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3,354,537

RENEWABLE MOINEAU-TYPE PUMPING MECHANISM

Filed Dec. 1, 1965

2 Sheets-Sheet 1

Fig. 1

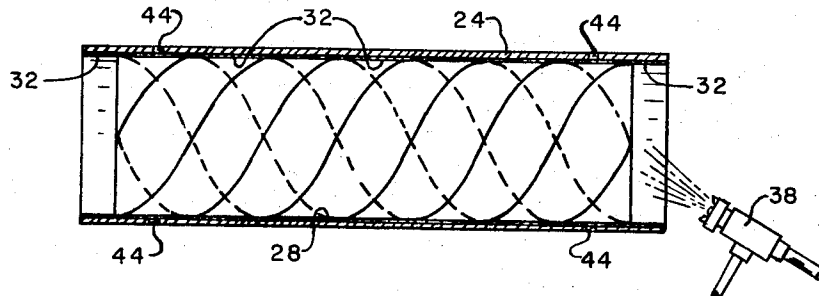


Fig. 2

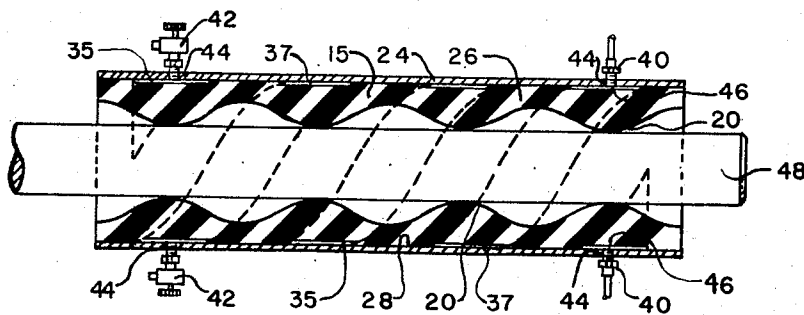


Fig. 3

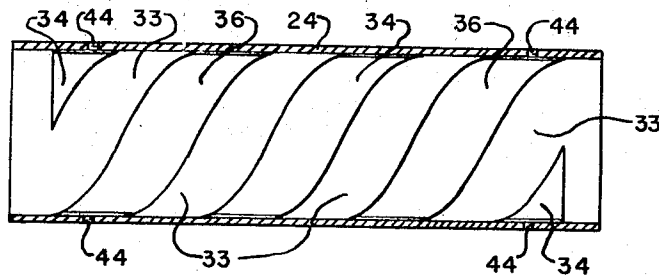
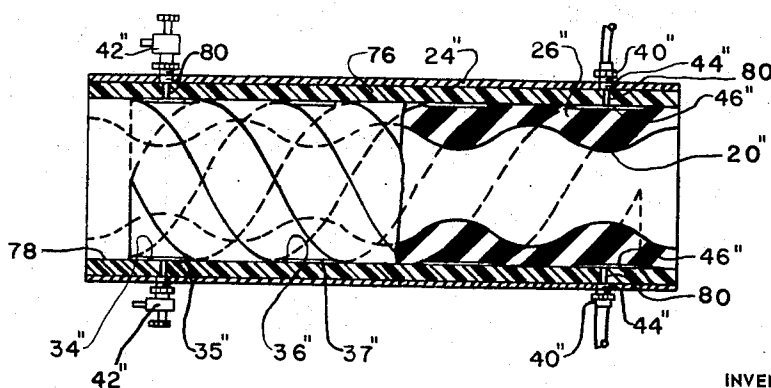


