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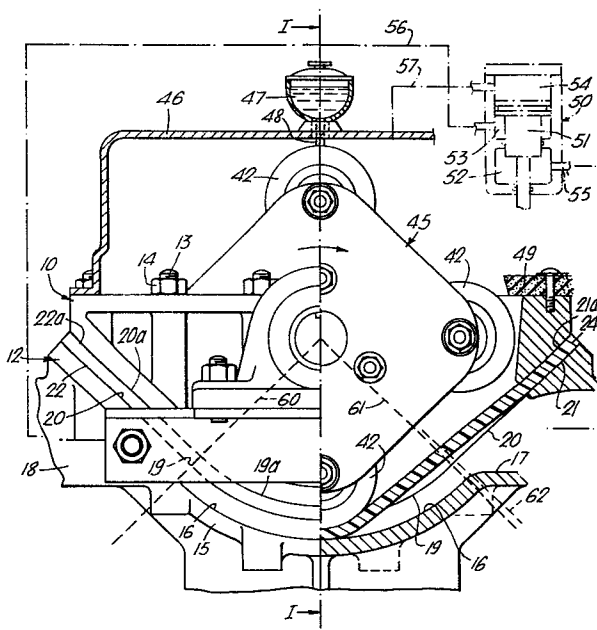
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54 **Pump or motor with a flexible diaphragm.**

57 A material handing device such as a pump or motor including a substantially longitudinally inextensible diaphragm clamped around its periphery between upper and lower housing parts, the lower housing part having an internal surface forming, together with the diaphragm the chamber of the device. A deflector assembly including at least three rollers is mounted in bearings which in turn are mounted, preferably pivotally, on the lower housing part so as to be readily releasable to enable the diaphragm to be changed. The upper housing part may be provided with a casing which can be pressurized to a pressure intermediate the inlet and outlet pressures of the device.



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DESCRIPTION"MATERIAL HANDLING DEVICE"TITLE MODIFIED
see front page

The present invention relates to material handling devices such as pumps or motors.

Diaphragm pumps have been proposed, such as in German Patent 6243, British Specification 208477; 5 562409; 1152912 and 1342847 and United States Patent 2794400. These pumps include a housing having an internal surface and a flexible resilient diaphragm mounted within the housing and secured thereto to form with the internal surface a chamber. The pumps are provided with first and 10 second ports which communicate with the chamber and a number of deflectors, such as rollers, are operable sequentially on the face of the diaphragm remote from the chamber to urge the diaphragm towards the internal surface to form a closure which traverses the chamber. The closures 15 each move from the first port to the second port, one of the closures being terminated after the succeeding closure has been initiated. A disadvantage of such a construction is that there is a necessity for the diaphragm to be resilient, to enable it to take up the necessary shapes, 20 and there is a tendency for the diaphragm to flex towards the low pressure side of the pump, thus causing the "slug" of material being pumped to be of small volume. For this reason, pumps of this nature are limited both in their size and by the low rotational speeds at which they can operate.

25 In British Patent Application No. 8037370, it has been proposed for the flexible diaphragm to be substantially longitudinally inextensible and for the pump configuration to be such that, as the deflectors move sequentially along a path on the surface of the diaphragm remote from the 30 chamber, the sum of the distances, measured along the diaphragm, between the clamping points of the diaphragm

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and the deflectors adjacent thereto, and, where appropriate, between adjacent deflectors, remains substantially constant. The housing is formed as a first part having a lower clamping surface and a second part which has an upper
5 clamping surface, the clamping surfaces being shaped to give the correct configuration for the pump and the rotor carrying the deflectors being mounted on the first housing part. Because the length of the diaphragm remains substantially constant, whatever the position of the
10 deflector means, the diaphragm is prevented from collapsing from the reduced pressure zone or extending into the housing interior. This enables the pump to be operated at relatively high speeds and pressures for lighter materials including slurries. The pump is also capable of handling
15 very heavy materials, such as mortars, and even concrete, quite adequately.

It is now proposed, according to the present invention, for the deflector means to be mounted on the second housing part, that is the part having the interior
20 surface against which the diaphragm is pressed by the deflector means. This may be achieved by providing mounting lugs on the sides of the second housing part, but this can produce foundry problems, if the second housing part is cast, and will give rise to subsequent machining problems.
25 Preferably, therefore, brackets are mounted on the second housing part and these can be used for lateral positioning of the rotor, the brackets also giving the possibility of adjustment of the vertical location of the rotor. One of the simplest ways of carrying out this vertical adjustment
30 would be by using shims or screw adjusters under plummer blocks which are used to mount the rotor. Alternatively, the bracket could be mounted pivotally at one end while the other end could be raised or lowered by various means. The plummer blocks or other bearings could be mounted on a
35 sub-frame which is pivotally mounted at one end on the

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second housing part, so that the sub-frame and rotor assembly could be pivoted between a first position in which the rotor assembly is in its working condition, and a second out-of-the-way position when the sub-frame is clear of the diaphragm altogether, this allowing the diaphragm to be changed readily. Provision would normally be made to clamp the sub-frame firmly in the first position.

A further possibility is to have the sub-frame held resiliently in the first position, e.g. by spring force, to enable the rotor assembly to move away slightly if the diaphragm is caused to deflect unduly by the passage of solids in the chamber. The resilient loading of the rotor can also be used to control the output pressure of the pump.

The pivotal position of the sub-frame or of the pivotally mounted bracket in the working condition of the pump could be made adjustable, to enable the pressure of the deflectors on the diaphragm to be increased for priming the pump to give start-up and then hinged to reduce the pressure on the diaphragm when the fluid itself is being pumped. This adjustment could be done manually or using an actuator, such as a hydraulic actuator.

Advantageously, the cooperating clamping surfaces of the first and second housing parts are so shaped that in the fully clamped condition, the surfaces are spaced apart by a substantially constant distance around the full periphery. This ensures a more even clamping effect, when the two housing parts are clamped on the periphery of the diaphragm.

Preferably, the arcuate portion of the trough which is, in essence, a portion of a circle centred on the centre of rotation of the rotor, is extended at each end by a significant amount to ensure that two rollers are in contact with the diaphragm simultaneously for a significant

time. This can substantially reduce the amount of slippage of the material being pumped past the rollers.

Preferably, the clamping bolts which hold the two housing parts together are located not only along the sides
5 of the housing (perpendicular to the axis of rotation of the rotor), but also along the ends.

The lateral and/or leading and trailing edges of the diaphragm may be provided with through-holes through which locating elements such as the previously mentioned bolts
10 extend to prevent those edges of the diaphragm being pulled in by the passage of the deflectors.

In order to reduce the wear on the diaphragm, where the deflectors are in the form of rollers, it is further proposed, according to another aspect of the invention, for
15 a belt to be passed around the rollers. This may be internally toothed to cooperate with toothed rollers. The belt may be arranged so that it does not move at all relative to the diaphragm and indeed it can be physically fixed thereto. If there is no relative movement between the belt and
20 the diaphragm, the wear of the deflectors on the diaphragm can be reduced significantly. Of course there will be wear on the belt itself, but this can more easily be replaced than the diaphragm.

