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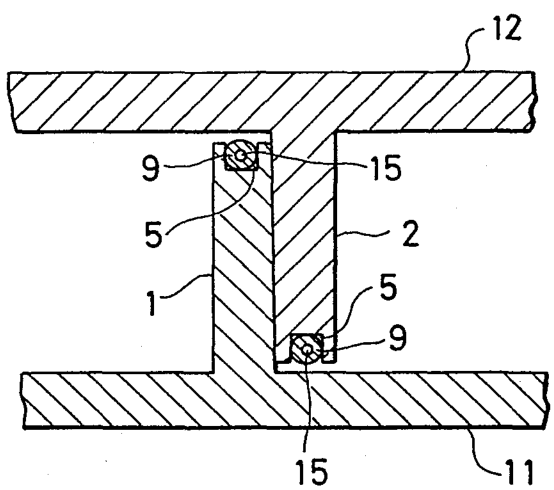
(54) Scroll-type compressor.

(57) A scroll-type compressor having improved tip seal elements (9) at the ends of scrolls (1, 2) of the compressor. Grooves (5) are formed in the ends of the stationary and orbiting scrolls (1, 2) of the compressor opposite the ends of the scrolls' end plates (11, 12). Tip seal elements (9) made of an expandable material and which are capable of being inflated preferably in response to a pressure difference between a high pressure side of the compression chamber of the compressor and the low pressure side thereof, are disposed along the grooves (5). In one embodiment the tip seal elements take the form of a hollow tube (9) having one end closed and the other end in communication with the high pressure side. In another embodiment, the tip seal elements are tubes in which a fluid such as a coolant is sealed. In still another embodiment, the tip seal elements take the form of a thin resilient strip sealed to the end surfaces of the grooves except for an innermost end portion, which is in fluid communication with the high pressure side of the compression chamber.



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SCROLL-TYPE COMPRESSOR

The present invention relates to a scroll-type compressor.

In order to facilitate an understanding of the present invention, the general structure and the principles of operation of a conventional scroll-type compressor will be discussed briefly.

Figs. 1A to 1D illustrate the operating principles of a scroll-type compressor. In Figs. 1A to 1D, a stationary scroll 1 having the shape of a spiral extending a predetermined distance in the lengthwise direction, is stationarily mounted. The term "spiral" as used herein refers to an involute of a circle, an arc of a circle, or the like. An orbiting scroll 2, which may be the complement in configuration of the scroll 1, is interleaved with the stationary scroll 1. The scroll 2 is made to orbit with respect to the stationary scroll 1, that is, to move in a circle without changing its angular orientation relative to the stationary scroll 1, by a suitable drive mechanism (not shown). Relative positions of the scrolls 1 and 2 at 0°, 90°, 180° and 270° of the 360° cycle of the orbiting scroll

2 are shown in Figs. 1A to 1D, respectively.

A plurality of compression chambers 4 are formed between the scrolls 1 and 2. Each of the compression chambers is moved inwardly with the volume thereof being continuously reduced when the orbiting scroll 2 orbits with respect to the stationary scroll 1. The contents of the innermost compression chamber, which is at the highest pressure, is discharged through a discharge port 3.

The distance between the center Θ of the stationary scroll 1 and an innermost fixed point Θ' on the orbiting scroll 2, that is, the crank radius of the orbiting scroll 2, is maintained constant during the orbital movement thereof, and can be represented by:

$$\Theta\Theta' = \frac{P}{2} - t,$$

where P is the distance between adjacent surfaces of the scrolls (which corresponds to the pitch thereof) and t is the thickness of the scrolls.

In such a conventional scroll-type compressor, it has been known that when the pressure in the compression chamber 4 gradually increases with the movement thereof from the outermost position to the innermost position, radial leakage of gas may occur from the high pressure side of the compressor through axial gaps between an end plate of one of the scrolls and the top edge of the other scroll to the low pressure side thereof, causing the compression efficiency of the compressor to be considerably lowered. Therefore, it is impossible to provide a desirably high compression efficiency without using highly precise machining operations, and thus very expensive scrolls and other components associated therewith.

