

[54] **NON-METALLIC PUMP**

[75] Inventor: **Valenteen S. Lobanoff**, Seneca Falls, N.Y.

[73] Assignee: **Goulds Pumps, Incorporated**, Seneca Falls, N.Y.

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[51] Int. Cl. **F04d 29/44**

[58] Field of Search..... **415/197, 200, 214; 60/39.69**

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Primary Examiner—Henry F. Raduazo

Attorney, Agent, or Firm—Bean & Bean

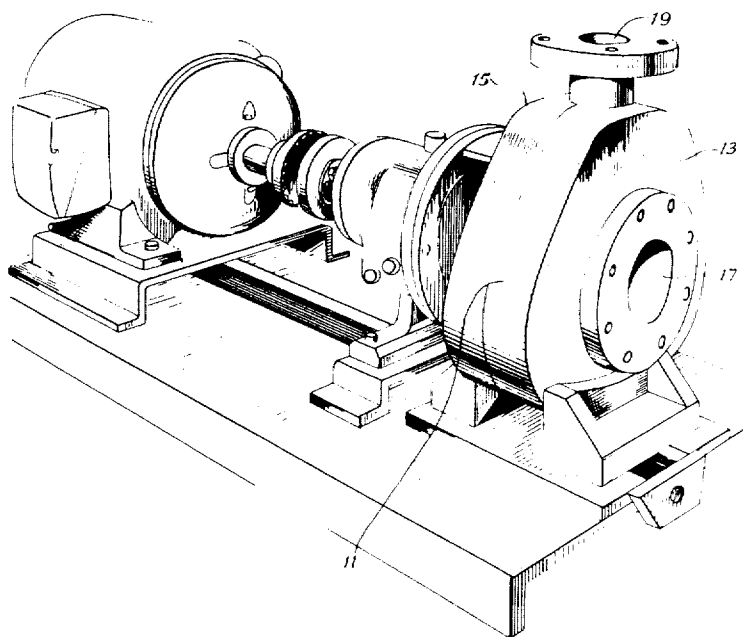
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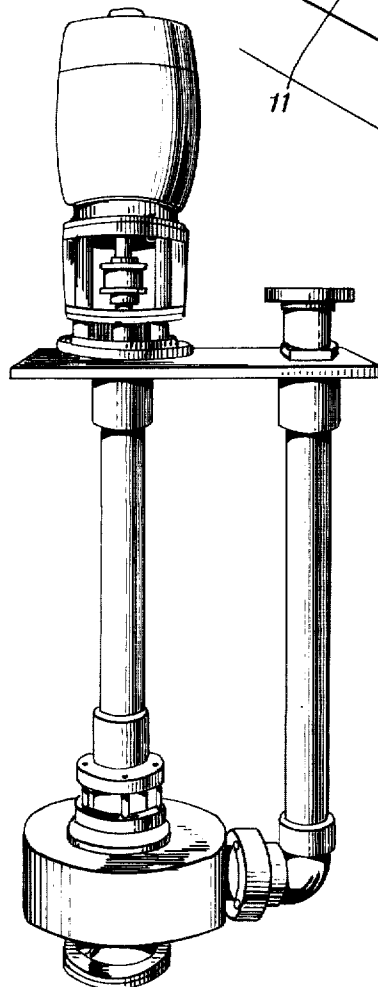
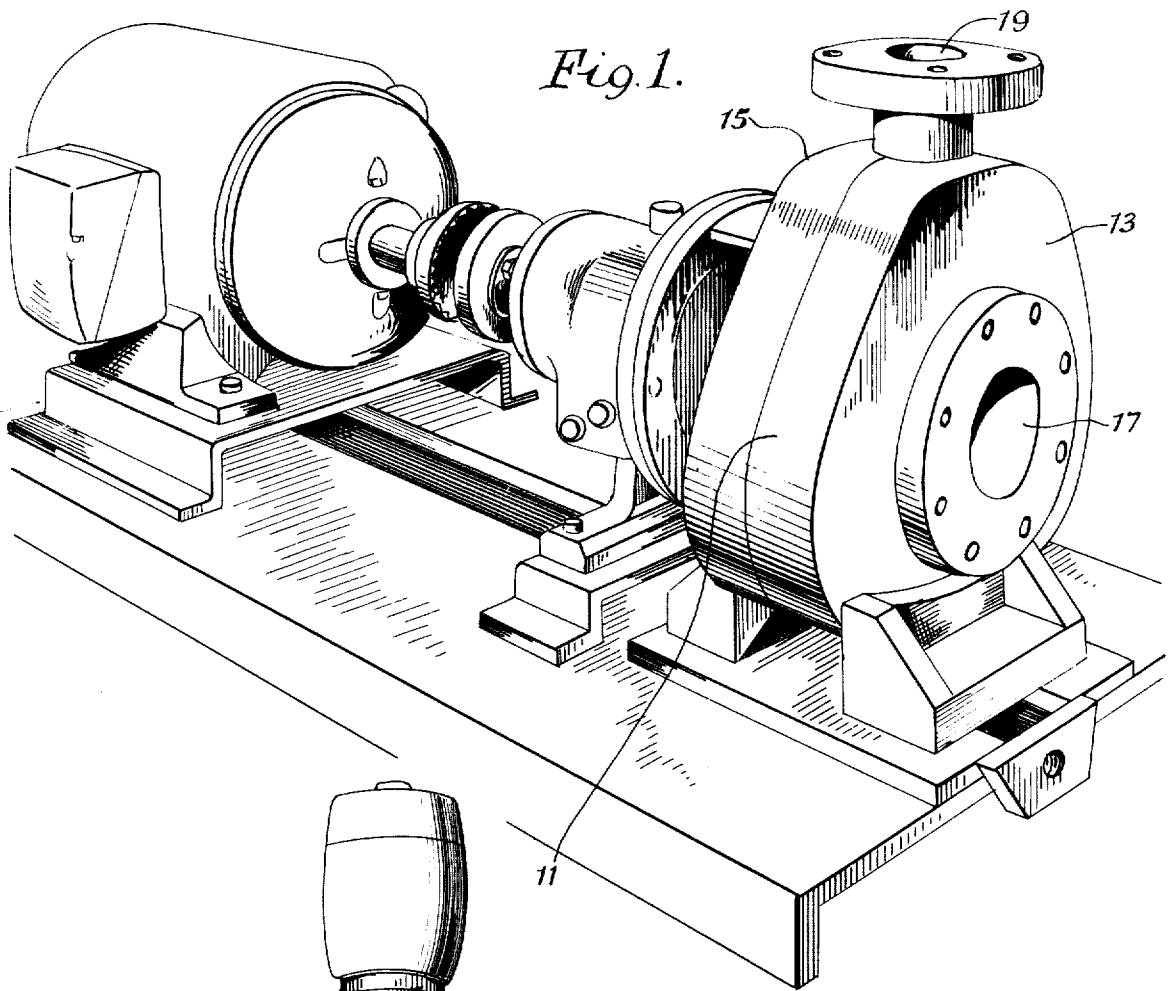
ABSTRACT

