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F1W

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(54) Improvements in or relating to pumps

(57) A diaphragm pump comprises a housing, a diaphragm 10 peripherally secured in the housing and in the form of a laminate, one layer of greater elasticity than another, a rod extending from a central support 15, 59 through a wall of the housing for reciprocating the diaphragm. The central support engages the diaphragm to a transverse extent which is between one half and two thirds of the major transverse active dimension (ie radius) of the diaphragm, at least one of parts 15, 16 diverging as it extends away from the diaphragm.

Fig. 9 (not shown) illustrates a control mechanism for a pair of pumps driven by one reciprocating piston under the influence of pneumatic pressure, reciprocation and the pump stoke/delivery stroke relationship being controlled by adjustable pressure restrictors acting on change-over spool valves.

Fig. 1.

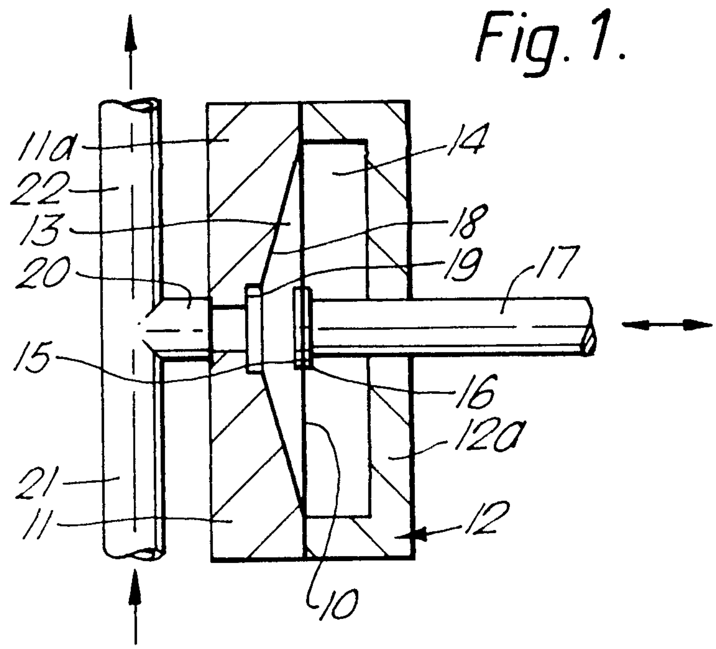

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Fig. 1.

