

Oct. 24, 1967

D. B. SPALDING
PRESSURE EXCHANGERS

3,348,765

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2 Sheets-Sheet 1

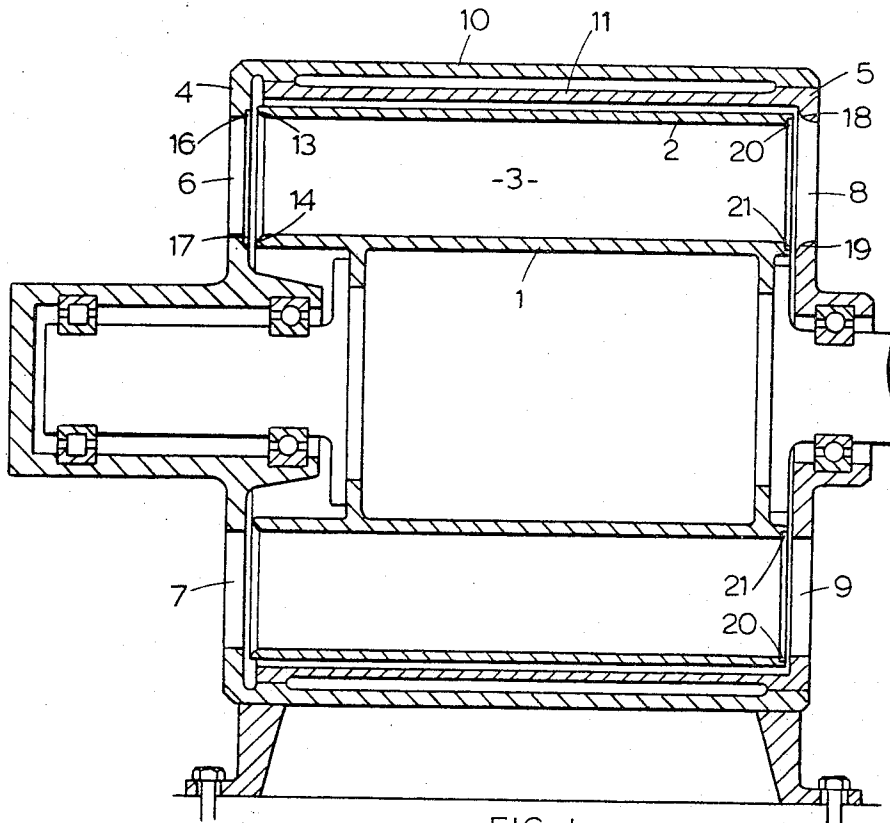


FIG. 1.

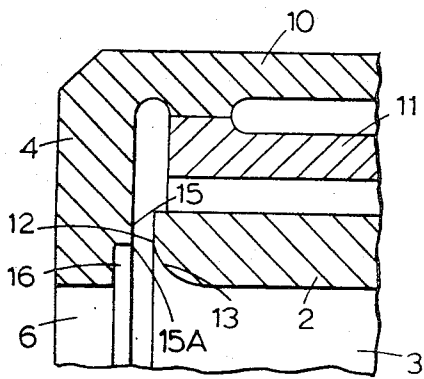


FIG. 2.

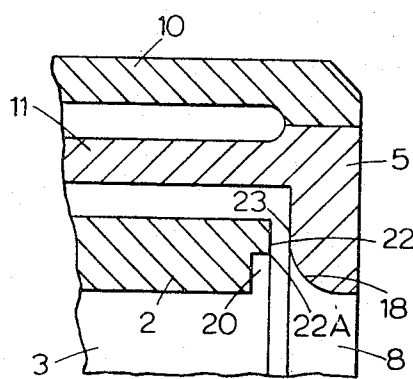


FIG. 3.

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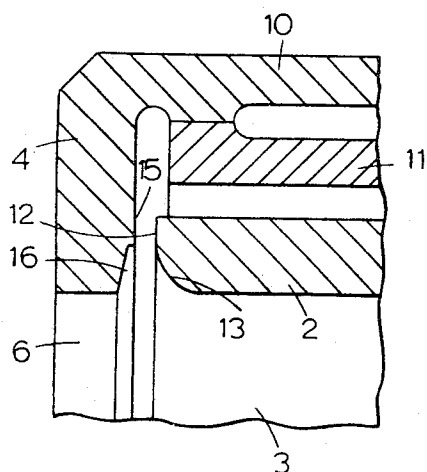


FIG. 4.

