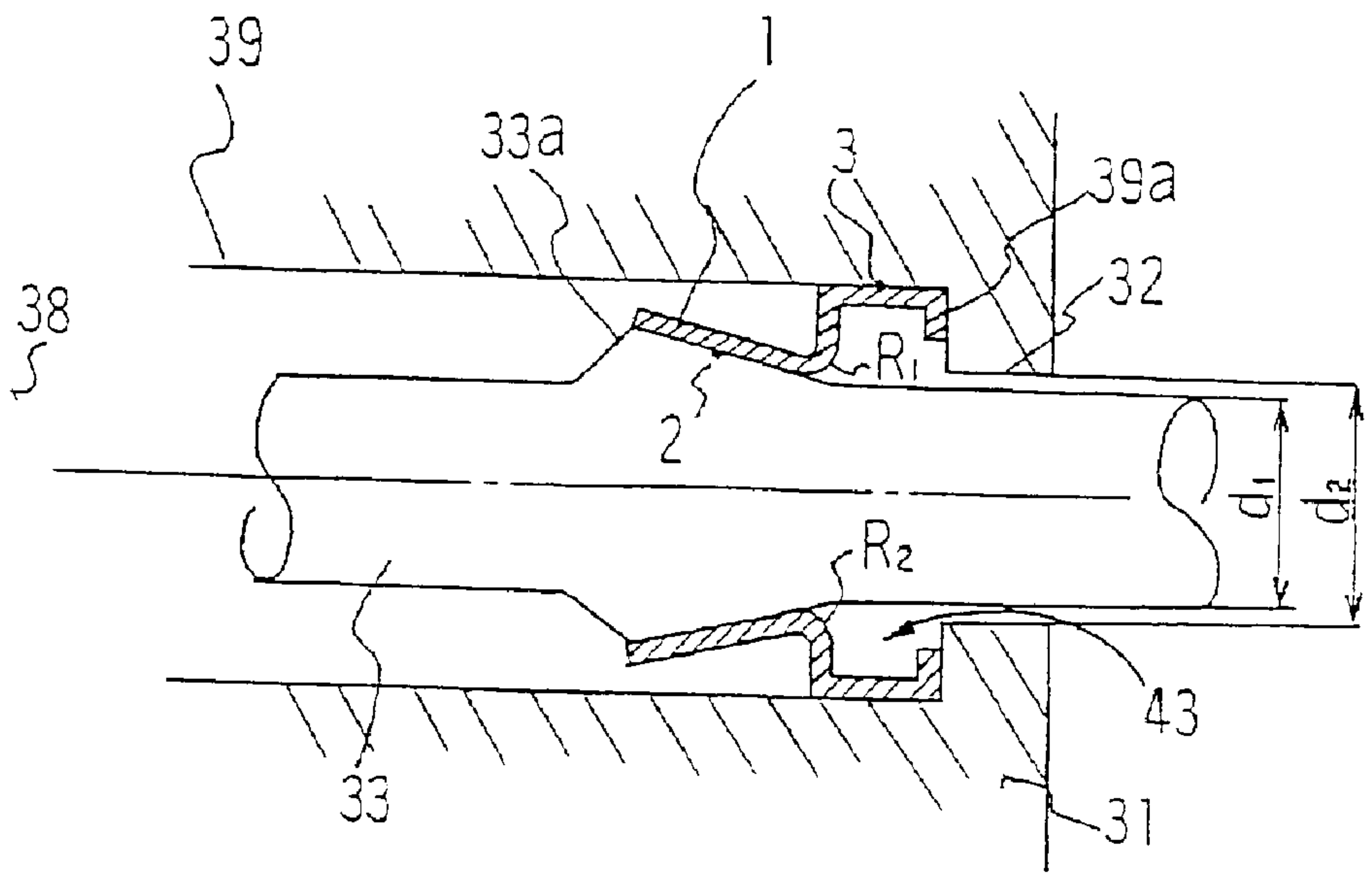
(54) Titre : DISPOSITIF D'ETANCHEITE ENTRE UN BOULON DE FIXATION ET UN TROU DE BOULON DANS UN DISQUE DE TURBINE A GAZ

(54) Title: SEAL DEVICE BETWEEN FASTENING BOLT AND BOLTHOLE IN GAS TURBINE DISC



(57) Abrégé/Abstract:
Seal device between fastening bolt and bolthole in gas turbine disc reduces cooling steam leaking from gap between the fastening bolt and the bolthole. In the gas turbine disc 31 carrying moving blades, fastening bolt 33 for fixing the disc 31 passes through in the bolthole 32. On low pressure side of the disc 31, bolthole diameter enlarged portion 39 having larger diameter than that d_2 of the bolthole 32 is provided. Fastening bolt 33 is provided with shaft diameter enlarged portion 33a. Seal piece 1 is fitted at its one end around the shaft diameter enlarged portion 33a and is engaged at the other end with stepped portion of the bolthole diameter enlarged portion 39. In operation of gas turbine, the bolt 33 is biased outwardly by centrifugal force and the gap between the bolt 33 and the bolthole 32 deforms. Nevertheless, the seal piece 1, having flexibility, deforms at bent portions R_1 and R_2 to maintain close contactability and steam 43 is prevented from leaking from high pressure side to low pressure part 38 and sealing ability is maintained.

Abstract of the Disclosure

Seal device between fastening bolt and bolthole in gas turbine disc reduces cooling steam leaking from gap between the fastening bolt and the bolthole. In the gas turbine disc 31 carrying moving blades, fastening bolt 33 for fixing the disc 31 passes through in the bolthole 32. On low pressure side of the disc 31, bolthole diameter enlarged portion 39 having larger diameter than that d_2 of the bolthole 32 is provided. Fastening bolt 33 is provided with shaft diameter enlarged portion 33a. Seal piece 1 is fitted at its one end around the shaft diameter enlarged portion 33a and is engaged at the other end with stepped portion of the bolthole diameter enlarged portion 39. In operation of gas turbine, the bolt 33 is biased outwardly by centrifugal force and the gap between the bolt 33 and the bolthole 32 deforms. Nevertheless, the seal piece 1, having flexibility, deforms at bent portions R_1 and R_2 to maintain close contactability and steam 43 is prevented from leaking from high pressure side to low pressure part 38 and sealing ability is maintained.

SPECIFICATION

SEAL DEVICE BETWEEN FASTENING BOLT AND BOLTHOLE IN GAS TURBINE DISC

BACKGROUND OF THE INVENTION:

Field of the Invention:

The present invention relates to a seal device between fastening bolt and bolthole in a gas turbine disc and more specifically to a seal device for sealing a gap between fastening bolt and bolthole in a disc of steam-cooled type gas turbine so as to reduce leakage of cooling medium outside.

