May 19, 1942.

H. E. ADAMS ET AL

2,283,348

PUMP

Filed Dec. 21, 1939

4 Sheets-Sheet 1

Fig. 1.

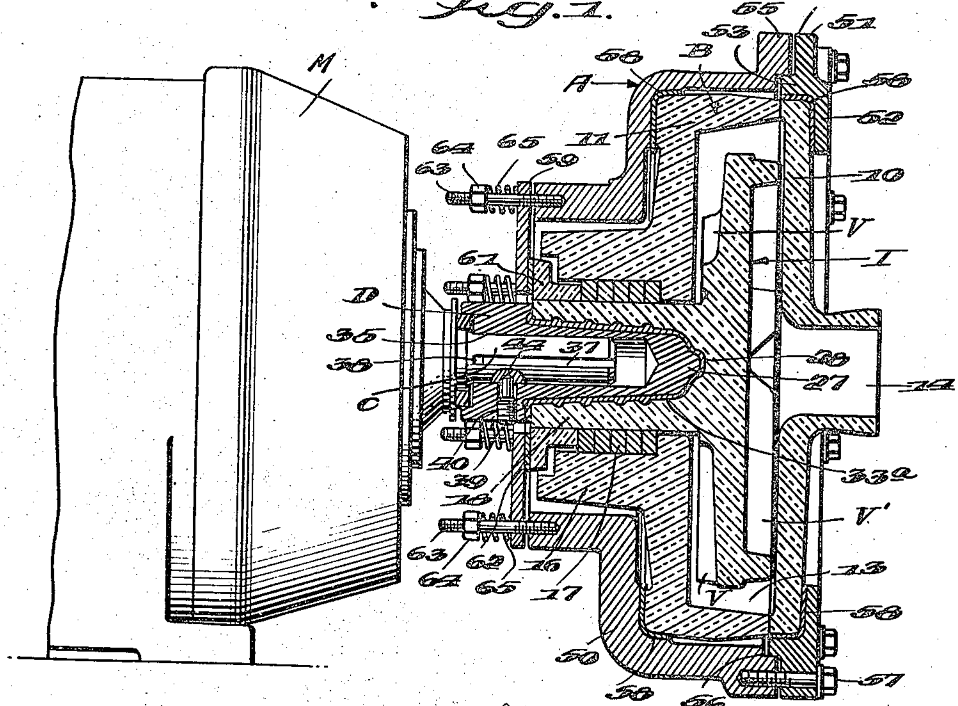

Fig. 2.

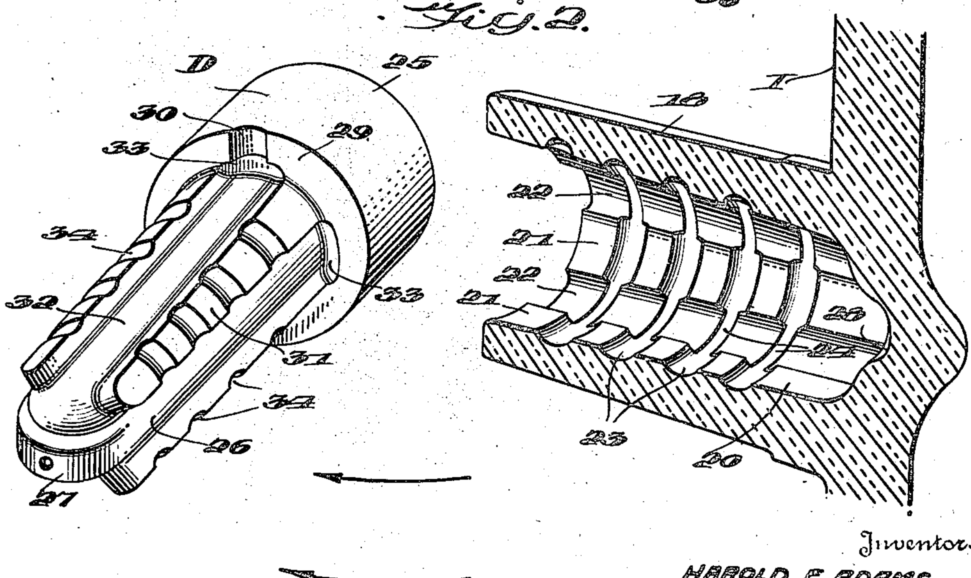

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Fig. 3.