Fig. 5



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Fig. 6

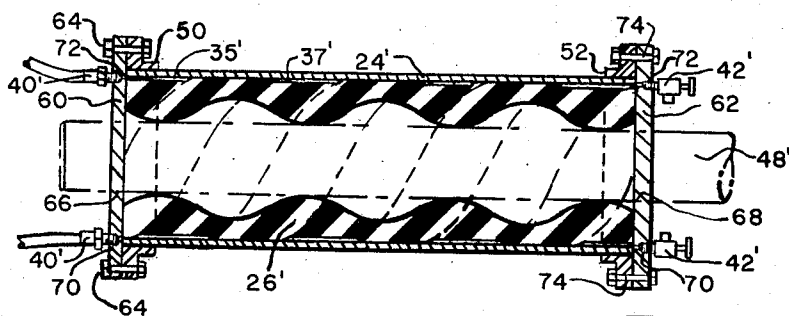


Fig. 7

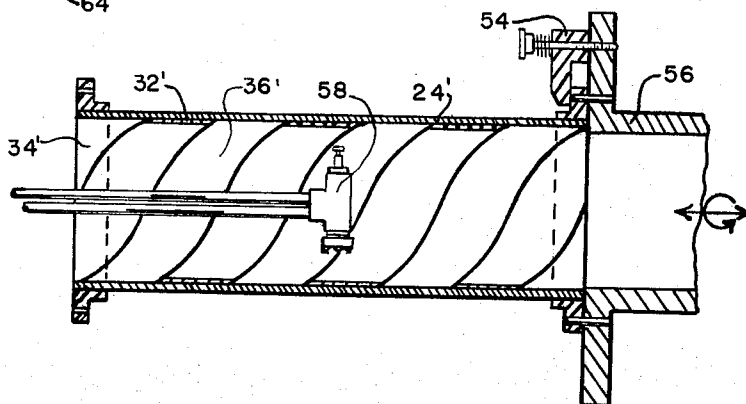


Fig. 8

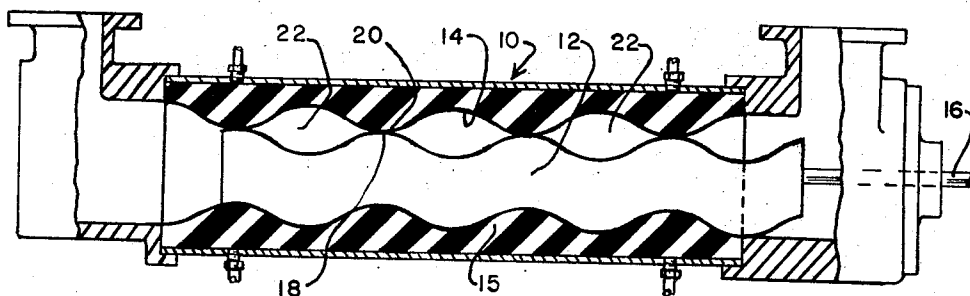
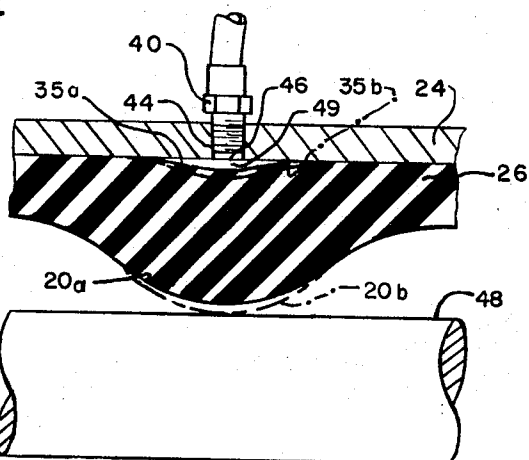


Fig. 4



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RENEWABLE MOINEAU-TYPE PUMPING MECHANISM

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My present invention relates to cavity pump mechanisms of the Moineau-type having helically threaded rotor and stator pumping elements, and more particularly to a method and means for adjusting, renewing, and maintaining a pumping element thereof.

This invention is an improvement upon my Patent No. 3,139,035, issued June 30, 1965, entitled, Cavity Pump Mechanism.

