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Bevan et al.

[11] **3,801,226**

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[54] **PUMP IMPELLER**

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[21] Appl. No.: **239,649**

Related U.S. Application Data

[62] Division of Ser. No. 67,866, Aug. 28, 1970, Pat. No. 3,676,014.

[52] **U.S. Cl.** **416/241**, 416/244

[51] **Int. Cl.** **F01d 1/02**

[58] **Field of Search** ..... 416/241 A, 244, 134; 415/196, 197, 200, 214

[56] **References Cited**

UNITED STATES PATENTS

2,852,238	9/1958	Varkony	416/241 UX
3,513,720	5/1970	Allport	287/53 R
3,576,336	4/1971	Uhlig	287/53 R
3,638,979	2/1972	Francois et al.	287/53 R
2,283,263	5/1942	Kates	415/201
2,433,589	12/1947	Adams	415/196 X
3,408,944	11/1968	Belonger et al.	416/241
3,676,014	7/1972	Bevan et al.	415/200

FOREIGN PATENTS OR APPLICATIONS

254,599	12/1962	Australia	416/244
528,068	8/1921	France	416/241

Primary Examiner—Everette A. Powell, Jr.
Attorney, Agent, or Firm—Bean & Bean

[57] **ABSTRACT**

A pump impeller, especially useful in the pumping of corrosive and abrasive liquids, includes a unitary blade-shaft member of a material such as a corrosion resistant vitreous or ceramic material, which is impracticable for threading or other such shaping operations or has insufficient strength to withstand normal forces on threads or other such elements thereof. To provide for affixation to means for rotating the impeller in a pump, a threadable shaft extension is employed, inserted into and cemented in place in a hollow portion of the blade-shaft member and threaded or otherwise formed or machined at its other end for connection with suitable driving means. By making the blade-shaft member so that the corrosion-resistant shaft portion is long enough to extend past a seal, contact of the pumped liquid with the impeller is limited to the corrosion-resistant part thereof.

Also disclosed are pumps and motor-pump combinations including the mentioned impellers, as well as methods for the manufacture of the impellers.

4 Claims, 8 Drawing Figures

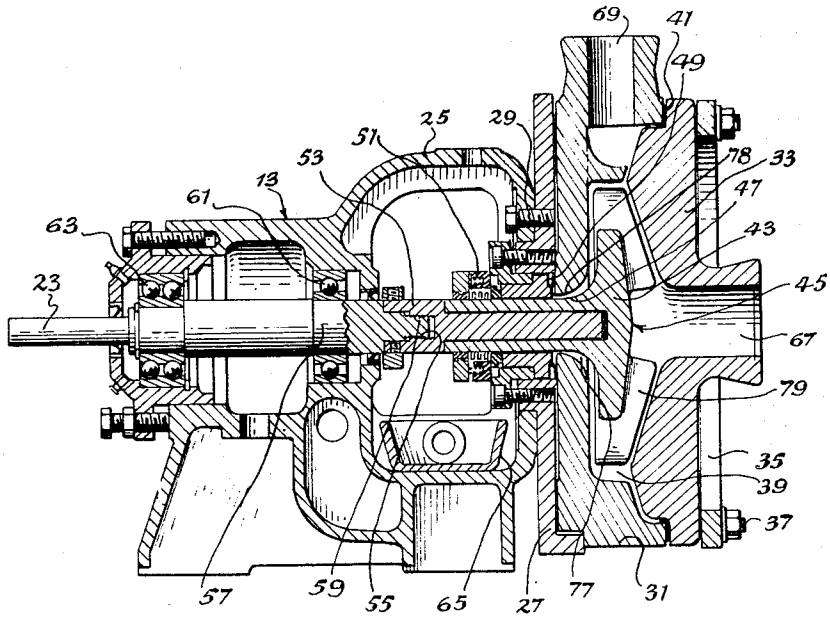
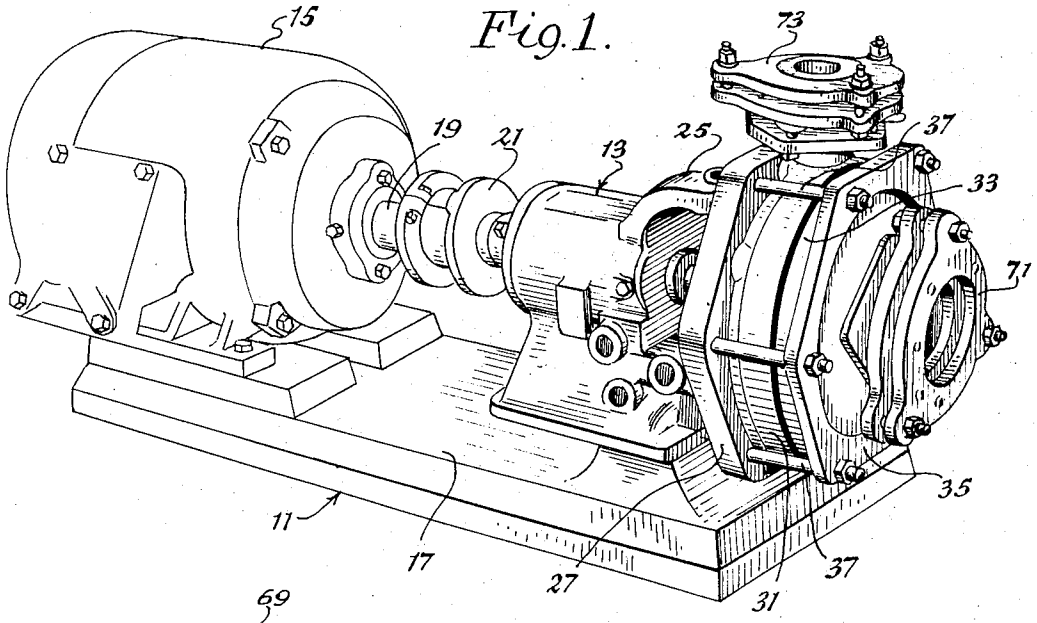