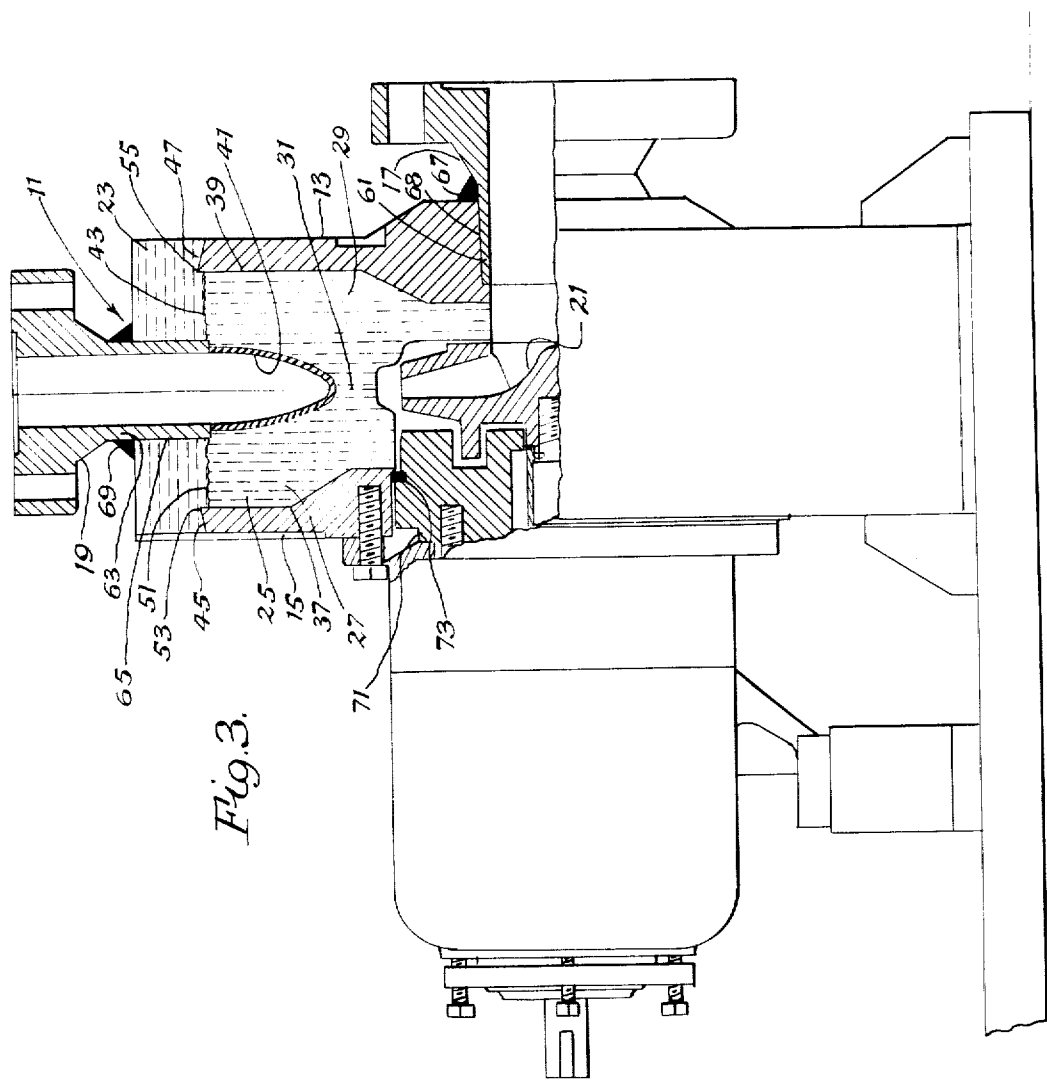
A non-metallic pump is made of synthetic organic polymeric elements, including casing, impeller, plates for the casing, cover and suction and discharge nozzles. The desired combination of strength and resistance to corrosion and wear from contacts with liquids to be pumped is obtained, utilizing unreinforced polymer in thin sections at surfaces which can contact the liquid being pumped, compressed molded filament-reinforced polymer or roving-wound sections to be threaded for screw attachment to other parts, and by having casing halves, and preferably also, covers for the casings, peripherally covered with filament-reinforced polymer, as by winding of liquid resin coated glass rovings on a bias about the casing periphery, followed by gelling and curing. Various parts of the pump are made by compression molding and hand or spray layup techniques and the preferred plastics employed are thermosets, such as polyester and epoxy resins.