Pumps of the Moineau-type generally utilize a solid, non-yieldable rotor coating with a stator having a wall of elastic or resilient material, in which the rotor must be closely fitted in order to attain the required relatively close tolerances or maximum pumping efficiency. A common problem in pumps of the Moineau-type (see U.S. Patent No. 2,028,407) has been to maintain a relatively precisely sized cavity in the stator element, inasmuch as the latter is defined by the adjacent stator wall structure of elastic or resilient material. The stator wall structure is usually molded and tends to change dimension throughout its useful life and often to an unpredictable extent. In particular, the helical crests-and-lands cavity of the stator wherein the helically threaded rotor is operated is particularly subject to wear at the crests thereof so that the aforesaid clearances become inordinately large for proper pumping efficiency. Accordingly, it is essential to provide means for periodically and predictably restoring the stator crests to their original close tolerances relative to the rotor element.

In the past, it has been proposed to restore the stator crests by providing juxtaposed fluid passages therein and periodically admitting a pressurized fluid into these passages or to increase the pressure of fluid initially contained therein in order to restore the stator crests. Although this solution has been found to be satisfactory in many pumping applications the arrangement afforded by this solution is difficult to manipulate in a predictable manner. Thus, it sometimes occurs that the wear of the stator crests is over-compensated so that the stator crest tolerances relative to the rotor crests become too close with the result that upon start up of the pump, particularly in cavities of greater length, the rotor element tends to "seize" the stator surface and in more extreme cases, the rotor element will twist the elastic or resilient stator wall and even tear it causing a breakdown of the device. On the other hand, if the initial, close tolerances between the rotor and stator surfaces are not sufficiently restored, pumping efficiency thereafter remains impaired.

These difficulties are overcome in my pumping mechanism wherein I provide a method and means for permanently remolding the stator crests to the original close tolerances initially provided in the pump mechanism. Such remolding can be done periodically throughout the life of the pump mechanism, so that the maximum or initial pumping efficiency thereof can be restored whenever desired. These desirable aims of my invention are accomplished in the disclosed pump mechanism by providing an inflatable passage in the stator structure juxtaposed to each of the crests thereof into which passage of a set-

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table material is injected after first treating the material or the walls of the cavity to insure that the settable material does not adhere thereto. The non-adherence of the settable material relative to the crest passages is essential to permit repeated and periodical injection of additional quantities of the settable material for future restorations of the crests to their initial sizes. At the same time a molding device is juxtaposed within the stator cavity, upon each injection of settable material, and the crests of the stator elements are remolded by injecting sufficient quantity of a settable material to urge the stator crests into contact with the mold device. The mold device therefore determines when the initial tolerances are restored relative to the rotor element, and the injection of the settable material is terminated wherein the stator crests are thus properly sized.

These and other objects, features and advantages of the invention together with structural details thereof will be elaborated upon during the forthcoming description of presently preferred embodiments of the invention, together with presently preferred methods of practicing the same.

In the accompanying drawings I have illustrated presently preferred embodiments of my invention and presently preferred methods of practicing the same, wherein:

FIGURE 1 is a longitudinally sectional view of a stator housing member associated with my pump mechanism, wherein certain steps in the method of preparing the housing member for the addition of other components of the stator element are illustrated;

FIGURE 2 is a longitudinally sectioned view of the novel stator element of my pump mechanism and illustrating certain steps useful in the periodic resizing thereof to initial tolerances;

FIGURE 3 is a longitudinally sectioned view of the housing structure of FIGURE 1, with certain preparatory steps having been completed;

FIGURE 4 is an enlarged, partially longitudinally sectioned view of one of the stator element crests of FIGURE 2 and more particularly illustrating certain steps in my method of crest restoration;

FIGURE 5 is a longitudinally sectioned view of another form of a stator element arranged in accordance with my invention;

FIGURE 6 is a longitudinally sectioned view of another form of stator assembly arranged in accordance with my invention and in addition illustrating alternative method steps useful in the restoration thereof;

FIGURE 7 is a longitudinally sectioned view, partially broken away, of the stator housing illustrated in FIGURE 6 and illustrating certain steps in the method of preparing the same for association with the resilient portions of the stator assembly; and

FIGURE 8 is a longitudinally sectional view of one form of pump mechanism arranged in accordance with my invention and showing a rotor element in operative association with one modification of my stator element.