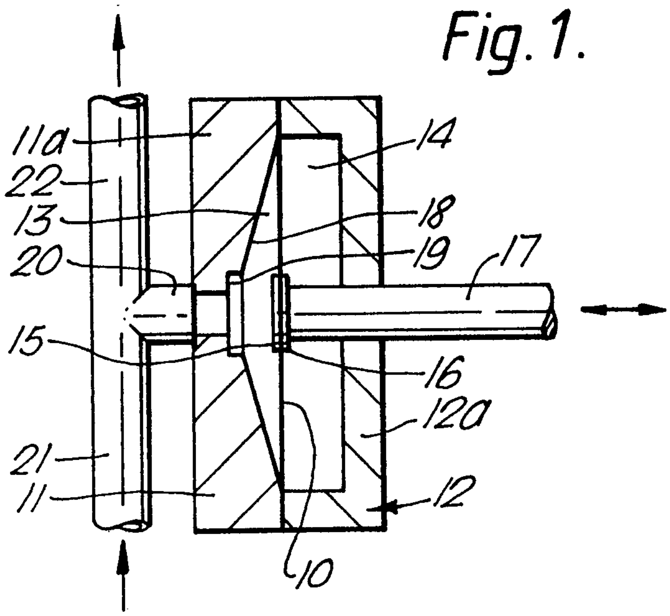
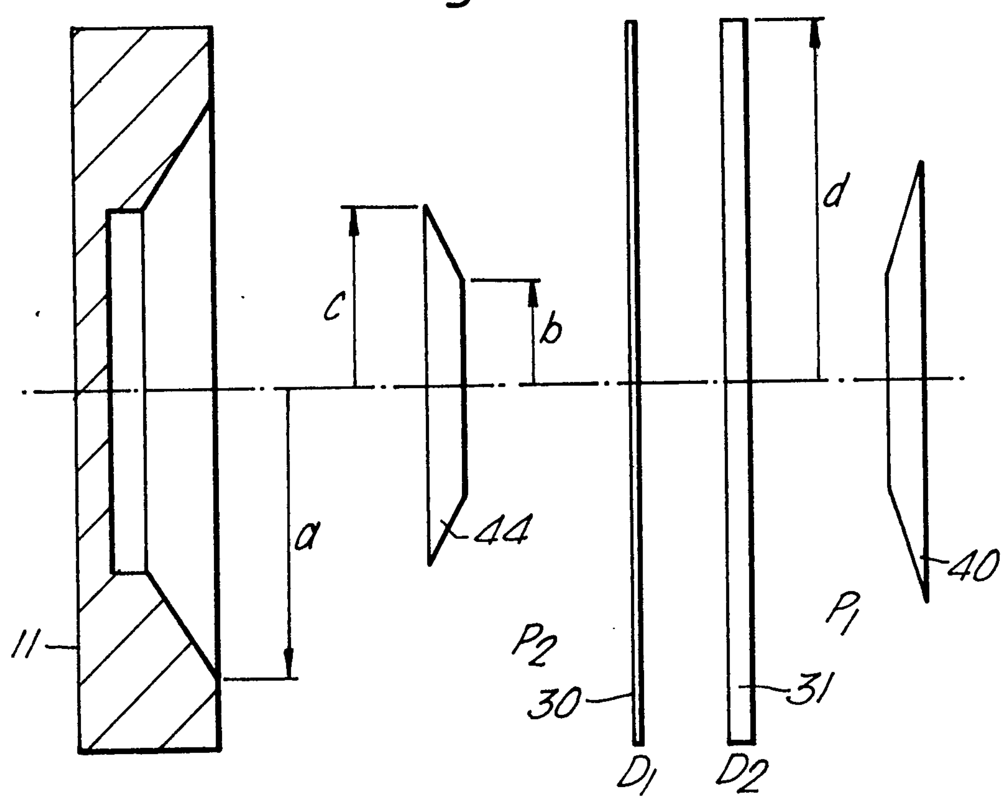

11a
22
13
20
15
21
11
14
18
19
17
16
12a
12
10

Fig. 6.


c
b
d
a
44
40
11
P2
P1
30
31
D1
D2

2152151

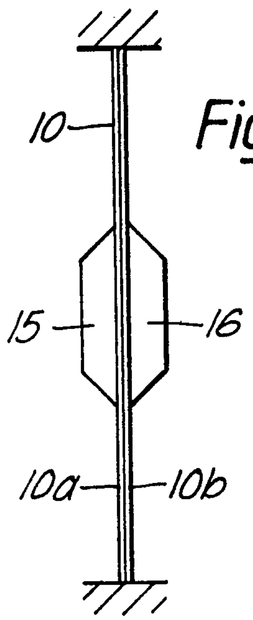


Fig. 2.

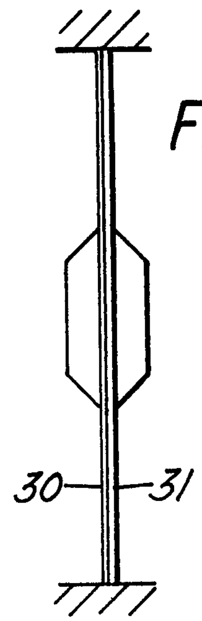


Fig. 3.

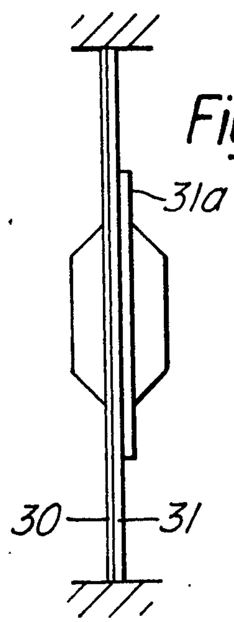


Fig. 4.

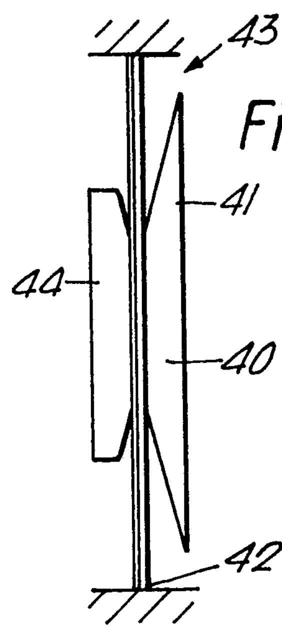


Fig. 5.