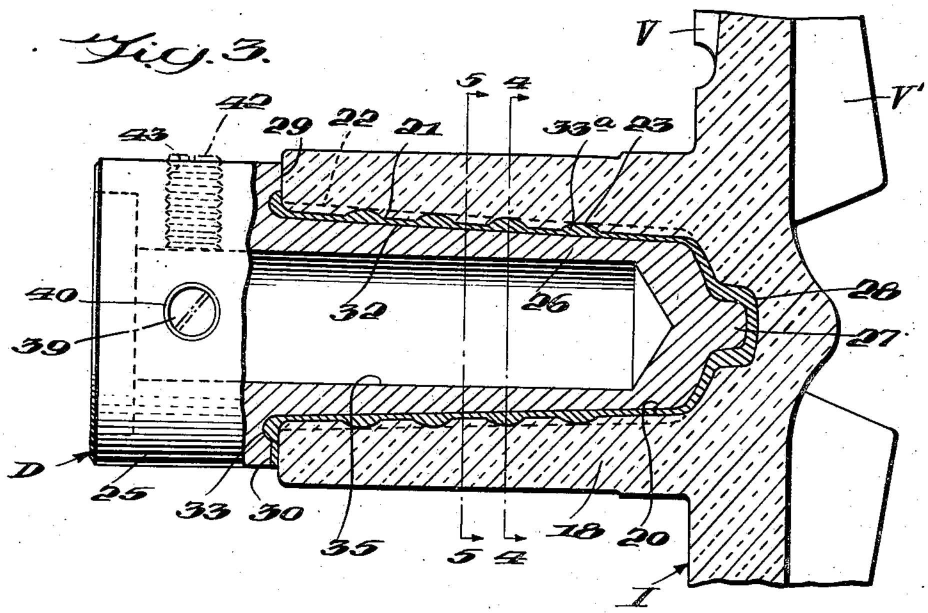


Fig. 4.

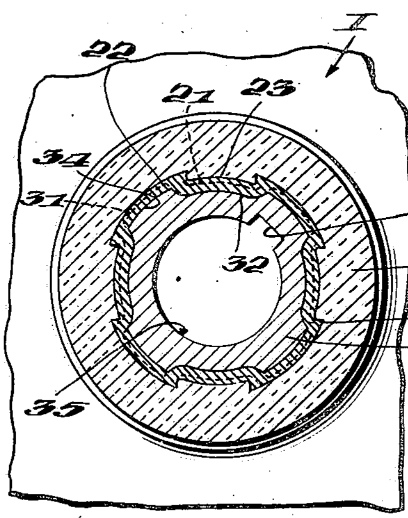
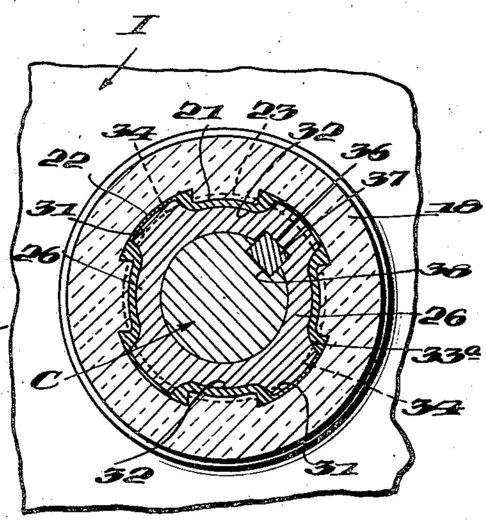


Fig. 5.