Fig. 1.



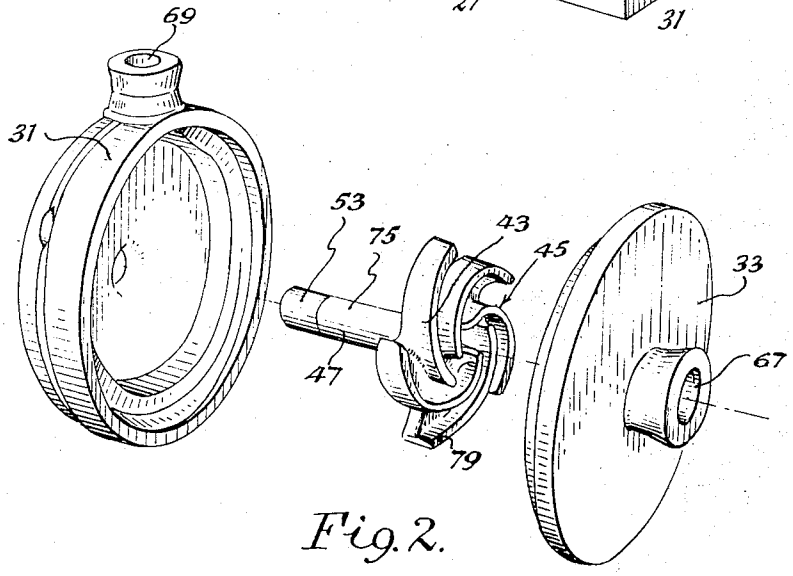


Fig. 2.

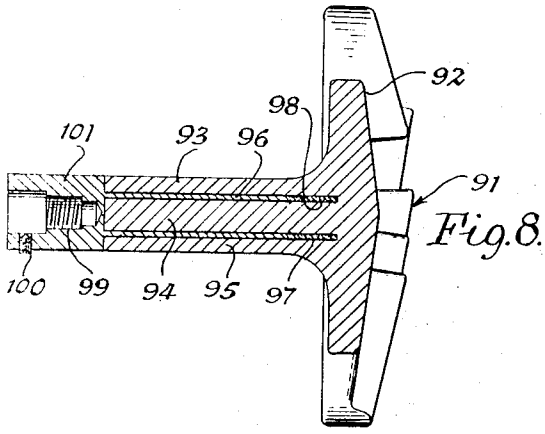


Fig. 8.

Fig. 3.