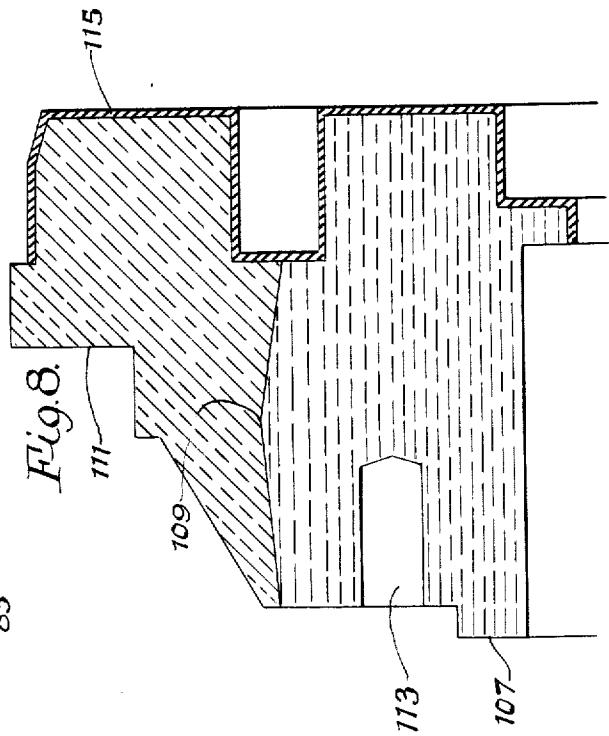
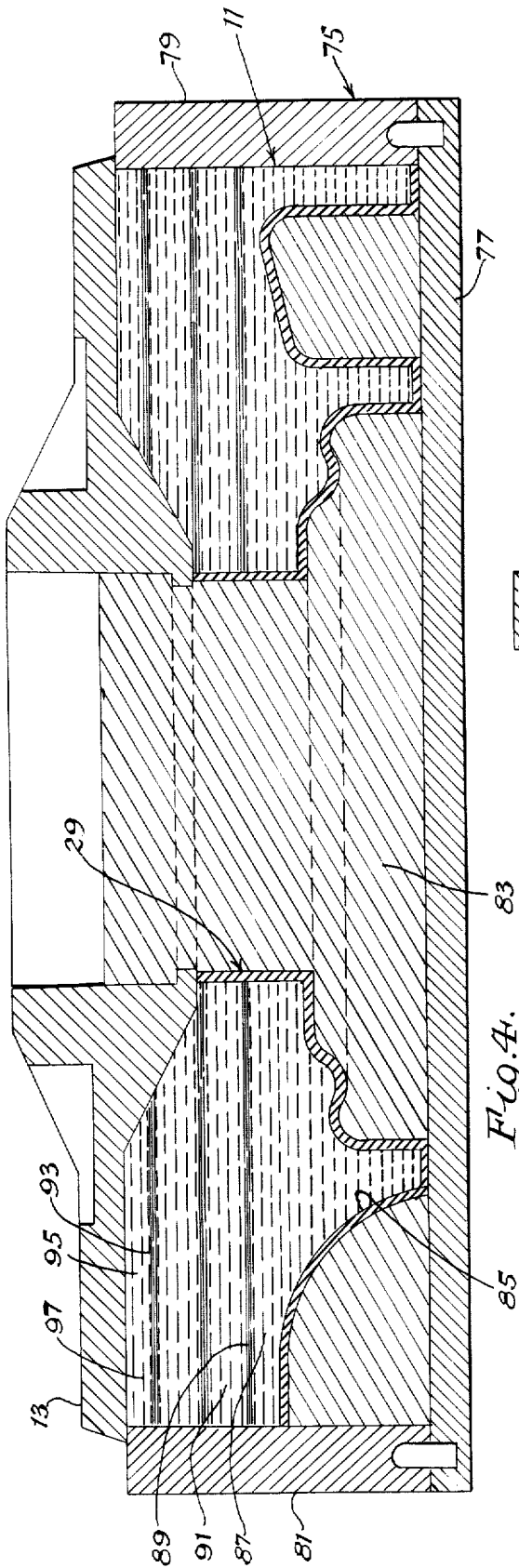
Also within the invention are processes for sealing the casing plates to the casing and for winding filament- or roving-reinforced thermosettable polymer about the casing periphery.

10 Claims, 8 Drawing Figures









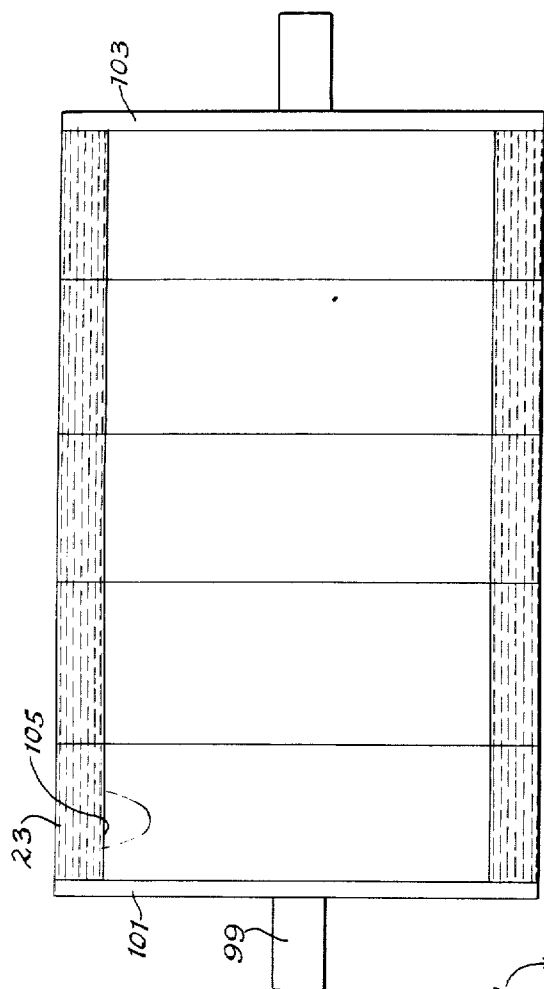


Fig. 6.

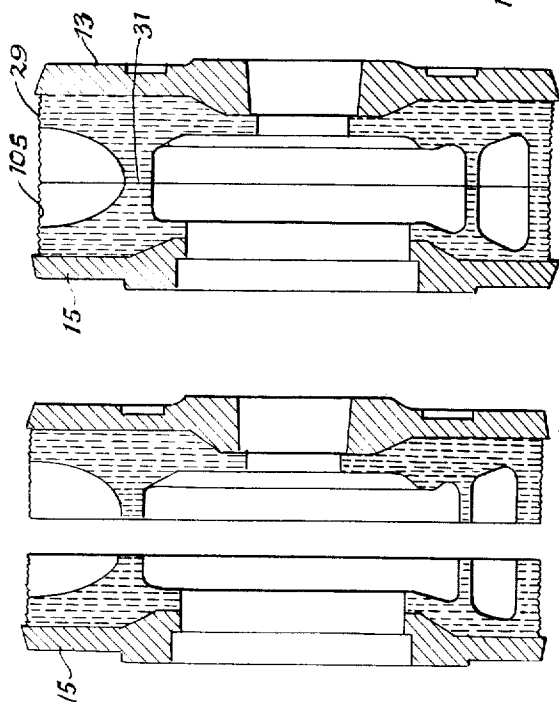


Fig. 5.

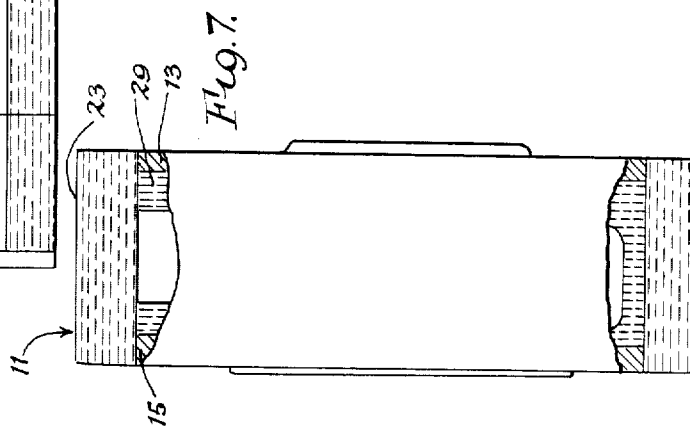


Fig. 7.