Referring now to FIGURES 1 to 4 and 8 of the drawings, the exemplary form of my pump mechanism 10 illustrated therein includes a rotor element 12 fabricated for example, from a non-yieldable structural material such as carbon or chrome steel and mounted for rotation within the stator cavity 14 by means of rotor shaft 16, a portion of which is illustrated in FIGURE 8 of the drawings. With this arrangement, the singly helical rotor crests 18 are, therefore, mounted for close clearance

movement relative to the doubly helical stator crests 20. The progressing pump cavities 22 are defined by the generally opposed lands of the stator and rotor elements and carry the fluid or semi-fluid material being pumped longitudinally of the rotor and stator elements.

In this arrangement, as better shown in FIGURE 2, the stator element 15 includes an outer housing or shell 24, which serves as a backing member for a resilient material 26 such as rubber or a suitable plastic. The material 26 can be molded by suitable conventional means (not shown) to produce initially the crest-and-land configuration of the stator cavity 14. The crests 20 of the stator element are molded into a double or reverse-threaded, helical configuration as aforesaid. The elastic or resilient material 26 is affixed at its outer surface 28 to the inner wall surface of the shell or housing 24 by a suitable adhesive or by vulcanization in a known manner.

Before the resilient material 26 is thus secured, however, the housing 24 is pretreated as shown in FIGURE 1 to prevent adherence of the resilient or plastic material to the shell 24 at selected positions therealong, with positions corresponding to the location of the stator element crests 20. In furtherance of this purpose, the inner wall surface 28 of the stator shell 24 is provided with a suitable mask 32, as better shown in FIGURE 1, which defines a pair of relatively reversed helices, the spirals or stator crests 20 of which correspond to the location of the spiral strips 34 and 36 coated on the inner surface of the shell 24 as described below. The mask 32 can be fabricated from a suitable material such as heavy paper or stencil cardboard. The inner surface of the shell 24 and the mask 32 are then sprayed with material such as plastic paint to which the aforementioned rubber or plastic material will not adhere. The aforementioned paint can be applied in any convenient manner for example with spray gun 38.

Following application of the paint or other material promoting non-adherence of the resilient material 26 to the inner surface of the housing or shell 24 a pair of spiral painted strips 34 and 36 are formed, which are separated by unpainted strips 33 which are exposed when the mask is removed from the interior of the stator shell 24, as better shown in FIGURE 3 of the drawings.

The mask 32 is then removed from the interior of the shell 24 which leaves a pair of painted helical bands 34 and 36 to which the rubber or plastic material will not adhere. The painted bands 34 and 36 constitute inner-twined or double helicies extending through the stator shell 24 and along the outer surface of the resilient material 26 but juxtaposed to the helical crests 20 formed on the inner surface or cavity of the stator element.

Due to the resiliency of the stator element material 26, the painted strips 34 and 36 define a pair of initially and normally collapsed tubular passages 35, 37, owing to the presence of which the heights of the stator crests 20, when worn, can be increased to restore the original engagement or close clearances of the stator crests relative to the rotor crests 18 (FIGURE 8). In furtherance of this purpose, the resiliency of the material 26, of course, permits dilation or expansion of the initially collapsed tubular passages 35 and 37.

As better shown in FIGURE 2 one arrangement for thus inflating the passages 35 and 37 includes the provision of an inlet tap 40 and valved outlet tap 42 for each of the passages 35 and 37. The taps 40 and 42 desirably are connected at the ends respectively of each passage 35 or 37, where apertures 44 therefor can be drilled and tapped through the stator shell 24 at these locations and extend also through the juxtaposed portions of the painted material defining the passages 35 and 37. The painted bands 34 and 36 are thus pierced as denoted by reference character 46 so that the inlet taps 40 and the valved outlet taps 42 communicates with their associated collapsed tubular passageways 35 and 37. In the arrangements of FIGURES 1 and 2, the thicknesses of the

painted strips 34 and 36 have been exaggerated in order to illustrate the invention more clearly.