Description of the Prior Art:

As a present state of the gas turbine cooling system, air-cooled one is a main current, wherein air is partially extracted from compressor to be introduced into stationary blade, moving blade and rotor for cooling thereof and the air after used for the cooling is discharged into combustion gas passage. Recently, accompanying with the high efficiency of power plant, a combined cycle plant is being developed in which gas turbine and steam turbine are used in combination and a steam-cooled system of gas turbine is in process of development to be used in the combined cycle plant, said steam-cooled system being such that steam is partially extracted from the steam turbine to be introduced into stationary blade, moving blade and rotor of the gas turbine for cooling thereof and the steam after used for the cooling is recovered to the steam turbine side for effective use thereof.

Fig. 6 is a cross sectional view showing one example of a steam-cooled type gas turbine in the prior art, wherein such a steam-cooled system as mentioned above is employed and cooling of moving blades by steam is carried out, same as in the present invention. In Fig. 6, numerals 21, 22, 23 and 24 designate a first to a fourth stage moving blades, respectively, and numerals 51, 52, 53 and 54 designate a first to a fourth stage stationary blades, respectively. Numeral 31 designates a disc on a rotor side and numeral 32 designates a bolthole, which is provided in plural pieces along the circumferential direction in the disc 31 so as to pass through the disc portion in the axial direction, said disc portion carrying the moving blades 21 to 24 of respective stages. Numeral 33 designates a fastening bolt, which is inserted so as to pass through the bolthole 32 in the axial direction and to fasten fixedly the disc portion carrying the moving blades of respective stages. Numeral 34 designates a steam introduction passage, into which steam of appropriate temperature extracted from the steam turbine side is introduced via a disc end portion. Numeral 35 designates a steam recovery passage, which is for recovering therethrough the steam after used for the cooling of moving blades and is provided with a deviated phase from the steam introduction passage 34 in the circumferential direction. Numeral 36, 37, respectively, designates a cavity of the disc 31.

The gas turbine of Fig. 6 is an example which employs a steam-cooled system for the first stage moving blade 21 and the second stage moving blade 22 and an air-cooled system for the third stage moving blade 23 and the fourth stage moving blade 24, as there is less thermal load and thus less advantage of steam-cooled system in the latter two stages as compared with the former two stages. In Fig. 6, the extracted steam is fed into the disc 31 end portion to be supplied therefrom into the steam introduction passage 34. The steam 41 so supplied enters the cavity 36 and then, passing through a steam passage (not shown), enters the second stage moving blade 22 to cool the blade 22 while passing through an introduction side of a cooling steam passage provided in the blade 22, and the steam after used for the cooling passes through a recovery side of the cooling steam passage to be recovered into the cavity 37. Likewise, the steam 41 enters the first stage moving blade 21 to cool the blade 21 and, after used for the cooling, is recovered into the cavity 37.

The steam so recovered after having cooled the first stage moving blade 21 and the second stage moving blade 22 gathers in the cavity 37 and then, passing through the steam recovery passage 35, is recovered from the disc 31 end portion as a recovery steam 42 of elevated temperature to be further returned to the steam turbine side for effective use thereof.

Fig. 7 is a cross sectional view taken on line X-X in arrow direction of Fig. 6. Fig. 7 shows a state where the rotor is rotating. The fastening bolt 33, inserted into the bolthole 32, has a diameter which is slightly smaller than that of the bolthole 32 and in the state of the rotor being rotating as shown there, the fastening bolt 33 is biased outwardly due to the centrifugal force, so that there occurs a gap S on an inner side within the bolthole 32. Thus, passing through the gap S, a portion of the steam from the cavity 36 or 37 leaks into a low pressure part 38, as shown by numeral 43 in Fig. 6. If amount of the leakage becomes large, there occurs a loss of recovery steam so as to cause an efficiency lowering.

As mentioned above, in the prior art gas turbine which uses air as cooling medium, the stationary blade, moving blade and rotor are cooled by air and the air after used for the cooling is discharged into the combustion gas passage with no recovery thereof being necessitated. In the gas turbine which employs the steam-cooled system, however, the steam after used for the cooling is recovered to be returned to the steam turbine side, so that the temperature-elevated steam through the cooling is used effectively. Therefore, if the steam leaks outside, it becomes a loss of thermal energy by that degree to lead to a lowering of efficiency. In the prior art gas turbine, if the bolt is biased in the bolthole due to the centrifugal force, there occurs a gap deformation between the bolt and the bolthole and there is a problem in this case that a ring-shape seal component that is widely used in the prior art for sealing a gap of concentric circle shape cannot be used.

SUMMARY OF THE INVENTION:

It is therefore an object of the present invention to provide a seal device between fastening bolt and bolthole in a gas turbine disc, and more specially a seal device for sealing a gap between fastening bolt and bolthole, from where a large amount of leakage of steam occurs, in a disc of steam-cooled type gas turbine, to thereby reduce greatly a leakage of steam outside even if the bolt is biased in the bolthole due to the centrifugal force and shape of the gap is deformed.

In order to attain said object, the present invention provides means of the following (1) to (3);

(1) A seal device between a fastening bolt and a bolthole in a disc of gas turbine, said disc of gas turbine being constructed such that a bolthole is provided to pass through said disc in an axial direction thereof from front stages to rear stages of the gas turbine, a fastening bolt is disposed insertedly in said bolthole so as to fix said disc, and a steam

introduction passage and a steam recovery passage for a moving blade cooling steam are provided in parallel with said fastening bolt in said disc so as to connect to an introduction side and a recovery side, respectively, of a cooling steam passage provided in each moving blade via a respective independent cavity, thereby steam flows from said steam introduction passage to said steam recovery passage while cooling the blade and, after used for the cooling, is recovered, characterized in that said seal device comprises a diameter enlarged portion provided in said bolthole on a disc low pressure side thereof and a seal piece, having a flexibility, disposed in said diameter enlarged portion so as to make a close contact at one end portion of said seal piece with an outer periphery of said fastening bolt and at the other end portion of said seal piece with an inner wall of said diameter enlarged portion.

(2) A seal device between a fastening bolt and a bolthole in a disc of gas turbine as mentioned in (1) above, characterized in that said seal piece is divided into two seal pieces in the axial direction, one seal piece thereof making a close contact at its one end portion with the outer periphery of said fastening bolt and at its the other end portion with the inner wall of said diameter enlarged portion and the other seal piece thereof being fixed to an inner periphery of a fitting element disposed in a stepped portion of said diameter

enlarged portion, and an O-ring is interposed between said two seal pieces and the inner wall of said diameter enlarged portion.

(3) A seal device between a fastening bolt and a bolthole in a disc of gas turbine as mentioned in (2) above, characterized in that said the other seal piece is in a thread engagement with the inner periphery of said fitting element disposed in the stepped portion of said diameter enlarged portion.

The fastening bolt for the gas turbine disc, having a slightly smaller diameter than the bolthole, is disposed insertedly in the bolthole to fix the disc. While the rotor is rotating, the fastening bolt in the disc is biased outwardly in the bolthole by the centrifugal force of rotation and the gap between the bolt and the bolthole deforms so that the inner side gap becomes larger than the outer side gap.

