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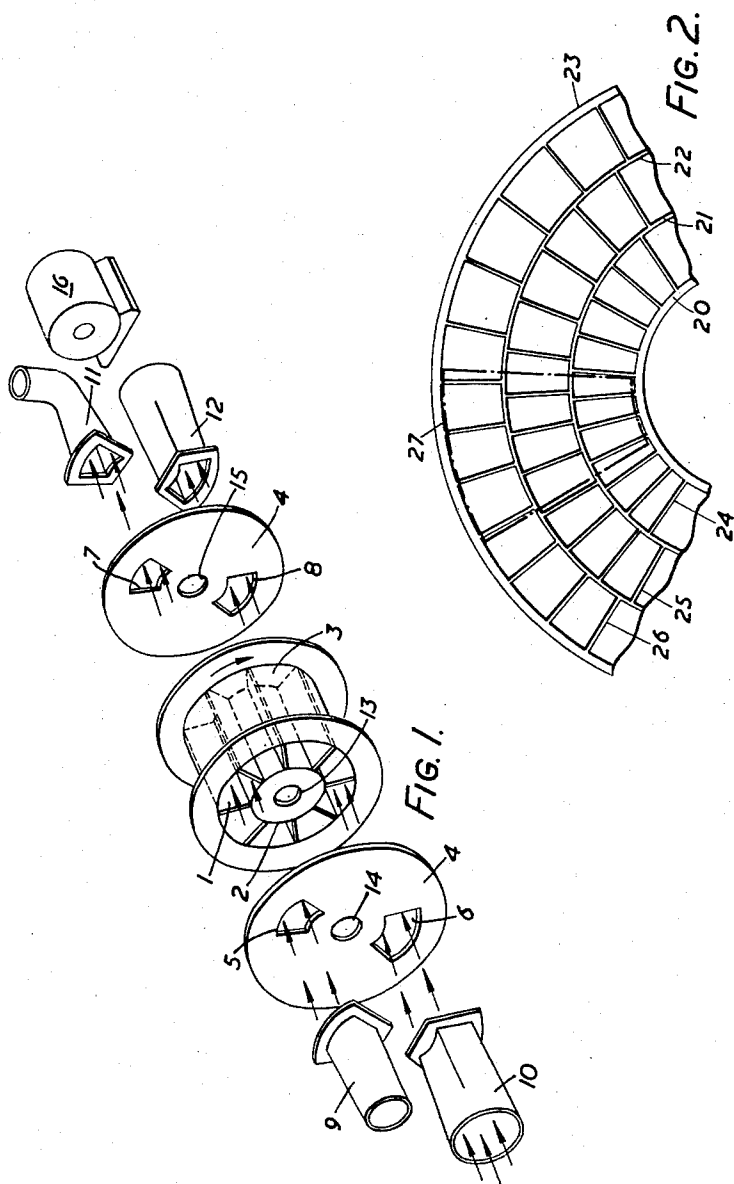
J. A. C. KENTFIELD

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PRESSURE EXCHANGERS

Filed Dec. 22, 1961

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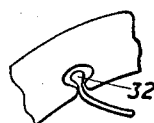
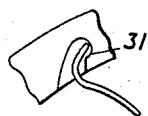
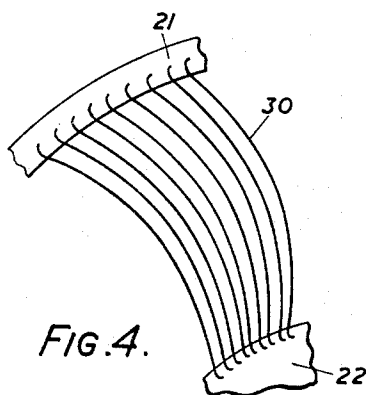
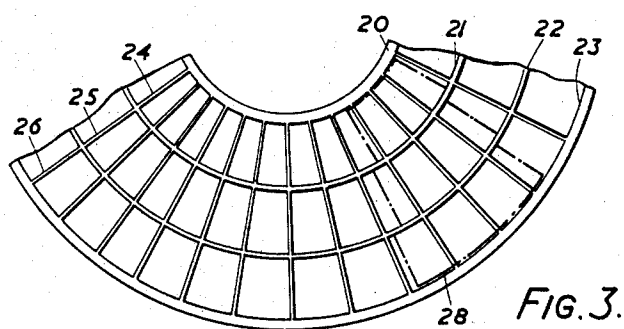
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PRESSURE EXCHANGERS

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4 Claims. (Cl. 230-69)

This invention relates to pressure exchangers.