Alternatively, or additionally, the diaphragm may
25 include two or more lamellates. One lamellate will form the deformable wall of the chamber and between this and the deflectors is located a further lamellate or lamellates. The face of the lamellate adjacent said one lamellate may be provided with notches or cuts extending generally
30 parallel to the axis of the rotor carrying the deflectors. These notches or cuts will flex open as the deflectors pass over the opposite surface, to relieve the strain on the diaphragm. Of course, the notches should not extend as far as the longitudinal reinforcement in the diaphragm, so that
35 the extensibility of the latter will not be affected thereby.

It is also contemplated that a renewable pad conforming to the shape of the said internal surface of

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the housing be placed within the housing so as to define one wall of the chamber. Such a pad can be replaced should it become worn, and this would give the apparatus a longer working life, particularly when it is used with abrasive fluids. The pad may be rigid or it may be resilient, in which case it would normally be provided as a moulded rubber or similar material pad which is bonded to a part-annular shaped plate which is bent so that before being mounted it has a slightly larger radius than the radius of the internal surface of the second housing part. The plate would be provided with a stud or studs or a nut or nuts and these would cooperate with a nut or nuts and a stud or studs so that the plate may be attached to the housing and during this attachment the plate would bend to the shape of the housing. This would ensure that the ends of the pad are restrained in a direction away from the chamber and will not tend to lift away from the pump chamber. The studs or nuts, when tightened, will seal in the same manner as the bolts securing the diaphragm.

The renewable pad need not necessarily present a solid face to the diaphragm but, for example, could have an undulating shape, for example of buttress shaped teeth, which would easily bend in one direction under the action of the rollers on the diaphragm, but only with much more difficulty than in the opposite direction. Either the softness of the renewable pad or the buttress shape teeth or both could allow solids up to a given size to pass through the pump without damaging it.

During operation, there will be a pressure differential across the diaphragm. Thus, at the inlet side of the pump, the pressure above the diaphragm, that is on the face remote from the chamber, will be higher than the normally sub-atmospheric pressure at the inlet, while it will be significantly lower than the pressure at the outlet. It is proposed according to a still

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further aspect of the present invention to provide a pressure-tight casing above the diaphragm and to pressurize this to a value between the inlet and outlet pressures. Now if the inlet pressure be represented by b and the
5 outlet pressure by c, it can be shown that if a positive pressure a is introduced into the casing such that

$$a = \frac{b + c}{2}$$

(all pressures being represented as absolute pressures)
10 the difference in pressure between the working side and the housing side will be the same at both the inlet and outlet sides of the pump. Further, if one assumes that there is either perfect sealing or equal leaking of the diaphragm on the pump housing when deflected by the
15 rollers, all portions of the diaphragm are subjected to the same difference in pressure (albeit of opposite sign).

To assist in sealing, the surface of the second housing part facing the diaphragm may be provided with
20 raised portions extending along the lateral margins of the area swept by the deflectors.

In order that the present invention may more readily be understood, the following description is given, merely by way of example, reference being made to
25 the accompanying drawings in which:-

Figure 1 is a side elevation of one embodiment of pump according to the present invention, having a cross-section taken along the line I-I of Figure 2;

Figure 2 is a side elevation of the pump of Figure
30 1, in half section taken along the line II-II of Figure 1;

Figure 3 is a perspective view of the diaphragm shown taken out of the pump and in its relaxed condition;

35 Figure 4 is an enlarged cross-section through the pressure regulating servo device;

Figure 5 is an enlarged schematic view of a modified form of the lower housing part;

Figure 6 is a schematic view similar to Figure 2
40 and showing a modified form of pump with a renewable pad in the pump chamber;

Figures 7 and 8 are side elevations, partly in

section, of two further forms of pump device according to the present invention;

Figure 9 is a perspective view of a still further modified construction;

5 Figure 10 is a schematic perspective view of the sub-frame of Figure 9; and

Figures 11A and 11B are somewhat diagrammatic perspective views of the front and back respectively of a further form of diaphragm for use in embodiments of 10 the present invention.

The pump illustrated in the drawings comprises an upper first housing part 10 and lower second housing part 12 bolted thereto by studs 13 and nuts 14. The second housing part 12 has a central dished portion 15 15 having an upwardly facing internal surface 16 blending into a first port 17 which can be seen clearly in Figure 2, and a second port 18 of corresponding shape on the lefthand side, as seen in the Figure. As can be seen more clearly in Figure 1, the second housing part 12 has 20 associated therewith, on each side, a raised clamping surface 19 which faces generally upwardly, that is in the same direction as the surface 16. The clamping surfaces 19 which are curved at the centre (see Figure 2) terminate in a straight surface 20, each end 25 extending over the ports 17 and 18. Instead or as well the first housing part may be provided with pads at the ends of the diaphragm to assist in sealing. Further clamping surfaces 21, 22 are provided at right angles to the clamping surfaces 19 and 20 and extend therebetween 30 so that there is a raised clamping surface constituted by the parts 19, 20, 21, 22 extending completely around the periphery of the internal surface 16 and the ports 17 and 18.

The first housing part 10 has a lower peripheral 35 clamping surface which is generally complementary to the clamping surfaces 19, 20, 21, 22 of the second housing part 12. Thus, the lower clamping surface of the housing part includes a curved clamping portion 19a bounded on each side by a straight clamping surface 20a 40 and end clamping surfaces 21a, 22a. Now the radius of

curvature of the curved portion 19a, the centre of which is coincident with that of curved portion 19, is less than the radius of curvature of the surface 19 by an amount which is equal to the thickness of the diaphragm
5 to be described below in the fully clamped condition. The effect of this is for the compression of the diaphragm to be substantially uniform around the whole of the periphery regardless of the fact that the clamping force in the area of the portions 20, 20a, 21,
10 21a, 22, 22a is taking place at approximately 45° to the axes of the studs 13, while in the central portion the clamping is taking place at right angles to this direction. This is intended to ensure that the edges of the diaphragm are not pulled in by the passage of the
15 rollers, described below, which cause the pumping action. Very satisfactory results are achieved if the studs 13 are substantially equally spaced along the sides of the diaphragm.

The diaphragm 24 is a moulded member having a
20 central dished portion 25 which has a natural configuration similar to that provided by the clamping surfaces and the surface 16, but the portion corresponding to the surface 16 is spaced or raised therefrom. The diaphragm is shown in its premoulded and
25 unmounted state in Figure 3 as having a clamping portion 26 along each side and a clamping portion 27 along each end, portions 26 and 27 extending around the full periphery. Longitudinal corrugations 28 extend along each side of the dished portion and are spaced inwardly
30 from the clamping portion 26. The diaphragm includes longitudinally extending reinforcement 29, for example in the form of substantially inextensible fibres which render the diaphragm longitudinally substantially inextensible itself. Just below the upper surface of
35 the diaphragm a further reinforcement 23 is provided which may include not only longitudinal elements but transverse elements. In fact, preferably, this further reinforcement is on the bias and extends across the full

width of the diaphragm. This enables the diaphragm to flex but not to extend longitudinally, the flexing being greatly facilitated by the corrugations 28.

5 The concave surface of the central portion 25 is moulded at a radius which gives the path length required when the diaphragm is distorted by the rollers.