Fig.7.

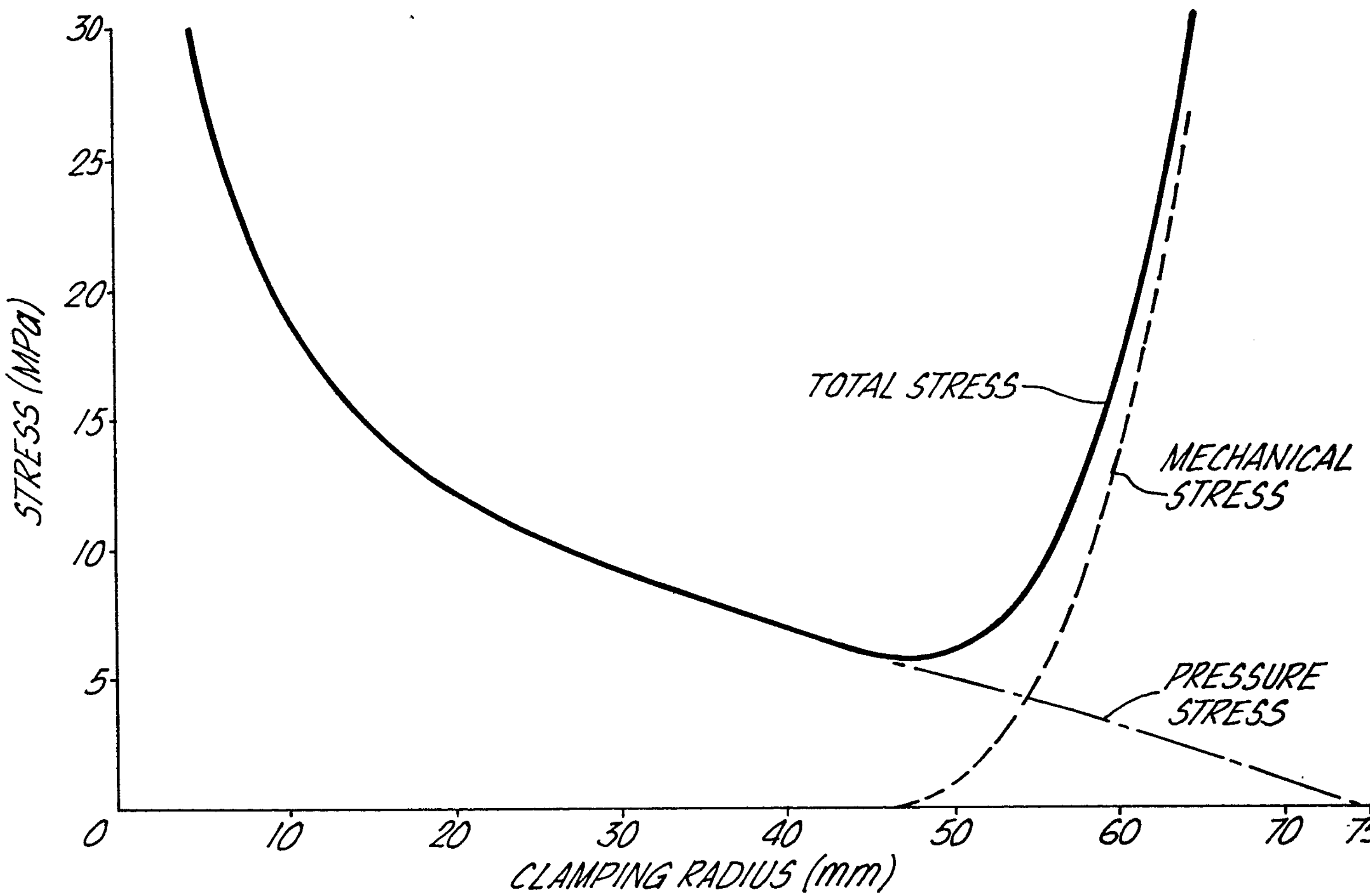

STRESS (MPa)
30
25
20
15
10
5
0
10
20
30
40
50
60
70
75
CLAMPING RADIUS (mm)
TOTAL STRESS
MECHANICAL STRESS
PRESSURE STRESS

Fig.8.