On the other hand, the steam introduction passage and the steam recovery passage for steam which cools the moving blades connect to the introduction side and the recovery side, respectively, of the cooling steam passage provided in each of the moving blades via the respective independent cavity, and a portion of the steam for cooling the moving blades will flow out from the cavity through the gap between the fastening bolt and the bolthole. But, as mentioned above, the fastening bolt is biased and the gap deforms due to the centrifugal force and thus a ring-shape sealing component that is widely used in the prior art for sealing a gap of concentric circle shape cannot exhibit its sealing function in the above case, as there occurs still a gap if that ring-shape sealing component is inserted as it is.

In the invention of (1) above, the seal piece is fitted around the fastening bolt at one end portion thereof and makes contact with the inner wall of the bolthole diameter enlarged portion at the other end portion, thereby the steam which is going to leak from the high pressure side into the low pressure part can be prevented. This seal piece has a flexibility enough and is made of a material of high tensile strength steel or the like which is excellent in a heat resistance, thereby if the fastening bolt deforms to be biased in the bolthole by the centrifugal force, as mentioned above, that deformation is absorbed by the flexibility of the seal piece and the portion of the seal piece in close contact with the inner wall of the bolthole diameter enlarged portion and the outer periphery of the fastening bolt do not peel off, so that the steam is prevented from leaking and the sealing ability can be secured. Also, loss of thermal energy due to steam leakage can be prevented.

In the invention of (2) and (3) above, the seal piece is divided into two parts, thereby workability at the time of assembling the seal piece becomes facilitated. That is, while one seal piece is fitted around the fastening bolt, the other seal piece can be fitted to the end portion of the bolthole diameter enlarged portion, hence there is no need of assembling a seal piece of complicated shape formed in one unit around the fastening bolt in the bolthole.

BRIEF DESCRIPTION OF THE DRAWINGS:

Fig. 1 is an entire cross sectional view showing state of fitting of a seal device between fastening bolt and bolthole in a disc of gas turbine of a first embodiment according to the present invention.

Fig. 2 is an enlarged cross sectional view of the seal device of the first embodiment of Fig. 1.

Fig. 3 is a cross sectional view showing state of a fastening bolt of the seal device of Fig. 1 being biased.

Fig. 4 is an enlarged cross sectional view of a seal device of a second embodiment according to the present invention.

Fig. 5 is an enlarged cross sectional view of an O-ring portion of the seal device of Fig. 4.

Fig. 6 is a cross sectional view showing one example of a steam-cooled type gas turbine in the prior art.

Fig. 7 is a cross sectional view taken on line X-X in arrow direction.

DESCRIPTION OF THE PREFERRED EMBODIMENTS:

Herebelow, description will be made concretely on embodiments according to the present invention with reference to the figures. Fig. 1 is an entire cross sectional view showing state of fitting of a seal device between fastening bolt and bolthole in a disc of gas turbine of a first embodiment according to the present invention. In Fig. 1, structure of the gas turbine itself is same as that of the prior art one shown in Fig. 6 with same numerals being used commonly for designating same components, and feature of the present invention of providing a seal piece 1 will be described in detail below.

Fig. 2 is an enlarged cross sectional view of the seal device comprising the seal piece 1. On a low pressure part 38 side of a bolthole 32 in a disc 31, there is provided a bolthole diameter enlarged portion 39. In the bolthole diameter enlarged portion 39 on the low pressure part 38 side of a fastening bolt 33, there is provided a shaft diameter enlarged portion 33a in which diameter of the fastening boflt 33 is enlarged with gradient. The seal piece 1 is disposed such that its one end portion has its seal face 3 abutting on the bolthole diameter enlarged portion 39 and a stepped portion 39a thereof so as to maintain a close contact therebetween along the circumferential direction and the other end portion of the seal piece 1 has its seal face 2 fitted around the enlarged portion with gradient of the shaft diameter enlarged portion 33a so as to maintain a close contact therebetween.

On the low pressure part 38 side of the disc 31, there is bored the bolthole diameter enlarged portion 39 of which diameter is larger than a diameter d_2 of the bolthole 32, and at a terminal end portion of the bolthole diameter enlarged portion 39, there is formed the stepped portion 39a which projects to extend to the bolthole 32.

The fastening bolt 33 is disposed insertedly in the bolthole 32, wherein a diameter d_1 of the fastening boflt 33 is smaller than the diameter d_2 of the bolthole 32, and the shaft diameter enlarged portion 33a is disposed in the bolthole diameter enlarged portion 39, wherein a diameter of the enlarged portion with gradient of the shaft diameter enlarged portion 33a is larger than the diameter d_1 of the fastening bolt 33.

The seal face 2 of the seal piece 1 is urged onto an outer peripheral surface of the shaft diameter enlarged portion 33a by a differential pressure acting from a high pressure side on a low pressure side and by a flexibility of the seal piece 1 itself which absorbs relative deformation of the disc 31 and the bolt 33 in a longitudinal direction of the bolt 33, and the seal face 3 of the seal piece 1 is also urged onto an inner peripheral surface of the bolthole diameter enlarged portion 39 by its own flexibility. Thus, the seal is so constructed and the seal piece 1 is made of a material of high tensile strength steel or the like which may resist a high temperature and provide a flexible effect.

Fig. 3 is a cross sectional view showing state of the seal piece 1 when the fastening bolt 33 is biased outwardly due to the centrifugal force while the gas turbine is rotating. The fastening bolt 33 is moved outwardly within the bolthole 32 by the centrifugal force and there occurs a deviation ΔL between bolt center O_1 and bolthole center O_2. At this time, the seal piece 1, by its flexible effect, contracts at its outer side bent portion R_1 and elongates at its inner side bent portion R_2 and thus the seal faces 2 and 3 make close contact with the outer peripheral surface of the shaft diameter enlarged portion 33a and the inner peripheral surface of the bolthole diameter enlarged portion 39, respectively, so as to maintain a sealing function.

In either of the mentioned state of Figs. 2 and 3, leakage steam 43 which will flow out through a gap between the bolt 33 and the bolthole 32 is prevented from flowing into the low pressure side from the high pressure side by the seal faces 2 and 3 of the seal piece 1, even though the leakage steam 43 once flows into the bolthole diameter enlarged portion 39 through said gap. Thus, the steam is prevented from leaking into the low pressure part 38.

Fig. 4 is an enlarged cross sectional view of a seal device of a second embodiment according to the present invention. A bolthole diameter enlarged portion 39 has a stepped portion 39b. This stepped portion 39b is recessed in the bolthole diameter enlarged portion 39 reversely of the stepped portion 39a of the first embodiment shown in Figs. 2 and 3 and a threaded fitting element 14 is fixed being inserted into the stepped portion 39b with an outer periphery of the threaded fitting element 14 being interference-fitted. Numeral 11 designates a seal piece, one end portion of which is bent to enlarge vertically and to form a contact line 15 with an O-ring 13 and the other end portion of which makes a close contact with an outer periphery of an enlarged portion with gradient of a shaft diameter enlarged portion 33a of the fastening bolt 33.