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

Customarily, the cells are mounted as a cell ring, which may be arranged for rotation, and the ducting communicates with the cells through ports in end-plates disposed immediately adjacent the open ends of the cells.

One of the disadvantages of a pressure exchanger is the noise generated during operation. The use of silencers for gas streams leaving and entering the apparatus and sound-insulating lagging around the apparatus as a whole has a merely palliative effect and such use does nothing towards the reduction of the noise at its source.

The object of the present invention is to reduce the noise generated by a pressure exchanger during operation.

The invention will now be explained with the aid of the accompanying diagrammatic drawing, in which:

FIGURE 1 is an exploded perspective view of a conventional pressure exchanger;

FIGURE 2 is a fragmentary end elevation of one embodiment of a pressure exchanger cell ring in accordance with the invention;

FIGURE 3 is a fragmentary end elevation of another embodiment of a pressure exchanger cell ring in accordance with the invention;

FIGURE 4 is a fragmentary end elevation of a third embodiment of a pressure exchanger cell ring in accordance with the invention; and

FIGURES 5 and 6 are details of cell ring construction of the pressure exchanger illustrated in FIGURE 4.

Referring now to FIGURE 1 of the drawings the pressure exchanger includes a cell ring having a multiplicity of radial walls 1 arranged around a hub 2 and having a cylindrical shroud 3. Cells defined by the walls 1, the hub 2 and the shroud 3 are in themselves open-ended but the effective opening of the cells is controlled by end-plates 4 having ports 5, 6, 7 and 8 to lead fluid to and from the cells. In the example shown high-pressure fluid is admitted through the port 5, low-pressure fluid is admitted through the port 6, high-pressure fluid leaves through the port 7 and low-pressure fluid leaves through the port 8. Ducts corresponding to these ports are referenced 9, 10, 11 and 12. It will be appreciated that the ports and ducts illustrated have been made of smaller circumferential extent than would be used in practice. A shaft (not shown) passes through bores 13, 14, 15 in the cell ring and end-plates.

It has been found by experiment that the frequency of the primary mode of oscillation of the noise emitted by a pressure exchanger during operation, corresponds directly to the frequency with which the cells move past a fixed point. One way in which this primary mode of oscillation may be raised above the upper limit of audio-frequency is by increasing the number of cells in the cell ring. However, such an increase will need to be considerable in relation to the number of cells hitherto suggested. Furthermore, such an increase leads to difficulties, the most important being a substantial increase in the build-

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up of boundary layer fluid in the cells, which will bring about a loss in efficiency of the pressure exchanger. If the mean width of a cell falls below a certain minimum, then the amount of boundary layer fluid along each cell wall will be inconveniently large. When the mean width of the cell is very small in comparison with the length of the cell, the boundary layer fluid along each cell wall will meet and will then occupy the whole of the cross-sectional area of the cell. To ensure that the boundary layer fluid does not give rise to a loss in efficiency, the ratio, δ ,

$$\frac{\text{time taken for cell to become fully open at a port}}{\text{time taken for wave to traverse the length of the cell}}$$

may not be less than about 0.3, the exact value being established by experiment.

The following derived expression gives a relationship between l the axial length of each cell in feet; the number of cells n in the cell ring; the ratio δ ; the local velocity of sound a_0 in feet/second; rotational speed of the cell ring N in r.p.m.; and the frequency f_{cell} with which a cell passes any fixed point.

The time for a cell to become fully open at a port

$$= \frac{60}{Nn} \text{ seconds}$$

The time for a wave to traverse the length of the cell

$$= \frac{l}{a_0} \text{ seconds}$$

$$\therefore \delta = \frac{60}{Nn} \cdot \frac{a_0}{l} \quad (1)$$

The frequency with which a cell passes a fixed point

$$f_{\text{cell}} = \frac{Nn}{60} \text{ per second} \quad (2)$$

Hence, from Equations 1 and 2

$$\delta = \frac{a_0}{l} f_{\text{cell}}$$

$$f_{\text{cell}} = \frac{a_0}{l \delta}$$

The limit of audio-frequency $\approx 16,000$ c.p.s.