NON-METALLIC PUMP

INTRODUCTION

This invention relates to non-metallic pumps and to methods for their manufacture. More particularly, it relates to such pumps which include filament reinforced sections to increase the strength of the pump where needed and to improve its resistance to wear and attack by liquids being pumped. The invention is also of methods of manufacture of such pumps, being particularly directed to the production of pump casings wherein the peripheral areas thereof are strengthened and casing parts are held together by winding of resin coated filaments about the periphery and subsequent curing thereof.

BACKGROUND OF THE INVENTION

Since the advent of synthetic organic polymers or "plastics" it has been known that they often possess significant corrosion resistance and are capable of being molded into many intricate shapes. However, ordinary "plastics" tend to distort more readily under pressure than do metal parts such as those made of cast iron, wrought iron or stainless steel. They may creep under maintained loads and can crack or craze when subjected to undesirable atmospheres or vibrations, as may be experienced by heavy duty pumps. Accordingly, plastic pumps have been unsuccessful in such uses except when armored (as when plastic coatings have been used over stronger metallic bases) and even in such cases coatings tended to be worn off, exposing the underlying substrate which might then corrode. Also, for fastening polymeric pump parts to supports, etc., metal inserts have usually been employed to prevent stripings of threads. Now however, in accordance with the present invention, improved all-polymeric or filament-reinforced plastic structures are utilized for centrifugal pump parts so that a maximum of corrosion resistance and abrasion resistance is obtained while structural parts of the polymer are strong enough to maintain dimensional stabilities during manufacturing processes and resist pumping pressures and strains.

DESCRIPTION OF THE INVENTION

In a broad aspect of the invention it is of a non-metallic pump comprising a casing, front and back plates for the casing, a cover and suction and discharge nozzles, the former nozzle being held to the front plate and the latter being held to the casing, and an impeller, with all such parts being of filament-reinforced synthetic organic polymer, preferably of the thermosetting type and with the filamentary material being glass fibers or rovings.

In the present pumps, wherever the interior of the pump can be in contact with liquid being pumped the surfaces are of plastic, at least to a depth of 0.5 millimeter and often to as deep as 1.5 mm., without filamentary reinforcement. Such reinforcement sometimes is attacked by materials being pumped or, due to unequal expansions and contractions during heating and cooling during manufacturing of the pump or during use, with subjections to the materials being pumped, may create strains at the surfaces, which could allow the pumped liquid to penetrate through the plastic. With the 0.5 mm. of polymer free of glass or other filamentary substance between the liquid and the reinforce-

ment such strains and attacks on the filaments are prevented. Wherever screws are intended to be threaded into the plastic pump parts, such as where they are to hold a packing gland to the pump, a cover to a plate or to mount the pump on feet or a support, the polymer into which the threads are tapped or into which they may be molded will contain filamentary material and is preferably compression molded or "roving-wound" for greatest thread strength. In the present all-plastic pump ("all-plastic" designates synthetic organic polymeric pumps made with filament reinforced parts) a very significant aspect of this invention is in the provision of such filament-reinforced parts. Filament reinforcing by roving winding has been found to be useful in producing strong covers for the back plates of the casings and in these, as also in the casing members, it is often considered desirable to manufacture in two or more stages, with filament reinforcing utilized in each.

In the manufacture of the casing it has been found desirable to mold the main casing section in two halves, especially where the pump casing is of the double volute or diffuser type. While the casing halves are uncured in the mold, and with filamentary or fibrous reinforcing therein, either in chopped fiber, filamentary fiber, veil, mat or cloth form, or with several or all of these present (all of which are hereby referred to generally as filaments or fibers), the premolded plate for each casing half is placed on top of it and in contact with it and the polymer of the casing is cured so as to form the volute and hold the plates firmly in place by means of the polymer or polymer plus desirable cement. Next, in a major process of this invention, considered to be of great importance in the making of successful non-metallic pumps, the casing halves, previously or presently cemented together, are clamped together, and preferably with the plates attached, they are placed on a mandrel and, as the mandrel is turned, filamentary reinforcing material, covered with curable (or polymerizable) material, is wound around the peripheries of the casings and back and forth, with its orientation being on a bias with respect to the casing circumference. The resin is then cured and holds the casing halves tightly together and assists in holding the plate portions to the casing. When a plurality of casings is placed on a single mandrel, they may all be wound and cured together and after curing, may be separated by sawing or otherwise cutting them apart.

Still another feature of the invention is the provision of tapered shanks on suction and discharge nozzle insert portions adapted to fit into receiving tapered openings in the front plate and casing periphery, respectively. The tapers help to distribute cement evenly throughout and enable the nozzles to resist pumping pressures which might otherwise cause them to be loosened. The holding of the nozzles in place is assisted by a fillet of cement (which may be the same polymer as of the rest of the parts) at the external joints of the nozzle shanks and the respective plate and casing portions. It has been found that when 5 to 40% of glass fibers of types to be described are in the polymer or cement binding the nozzles, improved bonds are obtained. Cement thicknesses may be from about 0.01 to 1 mm. Apparently, the combination of taper and glass filaments produces an even cement layer of improved properties.

The materials of construction may include any suitable synthetic organic polymeric materials of sufficient strength and resistance to fluids intended to be pumped

and the reinforcing filaments may be any of various suitable filamentary materials possessing sufficient strength to aid in enabling the polymer to resist deformation, leakage or bursting due to the pump pressure, and to withstand thread-stripping forces. The pumps made may generate a pressure of as little as five pounds per square inch, at shut-off, or as much as 1,500 feet of water. They may be of various sizes, having impeller diameters from as little as three or four inches up to three feet but normally these will be in the range of six inches to 25 inches. Impeller speeds may be from 1,000 to 5,000 revolutions per minute and pumping rates may be from five to 10,000 gallons per minute.