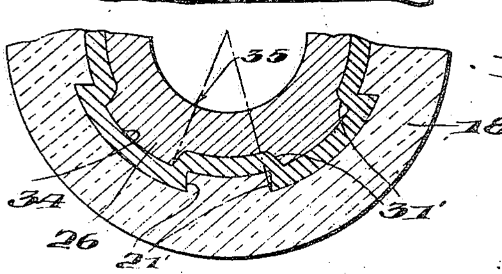


Fig. 4a

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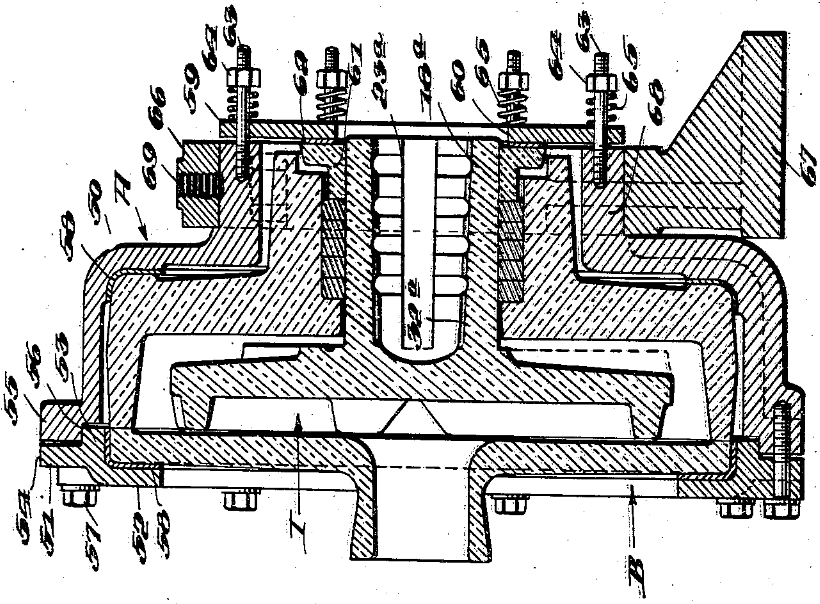

Fig. 7.

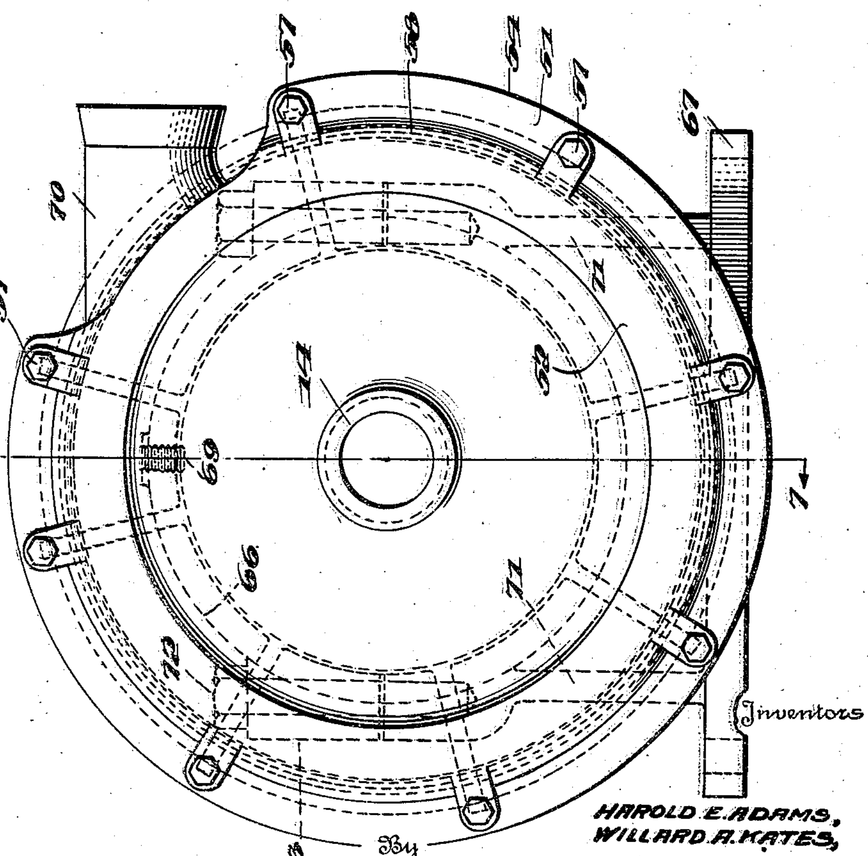

Fig. 6.