U.S. Patent 3,994,636 discloses the use of a tip seal element at the edge of the spiral arm of each scroll. Such a seal element is illustrated schematically in Figs. 2 and 3. In the case of Fig. 2, which illustrates the relationship of the tip seal element 6 to the scrolls, here, the orbiting scroll, the tip seal element 6 is disposed in a tip seal groove 5 formed in the top edge of the scroll. The tip seal element 6, which is prepared by curling a rectangular rod of a rigid abrasion-resistant material, functions to seal the axial gap between end plate 11 of the stationary scroll 1 and the edge of the orbiting scroll 2 and the axial gap between the end plate 12 of the orbiting scroll 2 and the edge of the stationary scroll 1. Backup springs 7 function to push the tip seal elements 6 against the end plates to seal the scrolls thereagainst.

In the conventional sealing technique illustrated in Fig. 3, the backup springs 7 are necessary to provide sufficient sealing by the tip seal elements 6. The use of

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such springs, however, is cumbersome, they are difficult to assemble, and relatively deep grooves must be formed in the ends of the scrolls to receive such springs. Further, since leakage of pressurized fluid from the high pressure side may still occur through the walls of the grooves to the low pressure side, the secondary sealing effect is insufficient.

An object of the present invention is to provide a scroll-type compressor which does not suffer the disadvantages inherent to the conventional scroll-type compressor having solid tip seal elements.

According to the invention there is provided a scroll-tpye compressor comprising a stationary scroll having one end attached to a first end plate; and orbiting scroll interleaved with said stationary scroll and having one end attached to a second end plate, each of said scrolls having formed in an end surface thereof opposite said one ends a tip seal groove extending along the scroll.

Preferably, in edge portions of the scrolls of the scroll-type compressor tip seal elements are provided which are made of an elastic material and which are capable of being inflated by a pressure on the high pressure side of the compression chamber of the compressor to seal the axial gaps between the stationary scroll and the orbiting scroll.

The tip seal element invention may take the form of either an elastic hollow tube having one end closed and which is fitted in the tip seal groove, or a resilient strip covering the groove except for an innermost end thereof, with the open end of the hollow tube or the open end of the groove being in fluid communication with the high pressure side of the compression chamber so that it is inflated by the pressure of the high pressure side.

For a better understanding of the invention, and to show how the same may be carried into effect, reference will now be made by way of example, to the accompanying drawings, in which:

Figs. 1A to 1D illustrate the operating principles of a scroll-type compressor;

Fig. 2 illustrates a conventional tip seal element fitted in a tip seal groove of a scroll of the compressor;

Fig. 3 is a cross-sectional view of a scroll having a conventional tip seal element;

Figs. 4A to 4C show a preferred embodiment of a tip seal element for use in a compressor according to the invention and in the form of a closed hollow tube, in a side view, in cross section, and in a perspective view, respectively,

Fig. 5 shows a cross section of a compressor having interleaved scrolls having tip sela elements in an uninflated state;

Fig. 6 shows a cross section of the interleaved scrolls in which the tip seal element of the orbiting scroll member has been inflated;

Fig. 7 shows a cross section of the interleaved scrolls having tip seal elements for use in a compressor in accordance with another embodiment of the present invention;

Fig. 8 is view similar to Fig. 2 showing still another embodiment of a compressor according to the invention;

Fig. 9 is a perspective view of the orbiting scroll with a tip seal element in place;

Fig. 10 shows a cross section of the interleaved scrolls with the tip seal element of Fig. 9 in an uninflated state; and

Fig. 11 is a view similar to Fig. 10 showing the tip seal in the inflated state.

Referring now to Figs. 4A to 4C, a tip seal element 9 of a first embodiment of the invention takes the form of a hollow tube having a center hole 15. An end 13 of the tip seal element 9, which is in fluid communication with the high pressure side of the compression chamber, is open while the other end 14, which is disposed on the low pressure side, is closed, as shown in Fig. 4A. The cross section of the tip seal element 9 is circular as shown in Fig. 4B.

The tip seal element 9 is formed by curling a straight hollow tube as shown in Fig. 4C so that it can be received in the tip seal grooves 5 formed in the edge of the scrolls 1 and 2. Tip seal elements 9 are fitted in the tip seal grooves 5 with the open ends 13 thereof at the innermost ends of the tip seal grooves 5 such that the open ends 13 communicate with the high pressure side of the compression chamber formed between the scroll 1 and 2. Fig. 5 shows in cross section tip seal elements 9 fitted in the respective tip seal grooves 5.