In order to inflate the initially collapsed tubular passages 35 and 37, a suitable fluid is admitted under pressure thereto through the respective inlet taps 40, with the valve outlet taps 42, of course, being closed. It is important, however, that means be provided for determining the heights of the crests 20 relative to the rotor 12 so that the original dimensions or clearances of the stator elements can be periodically restored. In accordance with my resizing method one arrangement for so determining the heights of the crests 20 includes the use of a sizing mandrel 48 as better shown in FIGURE 2 of the drawings. The mandrel 48, after prior removal of the rotor 12, is inserted through the stator cavity and the aforementioned pressurized fluid is admitted through the inlet taps 40 until the crests 20 are expanded or distended into engagement with the adjacent wall surfaces of the sizing mandrel 48.

For a clearer exemplification of this step of my method reference can be had to FIGURE 4 of the drawings. In this illustration, the tubular passage 35a has previously been expanded as denoted by the solid outlines thereof and by the mass of previously introduced sizing material 49 therein; however, through continued use of the pump mechanism the associated crest 20a has become worn, as indicated by the solid outlines thereof, so that a separation exists between the worn crest 20a and the sizing mandrel 48 when inserted. Accordingly, means are provided by my invention for further and permanently inflating the passage 35a to an additional extent indicated for example, by the chain line outline 35b thereof which produces an attendant increase in crest height, as indicated by the chain line outline 20b of the associated crest, and a proper sizing engagement thereof with the sizing mandrel 48.

In this arrangement of the invention, the aforementioned sizing fluid, which is introduced under pressure into the initially collapsed tubular passages 35 and 37, is an initially fluid, settable compound which sets up or hardens in the passages 35 and 37, after they have been inflated by the sizing fluid to the desired extent, to preserve the inflated condition of the passages and the attendant expansion and rise in the stator crests 20 without the application of continued pressure from an external source after the sizing fluid has set up. In this application of the invention, a suitable fluid of this character is a liquid epoxy resin which cures to a solid material. A specific example of a class of liquid epoxy resins which are useful for this purpose are the bisphenol-A epichlorohydrin liquid epoxy resins, which are available from the Dow Chemical Company, Midland, Michigan. The epoxy resins are particularly desirable because of their dimensional stability and lack of shrinkage during curing. They are chemically inert when set and exhibit considerable toughness and shock resistance. Many other known settable compounds can be used depending on the application of the invention. However, because of the adhesive character of the aforementioned settable compounds, the initially collapsed tubular passages 35 and 37 are desirably inflated before the introduction of the epoxy resin or other settable compound, with a material under pressure which will prevent the adherence of the settable fluid to the adjacent walls of the resilient stator material 26 and of the stator shell 24. Examples of such material are silicone and other mold lubricating or parting compounds. The adherence preventive is first admitted into the passages 35 and 37 through the inlet taps 40 under sufficient pressure with the valve taps 42 being closed, to ensure sufficient inflation of the passages and complete contact thereof with the adherence preventive fluid or other suitable lubricant. After the passages 35 and 37 have thus been lubricated, the valve outlet taps 42 can be opened to release the excess lubricating fluid from the passages. Following this operation the aforementioned

liquid epoxy material or other liquid settable material is admitted through inlet taps 40 under sufficient pressure suitably to expand the passages 35 and 37 to attain the proper heights of the crests 20 as described above in connection with the crest 20b of FIGURE 4. After allowing sufficient time for the epoxy resin or other settable material to set up the pressure applied to the material through the inlet taps 40 (with the outlet taps 42 being closed) can be released. The sizing mandrel 48 can then be withdrawn, and the rotor 12 can be reinserted for operation within the stator element 15.