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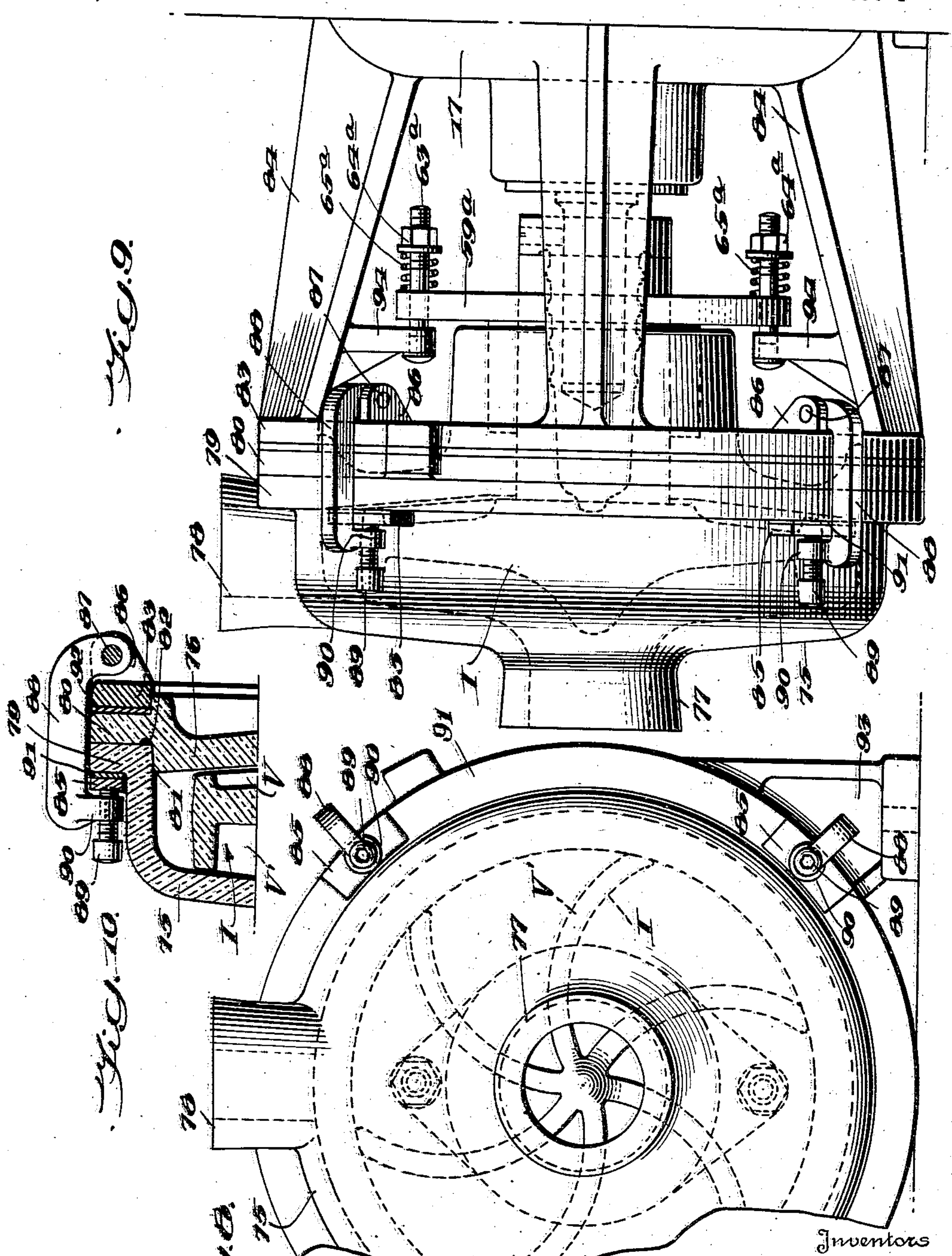

Fig. 9.