Since the open end 13 of each tip seal element 9 communicates with the high pressure side of the compression chamber when the compressor is in operation, the interior 15 of the tip seal element 9 is at a higher pressure than the exterior thereof, and hence the tip seal element 9 is inflated to seal the axial gap between the edge of the scrolls and the adjacent end plates as shown in Fig. 6. The higher the pressure in the discharge chamber the larger will be the sealing effect.

Although in the described embodiment the cross-sectional shape of the tube-type tip seal 9 is circular, it is possible to employ a tube-type tip seal 9' having a rectangular cross section as shown in Fig. 7. Any convenient configuration can be employed so long as the outside wall of the element can intimately contact the walls of the groove and abutting end plate. Further, the cross-sectional shape of the interior 15 of the tube may be any desired practical shape.

In the described embodiments, the tube-type tip seal element has an open end in communication with the high pressure side of the compression chamber so that a high pressure is introduced into the interior of the seal element to inflate it. Alternatively, it is possible to fill the interior with a fluid such as a coolant to form a fluid-tight seal. In the latter case, the coolant pressure in the tube will increase with the temperature increase which occurs during normal operation to inflate the tube to thereby seal the radial gaps in the same manner described above.

The tip seal element according to the present invention provides a secondary sealing effect against leakage of gas along the groove walls.

Fig. 8 shows another embodiment of the present invention. This embodiment differs from the previous embodiments in that the grooves formed in the edge of the scrolls are used to directly introduce the high pressure.

In Fig. 8, the scroll, in this case, the orbiting scroll 2, has the same configuration as that shown in Fig. 2. Instead of one end of the tube 9 being closed, a thin strip 19 in convoluted form corresponding to the groove 5 in the scroll 2 is used as the tip seal element. The thin plate 19 has a width larger than the width of the groove 5 and a length slightly shorter than the length of the groove 5. The plate 19 is fixedly secured to the edge of the scroll 2 so that it completely covers the groove 5 except for the inner end of the groove 5 as shown in Fig. 9.

Fig. 10 shows a cross-sectional view of the orbiting scroll 2 and the stationary scroll 1, specifically showing the arrangement of the strip-type tip seal member 19 on the groove 5 of the orbiting scroll 2. In Fig. 10, the strip-type seal member 19 is attached to the end surface of the scroll 2 by an adhesive or the like 16 so that the groove 5 is closed thereby air-tightly except for the inner end portion, that is, the high pressure side end portion thereof.

When the compressor is in operation with the orbiting scroll driven by a suitable drive mechanism, the pressure in the discharge chamber connected to the discharge port 3 increases, and the increased pressure is introduced through the open end of the groove thereinto. Therefore, the tip seal member 9 is inflated, pushing it upwardly as shown in Fig. 11, to contact the end plate 11 of the stationary scroll 1 to thereby provide the same sealing effect as that obtained by the preceding embodiments.

In this embodiment, it is possible to cover the groove 5 with the tip seal element 19 completely and to form a small hole in the seal element 19 at the position corresponding to the innermost portion of the groove 5. The strip-type tip seal element 19 should be as thin as possible and preferably be made of metal or synthetic resin.

As described hereinbefore, according to the present invention, tip seal elements which are made of elastic material are used in conjunction with grooves formed in the end surfaces of the stationary and orbiting scrolls. The tip seal elements are inflated by the higher pressure introduced through the opening formed at the innermost portion of the grooves to seal the radial gaps. That is, the present invention resides in the utilization of the difference in pressure between the high pressure side of the compression chamber of the scroll-type compressor and the low pressure side thereof and the utilization of an elastic tip seal element which is inflated due to the pressure difference to seal the radial gaps between the stationary scroll and the end plate of the orbiting scroll and between the orbiting scroll and the end plate of the stationary scroll. Thus, the invention is much simpler in structure than the conventional tip seal mechanism and the tip seal of the present invention does not require any elements which need high precision machining or elements such as backup springs which are necessary in the conventional tip seal mechanism, resulting in a considerably improved reliability at a low cost. Further, according to the present invention, secondary leakage of gas along the walls of the grooves is also prevented, resulting in a considerable improvement of the efficiency of the compressor.