Another seal piece 12 has a threaded portion 12a around its outer periphery and has a tapered portion at its one end. The threaded portion 12a is in a thread engagement with the threaded fitting element 14 so that the seal piece 12 is fixed. Between a vertical face of the seal piece 11 and the tapered portion of the seal piece 12, there is disposed the O-ring 13 pinchedly. The seal piece 11 is flexible at bent portions R_1 and R_2, like the seal piece 1 of the first embodiment so as to absorb deformation due to biasing of the fastening bolt 33, like in Fig. 3. Thus, there are formed contact lines between the seal piece 11 and the O-ring 13, the seal piece 12 and the O-ring 13 and the O-ring 13 and an inner wall of the bolthole diameter enlarged portion 39, respectively, so that the respective seal faces are ensured.

Fig. 5 is an enlarged cross sectional view of the O-ring portion of the second embodiment. As shown there, by virtue of the three contact lines, that is, the contact line 15 of the O-ring 13 and the seal piece 11, a contact line 16 of the O-ring 13 and the inner wall of the bolthole diameter enlarged portion 39 and a contact line 17 of the O-ring 13 and the seal piece 12, the sealing function is secured so that the steam which will flow out from the high pressure side to the low pressure side through the gap between the bolt 33 and the bolthole 32 is prevented from so leaking.

It is understood that the invention is not limited to the particular construction and arrangement herein illustrated and described but embraces such modified forms thereof as come within the scope of the following claims.

WHAT IS CLAIMED IS:

1. A seal device between a fastening bolt and a bolthole in a disc of gas turbine, said disc (31) of gas turbine being constructed such that a bolthole (32) is provided to pass through said disc (31) in an axial direction thereof from front stages to rear stages of the gas turbine, a fastening bolt (33) is disposed insertedly in said bolthole (32) so as to fix said disc (31), and a steam introduction passage (34) and a steam recovery passage (35) for a moving blade cooling steam are provided in parallel with said fastening bolt (33) in said disc (31) so as to connect to an introduction side and a recovery side, respectively, of a cooling steam passage provided in each moving blade via a respective independent cavity, thereby steam flows from said steam introduction passage (34) to said steam recovery passage (35) while cooling the blade and, after used for the cooling, is recovered, characterized in that said seal device comprises an enlarged diameter portion (39) provided in said bolthole (32) on a disc low pressure side thereof and a seal piece (1), having a flexibility, disposed in said enlarged diameter portion (39) so as to make a close contact at one end portion of said seal piece (1) with an outer periphery of said fastening bolt (33) and at the other end portion of said seal piece (1) with an inner wall of said enlarged diameter portion (39).

2. A seal device between a fastening bolt and a bolthole in a disc of gas turbine as claimed in claim 1, characterized in that said seal piece (1) is divided into two seal pieces (11, 12) being coaxial with each other,

one seal piece (11) thereof making a close contact at one end portion thereof with the outer periphery of said fastening bolt (33) and at the other end portion thereof with the inner wall of said enlarged diameter portion (39) and the other seal piece (12) thereof being fixed to an inner periphery of a fitting element (14) disposed in a stepped portion (39b) of said enlarged diameter portion (39), and an O-ring (13) is interposed between said two seal pieces (11, 12) and the inner wall of said enlarged diameter portion (39).

3. A seal device between a fastening bolt and a bolthole in a disc of gas turbine as claimed in claim 2, characterized in that said the other seal piece (12) is in a thread engagement with the inner periphery of said fitting element (14) disposed in the stepped portion (39b) of said enlarged diameter portion (39).