Under the heavy duty conditions of high impeller speed, high pressure and high pumping capacity, often at high temperatures, it is most desirable that the plastic parts be of a strong plastic and one which does not weaken at higher or lower temperatures, within the range of -50° to $+250^{\circ}\text{C}$. It is especially important that such plastic should be operative over the full range of 0°C . to 90°C . and preferably to 150°C . Because thermoplastics may tend to soften, even at only moderately elevated temperatures, it is generally much preferred to employ thermosetting plastics and in some of the manufacturing processes of the invention their curing is more readily controlled without the need for refrigeration equipment, etc., which is advantageous. Of the thermosetting plastics the polyesters and epoxy resins have been found to be most desirable although others, such as polyvinyl esters, phenol formaldehydes, urea formaldehydes, melamine formaldehydes and various other well-known thermosetting cross-linkable engineering and other plastics may also be used. Of the preferred polyesters one which has been found to be exceptionally satisfactory is that of Bisphenol A and fumaric acid and the Bisphenol A-based epoxy resins are also preferred, in both cases the polymerization being carried out to produce high molecular weight products, e.g., polymers of molecular weights over 10,000 and often over 50,000. With respect to the reinforcing filaments, including short fibers, threads, rovings, yarns, cloths, veils, mats and baskets, it is preferred that these be of glass fiber, normally of a diameter of 0.005 to 0.2 millimeter, but ceramic fibers, graphite filaments, asbestos fibers and steel wires may also be employed in the appropriate circumstances, and such are considered to be within this invention.

Lengthier descriptions of useful thermosettable resins which may be employed in the manufacture of pump parts may be found in *Modern Plastics Encyclopedia* (1972-1973) at pages 126, 127. Various additives and reinforcements, including the desired forms of glass and other fibrous materials are mentioned there, together with processing techniques. For those cases wherein thermoplastics may be of use, similar descriptions or found at pages 122, 124 and 126. In the same publication at pages 365, 366, 371, 372, 374, 376 and 378, especially at pages 376 and 378, wherein glass fibers discussed, fibrous reinforcements are described. Finally, at pages 142-164 various suitable plastics and their properties are mentioned. Such disclosures are hereby incorporated by reference.

Various forming processes for making the plastic parts, such as compression molding, layup molding, gelling and curing, are known in the plastics art and in themselves are not considered to be parts of the present invention, although the joining of pump cover parts to

casing halves by the methods described, the reinforcing of peripheral areas of pumps by the winding of filament reinforced curable plastic about the peripheries thereof and the joiner of tapered shank portions of plastic nozzles to the plastic pump parts are aspects of the present invention.

Various objects, details, constructions, operations, processes and advantages of the invention will be apparent from the following description, taken in conjunction with the accompanying illustrative drawing of preferred embodiments of the invention, in which drawing:

THE DRAWING

FIG. 1 is a perspective view of a horizontal pump of this invention:

FIG. 2 is a perspective view of a corresponding vertical pump;

FIG. 3 is a partial, longitudinal vertical section of a pump like that of FIG. 1, taken axially;

FIG. 4 is a central, vertical section of a mold for a casing half, showing the resin rich inner portion of the casing, uncured resin, chopped glass filaments and glass veil and mat reinforcements therein, with a front plate for the casing in position for cure-sealing;

FIG. 5 is a central, longitudinal vertical section of a casing with plates thereon prior to peripheral winding with resin coated filament and curing;

FIG. 6 is a central, longitudinal vertical sectional view of a plurality of casings, including covers, assembled on a mandrel, illustrating several peripheries of the casings coated with windings of filament reinforced polymerizable material and cured;

FIG. 7 is a partial, longitudinal vertical sectional elevation of a finished casing, with front and back plates held thereto; and

FIG. 8 is a partial, longitudinal vertical sectional view of the back cover, illustrating sections thereof separately filament wound for shrinkage resistance and strength.

In FIGS. 1 and 2 a non-metallic pump is illustrated, in horizontal and vertical modes, the horizontal being further shown in FIG. 3. The pump comprises a casing 11, front plate 13, back plate 15, suction nozzle 17, discharge nozzle 19 and impeller 21. The pump is of the double volute design and the impeller is multivaned and sleeve supported at one end only. The external or peripheral filament reinforced portion 23 of the casing is shown, as is the balance 25 of the casing.

Casing back section 27 and front section 29 are shown cemented together along a dividing plane at 31 and with back plate 15 and front plate 13 cure-joined to them along surfaces 37 and 39, respectively. The casing halves are made of a mixture of chopped fiber in resin and hand or spray laid-up filament veils, mats, cloths and/or baskets, impregnated with curable thermosetting resin. They have the liquid contacting portions thereof, as at surface 41, resin rich and preferably 100% cured resin to a depth of at least 0.5 mm. About the periphery 43 of the casing and, as illustrated, also about ends 45 and 47 of the back and front plates, is a cured filament-reinforced bias wound resin portion 23 which is cured to the casing halves and the plates and holds them tightly together, while giving them burst-resistant strength under high pressure pumping operations. Irregularities 51 and projections 53 and 55 at the inner ends of the plates help to hold the filament-

reinforced resin winding tightly in place and prevent lateral distortions under pressure.

Flanged suction nozzle 17 and discharge nozzle 19 have tapered shank portions 61 and 63, respectively, fitted into tapered openings in the front cover 13 and casing winding 23, respectively. Cement layers 68 and 65 along the tapered lines of fits between the nozzles and pump body hold the nozzles tightly in place. Supplementing fillets of cement or polymerized resin 67 and 69 provide additional strength to maintain the nozzles in positions despite pump stresses. As shown, all portions of the interior of the pump which may come in contact with the pump liquid are resin-rich and preferably are of 100% resin, with no ends of the reinforcing filaments to make contact with the liquids being pumped.

Whether the pumps are large or small the parts described are essentially the same, although some changes in shapes are contemplated. Similarly, the manufacturing methods will be essentially the same with a few possible exceptions. In cases where high pressures and high temperatures will not be encountered and where the liquids being pumped will not be corrosive, it may be possible to dispense with the resin rich interior portions of the pump parts since the filaments contacting liquids pumped under such mild conditions will not cause undue strain on the pump parts or tend to react with the pumped liquid. When a resin rich "lining" is not necessary, a processing step can be saved. Similarly, when small pumps are being made, e.g., those with impellers less than 13 inches in diameter, the casing portions may be made by compression molding of a curable resin in which the filament reinforcement portion is short in length, usually less than two inches and sometimes less than $\frac{1}{2}$ or $\frac{1}{4}$ inch long, and the percentage of filament reinforcing is from 25 to 55%. Thus, the hand lay-up method of manufacture, which is desirable in producing the more intricate double volute pumps, may be obviated.

As illustrated in FIG. 3, back plate 15 and cover 71 associated therewith include threaded openings. As shown, these are in compression molded parts but threading may also be of roving-wound reinforced parts. Gasket 73 acts to prevent leakage between the back cover and the back plate.