CLAIMS

1. A scroll-type compressor comprising a stationary scroll (1) having one end attached to a first end plate (11); and orbiting scroll (2) interleaved with said stationary scroll (1) and having one end attached to a second end plate (12), each of said scrolls (1, 2) having formed in an end surface thereof opposite said one ends a tip seal groove (5) extending along the scroll; characterized by two tip seal means (9; 9'; 19) arranged along respective grooves (5) and being capable of being expanded to seal axial gaps between said end surfaces of said scrolls (1, 2) and respective ones of said end plates (11, 12) thereby to prevent radial fluid leakage.

2. A compressor according to claim 1, characterized in that said seal means (9; 9'; 19) are capable of being inflated by pressure difference between a high pressure side and a low pressure side of said compression chamber.

3. A compressor according to claim 1 or 2, characterized in that said seal means (9; 9'; 19) are disposed in respective grooves.

4. A compressor as claimed in claim 3, characterized in that each said tip seal means comprises a hollow tube (9; 9') of an elastic material.

5. A compressor as claimed in claim 4, characterized in that one end of said hollow tube (9; 9') on said low pressure side of said compressor is closed and the other end thereof is in fluid communication with said high pressure side.

6. A compressor as claimed in claim 4 or 5, characterized in that said hollow tube (9; 9') is circular in cross section.

7. A compressor as claimed in claim 4 or 5, characterized in that said hollow tube (9; 9') is rectangular in cross section.

8. A compressor as claimed in claim 2, characterized in that each said tip seal means comprises a thin resilient strip (19') sealed to said end surface along said groove except for an innermost protion thereof which is in fluid communication with said high pressure side.

9. A compressor as claimed in claim 1, characterized in that said tip seal means are sealed to said tip seal grooves and are filled with a fluid, e.g. a coolant, for inflating said tip seal elements in response to temperature increase.