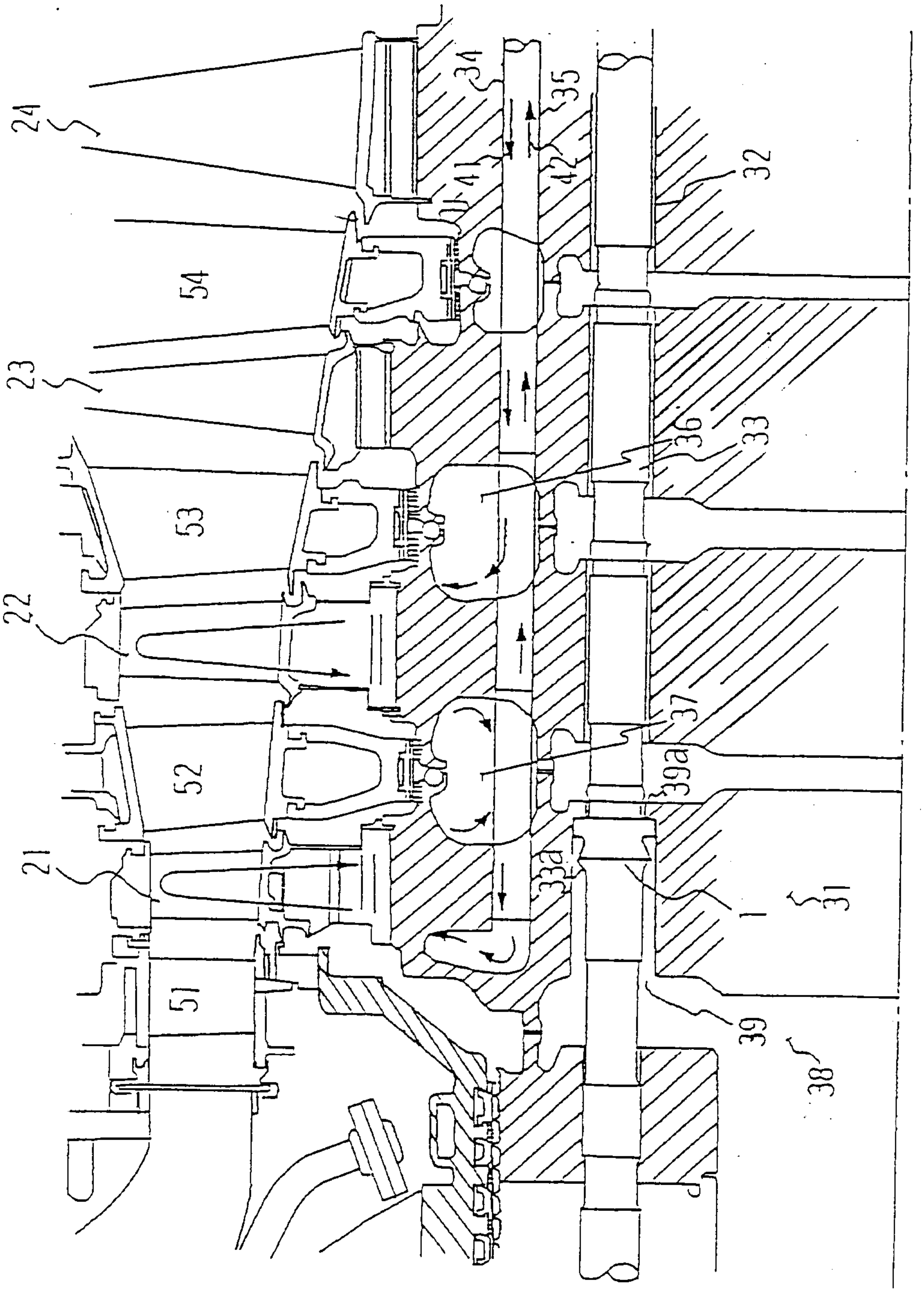
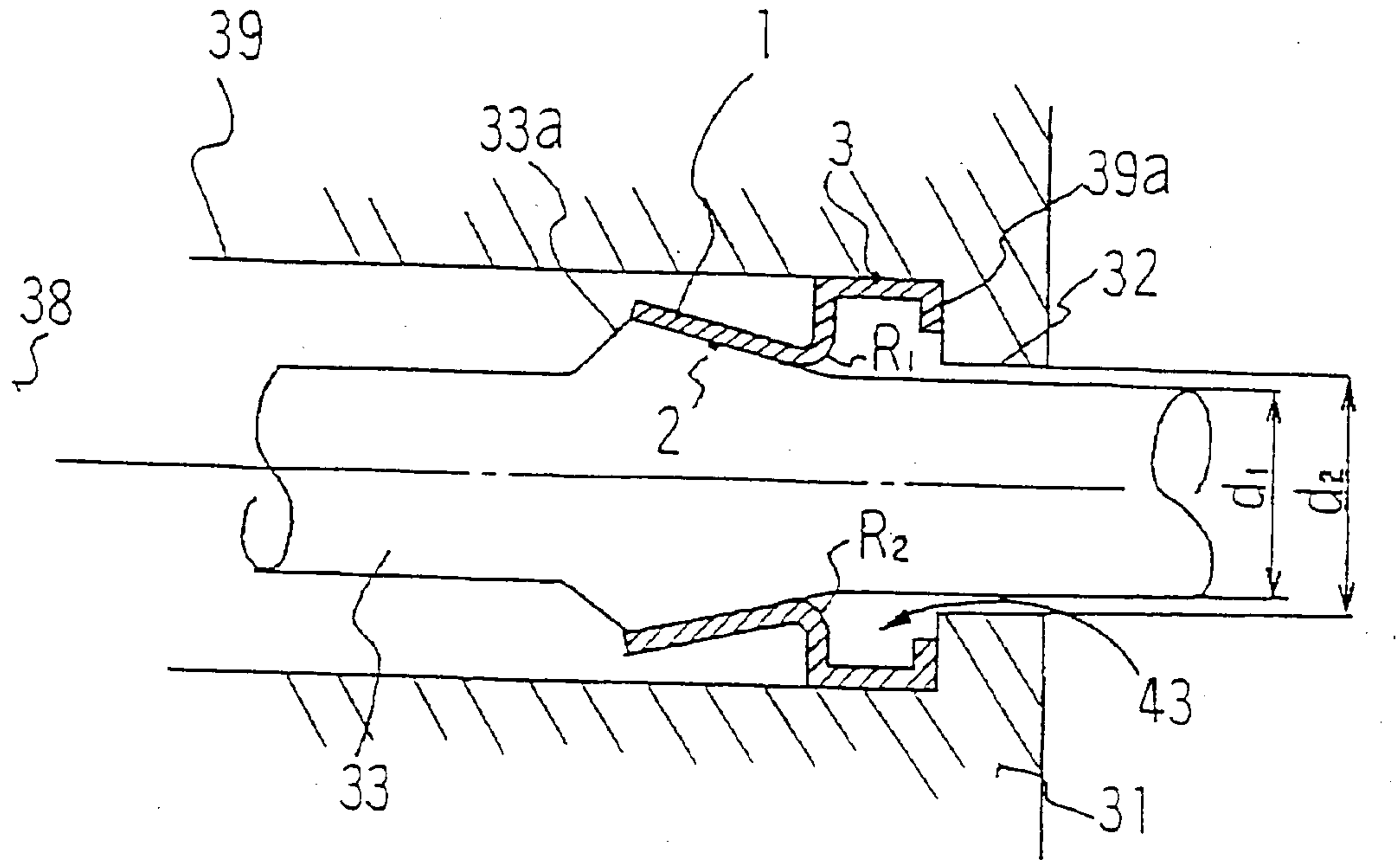


Fig. 1

Fig. 2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33a
3
39a
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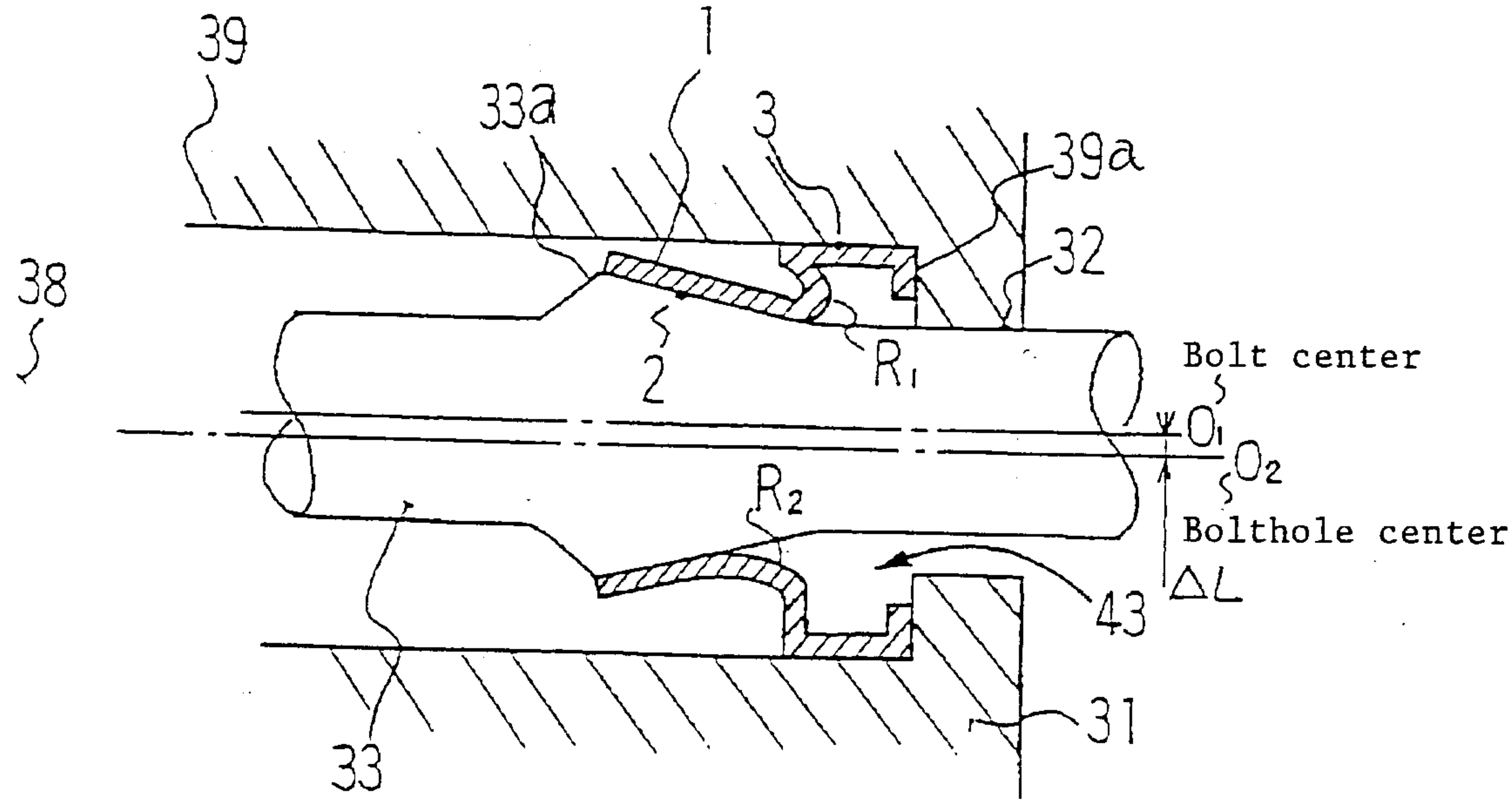
38
R1
2
d1
d2
R2
43
33
31

