Nov. 8, 1960 G. T. SHOOSMITH 2,959,131

PUMPS

Filed May 6, 1958

FIG. 1.

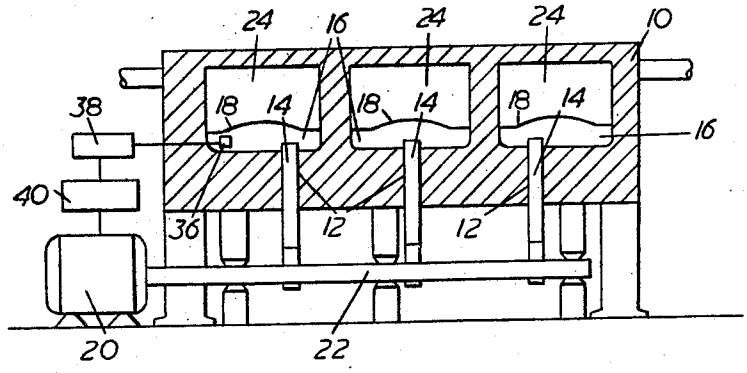
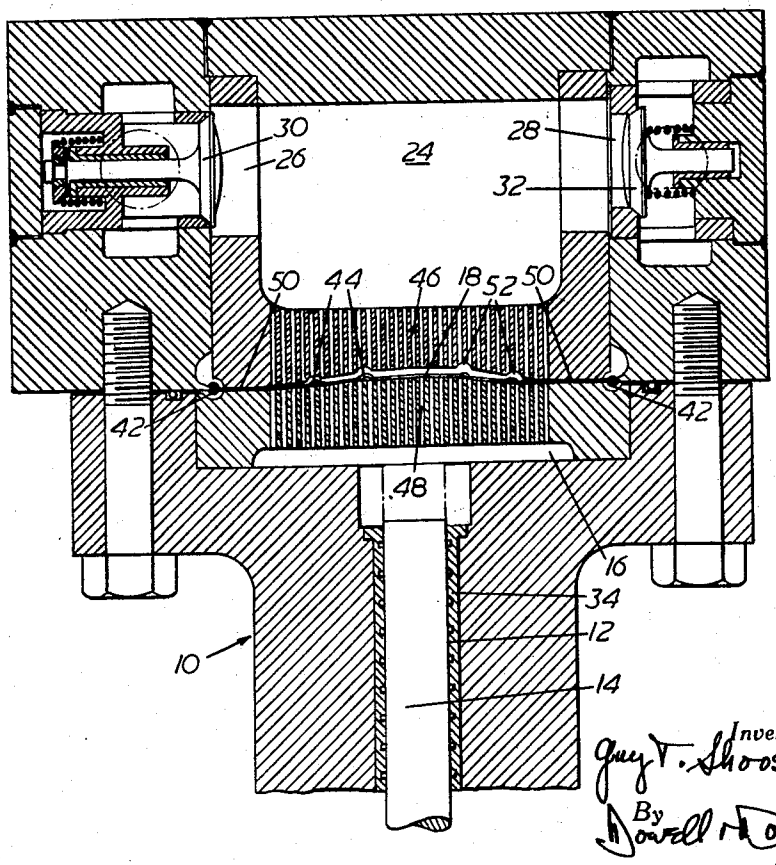



FIG. 2.




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# PUMPS

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3 Claims. (Cl. 103—44)

This invention relates to pumps, and more specifically to diaphragm pumps.

In certain nuclear power plants, pure water is circulated through or near to the reactor. This water can become radio-active and stringent measures must be taken to prevent its leakage. The present invention is concerned with a pump for circulating the water which does not allow leakage from the circuit past the moving parts of the pump.

According to the invention, a diaphragm pump for pumping liquid comprises a metal diaphragm which is fastened round its edge without a break to its support, and which is designed to be flexed during operation of the pump between two positions in both of which it remains convex so that reverse bending of the diaphragm is avoided.

In order that the invention may be thoroughly understood, a specific pump in accordance with it will now be described, by way of example, with reference to the accompanying drawing, in which:

Figure 1 is a diagrammatic part-sectional view of the pump; and

Figure 2 is an enlarged vertical section through part of the pump.

The pump shown in the drawing is designed to circulate pure water which is at a temperature of about 600° F. and at a pressure of about 2000 p.s.i., the water pressure being boosted by the pump to about 3000 p.s.i. It comprises a cylinder block **10** having three cylinders **12** in which are arranged sliding pistons or rams **14**. The upper parts of the cylinders lead into shallow liquid-tight chambers **16** containing pure water which serves as hydraulic fluid, the chambers **16** each having an upper portion comprising a dish-shaped metal diaphragm **18**. Driving means including a motor **20** and a shaft **22** are provided for reciprocating the rams **14** in the cylinders **12** so that the diaphragms **18** can be flexed in synchronism with the rams by the pressure of the water in the chambers **16**.

The flexing of the diaphragms **18** provides a pumping action which is transmitted to pure water on the sides of the diaphragms remote from the cylinders **12** and forces the water round a circulatory system (not shown in the drawing). The pumping action of the diaphragms is made effective by providing pumping chambers **24** immediately above the diaphragms **18** through which the circulating water is passed. As shown in Figure 2, each of these chambers **24** has a valve-controlled inlet **26** and a valve-controlled outlet **28** in the same way as a normal piston pump, the inlet valve **30** being spring-loaded so that it opens automatically on the suction stroke, and the outlet valve **32** being spring-loaded so that it opens automatically on the delivery stroke.