FIG. 1A
PRIOR ART

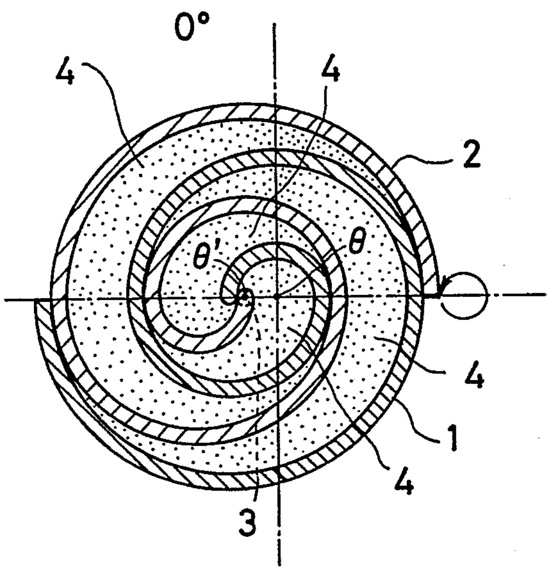

FIG. 1D
PRIOR ART

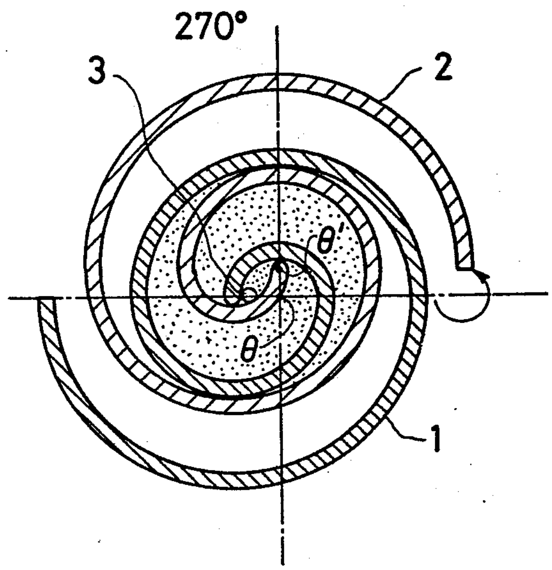

FIG. 1B
PRIOR ART

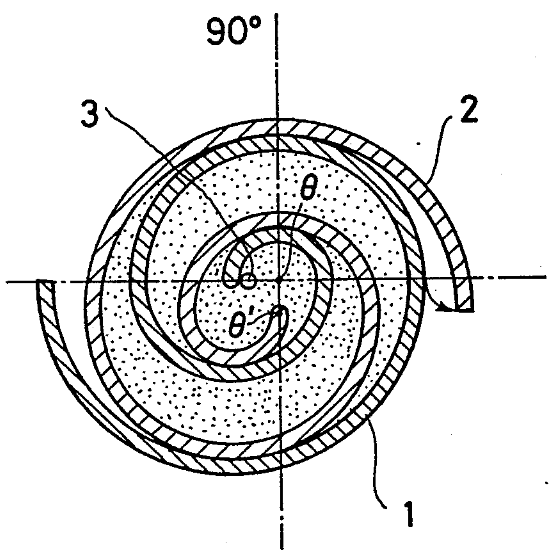

FIG. 1C
PRIOR ART