10 Mounted on the second casing part 12, on each side thereof, are two brackets 30, each bracket being secured by two spaced bolts 31, only one of which is shown in each Figure. The brackets are of angle iron form having a vertical limb 32 and a horizontal limb 33, the bolts 31 passing through the limbs 32. The holes in these limbs may be somewhat larger than the bolts to allow for a small amount of vertical and horizontal adjustment of
15 the brackets. The horizontal limbs 33 each have bolted thereto by bolts 34 plummer blocks 35. These plummer blocks may be mounted, if desired, on shims to provide further vertical adjustment thereof. The two plummer blocks form bearings for a drive shaft 36 provided with
20 a keyway 37. Welded to the shaft 36 are two radial flanges 38 (only one of which can be seen), each flange 38 carrying an annular mounting plate 39. Between the plates 39 are mounted four equi-angularly spaced roller shafts 40 provided with bearings 41 for mounting four
25 rollers 42. The shaft 37, flanges 38, plates 39 and rollers 42 constitute a rotor indicated by the general reference numeral 45.

A cover 46 mounted on the first housing part 10, is held in position by studs and nuts (not shown). Mounted on the top of the housing 46 is a reservoir 47 for lubricant, this having a wick 48 extending through the
5 top of the housing 46 so as to touch the rollers 42 as the rotor 45 rotates. An alternative method of applying lubricant to the outer surface of the rollers is illustrated in Figure 2 in which an impregnated pad 49 is bolted to the top of the housing part 10 which again
10 is contacted by the rollers 42 as the rotor 45 rotates. Figure 1 illustrates a still further arrangement for providing lubricant on the outer surface of the rollers 42, this being in the form of an impregnated ring 50 through which the shaft 37 is passed, the ring having a
15 diameter such as to enable it to contact the outer surface of the rollers 42 when the latter are immediately below the shaft 37.

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The configuration of the pump is chosen so that the effective length of the upper surfaces of the diaphragm remains constant. That is, the sum of the distances, noted along the diaphragm, between the clamping surfaces 21 and 21a at one side of the pump and the adjacent roller 42, and from that roller to the next roller, when two rollers are in contact with the diaphragm, and from that next roller to the other clamping surfaces 22, 22a, remains constant regardless of the position of the rotor and regardless of whether one or two rollers are in contact. This means that the diaphragm need not elongate at all during the action of the rollers and it is for this reason that it is possible to have the reinforcement in the longitudinal direction which prevents the diaphragm from elongating, the other reinforcement arranged on the bias preventing too much distortion, but allowing an adequate amount for the flexure of the diaphragm under the action of the rollers 42. As the rotor 45 rotates, the constriction or closed off chamber which is formed between the diaphragm and the surface 16 is moved from the inlet port 17 to the outlet port 18 and because there are at least three rollers 42, the capsule thus formed is always isolated from at least one of the ports. Because the sum of the distances mentioned above is constant, a positive pumping action can take place in an adequate manner. It will be appreciated that the closure caused by one roller is terminated after the succeeding closure is initiated.

Mounted in a suitable manner on the pump housing is a servo arrangement indicated by the general reference numeral 50 in Figures 1, 2 and 4. As can be seen particularly in Figures 2 and 4 the servo device 50 comprises a cylindrical housing with an axially movable stepped piston 51 defining a first chamber 52, a second chamber 53 and a third chamber 54. The first chamber 52 is connected via a line 55 to the pump inlet port 17 and

the second chamber 53 via line 56 to the pump outlet port 18. Finally the third chamber 54 is connected via line 57 to the housing 46 to pressurise the same.

If the inlet pressure at 17 is represented by b and outlet pressure by c and the casing pressure by a, then as the pump inlet pressure b reduces and increases, and/or the pump outlet pressure reduces and increases this will cause a movement of the piston 51 down and up respectively. If the differential area between the piston 10 rod 58 and the main portion of the piston 51 is represented by d and the differential area between the mid portion 51 and the upper land 59 is represented also by d and the total area of the top surface of the land 59 is represented as 2d, then the relationship will exist whereby the 15 pressure in the casing a will equal $\frac{b + c}{2}$. This ensures that the differential pressure across the diaphragm will always be substantially the same, although of opposite sign.

As can be seen in Figure 2, the curved surface 16 is extended slightly, so that there is a significant 20 amount of overlap. The two chain-dotted lines 60 and 61, which are arranged at right angles to one another, indicate the position of two adjacent rollers 42 when these force the diaphragm simultaneously in two places into contact with the surface 16. As can be seen, the surface 16 in 25 fact continues further to the line 62, at each end, thus assuring a degree of overlap. This greatly reduces the amount of slippage which occurs through fluid being pumped passing under the clamped diaphragm-surface 16 interface.

As can be seen from Figure 1, the trough 16 30 merges into the surface 19 by way of two arcuate surfaces 64 and 65 having a common tangent 66. This tangent 66 is arranged at an angle of $40^\circ \pm 5^\circ$ and this has been found to be the best angle (in Figure 5, described below, the corresponding angle is preferably 30°). If the angle is 35 too steep, then there is a tendency to arch the diaphragm across the bottom corner of the trough and there is a greater inversion of

the diaphragm from its original shape, to the fully distorted shape, this creating a very high flexing stress. If the angle is too shallow, then it means that the pump will require a much wider housing. It will also be noted that flexure of the membrane can be improved by that portion of the diaphragm which is subject to the most flexure and indicated by the reference numeral 67 being significantly thinner than the remainder of the diaphragm; this portion thus acts as a solid hinge.

Figure 5 illustrates a portion of the upper surface of the lower or second housing part 12 in a modified construction. It will be seen here that the lower surface 70 curves upwardly at 71 to a ridge 72 of curvilinear cross-section which extends above the clamping surface 74. Thus, when a diaphragm is clamped the bolt passing through holes in the diaphragm will prevent the outermost parts of the diaphragm from moving, but the effect of the ridges causes a certain lateral stretching of the diaphragm allowing the housing parts to clamp together. This will reduce the possibility of the longitudinal bulges forming laterally outwardly of the deflector rollers and provides a barrier between the clamping surface and the pumping chamber to improve the sealing properties of the diaphragm.

Referring now to Figure 6, the modified form of pump illustrated therein includes a housing 100, the internal shape of which has been somewhat modified and, so to speak, expanded. The enlarged cross-section 102 enables a pad indicated by the reference numeral 104 to be introduced. This pad consists of a central part-annular plate 105 surrounded by a resilient material, such as artificial rubber, the internal surface 106 of which is substantially similar to the conventionally shaped surface 16 (Figure 2).

The plate 105 is provided with one or more bolts 107 projected through holes (not shown) in the housing 100, and enabling the plates to be secured by nuts 108. The

shape of the plate 105 is such as to have a slightly larger radius of curvature than the housing 100 so that the ends of the rubber-like pad material 104 surrounding the plate 105 abut the surface 102 of the housing before
5 the centre part thereof. As the nuts 108 are tightened, the plate will flex slightly thus ensuring the ends do not pull away in use.