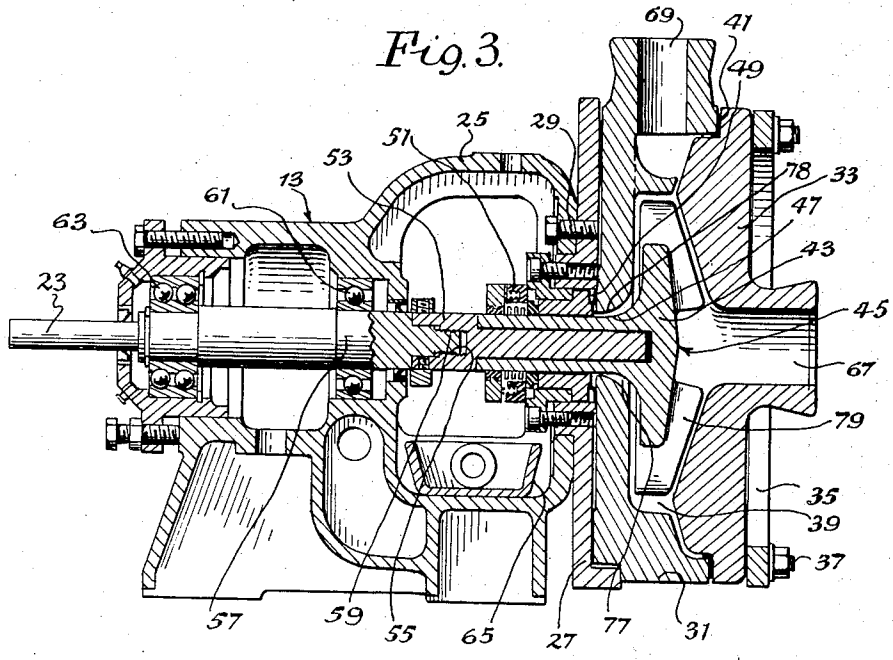
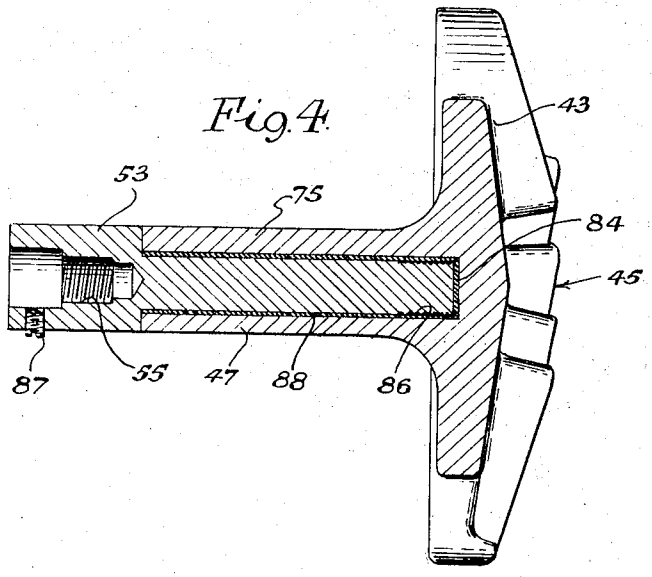

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Fig. 4.


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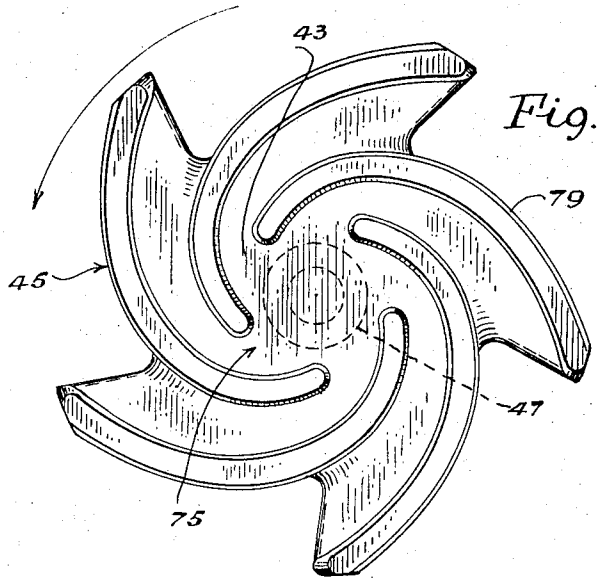


Fig. 5.