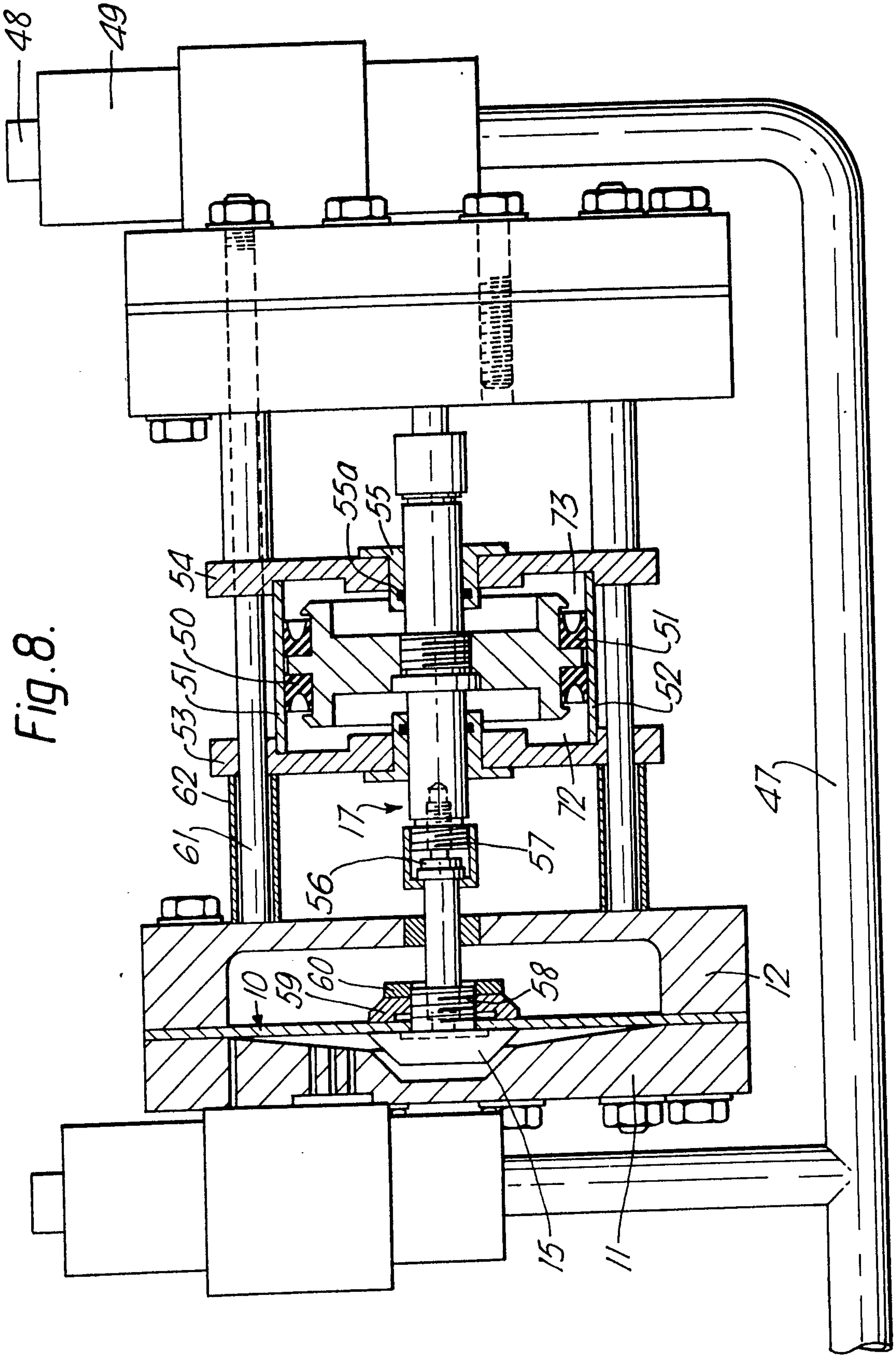

48
49
55a
55
73
54
50
51
51
53
62
61
52
51
17
56
57
72
47
10
59
60
58
12
15
11

Fig. 9.