Fig. 10.

Fig. 8.

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Patented May 19, 1942

2,283,348

UNITED STATES PATENT OFFICE

2,283,348

PUMP

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Application December 21, 1939, Serial No. 310,462

13 Claims. (Cl. 287—53)

This invention relates to pumps, and more particularly to a pump assemblage of casing, impeller, driving means, and frame for the casing, wherein the casing and impeller parts are formed of corrosion resisting material and, therefore, particularly applicable to the handling of acids, and the like.

An object of the invention is to provide a pump construction, wherein substantially all of the parts that will contact in any manner with the fluid being pumped are formed of corrosion resisting material.

Another object of the invention concerns a centrifugal liquid pump in which the pump elements that come in contact with the fluids being pumped are formed of vitreous material, such as glass, or like refractory material. In this connection it has been found that glass is the most desirable because of its high resistance to corrosion from most acids, and because of its adaptability in handling liquids containing acids under the most efficient sanitary conditions.

Another object of the invention particularly concerns all glass pumps and means whereby they may be satisfactorily sealed against escape of fluid without, in so doing, developing sufficient localized heat to destroy the parts by differential expansion.

However, in the use of such materials for pump elements, the frangible nature of the materials under various conditions of stress and temperature is a hazard, and accordingly it is a further object to construct a pump in which is provided a strong metal frame, or housing, which not only functions in the operation of the pump, but it is devised to support the pump casing under controlled pressure, in a manner to minimize crushing or breakage, and also to afford protection from flying fragments, in the event that a breakage should occur.

One feature of the invention is concerned with the mounting of the pump casing within such a frame or housing in a manner which is protective to the casing while, at the same time, holding the casing firmly and securely during normal operations.

Another feature is the provision of a stuffing box assembly between the impeller and the portions of the pump casing which avoids the wiping of a movable vitreous member, such as the impeller, against a stationary vitreous member, such as the pump casing. Such a frictional action might readily develop heat between the parts, and the stuffing box assembly of the present invention is designed to avoid or reduce to a minimum the dangers of such overheating.

In a stuffing box assembly as contemplated herein, it is desirable to provide for quick repair and replacement of worn parts, and to this end there is disclosed a novel arrangement of stuffing box elements and retaining members which promotes ease and dispatch in the assembly and disassembly.

A further feature of the invention is the provision of means within the pump chamber by which the pressure of fluid on the stuffing within the stuffing box is materially reduced so that an effective seal may be maintained with a limited degree of pressure and a corresponding relatively slight generation of heat within the sealing means.

Considering that the impeller of the pump, as well as the casing, is formed of materials of relatively low tensile strength, and therefore frangible in nature, it is still another and an important object of the present invention to devise a joint between the impeller and the driving means therefor, which will form a good mechanical bond without, however, placing undue stress upon the impeller.

This latter object contemplates the formation of a joint between one member which acts as a moving driving member, and another member which is driven by said moving member, of more or less general application, but particularly adapted to uses in connection with a pump of the type herein described.

The invention has particular application, but is by no means limited thereby, in joining a rotary glass impeller of a pump, to a metal driving member or shaft of the type illustrated and claimed in a co-pending U. S. application of Harold E. Adams, Serial No. 275,755, filed May 25, 1939.

A particular problem arises in the joining of a frangible rotary member, such as an impeller, constructed of glass, to a metal driving member. The strength of the materials in tension, in a rotatable member formed of such materials as herein contemplated, makes it imperative that the joint between the metal driver and the frangible driven member be somewhat resilient, yet free of play. By the construction of the present invention a joint is provided which overcomes these difficulties in a very efficient and economical manner, and the invention contemplates the use of a bonding material between the driving and driven members, which is resilient in nature and has a lower modulus of elasticity than the members which are joined together.