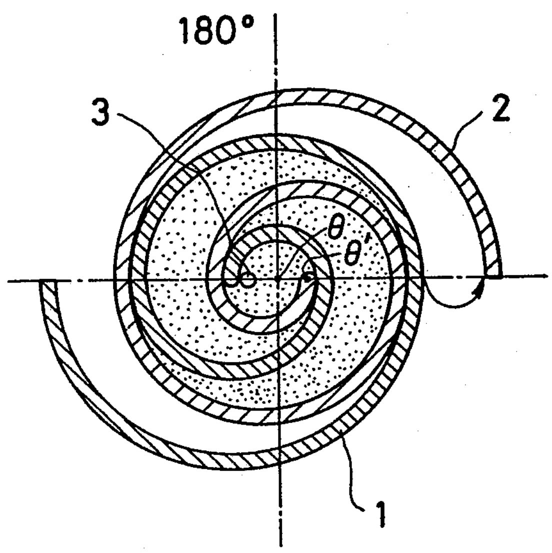

FIG. 2

PRIOR ART

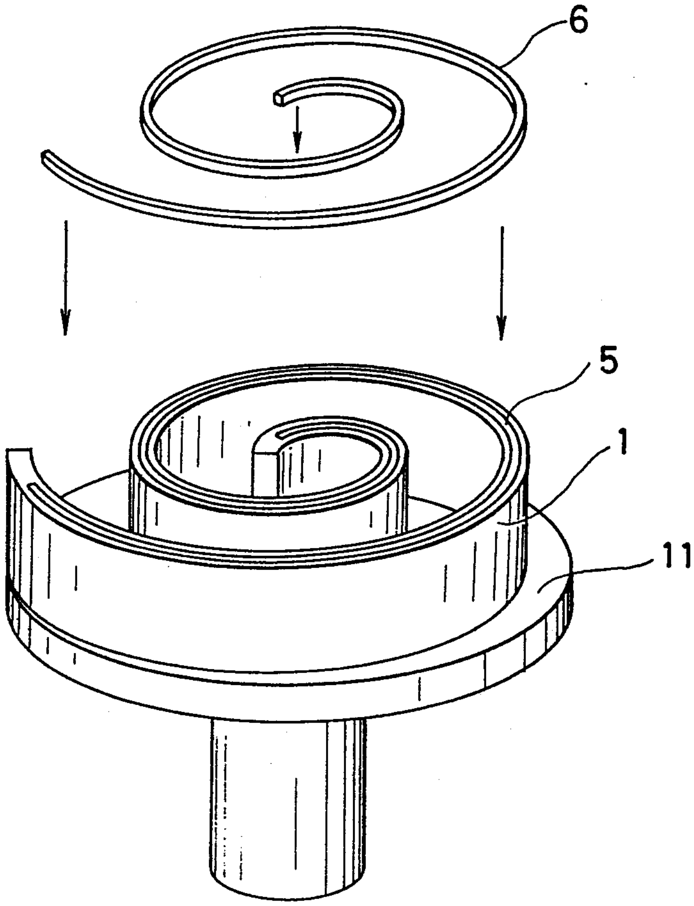

FIG. 3

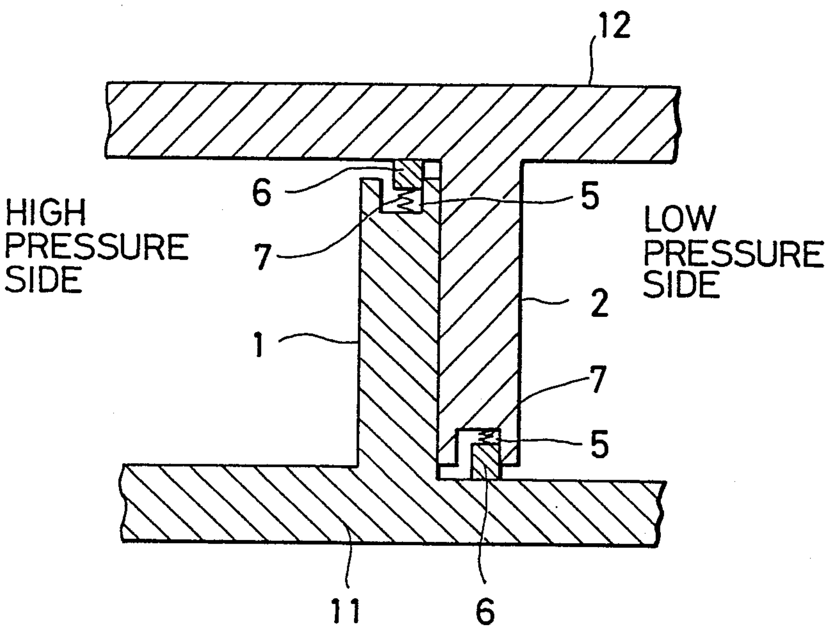

FIG. 4A

FIG. 4B

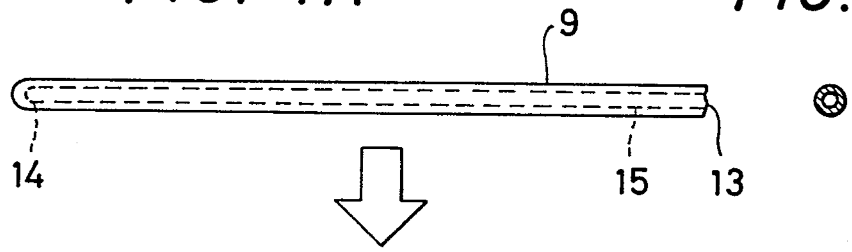