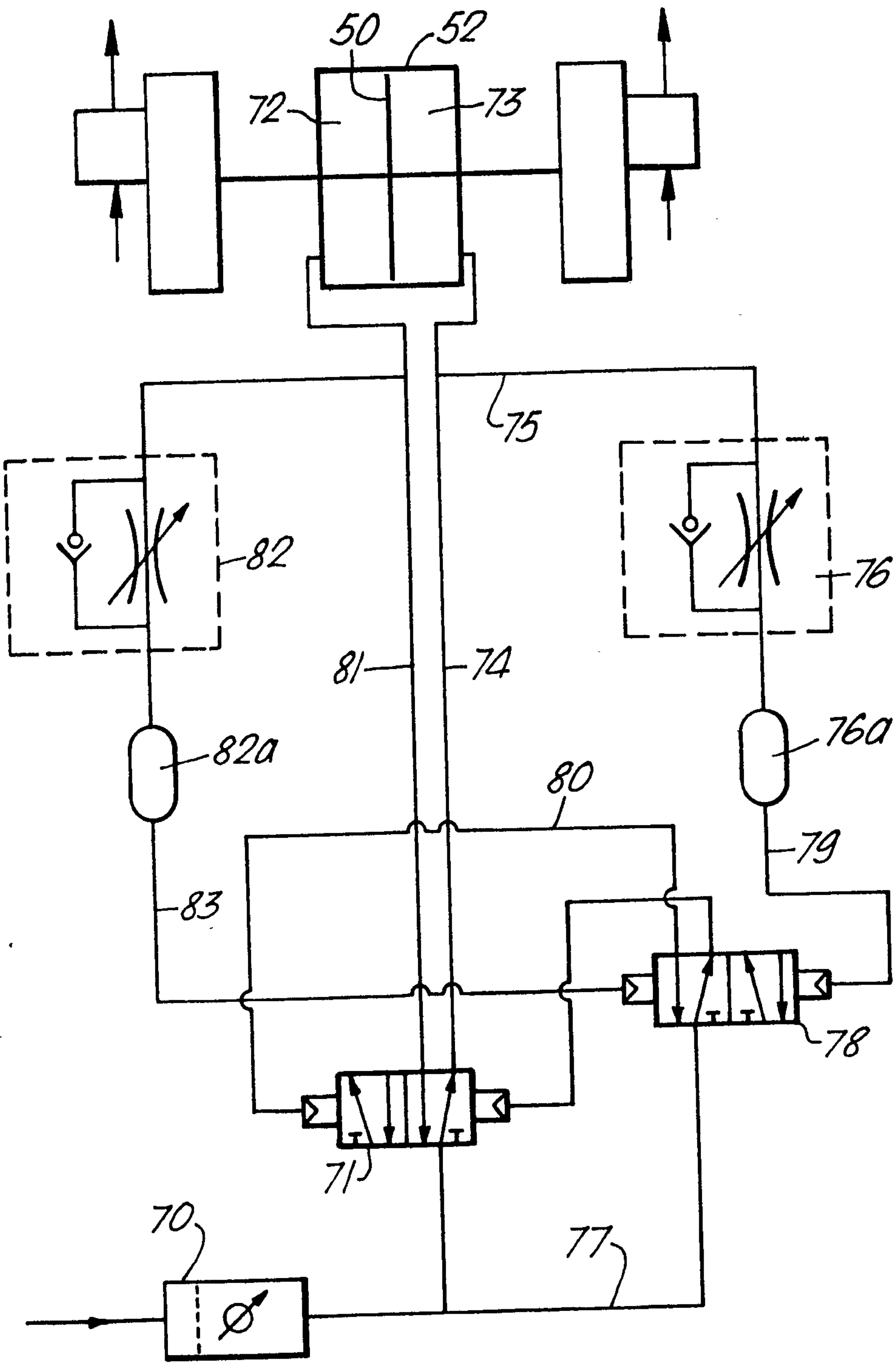