One of the objects of the invention, particularly with reference to the joint between the drive shaft and the glass impeller, takes into consideration the use of an unshrinkable bond between the two.

Another feature of the present invention is to provide a bonding material that has the property of expanding during the cooling or congealing stage so as to embrace a mechanical lock between radially overhanging or radially overlapping surfaces on the drive and driven members.

A further feature of the invention is the provision of a joint structure employing a bonding medium between two preformed parts in which any possible shrinkage of the bonding material will result in a further strengthening of the mechanical interengagement of said parts.

Although the construction and operation of preferred forms of the invention are illustrated and described, it will be understood that they are intended only as illustrative and not as limiting, it being understood that the invention is not to be limited, other than as defined by the claims hereinafter appended.

To the attainment of the foregoing, and other objects which will appear as the description proceeds, reference is made to the accompanying drawings, in which:

Fig. 1 is a sectional elevation of a centrifugal pump showing one application of the present invention therewith;

Fig. 2 is an exploded perspective view partly broken away, illustrating a joint constructed in accordance with the present invention, between a metal drive member and an impeller removed from the drive shaft and without the bonding material;

Fig. 3 is an enlarged fragmentary sectional elevation through the drive and driven member, removed from the drive shaft;

Fig. 4 is a section taken substantially on the plane of line 4—4 of Fig. 3 which section is taken through the radial grooves;

Fig. 4a is a fragmentary enlargement of a part of Fig. 4;

Fig. 5 is a section taken substantially on the plane of lines 5—5 of Fig. 3 when mounted on the drive shaft, said section being taken on a plane spaced from the radial grooves;

Fig. 6 is an elevation of a pump embodying a slightly modified form of frame or housing;

Fig. 7 is a central section taken on the line 7—7 of Fig. 6;

Fig. 8 is a fragmentary end elevation of a pump embodying different modifications of frame or housing, and means of joining the housing sections together;

Fig. 9 is a side elevation of the pump shown in Fig. 8; and

Fig. 10 is a detail partly in section showing the mode of securing the frame sections together in the form of invention illustrated in Figs. 8 and 9.

Referring now more specifically to the drawings, wherein like reference numerals designate like parts, and with particular reference to Figs. 1 to 5, it will be seen that the pump assemblage comprises a supporting frame or housing A, preferably made of metal, having acid resisting qualities or acid resisting coatings, a sectional centrifugal pump casing indicated generally at B, which casing is formed of a head section 10 and a crown or volute portion 11. In the form of pump casing selected for illustration, the sections 10 and 11 are made of refractory vitreous material such as glass, for accommodating the pumping of highly corrosive fluids, and the casing sections are secured together in a suitably clamped relation, as hereinafter described.

A centrifugal pump chamber 13 is formed by the casing sections 10 and 11 and in the chamber is mounted the centrifugal impeller I for pumping liquid. The eye or inlet port of the pump casing is indicated at 14, and the outlet port (not shown) leads from the periphery of the casing B. In the center of the volute section, an integral stuffing box extension or neck 16 is formed and this extension provides the stuffing box or seal chamber for the packing or sealing elements 17 through which the hub 18 of the impeller I extends. In practice, the packing and sealing elements 17 provide a mechanical seal between the chamber and the hub to seal the pump chamber from the exterior of the casing and prevent leakage of the liquid being pumped, and at the same time prevent air from entering the casing and impairing the suction of the pump. While the preferred form of the pump of the present invention is made of glass substantially as shown in the drawings, it is obvious that certain of the mechanical details therein illustrated may be modified without eliminating the features of the present invention. Similarly the impeller and casing may be made of high silicon iron, or high chromium, or high nickel steel, all of which are sufficiently resistant to corrosion for application to pumping certain corrosive liquids while retaining certain other features of the invention. However, these metals like glass, are very difficult to machine and are usually machined by grinding, which characteristics are the same as glass used in the preferred embodiment in the present disclosure.