In FIG. 4 mold 75 includes a bottom 77 and sides 79 and 81, with a form 83 inside the mold. Thermosettable resin liquid 85 is poured into the mold and is used to form a coating of 0.5 millimeter to one centimeter thickness on the inside walls thereof, preferably 0.5 to 1.5 mm. Resin viscosity and temperature are desirably regulated so as to maintain the resin or polymerizable material in contact with such walls and to prevent subsequently applied veils, mats, cloths, or molding compositions, containing filamentary reinforcing materials, from penetrating the resin-rich wall. The resin contains a curing agent and possibly, also, an accelerator. Then, a molding composition 87 of thermosettable resin containing from 25 to 55%, preferably from 40 to 45% of chopped filaments, preferably glass, about $\frac{1}{8}$ to $\frac{1}{4}$ inch long, is poured into the mold. After a suitable quantity of such resin is applied a veil or mat of filamentary material 89 is placed on top of it, followed by more resin 91 containing filament choppings, another mat 93, more resin with chopped filament, another mat and additional resin containing the chopped filament. The final resin 95 is not filled to the top of the mold because

the front plate 13 for the casing section 29 is placed atop the mold and a central portion thereof presses against the resin for the casing and causes the outer portion 97 to be raised to the top of the mold. During the molding operation care is taken to avoid air bubbles and good release from the mold is assured by use of a release agent, e.g., stearic acid, silicone oil, carnauba wax, beforehand.

After the front cover is in place the mold may be clamped shut, as by holding in an arbor press until the plastic is gelled and then cured. The cure may be effected chemically by a curing agent or may be assisted by heating in the mold. Upon removal from the mold the cover is found to be held to the casing part and the double volute inner portion of the casing is found to be resin rich to a depth at least 0.5 millimeter and contains no filament, veil or mat sections penetrating the inner walls. The fibrous or filamentary reinforcing material gives the volute walls the strength required to withstand heavy duty pumping strains and the resin rich interiors resist corrosion and wear due to abrasion and vibration.

The other half section of the casing is molded in a similar manner and held to the back plate or a portion thereof. Then, both casing sections are sanded, machined or otherwise dressed along a plane of desired contact and joinder and are cemented, preferably by a thermosettable resin cement of the same type as the base polymer but usually without any filamentary reinforcement. The cemented and cured casing-plates assembly is illustrated in FIG. 5.

In FIG. 6 the casing-cover assembly of FIG. 5 is shown with similar assemblies mounted on mandrel 99 and held tightly together by compressive forces exerted on end members 101 and 103 by compression devices, not illustrated. The peripheral portions of ends 101 and 103 also serve to retain the plastic used to coat the casings and serve as limits for the resin coated winding filaments or rovings which cover the casing and produce exterior walls for portions thereof. After mountings of the casings and associated plates on the mandrel, turning is begun and polymerizable resin coated onto glass rovings or, rarely, on individual filaments, is wound into place on a bias with the circumference, at an angle of from 5° to 53°, preferably 5° to 30°. In some cases larger or smaller angles may be utilized but best results are obtained in the range recited. Usually, at larger and smaller angles transverse and bursting strengths are diminished. After winding to one end of the assembly on the mandrel the winding direction is reversed and windings proceed to the other end. This procedure is continued until a complete coating is obtained of the desired depth, often with from 5 to 100 layers of rovings being used. Due to the design of the pump casing, even open sections such as that identified by numeral 105 are desirably covered with the winding filament coated with resin, which forms a wall thereon. Usually, due to the surface tension of the monomers and polymers, and compressive forces applied, the reinforcement will not extend to within 0.5 millimeter of the inner portion of the winding so that section may be considered as being resin rich. (Incidentally, such action is also noted in the production of the compression molded pump parts). Also, so that the discharge nozzle may be inserted, the fiber-reinforced winding that covers the discharge opening will have to be removed. Therefore, if any sagging of the wall occurs at such point due to the method of manufacture, little harm will be done.

After a sufficient thickness of winding has been applied the resin is brought to a gel stage either by passage of time and chemical action or by application of heat or radiation, while the mandrel is still rotating, usually at a slow speed, such as one to five revolutions per minute. The rotation helps to keep the coating even until the resin has gelled. After gelation, the mandrel containing the casing-covers assemblies may be placed in an oven and heat cured, may be radiation cured or may be held for a sufficient time for a chemical cure to be effected. The parts are then sliced or sawn apart, the cut surfaces are smoothed and the flanged nozzles are cemented in place, as previously described. The finished casing-plates assembly is illustrated in FIG. 7, without the nozzles and casing discharge opening.

In FIG. 8 is partly shown in the back cover, wherein two sections have been produced by filament winding techniques. A first portion 107 of the back cover is wound over a form on a mandrel and winding regulated so that on completion thereof the top has a peak 109. This section is then allowed to gel while the mandrel is rotated (and subsequently may be cured), after which an additional section 111 is wound atop it, is gelled while the mandrel is rotated and is cured, being cured joined in place of initial section 107. In this and the previous work described the filament or roving winding material is approximately 55 to 85% of filamentary material, with the balance being thermosettable resin and preferably is from 60 to 75% of such filament. Screw thread section 113 is strong enough to resist stripping of threads when being assembled and in use and resin rich portion 115 resists corrosive effects of the pumped liquid.

The three general manufacturing techniques described above for making the pump parts may be applied to the manufacture of other pump elements, too. For example, compression molding, using about 30 to 40% of reinforcing glass, may be employed to make (a) end plates for the casing; (b) flanges; (c) feet; (d) impellers; (e) gland plates; (f) stuffing box covers; (g) shaft sleeves; (h) steady bearing holders (for vertical pumps); (i) suction bells; and (j) suction screens. Such materials will have ultimate tensile strengths of about 25,000 lbs./sq. in., compressive strengths of about 45,000 lbs./sq. in. and flexural strengths of about 42,000 lbs./sq. in., $\pm 5,000$ lbs./sq. in. for each. Their Barcol hardnesses will be in the 50-55 range.

Filament winding, in which the glass content is from 50 to 70%, is especially useful for the manufacture of the pump casings, adapter rings and lock collars. In such applications, especially the pump casing, the ultimate tensile strength or hoop strength will be about 55,000 lbs./sq. in., the compressive strength will be about 65,000 lbs./sq. in. and the flexural strength will be about 62,000 lbs./sq. in., again $\pm 5,000$ lbs./sq. in., with the Barcol hardness being about 60-70. Sprayed-up or hand laid-up elements, which normally will be of about 3 to 7 plies and contain 40-45% of glass or other fibrous reinforcement, are the volutes, mounting plates and covers (for vertical pumps). Their ultimate tensile strengths are about 40,000 lbs./sq. in., compressive strengths are 45,000 lbs./sq. in. and flexural strengths are 43,000 lbs./sq. in., $\pm 5,000$ lbs./sq. in. Barcol hardness is about 50-55. The maximum service temperature for all such elements is about 250°F.