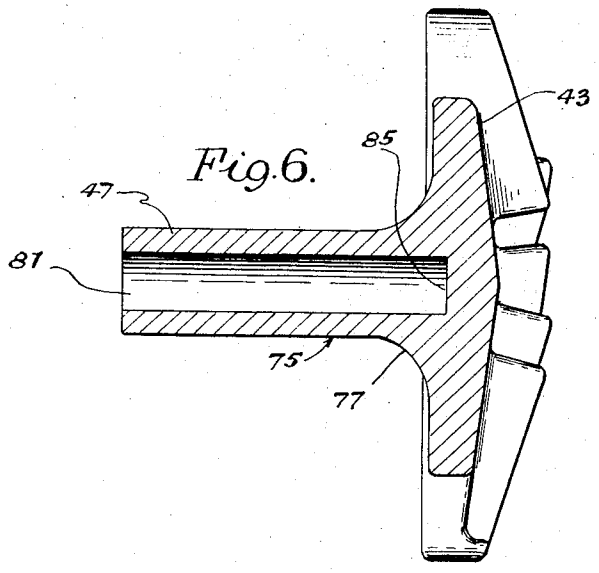


Fig. 6.

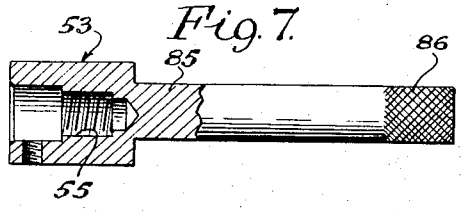


Fig. 7.

PUMP IMPELLER

This is a division of our application Ser. No. 67,866, filed Aug. 28, 1970, now U.S. pat. No. 3,676,014.

INTRODUCTION

This invention relates to pumps and pump impellers. More particularly, it is of a pump impeller in which the blades or vanes and a substantial portion of the shaft are unitary and of a material which is difficult to thread or similarly shape or machine or is of insufficient strength for threads on the shaft thereof to withstand pumping forces. These limitations are overcome by joinder to the shaft of a shaft extension capable of being threaded and of sufficient strength. The pump starts which contact material being pumped, including the unitary blade-shaft portion of the impeller, are usually of ceramic and/or vitreous material which is corrosion resistant. The invention also relates to an integral prime mover-pump combination and a method of making the impeller blades.

BACKGROUND OF THE INVENTION

Corrosion resistant pumps and pump parts have been made from ceramics, vitreous ware, plastics, suitable metals and other materials of construction capable of withstanding extended use in contact with normally corroding fluids being pumped. Some pump parts have been formed entirely of such materials and in other cases, corrodible supporting members have been coated or lined with them. It has been found that although coated or lined pump parts are useful for many purposes, under some applications they fail, often due to minute cracks or chips in the coating caused by pumping stresses or strains, which openings in the relatively thin coating then allow the corrosive liquid or other material being pumped to contact the base and weaken or destroy it. Accordingly, to avoid such adverse results, the employment of solid corrosion resistant pump parts has been suggested. Here too, problems arise, especially with ceramic or vitreous articles, often due to the difficulties encountered in producing such parts of sufficient strength and machinability to make them useful. Furthermore, when impellers, whether of solid corrosion resistant material or of such material on a corrodible base like metal are employed shaft connections to the impeller are usually of corrodible material and contact between the fluid being pumped and the shaft leads to chemical reactions which attack it. Thus, the shaft may be weakened or may become unbalanced and corrosion build up at a shaft seal may cause poor seating thereof and leakage external to the pump. When sleeves of ceramic, vitreous or other corrosion resistance materials are used to cover the shaft and to contact the seal, they must often be joined to the shaft by special means and even in such cases, leakage through the points at which such sleeves contact the impeller blades or hub portion can occur.

DESCRIPTION OF THE INVENTION

Many of the difficulties previously encountered in utilizing corrosion resistant materials for pump impellers have been overcome by the present invention, which provides a way to make corrosion resistant pumps including such impellers, which may be of ceramic and/or vitreous or similar such materials which

are normally difficult to shape or machine into thread-like configurations or which will have insufficient strength for threads thereof to be used in practical applications as joinders to drive means.

In accordance with the present invention there is provided: a unitary impeller blade-shaft member, the material of construction of which is such as to make threading of the shaft portion impracticable, said shaft portion including a longitudinally extending walled hallow section; a shaft extension which is of a threadable material, said shaft extension comprising a portion for insertion into the blade-shaft member hollow section and a section external to said hollow, by which section the impeller blade-shaft member and shaft extension are connectable to rotating driving means; and means for fastening the wall of the impeller blade-shaft member hollow to the shaft extension. In preferred embodiments of the pump impeller, the blade-shaft member is of a non-metallic, corrosion resistant ceramic and/or vitreous material, such as nucleated glass and the shaft extension is of a metal, held to the blade-shaft member by a permanent cement and threaded at the opposite end thereof. Also relevant to the invention are a centrifugal pump comprising the described pump impeller, a pump-motor combination and a method of making the impeller.