In order to produce a successful glass or vitreous pump capable of handling corrosive liquids, it is essential that all parts of the pump coming in contact with such liquids be formed from glass or whatever resistant material is being employed. In a centrifugal pump of the type disclosed this requires that the shank 18 of the impeller I and the sleeve 16 of the casing B be formed from glass as integral parts of their respective bodies. Thus, the only non-vitreous material exposed to the action of the fluid being handled is the inner portion of the packing 17. While various glasses are particularly resistant to attack by acids and by alkalis, all glasses, even those commonly referred to as "heat resistant," have only a rather limited ability to withstand differential heating and the resultant differential expansion stresses within the glass. This inherent weakness of glass has consistently thwarted all attempts to produce a satisfactory seal for an all glass pump inasmuch as the friction of a packing sufficiently tight to establish a fluid tight seal has generated sufficient heat in the adjacent portions of the glass parts to destroy them.

In the present invention the above difficulties and weaknesses have been overcome by increasing the area of the packing 17 in contact with shank 18 and by providing on the back or adjacent face of the impeller I a series of pump vanes V similar to, but somewhat smaller than the main pump vanes V' on the front or working face of the impeller. It has been found that if vanes are provided on only one side of the impeller disc, fluid at the pressure developed at the periphery of the impeller will flow down its other face. Thus, if no means is provided to diminish this pressure the packing about the pump shaft must withstand and seal the maximum pressure developed by the pump. On the other hand it is desirable that a certain amount of the fluid being pumped penetrates into the packing to lubricate the same since otherwise some foreign lubricant must be provided which may dilute or contaminate the material being pumped. In the present structure the size and contours of the secondary vanes V are so chosen with respect to the working vanes V' and the length of the packing 17 as to prevent any excessive pressure on the packing while permitting such seepage as is absolutely required.

While it is feasible to couple metal to metal having suitable elastic limits by the commonly practiced methods of keyways and set screws, such practice is not adaptable to vitreous, pottery, or ceramic products, and frangible rigid metals. The primary reason is that the strength of the materials in tension will not permit of a satisfactory coupling. Another reason is because molding and casting of articles from vitreous and allied metal material with precision keyways and set screw openings is extremely difficult, if not impossible, and since vitreous and allied metal materials cannot be machined in conventional ways, grinding must be resorted to, and it is very expensive to grind keyways and openings for set screws. Even though it were feasible to do this, the torsional stresses and strains in set screw and keyway couplings would be localized to the spot of the set screw, or the line of the keyway, which it is desirable to avoid.

Thus, a further problem which arises from the use of glass, pottery, and similar vitreous materials which are relatively weak in tension is that of suitably connecting the frangible impeller I to a metal drive shaft C, driven by a prime mover, such as the electric motor M. It will be seen that the joint of the present invention must not only provide a supporting connection between the drive and driven members, but it must also be the instrumentality by which rotary motion is transmitted to the driven member, whereby the driven member performs work.

In order to connect the driven member, such as the impeller I, to the driving member, it is desirable to provide the impeller with some character of opening or cavity in which the driving member may be seated, or through which the driving member may extend. Since it is undesirable to permit any part of the prime mover connections to pass through the impeller where they would come in contact with the fluid being pumped, it is preferred to adopt the cavity principle, and in the preferred form of the invention a longitudinally fluted socket 20 is molded in the impeller hub 18 (Fig. 2). The flutes provide the crests 21 and the intervening valleys or troughs 22. The crests 21 serve as key-like protuberances, and the valleys 22 serve in the nature of keyways so as to conform to the corresponding configurations on the driving member. The side walls 21' of the crests 21 are preferably parallel to each other and to the radius passing through the center of the crest, as shown in Figs. 4, 4a, and 5 for purposes to be hereinafter explained. Across the crests of each of the flutes are axially spaced circumferentially extending grooves 23, connected across the valleys 22 by shallow grooves 24. The grooves 23 form a series of spaced rings substantially interrupted by the valleys 22 in the wall of the socket 20.