Since the frequency with which a cell passes a fixed point corresponds directly to the frequency of the primary mode of oscillation of the pressure exchanger during operation, then in order that this primary mode of oscillation is above the limit of audio-frequency

$$f_{\text{cell}} \geq 16,000 \text{ c.p.s.}$$

$$\frac{Nn}{60} \geq 16,000 \text{ c.p.s.} \leq \frac{a_0}{l \delta}$$

A cell ring construction which enables a large number of cells to be accommodated, but conforming with the expression derived above, is shown in FIGURE 2. The length of each cell will be less than has been proposed hitherto, but more than is called for with a cell ring having only one ring of cells conforming to the expression

$$\frac{Nn}{60} \geq 16,000 \leq \frac{a_0}{l \delta}$$

The cell ring includes concentric cylindrical members 20, 21, 22, and 23. Three rings of plane cell walls 24, 25, 26 are secured respectively between the members 20, 21; 21, 22, and 22, 23 and are so arranged that no two walls lie in the same radial plane or in other words the individual cell walls are staggered relatively to one another. A port indicated by a chain line 27 forms one end of a duct to lead fluid to or from the cells. The remaining

ports and ducts are disposed according to the requirements of the pressure exchanger cycle chosen.

When in operation, the individual cell walls of each of the three rings pass the opening edge of the port at slightly different times thus giving rise to a noise frequency related to the product of the rotational speed and the total number of cells in all three rings.

The embodiment of FIGURE 3 is an inversion of the embodiment of FIGURE 2. The corresponding cell walls of each ring lie in the same radial plane, and the required noise frequency is achieved by the provision of ports such as 28 (shown in chain lines), the opening and closing edges of which are divided into three portions corresponding to the rings of cells, each portion lying on a different radius. It will be seen that although inverted, the embodiment of FIGURE 3 operates effectively in the same manner as that of FIGURE 2. Compared with a pressure exchanger including a cell ring conforming to the derived expression and having only a single ring of cells, the cell rings illustrated in FIGURES 2 and 3 permit, for the same number of cells, the cells to be of greater mean width and therefore of greater axial length.

In certain circumstances the embodiments of FIGURES 2 and 3 would not be convenient. A fragment of a cell ring with a single ring of cells is illustrated in FIGURE 4. Again, the dimensions of the cell ring conform to the expression

$$\frac{Nn}{60} \geq 16,000 \leq \frac{a_0}{l\delta}$$

in which δ is, of course, not less than 0.3. It is expected that from 160 to 180 cells will be required if the length of the cells is not to be too small or the speed of revolution too high. Each wall 30 is arcuate but has hooked edges 31 as shown in detail in FIGURE 5 or swaged edges 32 as shown in FIGURE 6. The walls may be curved to form an arc of a circle or may be in the form of a catenary and will inevitably be of thinner cross-section than in pressure exchangers proposed previously. For either form of wall the stresses can be readily pre-determined and the fixing moment at the edges is zero.

I claim:

1. A pressure exchanger including a hub means, a plurality of open-ended cells arranged around the hub means, the hub means and the plurality of open-ended cells constituting a cell ring, end-plate structure at each end of the cell ring, ports in the end-plate structure for the admission of fluid to and the extraction of fluid from the cells, the cell ring having a relationship of

$$\frac{Nn}{60} \geq 16,000 \leq \frac{a_0}{l\delta}$$

where N is the rotational speed of the cell ring in r.p.m., n is the number of cells; a_0 is the local velocity of sound in feet/second; l is the axial length of each cell in feet and

$\delta = \frac{\text{time taken for cell to become fully open at a port}}{\text{time taken for a wave to traverse the length of the cell}}$

2. A pressure exchanger as claimed in claim 1, in which the cells are arranged as two or more concentric rings, the individual cell walls of each cell ring being staggered in relation to the individual cell walls of the other cell ring or rings.

3. A pressure exchanger as claimed in claim 1, in which the cells are arranged as two or more concentric rings, the individual cell walls of each cell ring being in line with the individual cell walls of the other cell ring or rings, each port having opening and closing edges including portions co-operating with each cell-ring, which ports are staggered in relation to one another.

4. A pressure exchanger as claimed in claim 1, in which the individual cell walls are of arcuate form and have hooked end portions which engage in slots in a hub portion and in slots in a shroud of the cell ring.

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