Various objects, details, constructions, operations 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 pump and drive motor assembly, incorporating the pump and impeller of the present invention;

FIG. 2 is a perspective view of the pump of FIG. 1, showing, in disassembled relationship, the impeller and pump housing parts;

FIG. 3 is a central vertical sectional view of the pump of FIG. 1;

FIG. 4 is an enlarged view of the impeller of FIG. 3;

FIG. 5 is an end elevation of the impeller;

FIG. 6 is a central vertical sectional view of the corrosion resistant blade-shaft portion of the impeller;

FIG. 7 is a partial central vertical sectional view of the metallic shaft extension portion thereof; and

FIG. 8 is an enlarged view of an impeller which may be used in place of that shown in FIGS. 3–7.

DETAILED DESCRIPTION OF THE INVENTION

As is shown in FIG. 1, a combination pump and drive motor assembly 11 comprises pump assembly 13 and electric drive motor 15, both of which are fastened to a supporting base 17. Motor shaft 19 is connected via coupling 21 to pump drive shaft 23, illustrated in FIG. 3 but hidden in FIG. 1.

Pump assembly 13 includes frame 25 in which are mounted or fastened the various other pump parts and which itself is held to base 17 by bolting or other conventional fastening means. Adapter plate 27 is held to frame 25 by bolts 29 and to it are fastened pump casing 31 and pump suction cover 33 by means of casing clamp ring 35 and bolts 37. The combination of pump casing and suction cover, comprising a pump body portion forming pump chamber 39, is maintained in liquid-

tight relationship by suction gasket **41**, which is held tightly against the surface of the casing and suction cover by bolts **37**.

Inside chamber **39** is a blade or vane portion **43** of pump impeller **45**. The shaft portion **47** thereof passes through casing **31** and contact of any pumped fluid contained in chamber **39** with other sections of the pump, base or motor other than the blade-shaft portion of the impeller, the pump interior and the inlet and outlet lines is prevented by an inner mechanical seal or gasket **49** and an outer mechanical seal **51**. Conventional gland means are provided for adjusting the pressures of the seals.

The blade-shaft portion of the pump impeller is cemented to a shaft extension **53**, the external surface of which is trued and balanced with the blade-shaft portion of the impeller. Extension **53** is internally threaded at **55** and is joined to drive shaft **23** via other shaft connecting means **57** which is turned down and externally threaded at **59** to fit threads **55**. Bearings **61** and **63**, illustrated as roller bearings, support the pump shafting and maintain the trueness of its rotation. Drip basin **65** is provided in case, due to improper adjustment, the mechanical seals **49** and **51** should leak. But usually, with proper maintenance, the drip basin will be unnecessary. As is seen from the drawing, even material leaking past the mechanical seals or stuffing boxes will not contact shaft extension **53**.

As illustrated in FIG. **1**, inlet **67** to suction cover **33** and outlet **69** from casing **31** are joinable respectively by adapting and clamping means **71** and **73** to ceramic, glass, plastic or other piping, preferably of corrosion resistant material. Thus, the entire pumping system may be made leakproof and corrosion resistant.

In the disassembled view of FIG. **2** the main elements of the pump of the present invention are illustrated, omitting seal, clamping means and gasket. The pump casing and suction cover may be substantially conventional is design, being preferably of ceramic, vitreous or mixed ceramic-vitreous material, such as nucleated glass, which materials are generally not of great tensile strength or resistance to vibrations and strains when in thin sections. Therefore, the pump parts may be thicker than would be required if they were made of ordinary materials of construction, such as cast iron, stainless steel or bronze. Such materials will often be impracticable for use as force transmitting members joined to a drive shaft by conventional means, such as screw threads, flutes, set screws, etc. Consequently, when the blade-shaft portion **75** of impeller **45** is of a material difficult to machine into threads or is incapable of having threads thereon satisfactorily transmit pumping force to the blade or van portion **43**, a shaft extension **53**, usually of metal, is used and is internally threaded and adaptable to fit with a similar part of a driving shaft. The details of attachment of the shaft extension **53** to the blade-shaft portion **75** of the impeller will be described in conjunction with FIGS. **4–7**. It will be noted, however, from FIG. **3** that the vanes or blades **79** of impeller **45** are wider at the central portions thereof than at the circumference and in this respect, they conform approximately to the internal shape of chamber **39**, as defined by the internal walls of suction cover **33**. Similarly, where the blade portion is blended into the shaft portion, the combined blade-shaft portion of the impeller usually being molded or pressed and fired together into a unitary structure, there is a curvature **77** which conforms approximately to that of the casing **31**. It will be noted that the opening in casing **31** is of greater diameter than the shaft passing through it, allowing for rotation of the shaft without contact with the casing. As was previously mentioned, leakage through this clearance **78** is prevented by seals **49** and **51** and rotation of the impeller is maintained true with respect to the housing by shaft support bearings **61** and **63**.