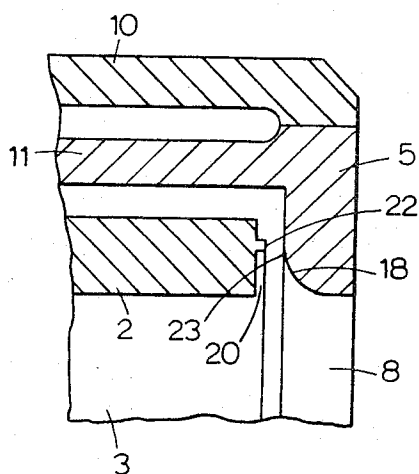


FIG. 5.

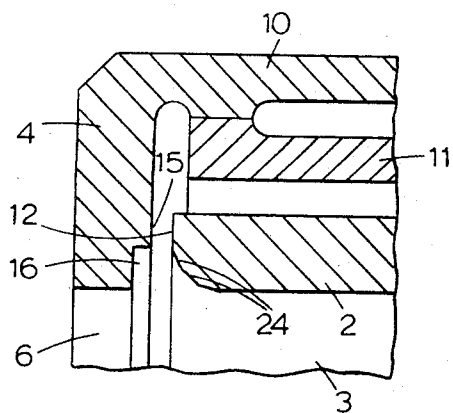


FIG. 6.

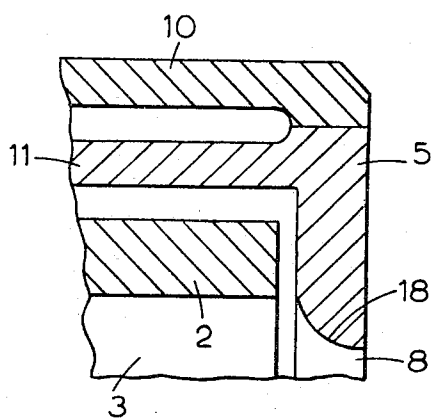


FIG. 7.

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PRESSURE EXCHANGERS

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6 Claims. (Cl. 230—69)

ABSTRACT OF THE DISCLOSURE

A pressure exchanger in which one of the surfaces bounding the clearance between the cell ring and end plate is shaped so that it terminates or sharply recedes in relation to the other surface which extends in the direction of leakage flow, beyond the termination or commencement of the recession, whereby the leakage gas is induced to follow the curved surface and thus enters the low-pressure zone in the same general direction as the flow of working gas in that zone.

The present invention relates to pressure exchangers.

The term "pressure exchanger" is used herein to define an apparatus comprising cells in which one gas quantity expands, so compressing another gas quantity with which it is in direct contact, ducting to lead gas at different pressures steadily to and from the cells and means to effect relative motion between the cells and the ducting.

One constructional form of a pressure exchanger as above defined includes an outer tubular member and an inner member, a plurality of walls carried by one of the members and extending therefrom to the other member to define therebetween a plurality of open-ended cells constituting a cell ring, the ends of the cells being effectively closed by end-plates having ports therein to place the interior of the cells in communication with the ducts on relative motion between the cells and the end-plates.

With this form of pressure exchanger it is necessary, if loss of efficiency is to be avoided, to maintain the working clearance between the cell ring and the end-plates at a minimum so as to reduce the leakage of gas from a high-pressure zone to a low-pressure zone of the pressure exchanger. It has been found, however, that when the working clearances between the relatively moving parts of the pressure exchanger have been made as small as is practical, there is still a loss in efficiency which cannot be explained simply by making allowances for the loss in pressure occurring at a high-pressure zone due to the escape of gas from that zone to a zone of lower pressure. This further loss in efficiency is now believed to be caused by interaction between the high-pressure gas leaking into the low-pressure zone and the low-pressure gas flowing in that zone.

For example, for one pressure exchanger it has been calculated that the leakage gas enters the low-pressure zone at a velocity of about three hundred feet per second, that is, about three times the velocity of the working gas in the low-pressure zone. If the leakage gas enters the low-pressure zone substantially at right angles to the direction of flow of the low-pressure working gas, the resulting interaction between the leakage gas and working gas creates turbulence in the working-gas flow with the result that there is a drop in the overall efficiency of the pressure exchanger.

The velocity of the leakage gas entering the low-pres-

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sure zone could be reduced by increasing the working clearance at that zone but it is desirable to keep the working clearance small to control the leakage of gas from the high-pressure zone.