For the assembled pump the overall casing strengths are as follows:

Tensile strength — 35,000 lbs./sq. in.;

Hoop stress (in the direction of the winding) — 50,000 lbs./sq. in.; and

Shear stress (in casing walls) — 25,000 lbs./sq. in.; each $\pm 5,000$ lbs./sq. in.

The fibrous reinforcements employed in the rovings or strands, each containing about 20 filaments, are about 0.01 cm. in diameter and include a silane binder. The strand or roving tensile strength is about 200,000 lbs./sq. in. The chopped glass used for spray-up or hand lay-up applications is preferably $\frac{1}{4}$ to one inch long and has a chrome binder adapting it for use with either polyesters or epoxies. The glass veils and cloths may be from 4 to 32 ounces and are positioned in the molds at such locations as to desirably strengthen the pump parts being produced, generally with the thinner mats (veils) closer to the surfaces. For the compression molded parts various thermosetting polymer premixes may be employed, some of which may contain additional compatible fillers. Generally, for the compression molded parts the glass used will be chopped glass of about $\frac{1}{2}$ inch length, randomly distributed.

In variations of the manufacturing methods previously described the all-resin pump portions to be in contact with liquids being pumped may be coated with monomer and gelled or may be "gel-coated" on the inner portions of the molds to the desired depths before adding other materials to the molds. Thus, before compression molding such gel coating may be utilized, instead of depending on the pressure, e.g., 500 to 10,000 lbs./sq. in., to drive the more fluid material to the outside of the mold. Instead of utilizing single thicknesses, in roving-wound or filament-wound parts plural thicknesses may be employed, with the maximum widths thereof generally being no more than $\frac{3}{4}$ inch. When the windings are limited to such thicknesses between curings it is found that greater strength is obtained in the casings or other wound parts made and incipient flaws are avoided. Thicknesses up to as much as six inches can be built up by such techniques without objectionable weakenings during curings. Increased strengths are also obtained when the entire pump is made of the same polymer and the same filamentary reinforcing material and when even the cements employed to bind parts together are of the same materials.

The non-metallic pumps and parts thereof described have many advantages over metal pumps and over the partially polymeric pumps of the prior art. Reference has already been made to their improved corrosion resistance, compared to metallic pump parts. The present pumps are also of greatly improved impact resistance, compared to ordinary pumps with molded ordinary polymeric parts. They are also better in these respects than pumps with metallic parts coated with "plastic" and pumps with only some "plastic" parts. Compared to other pumps with "plastic" parts, the present pumps are superior because they are dimensionally stable in three dimensions over a wide range of performance conditions, including high and low temperatures, high and low pumping rates, high and low pressures and with corrosive, abrasive and solvent materials being pumped. The pumps are non-magnetic and non-sparking and, because of their dielectric or insulating nature, no corrosion thereof is produced due to stray galvanic currents. They are also quieter running than

the metal pumps and operation thereof causes less vibration. Reduced noise level is especially important today when efforts are being made to limit or prevent noise pollution. Another feature of the present pumps is that if they run dry they can do so without seizing. The various parts of the pump are as strong as metal parts in many cases, satisfactorily resisting shearing, compressing, tensile, impact, abrasive, centrifugal and vibratory forces. Yet, the weights thereof may be only 40 to 50% those of metal pumps of comparable capacities and pumping characteristics. A final advantage is in the comparative ease of manufacturing the present pump parts, compared to difficulties which are often experienced in producing molds for the production of metal pump parts and molding such pump parts.

The following examples illustrate but do not limit the invention. Unless otherwise mentioned, all parts are by weight and all temperatures are in °C.

EXAMPLE 1

A propoxylated Bisphenol A fumarate polyester resin composition, identified as Atlac 4010A (40 parts Atlac 382, 10 parts Atlac 387 and 50 parts of styrene), made by ICI America, Inc., is mixed with 1% of a 6% cobalt naphthenate for three hours in a mixing drum, utilizing a propeller blade mixer of the "Lightnin" type. Then, for the various pump parts to be manufactured, depending on the pot lives desired, from 0.75 to 1.25% of a 60% methylethyl ketone peroxide is added. Such a material is marketed by Plumb Chemical Corporation, Philadelphia Pennsylvania, as Polyester Premix 2000-F. For filament windings 0.75% is utilized and results in a 90 minute pot life. For hand and spray layup of larger pieces 1% is employed and the pot life is 60 minutes, while for smaller pieces 1.25% is used and a pot life of 30 to 40 minutes results. Post-curing is effected for 2½ hours at 250° F. Compression molded pieces are made from the same mixes or from previously prepared molding compounds of essentially the same compositions. For hand layup or sprayup items 30 to 45% of glass reinforcement is employed while for filament winding this is from 60 to 75% and for compression molding from 25 to 55%.

Productions of the various parts described in the drawing are carried out by the compression molding, layup, winding and other such procedures described, utilizing a 20 filament roving, standard glass veils, mats and cloths of the silane and chrome finished types and Atlac 4010A resin mix with 1.25% of curing agent (30-40 minute pot life). For cementing various parts together, the same resins are employed, with chopped glass filaments being present to the extent of about 35% in the cement employed for fastening the nozzles to the casing and back plate.

The finished pumps are attractive in appearance, are of low coefficients of expansion, are thermal shock-resistant and corrosion-resistant and are of sufficient flexibility to withstand the mechanical shocks of heavy duty usage. They are capable of service without deterioration in the handling of corrosive and solvent chemicals, including chlorine, chlorides and hydrochloric acid. Their weights are much less than those of corresponding metal pumps (often being as little as ¼ the weight of stainless steel pumps) and they are less expensive than metals of comparable corrosion resistant properties, e.g., titanium. For example, a pump having a six inch diameter impeller may weigh about 50 lbs.

with the casing, including plates, nozzles and feet, being about 42 lbs. the impeller about 2 lbs. and the cover about 5 lbs. Such a pump delivers about 500 gallons per minute of liquid at a head of 100 feet of water. Correspondingly, a pump with a 9-inch impeller delivers 700 g.p.m. at a head of 250 feet of water and a 13-inch impeller pump delivers 1,000 g.p.m. at 350 feet of water head. 13-25 in. impellers deliver more at higher pressures.

Experimentation indicates that the best winding speeds for producing strong and regular casings are in the 40 to 120 r.p.m. range and the present pumps are wound at an average of about 80 r.p.m. Also, the percentage of veil utilized, compared to mat or chopped fiber, is normally about 5 to 10% of the total glass for the hand or spray layup items. The glass of the filament wound parts is all of continuous rovings and the compression molded parts usually contain only chopped glass as reinforcement. The strands or rovings are of 10-60 filaments each.