In FIG. **5** the various vanes or blades **79** which form the blade portion **43** of the impeller are shown, together with the direction of rotation of such an impeller and the path followed by liquid being pumped. It is seen that the blades are generally spirally shaped and balanced about blade-shaft portion **75**.

In FIG. **4** the novel impeller of the present invention is illustrated in section. Blade-shaft portion **75** of the impeller has an internal longitudinally located hollow section **81**, as shown in FIG. **6**, into which the shaft extension **53**, of FIG. **7**, is inserted and joined in place. The hollow extends into the blade portion of the blade-shaft, as illustrated at **84**. Set screw **87** is provided to hold the impeller in place, once it is threaded onto driving shaft means. The combination of the bearings supporting driving shaft means, the drive shaft end threaded into the impeller shaft extension, the set screw and the means for holding the shaft extension to the blade-shaft portion of the impeller all combine to maintain a firm and aligned relationship between the impeller, driving means and the other pump parts, including the casing and suction cover.

As shown in FIG. **7**, a portion of the inserted part **85** of the shaft extension is knurled or otherwise roughened at **86** to aid in maintaining a tight bond to the interior of the impeller shaft. Such bond is preferably effected by a permanent adhesive of a suitable type, illustrated at **88**, which will satisfactorily and permanently fasten the shaft and shaft extension together. Although knurling or roughening of a surface or surfaces to be joined is desirable, it is not always essential and may be dispensed with if the adhesive employed is capable of excellent joinder to comparatively smooth surfaces.

An impeller which may be used instead of that shown in FIGS. **3–7** is shown in FIG. **8**. In that view impeller **91** is of the same external appearance and function but its internal construction is modified. In addition to the blade **92** and the blade-shaft portion **93**, a quill portion **94** is also an integral part of the impeller, thus forming an annular opening in the shaft **95** into which a hollow cylindrical portion **96** of shaft extension **101** fits. Cylindrical part **96** is externally and internally roughened or knurled at **97** and **98** and held to the blade-shaft part of the impeller there and throughout its length by a permanent adhesive applied both internally and externally. The impeller also includes an internally threaded portion **99** on shaft extension **101** plus a set screw **100**, to hold tightly and truly to the shaft connecting means which transmits the motion of the drive motor to the pump impeller.

The manufacturer of the present impellers and pumps, while it may be effected by various suitable means, is preferably carried out by first molding the blade-shaft portion of the impeller, in a single piece, from a suitable ceramic, vitreous or combination material. Such material is corrosion resistant and yet, not strong enough, usually in tensile strength, to be threaded or similarly shaped and to have such threads

resist driving forces. Instead of molding, the impeller may be made of pressing or otherwise fabricating. When, instead of vitreous and/or ceramic materials being employed, plastics are used, these may be chemically reacted during the forming process or may be fused together with cement or solvent, whichever is suitable. Also, reinforcements may be employed to strengthen the blades and other portions of the impellers. For example, fiberglass reinforced polyesters are useful. When employing ceramics the pressed or shaped blade-impeller may be fired to give it the desired mechanical and chemical properties. Various parts of the blade-impeller may be machined to desired shapes, smoothnesses or clearances. The bore in the impeller shaft may be drilled either with or without previous molding and firing. When dressing or drilling ceramics, the tool employed will often be diamond tipped but in some cases corundum or other such materials are also useful.