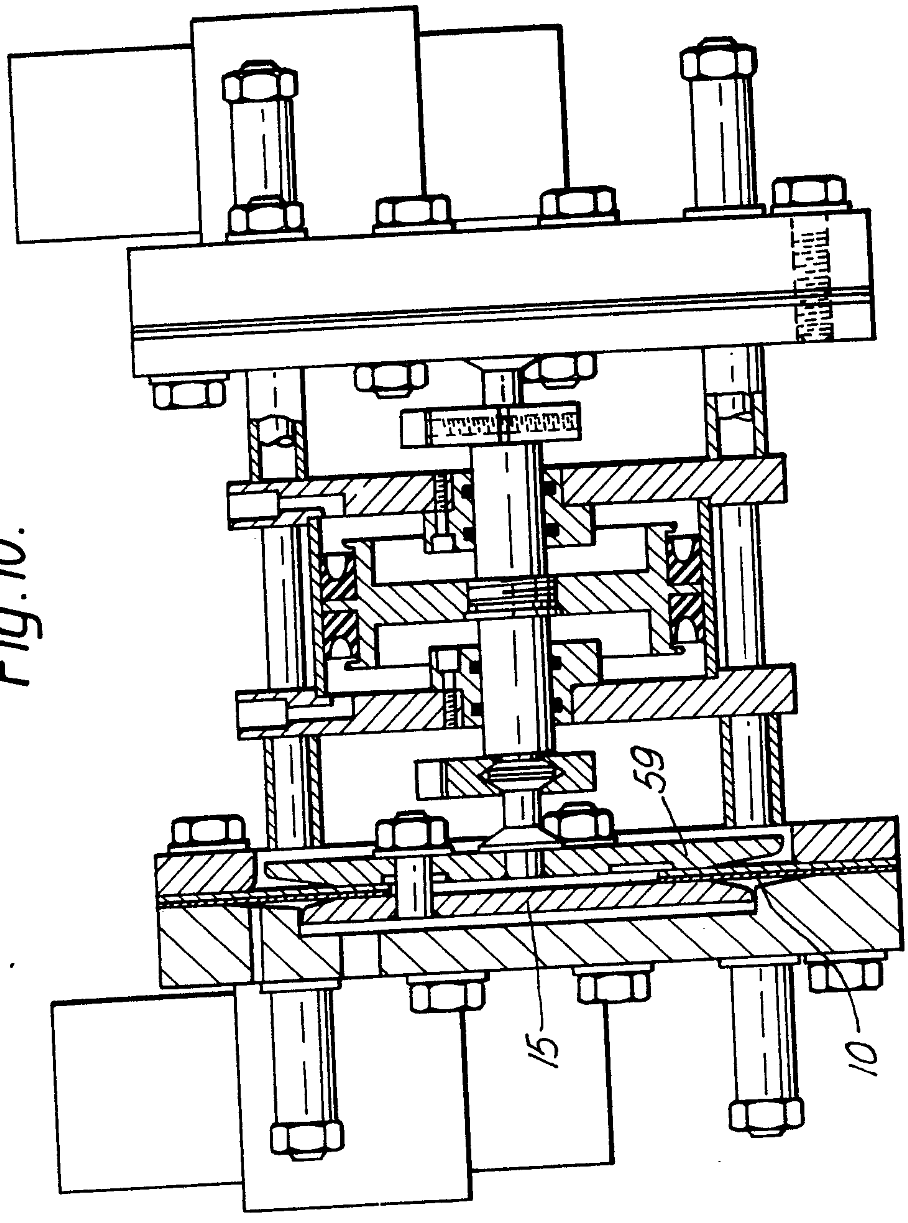