After a period of operation, when the crests 20 have again become worn as denoted by the crest 20a of FIGURE 4, the aforescribed operation can be repeated in order to resize the crests 20 against the reinserted mandrel 48. As a precautionary measure an additional quantity of the aforementioned mold lubricant is reintroduced through the inlet taps 40, with the outlet taps 42 being closed under pressure to expand the resilient stator material 26 away from the sizing or settable material 49 (FIGURE 4) and to displace the settable material slightly away from the adjacent inner surfaces of the stator shell 24, in order to recoat the passages 35 and 37. An additional quantity of the aforementioned liquid settable material is then introduced through the inlet taps 40 under pressure further and permanently to expand the passages 35 and 37, for example to the outline 35b thereof as shown in FIGURE 4. This further expansion of the passages restores the crest heights (such as indicated by crest 20b of FIGURE 4) of the resilient material 26 to their original condition as defined by their relatively light engagement with the sizing mandrel 48. Such condition of engagement can be determined, for example by angularly displacing the mandrel about its longitudinal axis and judging or measuring its frictional resistance to rotation. The resizing and re-expansion procedure can be repeated periodically throughout the useful life of the stator element 15 in order to preserve optimum pumping efficiencies of the pump mechanism 10 (FIGURE 8).

Referring now to FIGURES 6 and 7 of the drawings an alternative fabricating method and structure of my pumping apparatus are illustrated therein. In the last-mentioned figures similar reference characters with primed accents are employed to designate components which are essentially similar to the components of FIGURES 1-4 and 8. In the last-mentioned modification, a stator shell 24' is provided at its ends respectively with connecting flanges 50 and 52. The non-adherence bands 34' and 36' can be coated upon the inner surface of the housing 24' as described above in connection with FIGURES 1 and 3, or alternatively the shell or housing 24' can be clamped as denoted by reference character 54 to the end of a rotatable supporting shaft therefor 56. A suitable spray gun 58 or the like is inserted into the housing 24' and longitudinally moved therealong while the housing is rotated. At this time, a non-adherence material (relative to the resilient stator material 26') is sprayed with the mask 32' in place to produce the non-adherence bands 34' and 36'.

After deposition of the resilient stator material 26' (FIGURE 6), a pair of annular end plates 60 and 62 are secured respectively to the housing end flanges 50 and 52. The left-hand end plate 60, as viewed in FIGURE 6, at this time can be bolted, as denoted by reference characters 64, to the associated end flange 50, and the aperture 66 of the plate 60 defines the pump discharge opening. The opening 68 of the other end plate 62 can serve as a support for the rotor shaft 16 when the rotor is assembled therewith as depicted in FIGURE 8. The openings of the end plates 60 and 62, which are aligned for this purpose, also serve to retain and position the sizing mandrel 48' when inserted into the housing 24' and associated stator structure for purposes explained previously in connection with FIGURES 2 and 4 of the drawings. The end plate openings 66 and 68 thus position the

mandrel 48' relative to the proper elevation of the stator crests 20', as denoted above in connection with crest 20b of FIGURE 4.

When thus assembled, suitably positioned apertures 70 and 72 are drilled and tapped through each end plate 60 or 62 so as to communicate with the adjacent ends respectively of the initially collapsed tubular passages 35' and 37'. A pair of inlet taps 40' are threadedly secured in the apertures 70 and 72 respectively of one of the end plates, for example the left end plate 60, and a pair of valved outlet taps 42' are threadedly secured in the tapped apertures 70 and 72, respectively, of the other end plate. The taps 40' and 42' therefore communicate with the respective associated ends of the passages, 35' and 37'. The stator assembly of FIGURE 6 can be secured to a suitably flanged end of an inlet or suction conduit (not shown) through the use of suitable fastening means (not shown) inserted through aligned apertures denoted by reference character 74 in the end plate and flange 52.

The resilient material 26' of the stator assembly of FIGURE 6 can be resized periodically in the manner described above, by the introduction of the aforementioned mold lubricant and liquid settable material through the inlet taps 40'.