During the formation of the blade-shaft portion, the internal cylindrical hollow left therein may be machined or may be roughened to make it better receptive to bonding means for joining it to the shaft extension. Alternatively, the walls of the hollow may be left as molded and fired or otherwise produced. Of course, the shaft extension, generally of metal such as steel or other suitable material of construction capable of being threaded or similarly machined, is of a shape to conform substantially to the hollow in the blade-shaft portion of the impeller. Enough clearance is left to insert the shaft extension and to vent any contained air. Knurling of a portion of the shaft extension may be employed if desired and aids in such venting and also helps to firmly fasten the extension and the blade-shaft portion together, since it furnishes a better substrate for the adhesive employed. The knurling is usually preferably effected as shown at **86** but may cover the entire insertable shaft extension length. The adhesive, glue or other bonding means may also extend up to such length and may also be applied at the shaft end and shoulder, to promote the strongest bond. The shaft extension may be solid (preferable), hollow, discontinuous, fluted or otherwise shaped to provide best bonding and operating characteristics at low cost.

After insertion of the shaft extension in the hollow, application of a permanent cement between the extension and blade-shaft and settling of the cement, the combined unit is then longitudinally machined so that the shaft is true and balanced and is in balance with respect to the blade-portion of the impeller. The "far" end of the shaft extension, which is preferably threaded but may be otherwise shaped to promote joinder to pump driving means, may be employed to help hold the work in a machine for truing the shaft. Such threading and the threading for insertion of a set screw to hold the shaft extension to driving means may be by any suitable method known to the art.

The impeller, casing and suction cover, together with the various gaskets, are assembled and the pump is connected to electric motor driving means by conventional attachments. Various seals, frames, shaft extensions, bearings, couplings and motors may be used. Preferably, the entire assembly is mounted on a rigid base so that an integral "package" pump is produced.

The materials of construction employed may be any of a wide variety suitable for producing the desired pumping, bonding, sealing, force-transmitting, supporting and driving effects. However, certain materials are highly preferred and especially useful in the present invention. Although ceramic, glass or glass-ceramic materials are preferred for the unitary blade-shaft portion of the impeller, plastics, such as thermoplastic and thermosetting materials may be used, including epoxy resins, polyester resins, phenol-formaldehyde resins, nylons, etc., either filled, unfilled or reinforced, as by fiberglass. Porcelains and high borosilicate glasses are useful but the most preferred of the ceramic and glass materials are the nucleated glasses. These materials are exceptionally corrosion resistant and have very low coefficients of thermal expansion. They also are comparatively brittle or poor in tension so that they cannot readily be threaded or similarly shaped to be joined to driving means. In certain instances there may be employed other materials which possess properties similar to the ceramics with respect to brittleness, strength or machinability.

The nucleated glasses or glass-ceramic materials which are very highly preferred materials of construction for the present impellers are crystalline ceramics derived from glass by a heat treatment which converts the glass to a substantially crystalline material, often about 90 percent crystallized. Such heat treatment is effected in the presence of nuclei seeded into the glass about which crystals grow. The nucleating agent employed is barely soluble in the glass. It remains dissolved at high temperature but crystallizes out when the glass is cooled, to furnish nuclei for crystal growth. Such growth occurs at a determined nucleating temperature and may be controlled by variations of temperature.

Methods for making the glass-ceramics are now known to those who are expert in the glass and ceramic arts, and are employed to make many products which are commercially marketed. Of course the techniques and the compositions utilized may be varied to obtain properties most desired for the particular impellers of this invention.

The shaft extension, while usually of a readily machinable and strong metal, may also be made of any of the mentioned plastics or other products having such properties, especially the mentioned plastics. In many instances it will be decidedly advantageous for such material to have a coefficient of thermal expansion equal to or close to that of the blade-shaft portion of the impeller. Thus, when the extension is inserted into the blade-shaft portion, there will be no unequal expansion which could strain the parts of the impeller. Therefore, employment of two different plastics of similar coefficients or ceramic material and a plastic of similar coefficients will be desirable.

To compensate for slightly different coefficients of expansion, the bonding agent or cement used to hold the shaft extension to the blade-shaft portion of the impeller may be a resilient or flexible one. Thus, epoxy resins, phenol-formaldehyde cements, rubber cements, and other well known adhesives and bonding agents may be used. Preferably, the bonds made will be permanent ones and the resins will be those which thermoset to hard but flexible films.