Fig. 3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33a
3
39a
32
38
R1
2
Bolt center
O1
O2
R2
Bolthole center
ΔL
43
33
31

Fig. 4

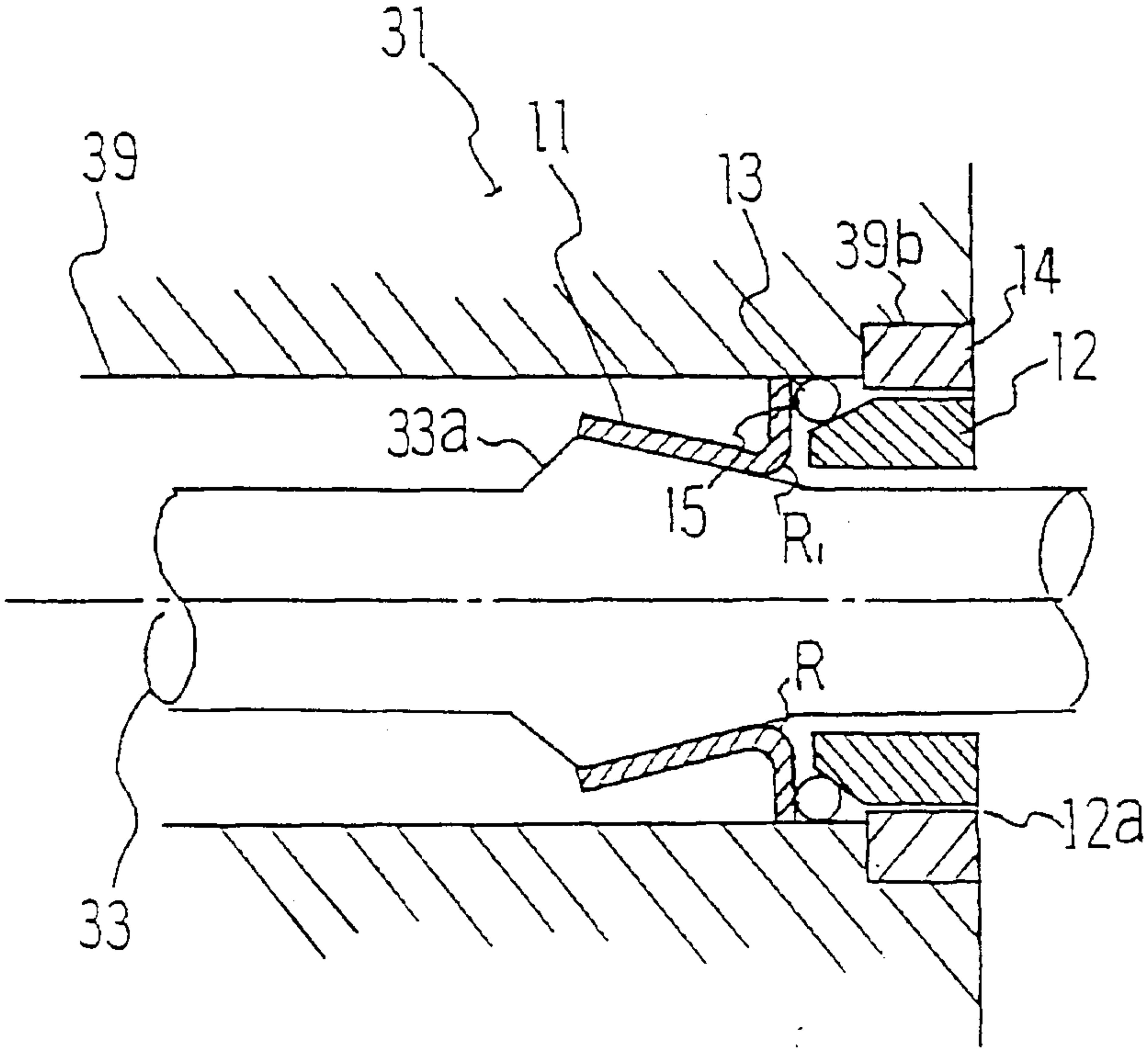
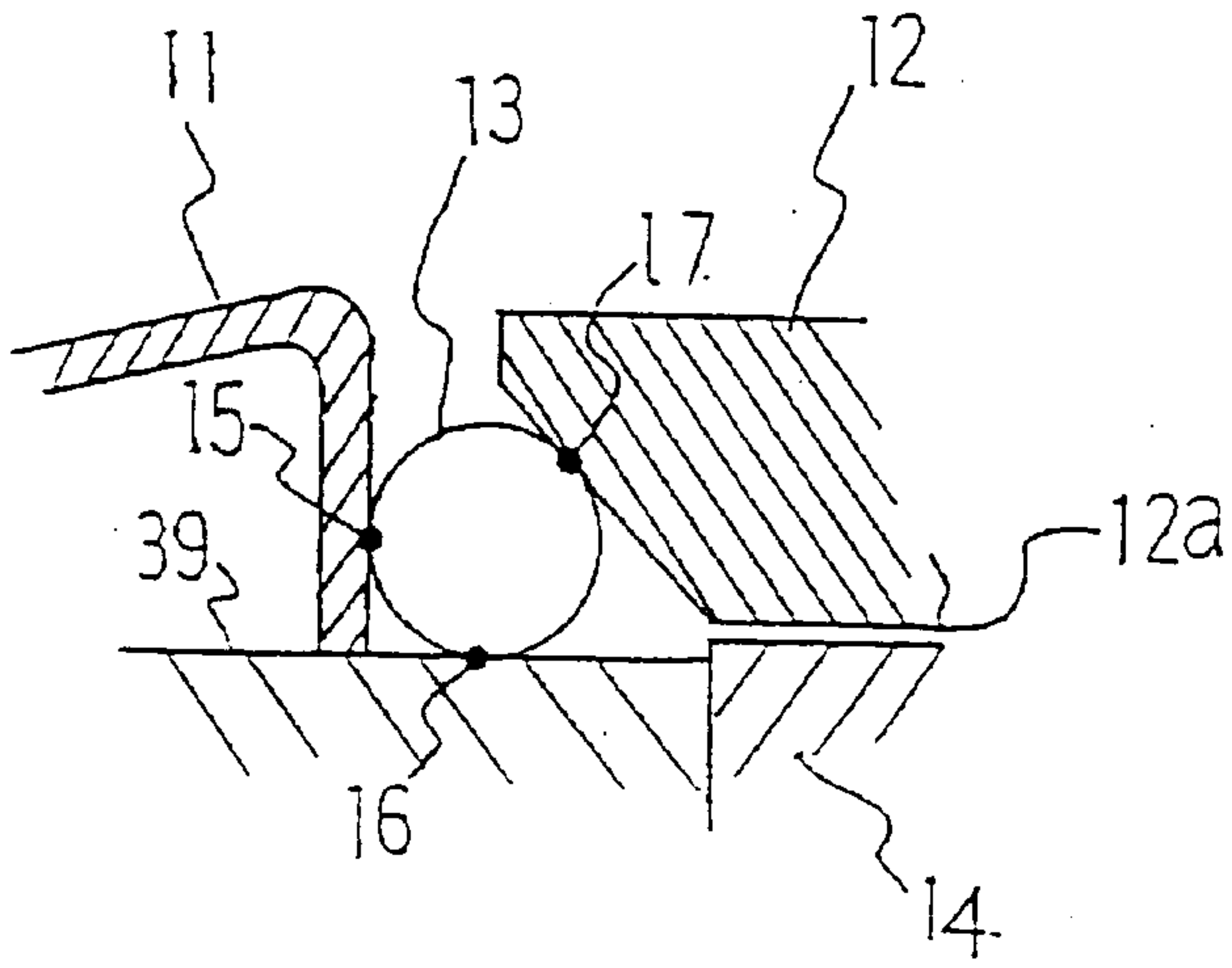