Fig.10.



SPECIFICATION

Improvements in or relating to pumps

This invention relates to pumps particularly but not exclusively pumps for use with radioactive liquid.

According to one aspect oi the invention a diaphragm pump has a laminate diaphragm comprising a first layer, and a second layer having greater elasticity than the first layer.

According to another aspect of invention a diaphragm pump comprises a housing, a diaphragm peripherally secured in the housing and dividing the housing into first and second chambers, a central support for the diaphragm, and means extending from the support through an end wall of the housing for effecting reciprocation of the diaphragm, in which the central support comprises first and second parts respectively on opposite sides of the diaphragm at least one of the first and second parts diverging outwardly as it extends away from the diaphragm.

Said at least one part may extend outwardly to adjacent the effective periphery of the diaphragm.

According to a further aspect of the invention a diaphragm pump comprises a housing, a diaphragm peripherally secured in the housing, a central support engaging the diaphragm, means extending from one side of the central support to the exterior of the housing for reciprocating the diaphragm, in which the central support engages the diaphragm to a transverse extent which is between 1/2 and 2/3 of the major transverse active dimension of the diaphragm.

The diaphragm may be a laminate having a first layer and a second layer of greater elasticity than the first layer. The central support may comprise first and second parts respectively on opposite sides of the diaphragm, at least one of the first and second parts diverging outwardly as it extends away from the diaphragm.

The invention may be performed in various ways and some specific embodiments with possible modifications will now be described by way of example with reference to the accompanying somewhat schematic drawings, in which:

Figure 1 is a section through a diaphragm pump;

Figures 2 to 5 show examples of laminate diaphragms;

Figure 6 is an exploded view of one diaphragm;

Figure 7 is a stress graph;

Figure 8 is an axial section through a double acting pump;

Figure 9 is a pneumatic circuit associated with the pump, and

Figure 10 is an axial section through another pump.

Referring to Figure 1, a diaphragm pump comprises basically diaphragm 10 whose periphery is clamped on a circumference between housing parts 11, 12, defining chambers 13, 14 on opposite sides of the diaphragm 10.

The centre of the flat diaphragm 10 is gripped between clamp elements 15, 16. A rod 17 is fixed to element 16 extends through chamber 14 and slidably through end wall 12a of housing part 12. The chamber 11 has sloping wall 18 leading to circular central recess 19. An axial bore in end wall lla of housing part 11 communicates with liquid inlet 20 which communicates with suction inlet pipe 21 and delivery pipe 22.

In use, the rod 17 is reciprocated by suitable means and the diaphragm reciprocates. At the end of the delivery stroke clamp 15 enters recess 19 and diaphragm 10 engages or is close to wall 18.

Difficulty with diaphragm pumps as indicated in Figure 1 is the life of the diaphragm and, with certain diaphragm materials, low volumetric efficiency of the pump.

In the present arrangement the diaphragm 10 is a laminate or composite, giving greater volumetric efficiency due to reduced diaphragm flexibility. Thus in Figure 2 the diaphragm is a laminate of two sheets of PTFE 10a, 10b of equal thickness.

In Figure 3, the diaphragm is a laminate of a sheet 30 (eg of PTFE) having a certain flexibility and another sheet 31 (eg neoprene rubber reinforced with woven nylon matting), giving even greater volumetric efficiency.

In Figure 4 an additional, central, sheet 31 of neoprene rubber reinforced with nylon matting is added to give a further increase in volumetric efficiency.

In Figure 5, the diaphragm is as in Figure 3 but the clamping elements 15, 16 are altered. In the dry chamber 14, the clamping element 40 diverges from its engagement with the diaphragm and has a maximum diameter at its inner face 41 which is the same as the active or outer diameter 42 of the diaphragm, less clearance 43.

The support plate or clamping element 44 on the wet side of the diaphragm also diverges from its engagement with the diaphragm but to a smaller maximum diameter than support 41 because the pump is intended to be self-priming, ie on initial reciprocation of rod 17 the pump will draw liquid up pipe 21 from a source and fill chamber 13 and then commence delivery through pipe 22. If the pump does not have to be self-priming, the maximum diameter of support 44 could be greater.

Figure 6 shows an exploded view of one form of diaphragm support as shown in Figure 5; in the drawing

a = diaphragm major active radius

b = diaphragm clamping radius

c = diaphragm support radius

d = diaphragm overall radius
P1 = atmospheric pressure
P2 = atmospheric pressure ± one atmosphere.

Figure 7 is a graph illustrating stress in the flat diaphragm membrane at the inner clamping radius for a 76.0cm, d = 101.5cm and b being variable. The diaphragm D1 was PTFE 0.8mm thick, D2 = 3.0mm neoprene rubber reinforced with nylon matting (assumed linearly elastic) and only membrane stresses and static forces are considered. Layer 31 had a Young's modulus of approx 900MPa and a free strain of 0.008.

Because PTFE deforms elastically, and will provide little support after one pump stroke, the PTFE part D1 is ignored in arriving at the graph.

Youngs modulus may vary depending on the lay of the matting to the applied load; the material may have a free strain region where the matting weave straightens out in the load direction before an appreciable load is applied. The diaphragm D2 can be improved by arranging the nylon fibres in a spiders web pattern so that the fibres are parallel to the principal stresses (radial and circumferential).