It will be appreciated that if the material is sufficiently resilient, then not only does the pad
10 overcome the problem of wear on the housing 100, but it also enables the pump to accommodate small hard solid materials without damage, these materials compressing the rubber-like material. If desired, the top surface of the pad 104 could be of buttress tooth shape so that
15 it does not flex in the reverse direction of movement of the rollers, but does flex in the forward direction of movement thus allowing again solid materials to be pumped. [In Figure 6, there is shown in full line the position of two of the four deflector rollers on the
20 diaphragm, in phantom the position of only one deflector roller at an intermediate rotational position of the deflector assembly.]

Figure 7 illustrates a further construction of device according to the invention in which a belt 110 is
25 shown passing around the rollers 42, the belt being anchored by a strap 111 to the casing part 10, so that the belt itself will not move. The belt may be free or may be secured to the diaphragm 24, for example at the centre of the length of the diaphragm. The belt may be
30 a simple belt or it may be a toothed belt in which case the rollers 42 would be themselves cooperatively toothed. The position of such a belt substantially removes all wear on the diaphragm by the deflector rollers.

35 Figure 8 shows a further construction in which a diaphragm 124 is illustrated, this consisting of an upper lamellate 125 and a lower lamellate 126. The two lamellates may in fact be bonded together so as to form a lamellate structure or they may be separate. The

materials of the two lamellates can be chosen to provide various effects. For example, an upper lamellate could be a hard material so that it is not worn by the roller and could in fact exist only in the central portion of width over which the rollers run, while the lower lamellate 126 would then be made of a flexible, but longitudinally inextensible material. The properties of the surface or layer in contact with the fluid can be chosen by using the optimum material to give the mechanical, chemical and temperature requirements for the fluid, while the materials in contact with the rollers can be designed to give the required wear resistance and mechanical properties. There may also be provided intermediate layers which would serve both to bond the other layers together and possibly to provide a general resilience to the diaphragm as a whole thus preventing damage due to the passage of solids in the pumping chamber or variations in the diameters of the rollers of the rotor.

20 If the lamellates are not bonded together, the flexural fatigue life of the diaphragm can be enhanced as compared with the single layer of the same total thickness. Figures 9 and 10 show a further construction which is generally similar to that of Figure 1 except that the plunger blocks 135 are mounted on a sub-frame 136 which is pivotally carried out 137 on the lower housing part 138. The other end of the sub-frame can be locked by means of wing nuts 139 which preferably engage in counter sinks formed in the sub-frame accurately to centre the sub-frame in the correct locked down condition. Figure 9 also illustrates the possibility of providing a spring 140 which can be used, when the wing nuts 139 are slacked off, to pull the sub-frame downwardly against a solid stop position defining the

correct relative positioning of the rotor and diaphragm. Other spring arrangements could equally well be provided but in the preferred construction the sub-frame can be locked securely.

5 Where the deflector roller assembly is mounted as a pivotal assembly on the second housing part, a further advantage can be derived. The pump can be used to start the flow in a pipe and thereafter the housing, together with the deflector rollers, can be pivoted away so that
10 the flow can continue on the siphon principle. When it is desired to stop the flow then the deflector assembly can be pivoted back to its working position and this will act as a stop valve. Thereafter, the flow can be started again by operating the pump and siphoning can be
15 continued by pivoting the assembly away again and so forth.

Figures 11A and 11B show a further form of the diaphragm 25' which is generally similar to that of Figure 3 and can be used in generally similar pump
20 constructions, although the following differences will be noted. Disposed along the lateral edges of the diaphragm 24' are two rows of substantially equally spaced through-holes such as 150, 151. Further, at the leading and trailing edges of the diaphragm 24' are
25 provided through-holes such as 152a, 152b which are preferably longitudinally aligned with the central portion 25' of the diaphragm - as shown their centres may be aligned with the laterally inner edges of the corrugations 28'. These through holes may be engaged by
30 studs or bolts extending between the clamping members so as to prevent the edges, in particular the leading and trailing edges being pulled in as the rollers pass over the diaphragm. The through holes may be provided with a circumferential rib such as 153 to assist in sealing.

C L A I M S

1. A material handling device comprising a substantially longitudinally inextensible diaphragm, a housing including a first housing part having a first peripheral clamping surface and a second housing part
5 having an internal surface and a second peripheral clamping surface surrounding said internal surface and facing generally in the same direction as said internal surface, a diaphragm having a peripheral clamping portion clamped between said first and second peripheral
10 clamping surfaces, the diaphragm forming, with said internal surface, a chamber, first and second ports communicating with said chamber, at least three spaced deflector means each operable to be sequentially movable longitudinally of the diaphragm on the face of the
15 diaphragm remote from the chamber, so as to urge said diaphragm towards said internal surface, to form a closure or constriction which, in use, traverses the chamber, which moves from the first to the second port, one such closure or constriction being terminated after
20 the succeeding closure or constriction is initiated, the configuration of the device being such that the sum of the distances measured along the diaphragm between the clamping points at the longitudinal ends of the diaphragm and the deflector means adjacent thereto and,
25 where appropriate, between the adjacent deflector means in contact with the diaphragm remains substantially constant, characterised in that the deflector means (45) comprises an assembly of spaced deflectors (42) rotatable in a bearing (35) and in that said bearing
30 (35) is mounted on said second housing part (12).

2. A device according to claim 1, characterised in that brackets (30) are mounted on the second housing

part (12) and in that said bearings (35) are mounted on said brackets, means (31) being provided to enable said brackets to be adjustable.

3. Apparatus according to claim 1, characterised in
5 that said bearings (35) and deflector means (45) are mounted on a subframe (136) which is pivotally mounted on said second housing part (12) and movable between a first position in which the deflector assembly is in its working position, with the deflectors (42) in contact
10 with the diaphragm (24), and a second out of the way position in which the deflectors are away from the diaphragm enabling it to be changed readily.

4. A device according to claim 3, characterised in that means (140) are provided to load the deflector
15 assembly resiliently towards said first position against a solid stop position.

5. A device according to any preceding claim, characterised in that the peripheral clamping surfaces (19-22, 19a-27a) of the first and second housing parts
20 (10, 12) are so shaped that, in the fully clamped condition, said clamping surfaces are spaced apart by a substantially constant distance around the full periphery.

6. A device according to any preceding claim,
25 characterised in that said deflector means comprise rollers (42) and in that a belt (110) is passed around said rollers.

7. A material handling device comprising a substantially longitudinally inextensible diaphragm, a
30 housing including a first housing part having a first

peripheral clamping surface and a second housing part having an internal surface and a second peripheral clamping surface surrounding said internal surface, and facing generally in the same direction as the internal surface, a diaphragm having a peripheral clamping portion clamped between said first and second peripheral clamping surfaces, the diaphragm forming, with said internal surface, a chamber, first and second ports communicating with said chamber, at least three spaced deflector means each operable to be sequentially movable longitudinally of the diaphragm on the face of the diaphragm remote from said chamber, so as to urge said diaphragm towards said internal surface, to form a closure or constriction, which, in use, traverses the chamber, which moves from the first to the second port, one such closure or constriction being terminated after the succeeding closure or constriction is initiated, the configuration of the device being such that the sum of the distances measured along the diaphragm between the clamping points at the longitudinal ends of the diaphragm and the deflector means adjacent thereto, and, where appropriate, between the adjacent deflector means in contact with the diaphragm remains substantially constant, characterised in that said deflector means comprises rollers (42) and in that a belt (110) is passed around the rollers.