According to the present invention a pressure exchanger comprises a first structure having cells in which one gas quantity expands, so compressing another gas quantity with which it is in direct contact, a second structure having ports communicating with the cells, ducting communicating with the ports to lead gas at different pressures steadily to and from the cells, means to effect relative motion between the structures, and a surface on each structure, which surfaces define a clearance permitting said motion and provide a path for the flow of leakage gas from a high-pressure zone to a low-pressure zone, one of the surfaces continuing beyond the termination of the other surface and having a portion which is curved away from said other surface whereby the leakage gas is induced to follow the curved surface and to enter the low-pressure zone in the same general direction as the flow of gas in that zone.

The curved portion of one surface is shaped and arranged with respect to the position at which the other surface terminates so as to take advantage of the Coanda effect. While the curved surfaces will be dimensioned to suit the particular pressure exchanger to which they are being applied, each curved surface will have a radius of curvature of not less than four times the width of the clearance defined by the surfaces.

The invention will now be described, by way of example, with reference to the accompanying diagrammatic drawings in which:

FIGURE 1 is an axial section through a pressure exchanger in accordance with the present invention;

FIGURES 2 and 3 are fragmentary views, of the left-hand and right-hand ends, respectively, of the pressure exchanger shown in FIGURE 1, to a larger scale;

FIGURES 4 and 5 are similar views to FIGURES 2 and 3, respectively, showing modifications, and

FIGURES 6 and 7 are similar views to FIGURES 2 and 3 showing further modifications.

In FIGURES 1, 2 and 3 of the drawings, the pressure exchanger comprises an inner member 1 located coaxially within an outer tubular member 2. A plurality of radially extending walls 3 divide the space between the members 1, 2 into a plurality of axially extending open-ended cells forming a cell-ring. The cell-ring is mounted for rotation between end-plates 4 and 5 which effectively close the ends of the cells. Sector-shaped ports 6 and 7 in the end-plate 4 permit working gas at low and high pressures, respectively, to enter the cells from ducts (not shown) and sector-shaped ports 8 and 9 in the end-plate 5 permit working gas at low and high-pressures, respectively, to leave the cells by way of ducts (not shown). Thus, ports 6, 8 and the cells at any one time in communication with them constitute a low-pressure zone of the pressure exchanger and the ports 7, 9 and the cells at any one time in communication with them constitute a high-pressure zone.

The end-plates 4, 5 have integral cylindrical extensions 10, 11 respectively, which are a sliding fit, one within the other, to form a casing about the cell ring. The extensions 10, 11 hold the end-plates 4, 5 in axial alignment while permitting them to move axially. The cell ring is so mounted that a predetermined clearance is left between the end-plates and the cell ring, which clearance is maintained under working conditions, despite any expansion or

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contraction of the cell ring, since each end-plate is constrained to follow any axial movement of the associated end of the cell ring.

At the inlet end of the pressure exchanger, illustrated in more detail in FIGURE 2, the end face 12 of the member 2 is provided with a curved surface 13 leading into the cells.

The surface 15 of the end-plate 4, opposite the curved surface 13, is terminated by a recess or cut-away portion 16, extending over the arc of the radially outer boundary of the sector-shaped low-pressure inlet port 6. It will be seen that the surfaces 12, 15 are parallel, defining a passage of predetermined width for the flow of leakage gas into the low-pressure zone, and that the curved surface 13 commences from a point along the end face 12 and runs smoothly into the radially inner surface of the member 2 while the surface 15 of the end-plate 4 terminates at a position 15a substantially opposite the commencement of the curved surface 13.

The curved surface 14 and recess 17 at the radially inner edge of the member 1 are similar to the corresponding parts 13 and 16.

At the outlet end of the pressure exchanger, illustrated in greater detail in FIGURE 3, the radially outer and inner edges of the outlet port 8 are formed with smoothly curved surfaces 18 and 19 respectively. Cut-away portions or recesses 20, 21 are formed in the adjacent end-faces of the outer member 2 and the inner member 1, respectively, and extend round the end of the cell ring. As at the inlet end of the pressure exchanger, a part 22 of the end-face of the outer member 2 terminated by the recess 20 at a position 22a and a part 23 of the end-plate 5 are parallel to define a passage for flow of the leakage gas.

The formation of the curved surface 19 and the recess 21 is similar to that of the corresponding parts 18 and 20.

While in the drawings the clearances have been exaggerated to facilitate the understanding of the invention, it will be understood that they are made as small as possible while permitting free rotation of the cell ring when the pressure exchanger is working under operating conditions. The actual dimensions of the clearance passages will depend upon the size of the pressure exchanger and whether a hot working gas is used.

When the pressure exchanger is in operation, part of the gas flowing in the high-pressure zone leaks through the adjacent working clearances radially outward to the space about the cell ring and radially inward to the space at the axis of the cell ring and thence to the low-pressure zone through the working clearances adjacent such zone.