Fig. 5



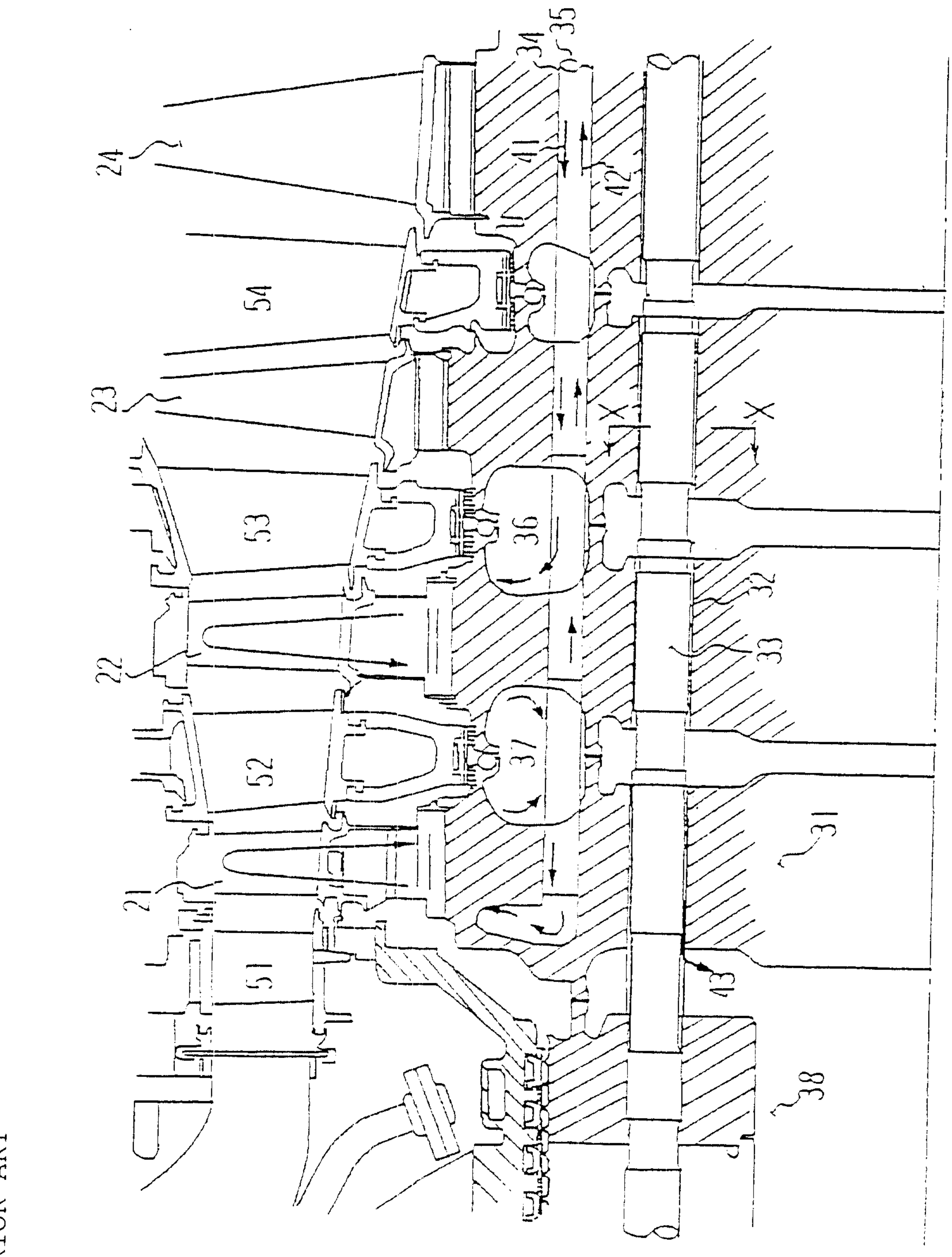
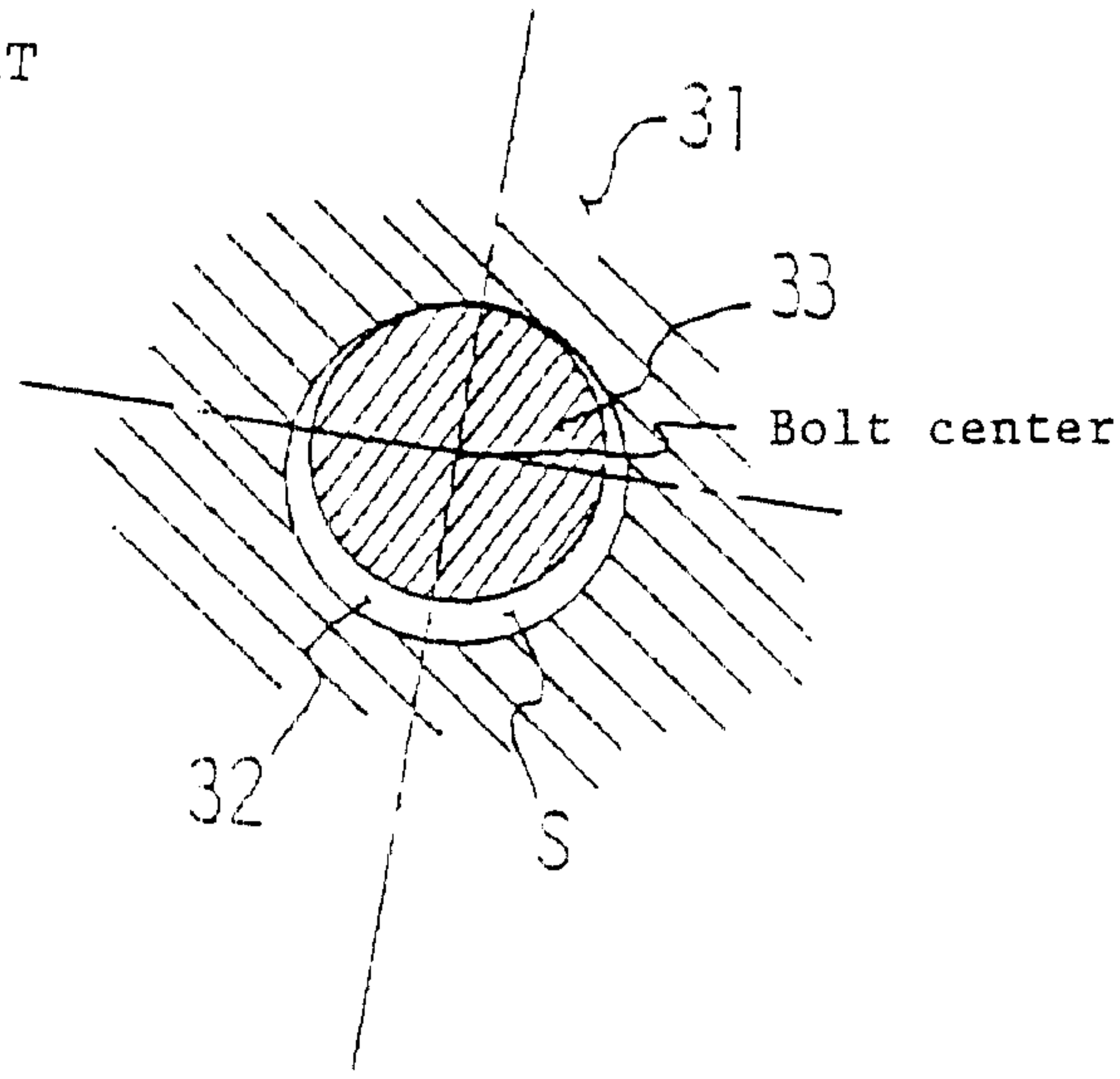