8. A device according to claim 6 or 7, characterised in that the diaphragm is physically fixed to the belt.

9. A device according to any preceding claim, characterised in that a renewable pad (104) conforming to the shape of the internal surface of the second

housing part is placed within the housing and defines one wall of the chamber.

10. A material handling device comprising a substantially longitudinally inextensible diaphragm, a
5 housing including a first housing part having a first peripheral clamping surface and a second housing part having an internal surface and a second peripheral clamping surface surrounding said internal surface, and facing generally in the same direction as the internal
10 surface, a diaphragm having a peripheral clamping portion clamped between said first and second peripheral clamping surfaces, the diaphragm forming, with said internal surface, a chamber, first and second ports communicating with said chamber, at least three spaced
15 deflector means each operable to be sequentially movable longitudinally of the diaphragm on the face of the diaphragm remote from said chamber, so as to urge said diaphragm towards said internal surface, to form a closure or constriction, which, in use, traverses the
20 chamber, which moves from the first to the second port, one such closure or constriction being terminated after the succeeding closure or constriction is initiated, the configuration of the device being such that the sum of the distances measured along the diaphragm between the
25 clamping points at the longitudinal ends of the diaphragm and the deflector means adjacent thereto, and, where appropriate, between the adjacent deflector means in contact with the diaphragm remains substantially constant, characterised in that a renewable pad (104)
30 conforming to the shape of the internal surface of the second housing part is placed within the housing and defines one wall of the chamber.

11. A device according to claim 9 or 10,
characterised in that said renewable pad comprises a
part annular shaped plate (105) which is formed to have
a larger radius of curvature than that of the inner
5 surface (102) of the second housing part (100), a
rubber-like material moulded around said plate and
cooperating threaded means (107, 108) enabling the plate
to be attached to the housing and during attachment
enabling the plate to be bent to the internal shape of
10 the housing.

12. A device according to any preceding claim,
characterised in that the first housing part is provided
with a pressure tight casing (46) and means (50, 59) are
provided to pressurize said casing to a pressure
15 intermediate the inlet and outlet pressure of the
device.

13. A material handling device comprising a
substantially longitudinally inextensible diaphragm, a
housing including a first housing part having a first
20 peripheral clamping surface and a second housing part
having an internal surface and a second peripheral
clamping surface surrounding said internal surface, and
facing generally in the same direction as the internal
surface, a diaphragm having a peripheral clamping
25 portion clamped between said first and second peripheral
clamping surfaces, the diaphragm forming, with said
internal surface, a chamber, first and second ports
communicating with said chamber, at least three spaced
deflector means each operable to be sequentially movable
30 longitudinally of the diaphragm on the face of the
diaphragm remote from said chamber, so as to urge said
diaphragm towards said internal surface, to form a

closure or constriction, which, in use, traverses the chamber, which moves from the first to the second port, one such closure or constriction being terminated after the succeeding closure or constriction is initiated, the
5 configuration of the device being such that the sum of the distances measured along the diaphragm between the clamping points at the longitudinal ends of the diaphragm and the deflector means adjacent thereto, and, where appropriate, between the adjacent deflector means
10 in contact with the diaphragm remains substantially constant, and characterised in that the first housing part is provided with a pressure tight casing (46) and means (50, 59) are provided to pressurize said casing to a pressure intermediate the inlet and outlet pressure of
15 the device.

14. A device according to any preceding claim, characterised in that the diaphragm (124) is formed of at least two layers (125, 126) of material, the layer facing the second housing part being formed of a
20 different material from that of the other layer or layers.

15. A material handling device comprising a substantially longitudinally inextensible diaphragm, a housing including a first housing part having a first
25 peripheral clamping surface and a second housing part having an internal surface and a second peripheral clamping surface surrounding said internal surface, and facing generally in the same direction as the internal surface, a diaphragm having a peripheral clamping
30 portion clamped between said first and second peripheral clamping surfaces, the diaphragm forming, with said internal surface, a chamber, first and second ports

communicating with said chamber, at least three spaced deflector means each operable to be sequentially movable longitudinally of the diaphragm on the face of the diaphragm remote from said chamber, so as to urge said
5 diaphragm towards said internal surface, to form a closure or constriction, which, in use, traverses the chamber, which moves from the first to the second port, one such closure or constriction being terminated after the succeeding closure or constriction is initiated, the
10 configuration of the device being such that the sum of the distances measured along the diaphragm between the clamping points at the longitudinal ends of the diaphragm and the deflector means adjacent thereto, and, where appropriate, between the adjacent deflector means
15 in contact with the diaphragm remains substantially constant, characterised in that the diaphragm (124) is formed of at least two layers (125, 126) of material, the layer facing the second housing part being formed of a different material from that of the other layer or layers.

20 16. A device according to any one of the preceding claims, wherein the surface of the second housing part facing the diaphragm is provided with raised portions (72) extending along the lateral margins of the area swept by the deflectors.

25 17. A device according to any one of the preceding claims, wherein the lateral and/or leading and trailing edges of the diaphragm are provided with locating through holes through which locating elements extend to prevent those edges of the diaphragm being pulled in by
30 the passage of the deflectors.

Fig. 1.