It will be seen that an inner clamping radius of between 40.mm and 53.mm (ie between about 1/2 and 2/3 of the major active radius of 76.mm) gives the region of least total stress and thus longest diaphragm life, with a minimum at about 50.mm.

Figure 8 shows a double-acting pump incorporating these improvements, where like reference numerals are used for like parts. A piston 50 has axially spaced peripheral seals 51 in cylinder 52 with end walls 53, 54 each having a central bush 55 with O-ring seals 55a slidably receiving rod 17 which in this case is in two parts connected by coupling 56 comprising a collar 57 and an adjusting screw by which the overall length of the rod can be adjusted. The dry-side diaphragm support comprises boss 58 having an external thread which receives a clamping washer 59 held in place by a nut 60. The end walls 53, 54 are mounted on tie rods 61 with spacers 62 between them and diaphragm plate 12. Valve assemblies 49 comprise double non-return ball or disc valves. Delivery pipe 48 and suction line 47.

The seals 55a are separated by a distance greater than the pump stroke so that any portion of the piston rod directly in contact with deleterious atmosphere eg a so-called glovebox, will not be in direct contact with the pneumatic supply of the pump (and vice versa) during normal operation. The plates 15, 59 are preferably between 1/2 and 2/3 of the major active dimension, as above.

As can be seen from Figure 9, the piston 50 is reciprocated pneumatically. Pressure air is supplied through control valve 70 to change-over spool valve 71 which feeds the air alternately to chambers 72, 73 in cylinder 52. In the position shown, air flows on line 74 to chamber 73 and also on line 75 to adjustable flow restrictor 76, communicating via reservoir 76a and line 79 with valve 78. Air is also in line 77 and passes through spool valve 78 to hold valve 71 in the position shown. After a certain time, pressure builds up in line 79 and changes over valve 78 so that air flows through valve 78 to line 80 to change-over valve 71 so that air from control 70 now flows on line 81 to chamber 72, chamber 73 exhausting through valve 71. Flow restrictor 82 permits pressure to increase in reservoir 82a and line 83 so that after a certain time valve 78 again changes over and the next cycle is started. Piston 50 is thus reciprocated. Adjustment of the restrictors 76, 82 enables the suction stroke/delivery stroke relationship of the pump to be adjusted, and the pump speed to be varied by operating control 70 to vary the supply pressure.

In a modified arrangement, instead of an all-pneumatic control arrangement, an electronic timing device may control the change-over periods of an electromagnetic valve similar to valve 71 with restrictors 76, 82 and valve 78 being omitted.

Limit switches could be fitted to the pump piston, the switches being associated with the electromagnetic valve; the pump speed could then be controlled by changing the supply pressure only, the timer being omitted.

In the case where the pump is for use with radioactive liquid obtained during reprocessing of nuclear fuel, the liquid may contain trinormalbutylphosphate and odourless kerosene and the wet side of the diaphragm should be of a material which can withstand chemical degradation from these materials and have acceptable fatigue life; PTFE is suitable. However, PTFE may suffer plastic deformation and creep, and lack the required flexural rigidity and elasticity. The material of laminate layer 31 provides this.

The pump could be provided with inlet and outlet manifolds and be used with acids and other hazardous liquids.

In a modification the diaphragm may comprise reinforced PTFE moulded round a separate central boss, and the diaphragm 31 and central clamping plates are then omitted.

Figure 10 shows a modified pump similar to Figure 8.

CLAIMS

1. A diaphragm pump comprising a housing, a diaphragm peripherally secured in the housing and dividing the housing into first and second chambers, the diaphragm comprising a first layer and a second layer of greater elasticity than the first layer, a central support for the draphragm, and means extending from one side of the central support through an end wall of the housing for effect-

ing reciprocation of the diaphragam, the central support comprising first and second parts respectively on opposite sides of the diaphragm, at least one of said first and second parts diverging outwardly as it extends away from the diaphragm, the central support engaging the diaphragm to a transverse location which is between one half and two thirds of the major transverse active dimension of the diaphragm.

2. A pump as claimed in claim 1, in which the diaphragm is flat.

3. A diaphragm pump substantially as hereinbefore described with reference to the accompanying drawings.

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