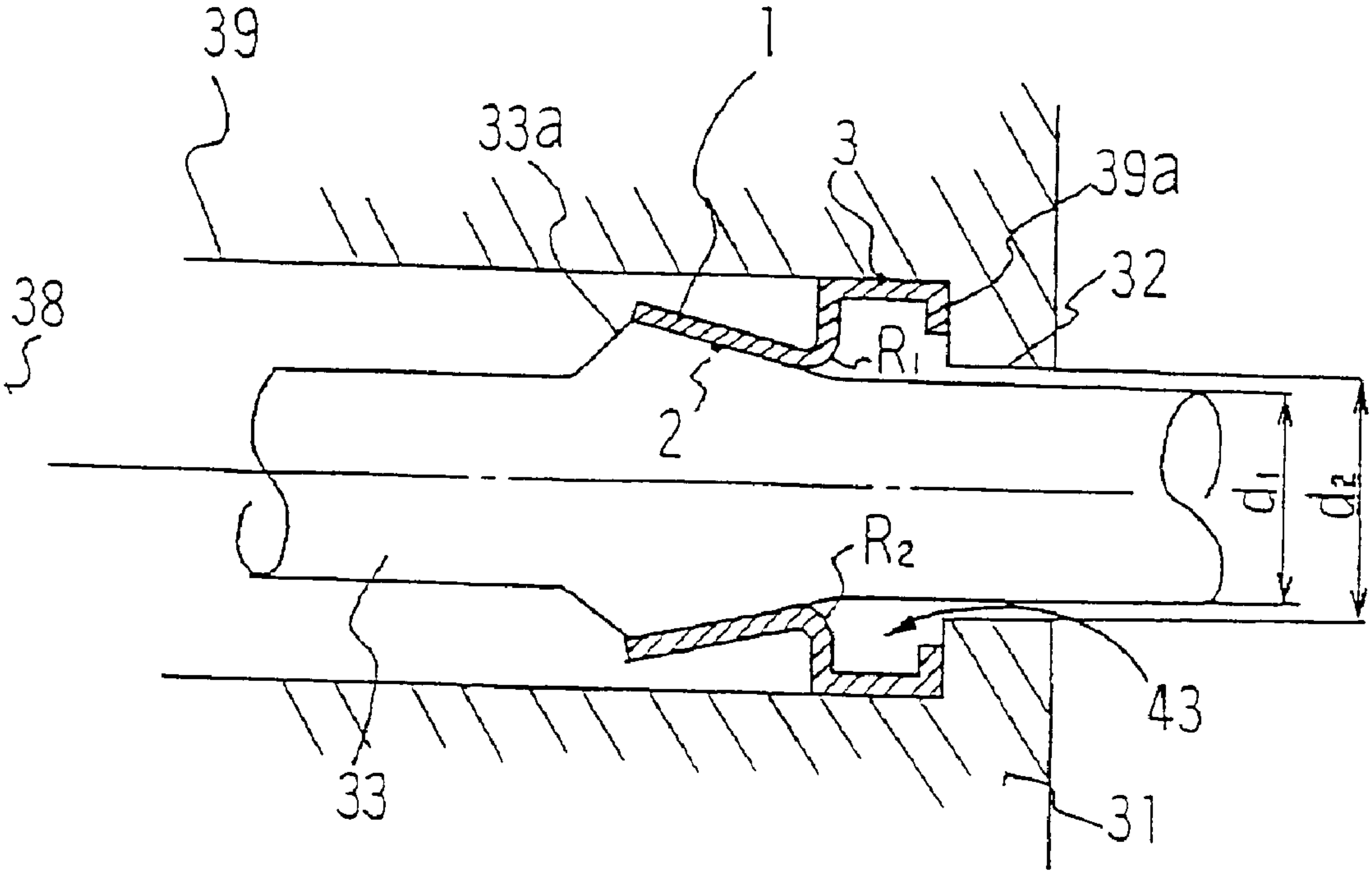
Fig. 6

PRIOR ART

Fig. 7

PRIOR ART





39
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33a
3
39a
32
38
R1
2
d1
d2
R2
43
33
31