FIG. 4C

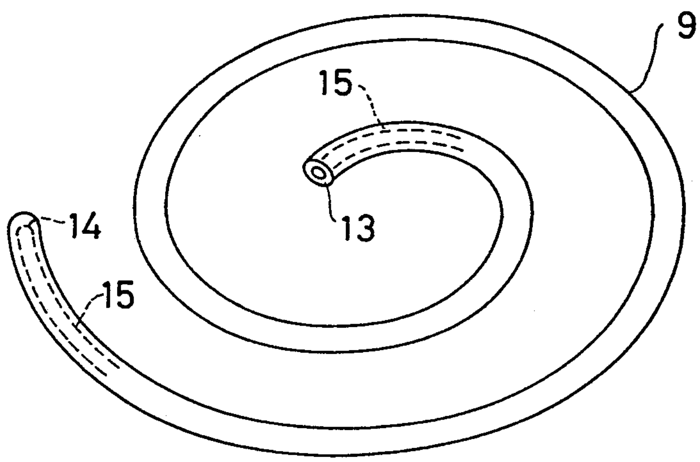

FIG. 5

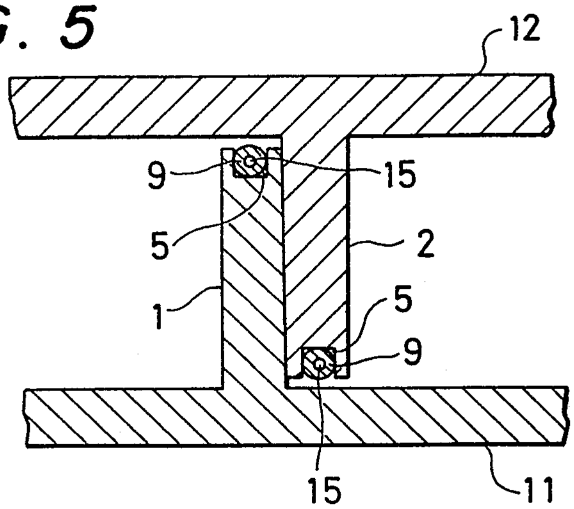

FIG. 6

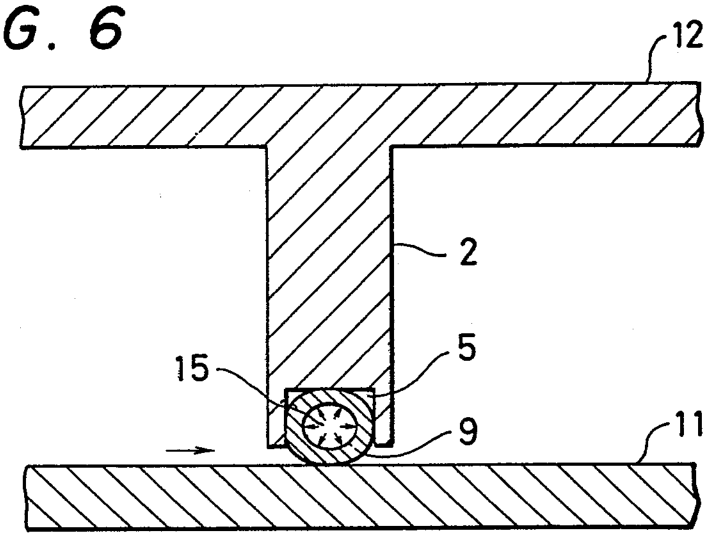

FIG. 7

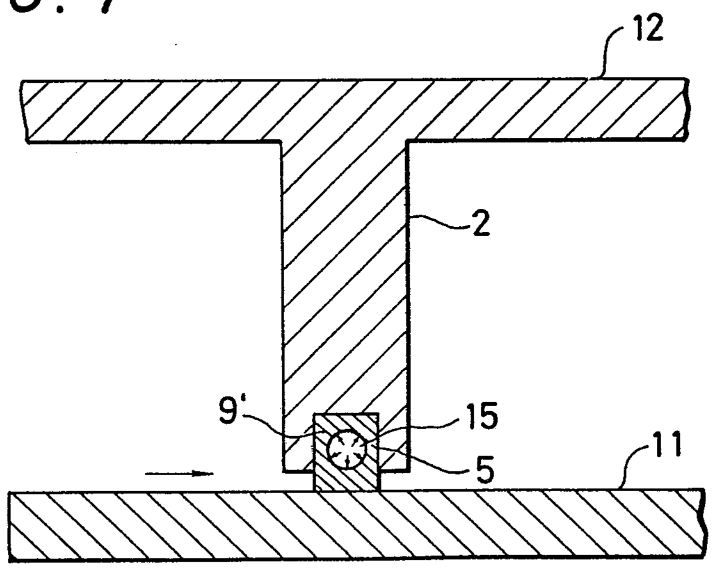

FIG. 8