Referring now to FIGURE 5 of the drawings another modified form of my stator assembly is shown therein together with means for facilitating the introduction of the aforementioned lubricant and settable materials. In FIGURE 5 components thereof which are illustrated as being generally similar to components of the preceding figures are identified with similar reference characters with double primed accents.

In my last-mentioned stator assembly a stator shell or housing 24'' is provided first with a uniform coating of a resilient or elastic, plastic or rubber material 76 which can be adhered by vulcanization or by the application of a suitable adhesive to the adjacent wall surfaces of the stator housing 24''. The housing 24'' including its resilient coating 76 therefore, has a relatively smooth walled cavity extending therethrough as denoted by reference character 78. In furtherance of the aims of this feature of the invention non-adherence bands 34'' and 36'' are coated upon the inner surface of the resilient coating layer 76, and collapsed tubular passages 35'' and 37'' and of the resilient stator material 26'' is accomplished in the manner described above in connection with FIGURES 1 to 3 to form the collapsed passages 35'' and 37'' of FIGURE 5. To provide communication with the passages 35'' and 37'' apertures 44'' are similarly drilled and tapped through the housing shell 24''. Before tapping, however, registering apertures 80 are further drilled through the outer resilient coating 76 and through the adjacent portions of the adherence preventing strips 34'' and 36'' to afford communication with collapsed passages 35'' and 37'' as denoted by reference characters 46''.

With the arrangement of FIGURE 5, the aforementioned mold lubricant and liquid settable materials can be introduced through inlet taps 40'' to expand permanently the passages 35'' and 37'' in the manner and for the purpose outlined above. However, after the settable material has hardened against the resistance offered by the adjacent surfaces of the stator materials 25'' and the shell coating 76, as denoted by reference character 80, the presence of the resilient shell coating material 76 facilitates the second and succeeding restoration of the stator crests 20'', when additional lubricant and settable material must be introduced. This results from the fact that the pressure exerted by a succeeding quantity of mold lubricant when introduced, slightly displaces the resilient material 76 in the area of the hardened material 80 filling the inflated tubular passages 35'', 37''. This displacement permits a more rapid flow of the mold lubricant into the tubular passages 35'', 37'', particularly in the area of their junction 46'' with the inlet apertures 44''. Accord-

ingly, the time and fluid pressures required to relubricate the tubular passages 35", 37", are reduced.

From the foregoing it will be apparent that novel and efficient forms of pump mechanism have been disclosed herein. While I have shown and described certain presently preferred embodiments of the invention and have illustrated certain presently preferred methods of practicing the same, it is to be distinctly understood that the invention is not limited thereto but may be otherwise variously embodied and practiced within the scope of the following claims.

I claim:

1. A method for resizing a resilient stator structure of the helical variety having inflatable passages extending therethrough and juxtaposed to the helical crests thereof, the steps of inserting a mold member through the cavity of said stator structure, positioning said mold member to determine the desired height of said helical crests, inflating said passages with a pressurized mold lubricant, releasing excess mold lubricant from said passages and filling said passages with a liquid settable material to inflate permanently said passages and to extend said resilient material into engagement of its crests with said mold member.

2. The method of claim 1 characterized in that said liquid settable material is introduced into said passages under pressure and the pressure is maintained after said passages are inflated and until said settable material has set up.

3. A method for resizing a helical stator assembly for a pump mechanism having a helical rotor insertable for operation within said assembly, said method comprising the steps of forming helical passages extending along the length of said stator assembly in juxtaposed position relative to the helical crests thereof, coating said passages with a mold lubricant, introducing a quantity of a liquid settable material into said passages under sufficient pressure to cause said crests to be distended to respective positions of engagement with said rotor when so inserted, and allowing said settable material to harden to maintain permanently said passages in their inflated position.