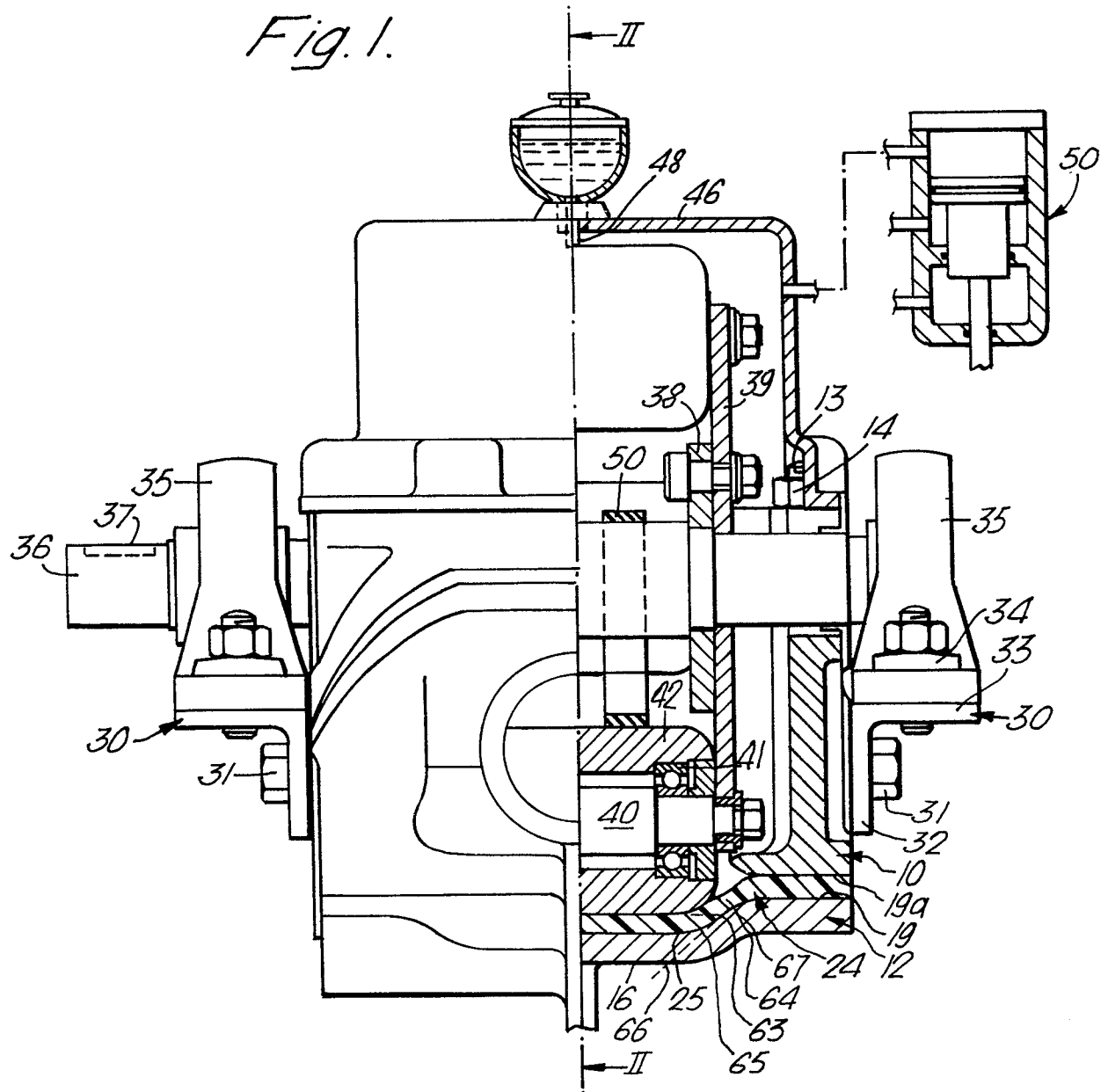


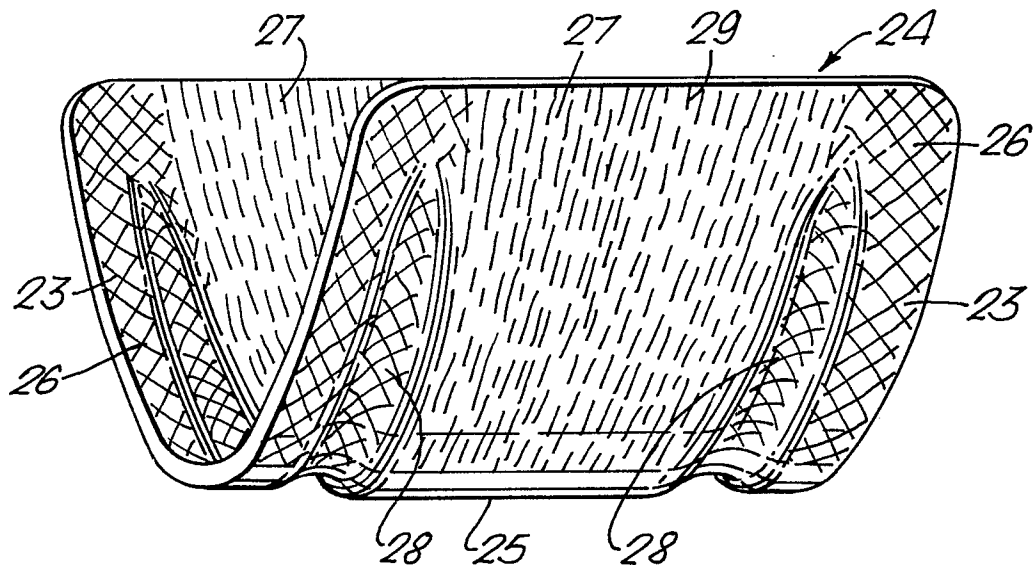
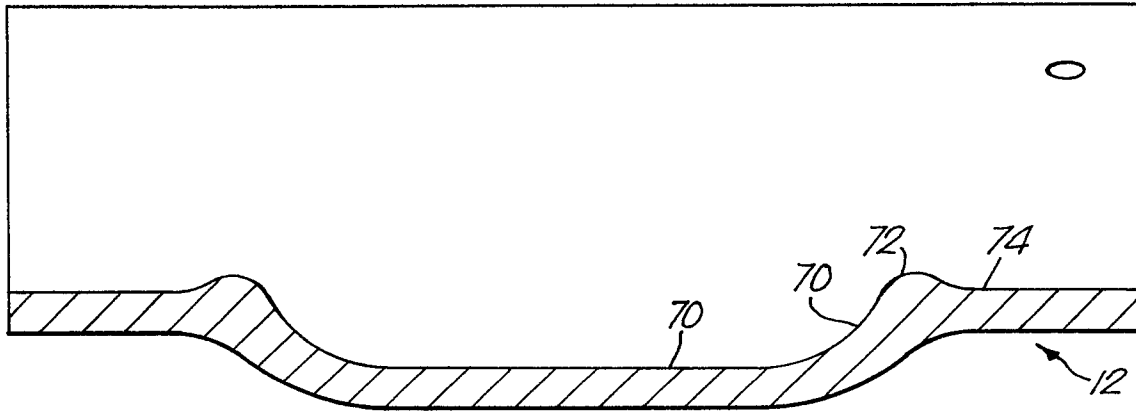
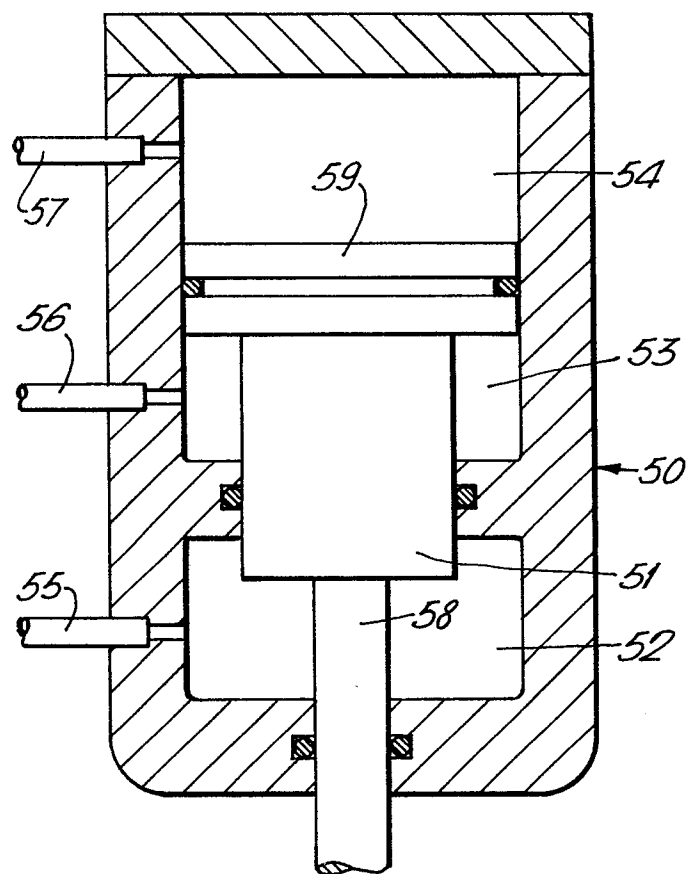
Fig. 3.