The leakage gas is travelling at a high-velocity in a direction normal to the direction of flow of working gas in the low-pressure zone but, on reaching the curved surfaces 13, 14, 18, 19, the leakage gas is subjected to the Coanda effect and follows the curved surfaces to enter the low-pressure zone in the same general direction of flow as that of the working gas in the zone. Thus the possibility of interaction between the two gas streams is reduced. The recesses 16, 17, 20, 21 ensure that the high-pressure leakage gas stream follows the curved surfaces.

By causing the high-pressure leakage gas to flow in the same general direction as the low-pressure gas, the flow of the latter gas is enhanced by the ejector effect.

The surface opposite the surface having the curved portion may be terminated by recesses of various cross-sectional shapes provided that the position of termination relative to the curved surface and the size and shape of the recesses are such that the leakage gas is induced to follow the curved surface.

A recess 16 of an alternative cross-sectional shape is shown in FIGURE 4 in the end-plate 4 and a similar recess of the same cross-sectional shape may be made at the outlet end but it will then be in the outer member 2. In the same manner the form of recess 20 shown in

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FIGURE 5 at the outlet end of the pressure exchanger may also be incorporated at the inlet end.

In a further modification, the height of the outlet port 8, that is the distance between its radially inner and outer surfaces, is made less than the height of the cells 3, that is the radial distance between the members 1 and 2. Thus, as can be seen from FIGURE 7, the working gas flowing from a cell to the port 8 passes over a "step" as it enters the port. As in the previously described embodiments the radially outer edge of the port 8 is formed with a smoothly curved surface 18 leading into the port. The difference in height between the port 8 and the cells 3 is made such that the curved surface commences opposite the termination of the end-face of the member 2 which therefore does not need to be recessed.

Similarly, the radially inner edge of the port 8 forms a "step" in the path of the working gas flow and is provided with a smoothly curved surface which commences opposite the termination of the end-face of the member 1.

At the inlet end of the pressure exchanger, not illustrated, the height of the cells 3 is made smaller than the height of the port 6 so that the working gas passes over a "step" as it enters the cells. The end-faces of the members 1 and 2 are each formed with a curved surface leading into the cells. The curved surfaces commence opposite the adjacent edges of the port 6 so that it is not necessary to form recesses in the end-plate 4.

When the pressure exchanger is in operation, the curved surfaces function as described with reference to the embodiment of FIGURE 1.

If desired, the height of the port 8 may be progressively increased downstream of the curved surfaces until it is the same height as the adjacent ends of the cells and, similarly, the inlet ends of the cells may be progressively increased in height downstream of the curved surfaces until they are the same height as the port 6 and the outlet ends of the cells.

It will be appreciated that the curved surfaces need not be smooth but may be formed with one or more inflexions provided that gas streams will become attached to the surfaces and substantially conform to their general shape. For example, in FIGURE 6, the surface to which a gas stream is to become attached is formed of plain surfaces 24 inclined with respect to each other. The expression "curved surface" used in this specification is, accordingly, to be construed as including such formations.

I claim:

1. A pressure exchanger comprising

- (a) a first structure having cells in which one gas quantity expands, so compressing another gas quantity with which it is in direct contact,
- (b) a second structure having ports communicating with the cells,
- (c) ducting communicating with the ports to lead gas at different pressures steadily to and from the cells,
- (d) means to effect relative motion between the structures, and
- (e) a surface on each structure, which surfaces define a clearance permitting said motion and providing a path for the flow of leakage gas from a high-pressure zone to a low-pressure zone, characterized in that one of said surfaces continues beyond the termination of the other surface and has a portion which is curved away from the other surface whereby the leakage gas is induced to follow the curved surface and to enter the low-pressure zone in the same general direction as the flow of gas in that zone.

2. A pressure exchanger according to claim 1, wherein the curved portion of said one surface has a radius of curvature not less than four times the clearance between the surfaces.

3. A pressure exchanger according to claim 2, wherein said other surface terminates at a position opposite the commencement of the curved portion of said one surface.

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4. A pressure exchanger according to claim 3, wherein the surface of the first structure has a curved portion.

5. A pressure exchanger according to claim 3, wherein the surface of the second structure has a curved portion.

6. A pressure exchanger according to claim 1, wherein the curved portion of said one surface is so shaped and arranged with respect to the position at which said other surface terminates that the flow of leakage gas following

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the curved surface has an ejector effect on the flow of gas into the low-pressure zone.

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ROBERT M. WALKER, *Primary Examiner*.