Some of the advantages of the present invention have been mentioned. Thus, a means is provided for enabling the use of brittle materials which could not withstand the shocks and tensile forces encountered in having an impeller shaft thereof threaded and joined to

driving means. By use of the shaft extension, as described herein, with a reinforcing part extending through the shaft and with internal or external threads or other joinder means, a strong, vibration-resistant and readily machinable shaft joinder to a driving means is obtainable. This enables the pump designer to utilize corrosion resistant materials for the portions of a pump impeller that contact corrosive material to be pumped. Shaft seals or stuffing boxes may thereby contact only the corrosion resistant materials, preventing attacks on metal impeller parts. By extending the shaft of the impeller for a length as great as or greater than the radius of the blade portion of the impeller, it leaves enough room for mechanical or stuffing box seals along the shaft. Desirably, the shaft extends at least one or two inches beyond the seal, to prevent any corrosion due to leakage, provision being made for such leakage to be removed without contacting a corrodible shaft extension.

The shaft extension into the blade-shaft part of the impeller strengthens the brittle ceramic and/or vitreous material of the shaft about it. Whereas, even a solid shaft of ceramic or nucleated glass would be of less strength, that which is hollow and filled with a metal shaft extension is strong enough to withstand the rigors of heavy duty pumping. This is also so when the reinforcing shaft extension is of tubular shape or is a solid of other cross-sectional configuration. The ceramics and glasses, in addition to being corrosion resistant, are of low coefficients of thermal expansion and therefore can be employed to pump materials at elevated temperature, without undue expansion or binding caused by restricted clearances from such expansion. Even with an insert of more readily expansible metal, the insulating value of the ceramic often keeps the metal temperature sufficiently low to diminish its expansion rate. Therefore, despite the unequal coefficients of expansion of the outer and inner portions of the impeller shaft, no cracking of the ceramic should occur.

The metal shaft extension also sufficiently increases the strength of the ceramic so that it is less prone to vibratory deterioration. Because of such effect, a packaged pump comprising the various elements and drive means can be mounted on a rigid base without fear that the vibrations resulting will destroy the impeller.

Due to the nature of nucleated glass materials pumps of the present type can satisfactorily handle liquids at relatively high temperatures. Changes in temperatures such that a thermal shock differential is imposed almost instantaneously are tolerable. Additionally, due to the hardnesses of the ceramics, they are even capable of pumping abrasive-containing liquids. The heat resistance of the pumps is due to their very low or zero coefficients of expansion under changing temperature conditions.

The invention has been described with respect to certain illustrations and drawings of preferred embodiments thereof. However, it will be clear to those of skill in this art that various equivalents may be substituted for elements of the articles, apparatuses and processes without departing from the invention or going outside the scope of the claims.

We claim:

1. A corrosion-resistant centrifugal pump impeller comprising a unitary blade-shaft member of nucleated glass which is a substantially crystalline material derived from glass by heat treatment effected in the presence of nuclei seeded into the glass, about which crystals grow at a nucleating temperature, said glass being comparatively brittle or poor in tension so that it is impracticable to thread the shaft portion thereof, such shaft portion including a longitudinally extending walled internal opening along the length of the shaft, and a shaft extension which is of threadable metal, such shaft extension comprising a portion for insertion into the blade-shaft member internal opening and a threaded portion external to said opening, by the threads of which latter portion the impeller blade-shaft member and the shaft extension thereof are connectable to rotating driving means, and cement or adhesive contacting the walls of the internal opening of the impeller blade-shaft member and the inserted portion of the shaft extension and cementing or bonding them together.

2. A corrosion-resistant centrifugal pump impeller according to claim **1**, wherein the portion of the shaft extension for insertion into the blade-shaft member internal opening and the longitudinally extending walled internal opening in the blade-shaft member are matching cylinders having a regular clearance between them for a cement, the cement is a flexible, permanent cement, the external surface of the insertable portion of the shaft extension is knurled or otherwise roughened to provide improved fastening of said portion to the walls of the internal opening in the blade-shaft member and the external surfaces of the shaft portion of the blade-shaft member and the threaded portion of the shaft extension are of substantially the same diameter.

3. A corrosion-resistant pump impeller according to claim **2** wherein the cement is a flexible, permanent cement selected from the group consisting of epoxy resin, phenol-formaldehyde and rubber cements.

4. A corrosion-resistant pump impeller according to claim **1** wherein the impeller includes a rod portion of nucleated glass which is integral with the blade-shaft portion thereof and the insertable portion of the shaft extension is a hollow cylinder which fits the annular opening between the rod and the wall of the impeller shaft internal opening and which is cemented to the nucleated glass walls of the rod and the blade-shaft member internal opening on both sides thereof.

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