Fig. 5.*Fig. 4.*

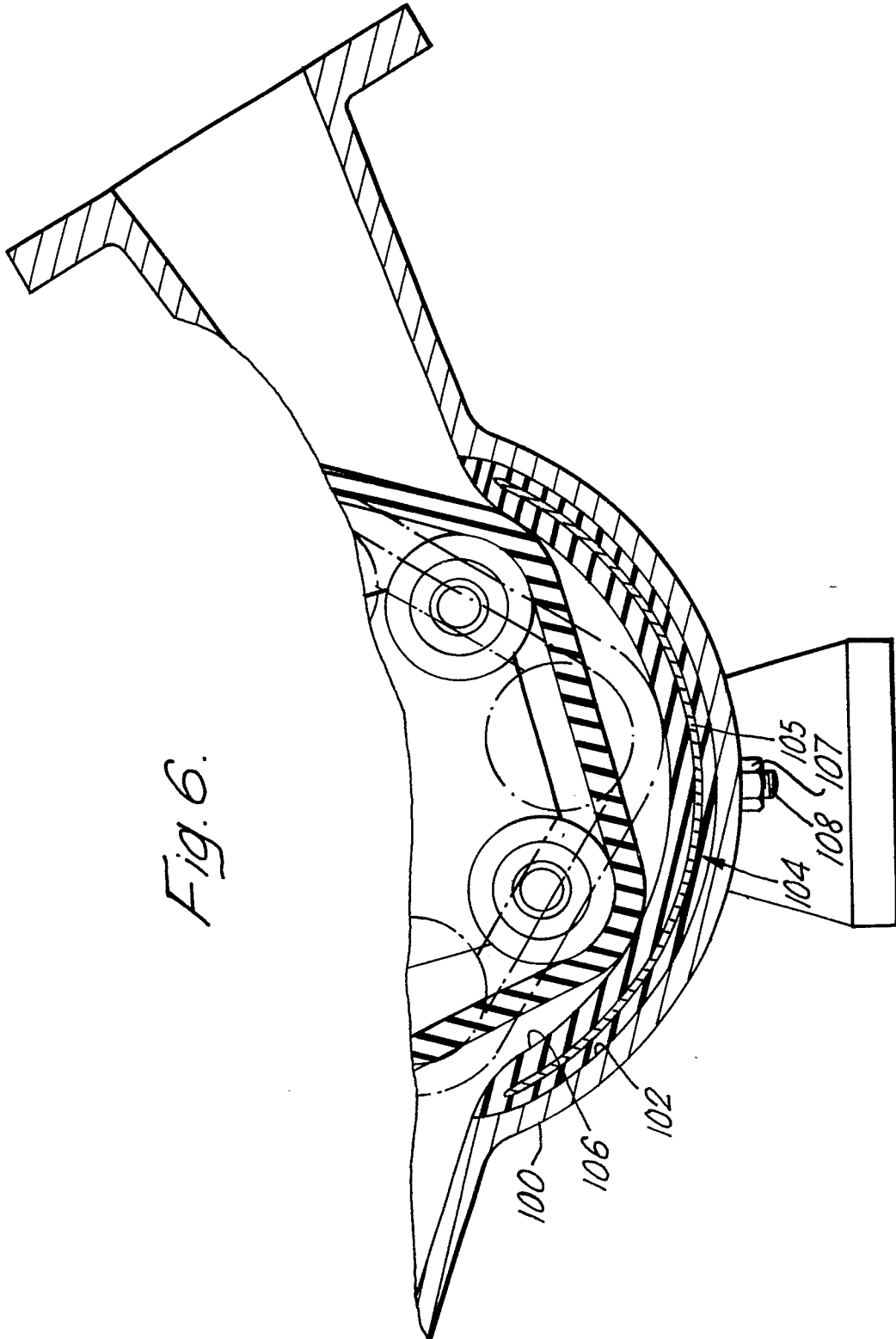
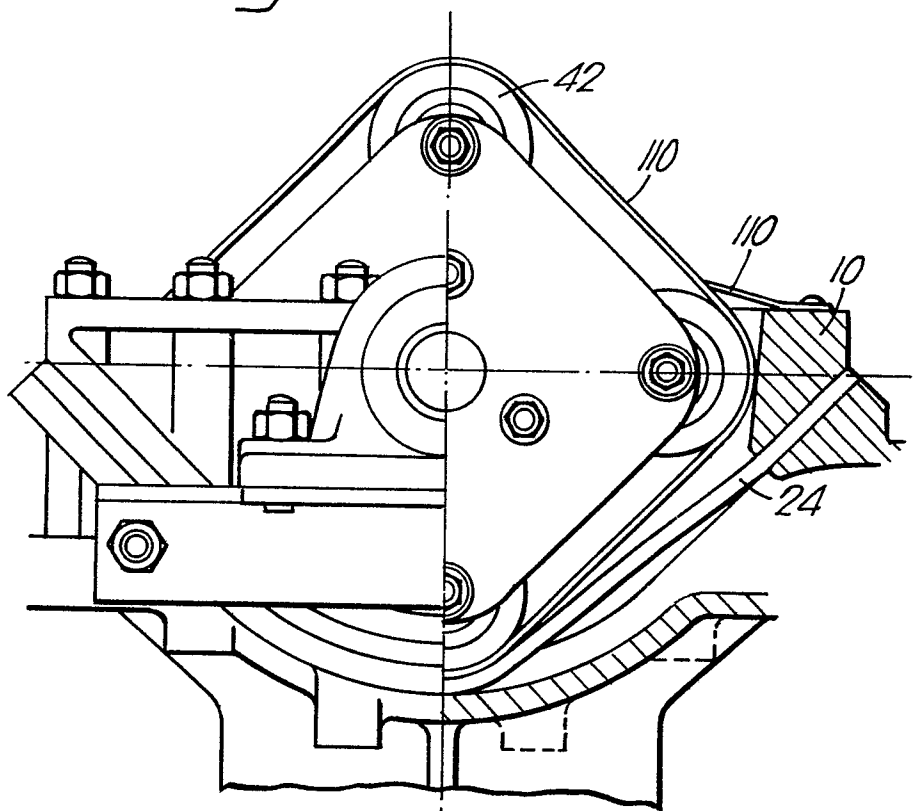
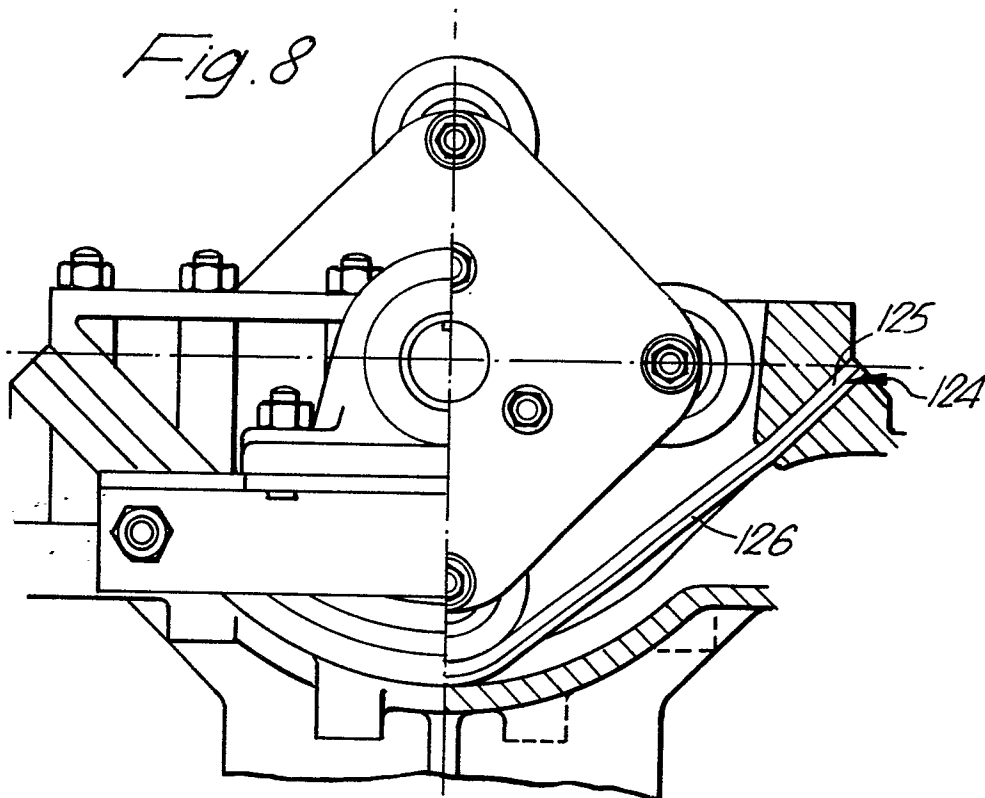