The pumps may be used at temperatures as high as 250°F. without damage, for extended periods of time.

When, in place of the described polyester resin there are employed other related polyesters resins such as are also within the descriptions of U.S. Pat. Nos. 2,634,251 and 3,214,491, comparable corrosion and abrasion resistant pumps are also produced. Of course, employing other Atlac and similar resins, of the type described in *The Fabricator's Notebook* published by Atlas Chemical Industries, Inc., Second Edition (1969), chemical resistances and molding characteristics will be modified somewhat and the particular plastic employed will be selected for best results in the use intended.

When the procedures are varied so as to effect a room temperature cure of the polymers utilized the product made is of essentially the same properties but manufacturing time is longer and production line efficiency is diminished.

When the glass fibers are replaced by boron fibers, graphite or ceramics, useful pumps are produced but these do not usually have the all-around superior properties and manufacturing characteristics possessed by those reinforced with glass fibers.

EXAMPLE 2

The procedures of Example 1 are followed in the manufacture of a vertical pump of the type illustrated in FIG. 2 instead of a horizontal pump, as in Example 1. The pump includes a six inch diameter impeller and otherwise is basically the same as that described in Example 1 except that the casing portion, as well as the plates, is made by compression molding of the curable resin containing the same proportion of glass reinforcement but in pieces about ¾ inch long, thereby obviating use of the hand layup or sprayup methods. The pump made is connected to drive members and piping as illustrated in FIG. 2 and is found to possess the desirable utilities and properties previously described for the corresponding horizontal pump of FIG. 1. Similar results are obtained when different polymers, previously described, are utilized, together with other filamentary reinforcements.

EXAMPLE 3

A horizontal pump equipped with a 15 inch impeller is made of the design of FIG. 1, according to the method of Example 1, as illustrated in FIGS. 3-8. In-

stead of the polyester resin of Example 1 there is employed an epoxy resin, Ciba's Araldite EPN 1139. The hardener employed is a amine hardener, designated No. 917. Proportions used are 50% resin and 50 % hardener. The proportions of glass reinforcements and the types thereof are the same as in Example 1. The curing cycle is 6 hours at ambient temperature, 2 hours at 250°F., 2 hours at 350°F., 2 hours at 450°F. and cooling slowly to 250°F., over 4 hours. In the molding operations it is found that the best mold release agent is Traffic Wax, made by S. C. Johnson & Son, Inc.

The pumps made have the desirable properties previously recited for those made by the method of Example 1, except that with respect to corrosion and solvent resistance they are found to be resistant to caustic, hydrochloric acid and some solvents. They may be run at higher temperatures, being stable to 350°F. under adverse operating conditions, e.g., pumping corrosive materials, abrasives, slurries, etc.

When various other epoxy resins are substituted for the particular one described, e.g., epichlorohydrin-Bisphenol A resins or epichlorohydrin-glycerol resins, cured with amines or anhydrides, comparable products are obtained. Similarly, vertical pumps are made by the same techniques, with the exception reported in Example 2. In other polymerizations different hardeners are employed and the curing cycles are changed to shorter times at temperatures in the higher part of the range given. In all such cases useful pumps of the highly desirable mentioned characteristics are produced.

The invention has been described with respect to illustrations and working embodiments thereof but is not to be limited to these because it is evident that one of skill in the art, with the present disclosure before him, would be able to utilize substitutes and equivalents without going beyond the scope of the claims or departing from the spirit of the invention.

I claim:

1. A non-metallic pump comprising a casing, front and back plates for the casing and a rotary impeller, the casing being of two halves, with an initial plane of separation thereof parallel to the plane of rotation of the pump impeller, the casing and the front and back plates for it being of glass filament-containing synthetic organic polymer, and means for holding the front and back plates to the casing and for holding the casing halves together, which means is glass filament-containing polymer bias wound about the casing and plate peripheries, which means strengthens the pump against outward pressures, with the interiors of the casing walls, where they are in contact with the liquid to be pumped, being of synthetic organic polymer free of filamentary reinforcement to a depth of at least 0.5 mm.

2. A pump according to claim 1 wherein the interiors of the casing walls which are in contact with liquid to be pumped and which are of synthetic organic polymer free of filamentary reinforcement are backed by polymer which is reinforced by veils, mats or cloths of glass filaments and, farther away from the liquid-contacting

interior surfaces of the casing, by such polymer reinforced with glass filaments randomly distributed therein.

3. A pump according to claim 2 wherein the plates are of glass filament-reinforced compression molded polymer.

4. A pump according to claim 3 which comprises suction and discharge nozzles of glass filament-reinforced polymer having tapered shank portions and cement means for holding said nozzles to the front plate and casing, respectively, and in which the front plate has an opening therein substantially axially located, a wall of which is tapered to fit the taper of the shank of the suction nozzle, the casing has a discharge opening on the periphery thereof with a wall thereof tapered to fit the taper of the shank of the discharge nozzle and the suction and discharge nozzles and the front cover and the casing periphery, respectively, have contacting surfaces which are held together by cementing means.

5. A pump according to claim 1 wherein all the non-metallic pump parts are of the same thermosetting synthetic organic polymer and all such parts are filament-reinforced with fiber glass.

6. A pump according to claim 1 wherein the synthetic organic polymer is selected from the group consisting of polyester and epoxy resins.

7. A pump according to claim 6 wherein the synthetic organic polymer is a bisphenol polyester.

8. A pump casing according to claim 1 wherein said bias wound glass filaments are in continuous rovings of about 10 to 60 filaments each, with diameters in the 0.05 to 0.2 mm. range.

9. A non-metallic pump comprising a casing of two halves, front and back plates for the casing, suction and discharge nozzles, a rotary impeller, all such parts being of glass filament-containing synthetic organic polymer, means for holding the suction nozzle to the front plate, means for holding the discharge nozzle to the casing and means for holding the casing halves, which have an initial plane of separation parallel to the plane of rotation of the pump impeller, together and holding the front and back plates to the casing so as to strengthen the casing and improve the resistance of the pump to internal pressures, said means for holding the casing halves together and holding the front and back plates to the casing being glass filament-containing polymer wound about the casing and plate peripheries, with the interiors of the casing walls, where they are in contact with the liquid to be pumped, being of synthetic organic polymer free of filamentary reinforcement to a depth of at least 0.5 mm.

10. A pump according to claim 9 wherein the halves of the casing and the front and back plates for the casing are held together by glass filament-reinforced plastic in which the glass filaments are bias wound about the peripheries of the front plate, casing halves and back plate to hold them together in a unitary pump body of improved resistance against internal pressures.

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