4. A method for resizing a helical stator assembly for a pump mechanism having a helical rotor insertable for operation within said assembly, said method comprising the steps of forming helical passages extending along the length of said stator assembly in juxtaposed position relative to the helical crests thereof, coating said passages with a mold lubricant, introducing a quantity of a liquid settable material into said passages under sufficient pressure to cause said crests to be distended to respective positions of engagement with said rotor when so inserted, allowing said settable material to harden to maintain permanently said passages in their inflated position, subjecting said pump mechanism to a period of operation sufficient to cause significant wear of said crests, introducing a mold lubricant between said hardened settable material and the adjacent surfaces of said passages, admitting an additional quantity of said liquid settable material under pressure between said hardened settable material and said passage surfaces to inflate further said passages and to distend said crests to their original positions engageable with said rotor.

5. The method according to claim 4 characterized in that said rotor is removed from said pump mechanism prior to expanding said passages and a mold member is inserted in place thereof to determine the heights to which the stator crests are permanently distended by said settable material.

6. The method of claim 5 characterized further in that said settable material is introduced under pressure into said passages until said stator crests lightly engage said mold member and said pressure is maintained until said settable material sets up to permanently distend said crests and thereafter said pressure is released.

7. A method for making and resizing a resilient stator element for a helical pump, said method comprising the steps of coating helical non-adherence strips upon the inner surface of a housing for said stator element, molding and adhering a resilient material to said housing member at the spaces between said strips to form collapsed tubular passages juxtaposed to said strips and said resilient material, said resilient material being molded with helical crests corresponding to the location of said helical strips, flowing a mold lubricant through said passages to coat said strips and the juxtaposed surfaces of said resilient material, and admitting a liquid settable material under pressure to said passages to distend said crests to a predetermined elevation thereof relative to said housing member.

8. The method of claim 7 characterized in that a molding member is positioned concentrically of said stator element and the introduction of said liquid settable material is continued until said crests lightly engage said molding member.

9. The method according to claim 8 characterized further in that said molding member is a rod shaped mandrel and said light engagement thereof with said crests is determined by angularly displacing said mandrel about its longitudinal axis.

10. The method according to claim 7 wherein a relatively thick coating of a resilient material is first applied to the inner surfaces of said housing member, and said non-adherence strips are applied to said resilient coating.

11. A stator structure for a helical pump, said structure comprising a shell member, a pair of helical non-adherence strips secured to the inner surface of said shell member and spaced from one another, a mass of resilient material molded within said shell member and adhered thereto at the inner surfaces thereof lying between said strips, said resilient material being shaped at its inner surface to form a pair of spaced helical crests extending along the inner surfaces thereof and defining a rotor cavity of said pump mechanism, the non-adherence of said resilient material with said strips defining tubular passages juxtaposed to said stator crests, and an inlet and an outlet tap communicating respectively with the ends of each of said passages, said inlet and said outlet taps extending through said housing member and through the juxtaposed portion of said strips.

12. The method according to claim 7 wherein a relatively thick coating of a resilient material is first applied to the inner surfaces of said housing member, said non-adherence strips are applied to said resilient coating, and a mass of settable compound disposed within said passages to inflate the same and to distend said crests.

13. The method according to claim 7 wherein a relatively thick coating of a resilient material is first applied to the inner surfaces of said housing member, said non-adherence strips are applied to said resilient coating, a helical rotor mounted for rotation within said stator assembly, and a mass of settable material disposed within said passages and inflating the same to distend said crests into engagement with said rotor.

14. The combination according to claim 11 characterized in that a relatively thick and relatively smooth coating of resilient material is adhered to said housing member and said non-adherence strips are secured to said coating so that the tubular passages formed thereby can expand in both directions.

15. The combination according to claim 11 characterized in that the end of said strips and the corresponding ends of said tubular passages extend to the ends respectively of said housing member, an end plate is secured to each end of said housing member, each of said end plates having a pair of tapped apertures in registration with the adjacent ends of said passages, and inlet and outlet tap means are secured to said apertures in communication with said passages.

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