Fig. 7.*Fig. 8*

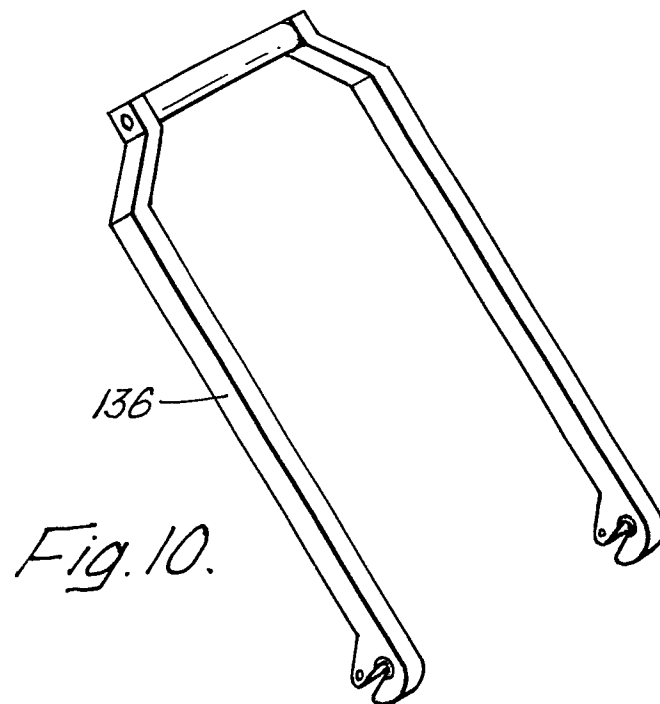
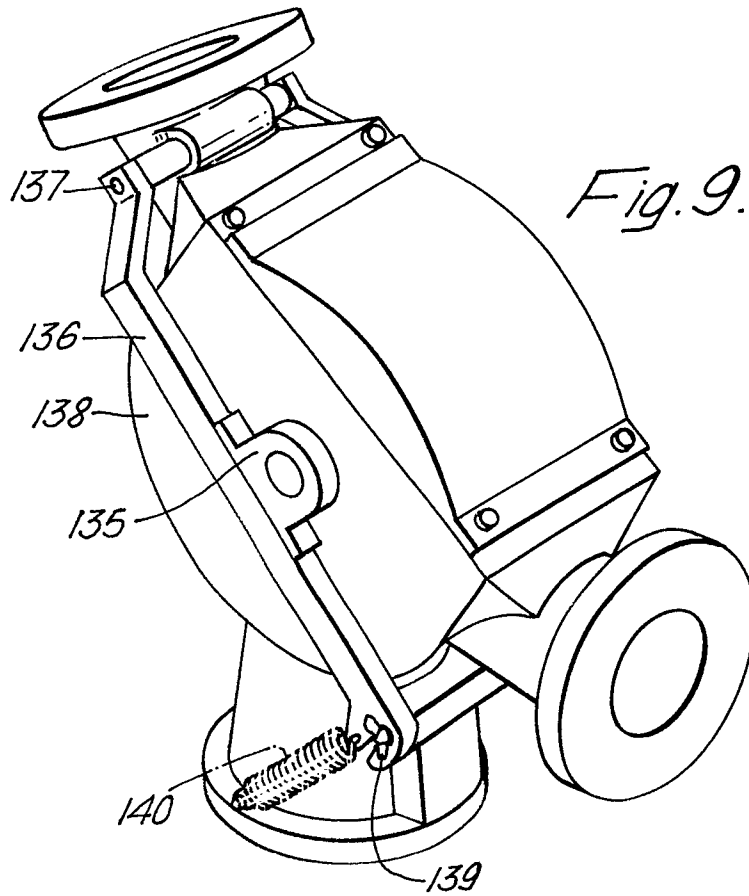
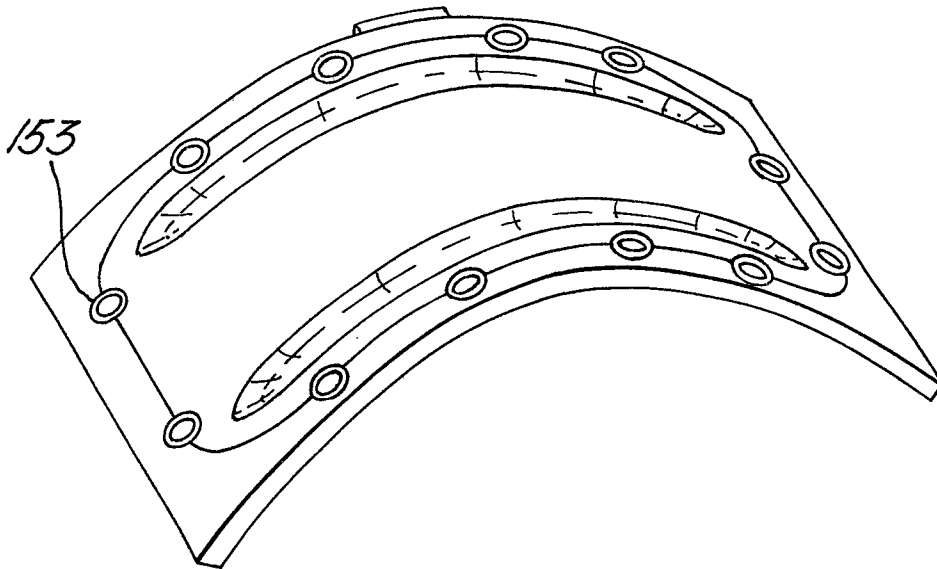


Fig. 11A.*Fig. 11B.*