The operation of the pump is as follows.

As each ram **14** is moved upwards within its cylinder **12**, the hydraulic fluid in the chambers **16** leading from the cylinders **12** (which chambers are referred to hereinafter as the primary chambers) is placed under pressure



and flexes the diaphragm **18** upwards. The movement of the diaphragm **18** places the water in the associated pumping chamber **24** under pressure, and some of the water is forced out through the outlet **28** against the action of the spring associated with the valve **32**. The return movement of the ram **14** causes the diaphragm **18** to return to its normal position (the position shown in Figure 2), and this has the effect of closing the outlet valve **32** in the pumping chamber **24** and drawing water by suction from the circuit into the pumping chamber through the inlet **26**. The inlet valve **30** closes when the ram **14** reaches the lowermost position of its stroke, and the cycle described above is then repeated as the ram **14** moves upwards again.

In the particular pump described herein, the three rams **14** have a diameter of 1¾ inches and are made of stainless steel or other metal which does not corrode when in contact with water. The driving means **20** and **22** for reciprocating the rams **14** are designed so that the rams have a stroke of 1½ inches and a rate of reciprocation per minute in the region of 1140. The rams are arranged for movement in labyrinth glands **34**, and any leakage of water from the primary chambers **16** past these glands is compensated for by make-up water supplied to the primary chambers **16** from a separate feed pump (not shown) through an hydraulic accumulator operating at 2000 p.s.i. and a non-return valve (also not shown). A leak detection device **36, 38** is provided so that, in the event of a diaphragm fracture, the pump is automatically taken out of the circuit and stopped through the operation of control means **40** shown in Figure 1. The device **36, 38** can comprise, for example, a radiation counter.

The diaphragms **18** are welded round their edges without a break to thin lips **42** machined in the cylinder head. This is very important having regard to the fact that the circulating water will probably become radio-active at some stage of its passage round the system. The diaphragms are preferably made of high carbon content heat-treated steel and are of convex shape, the diaphragms being so disposed in relation to the rams **14** that their convexity is increased during the compression stroke of the rams. Thus, the diaphragms work between two degrees of convexity, reverse bending with its consequent risk of fracture being avoided. Each diaphragm **18** has a pair of radial expansion rings **44** pressed in it, and is of about 8 inches diameter.

The central portions of the diaphragms **18** have a working stroke of about 0.22 inch between steel grids **46** and **48** arranged one on either side of each diaphragm. These steel grids limit the movement of the diaphragm and serve also to clamp its outer portions **50** between them so as to reduce bending stresses. Annular grooves **52** are provided in one or both of the grids **46** and **48** to accommodate the rings **44** on the diaphragms. Preferably, the steel grids take the form of thick plate portions having straight holes bored through them which lie parallel to the longitudinal axes of the rams **18**.

A pump of the design described above meets the severe requirements of nuclear power plants where the possibility of leakage must be reduced to a minimum, and where fluid circuits must remain isolated from one another. The leakage of water from the circulatory system past the moving parts of the pump can only happen if one of the diaphragms **18** is fractured, and this can be avoided by determining in advance the minimum working life of the diaphragms. If such a leakage does occur however, the pure water in the circuit will not be harmfully contaminated because the hydraulic liquid used in the primary chambers **16** is also pure water.

I claim:

1. A diaphragm pump for pumping liquid comprising

a generally-cylindrical pumping chamber arranged with the longitudinal axis thereof extending in a substantially vertical direction, an annular diaphragm support forming part of the lower portion of the cylindrical wall of said chamber, a circular dish-shaped metal diaphragm extending across the entire area of the circular aperture defined by said annular support and fastened in a liquid-tight manner to said support round the entire edge of said diaphragm, a rigid metal grid opposing the upper side face of said diaphragm and in close contact with a peripheral portion of said diaphragm, a second rigid metal grid opposing the lower side face of said diaphragm and in close contact with a peripheral portion of said diaphragm, a plurality of vertically-extending apertures in each of said grids, a depression of substantially concave cross-section in one of said grids, said depression opposing said one side face of said diaphragm, a raised surface of substantially convex cross-section in said other grid, said raised surface opposing said other side face of said diaphragm, said concave depression and said convex raised surface in said grids being of different curvatures whereby a working space for said diaphragm is formed between said grids, at least one radial expansion ring pressed in said diaphragm, a corresponding annular groove in said concave depression of said one grid adapted to receive said expansion ring when said diaphragm is flexed towards said one grid, a corresponding annular ridge in said convex raised surface of said other grid, adapted to enter



said expansion ring when said diaphragm is flexed towards said other grid, a primary chamber containing hydraulic liquid bounded at the upper portion thereof by said diaphragm, a reciprocatory piston arranged to act directly on said hydraulic fluid in said chamber whereby said hydraulic fluid transmits movement of said piston to said diaphragm, said hydraulic fluid being the same in composition as fluid handled by said pumping chamber, and power means operatively connected to said piston whereby to cause reciprocation of said piston.

2. A diaphragm pump as claimed in claim 1 wherein said hydraulic fluid is pure water.

3. A diaphragm pump as claimed in claim 1 wherein said diaphragm is made of high carbon content steel and is welded to said support.

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