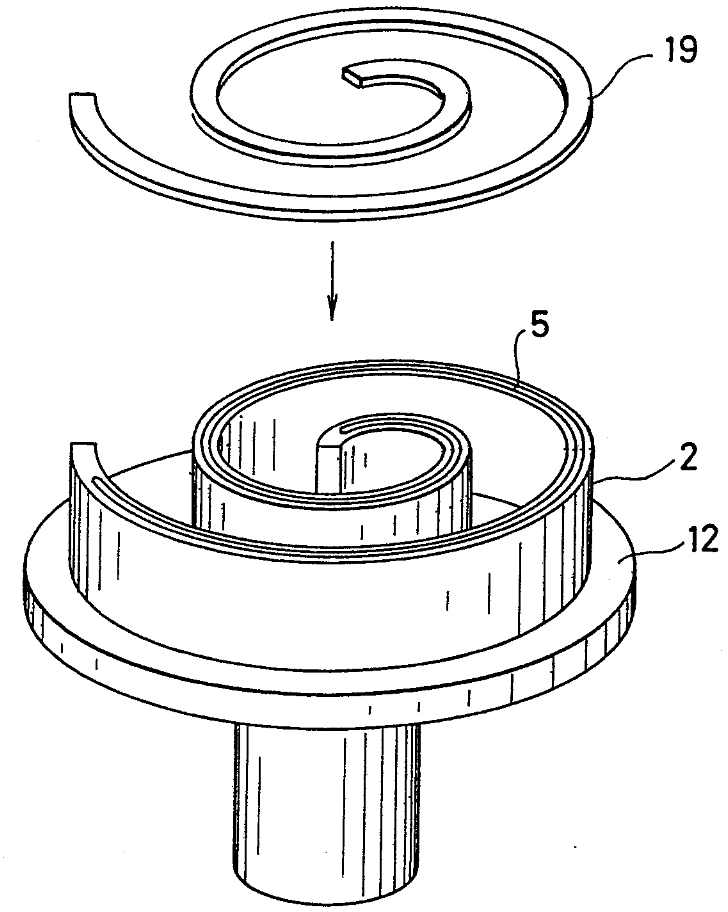

FIG. 9

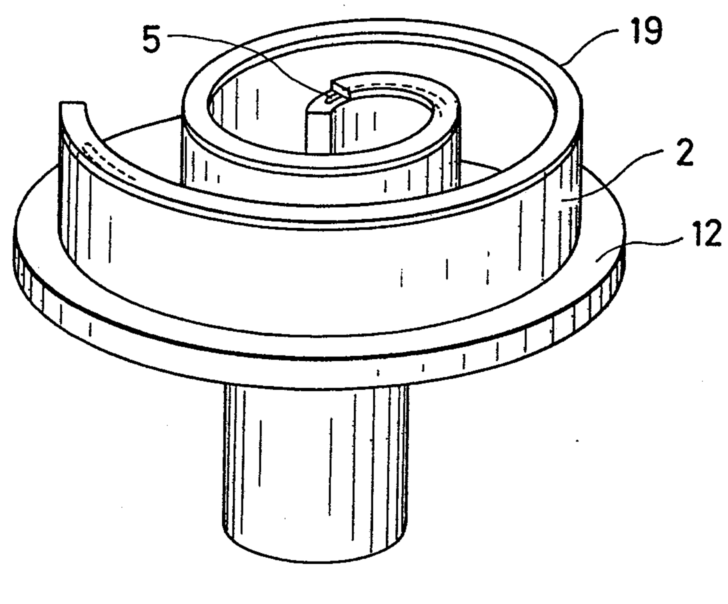

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FIG. 10

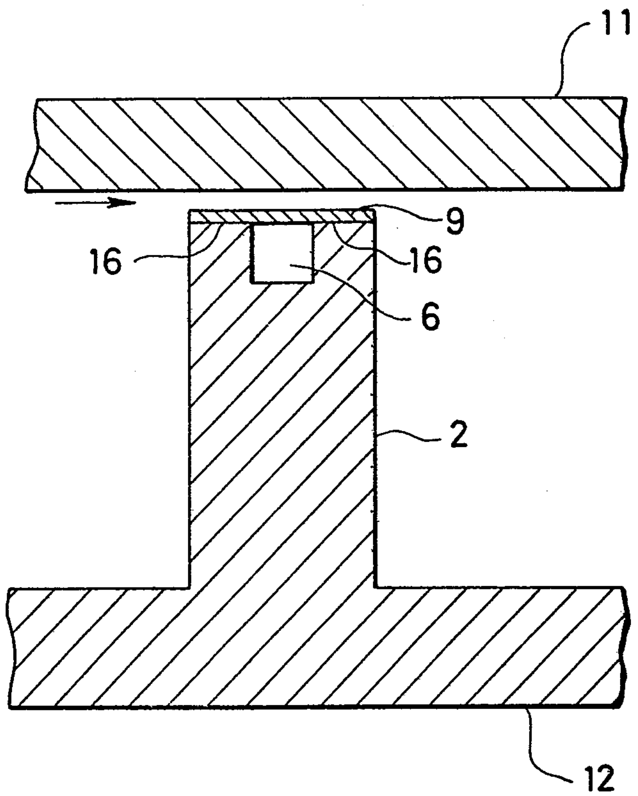

FIG. 11