While the hub 18 may be secured directly to the drive shaft C, in the manner explained in the present invention, it has been found to be more practical to interpose an intermediate connection, and toward this end, there is used as the driving member D, a hollow spindle or thimble generally known as a quill, which is made preferably of acid resisting metal.

The quill performs the function of distributing the stresses and strains between the hub and the shaft C over a greater area than is possible with known impeller couplings, and it accordingly functions as a torque distributing member, as well as a driving member.

The quill is an elongated body and has an enlarged cylindrical head 25 and a reduced extension, indicated generally at 26, terminating in a flattened transverse tang 27. A radially disposed cavity 28 in the inner wall of the socket 20 receives the tang when it is brought into registration, and cooperates therewith to form a mechanical driving connection between the quill and socket. There will be sufficient clearance between the tang and cavity to accommodate a layer of cementing or bonding material. The head and reduced part are separated by a radial shoulder 29 that has a semi-circular radially extending groove 30 in its face. The groove 30 forms a vent or riser for excess cementing or bonding material when the quill is inserted in the socket 20, thus allowing the shoulder 29 to be brought up against the free edge of the hub 18 and giving better positioning of the quill in assembling with the impeller, and also providing an index that the cavity between the quill and the hub socket 20 has been completely filled with bonding material during the assembly operation. There is a slight overall taper from the outer to the inner end of the socket 20 in the hub and the reduced part 26 of the quill is correspondingly tapered.

The reduced part 26 is formed with flutes slightly smaller than the flutes in the socket so that the crests 31 and the valleys or troughs 32 on the reduced part 26 will leave a clearance with the corresponding crests 21 and valleys 22 in the socket 20 so as to permit a certain amount of the bonding material 33ᵃ to congeal between the confronting surfaces and resiliently lock the hub, and driving or torque distributing member D together. The side walls 31' of the crests 31 are likewise parallel to each other and to the radius passing through the center of the crest. It will be seen that when the quill is assembled in the hub, the crests of the flutes on the hub overlap or overhang the flutes on the quill in a radial direction, and vice versa, with the bond 33ᵃ in between, and this prevents rotary play between the parts.

At the outer end, each of the valleys 32 terminates in an outwardly flared pocket 33. The pocket 33 allows clearance for the ends of the crests 21 of the flutes in the socket should any fins be adhering to them due to faulty casting, molding, or grinding. The riser groove 30 registers with one of the pockets 33. Extending across the crests 31 are a plurality of circumferentially extending axially spaced grooves 34, and these grooves cooperate with the grooves 23 in the crests 21 of the flutes in the hub socket 20 when the quill is assembled in the hub. Like the grooves 23 in the socket 20 of the hub, the grooves 34 form a series of spaced rings interrupted by the intervening valleys 32. These grooves 23 and 34 prevent longitudinal movement between the quill and impeller, while the radially overhanging flutes on the quill and hub prevent rotary movement, when the bonding material 33ᵃ is applied.

Along the axis of the quill is a socket 35 which receives the stub drive shaft C of the prime mover M. In the wall of this socket is a keyway 36 (Figs. 4 and 5) which receives one-half of the key 37, while the other half of the key seats in the keyway 38 on the drive shaft. The quill is selectively positioned on the drive shaft C and locked thereto by the positioning set screw 39 threaded in an opening 40 in the head 25 of the quill, and a second set screw 42 threaded in an opening 43 in the head 25. The positioning set screw 39 engages with an opening 44 (Fig. 1) in the stub drive shaft C, and when seated in this opening the impeller will be locked in its proper position on the shaft. The inner end of the set screw 42 abuts the periphery of the drive shaft C and takes up all play in the parts whereby any tendency of the impeller to wobble is eliminated.

The quill is anchored to the impeller I by a bonding material 33*a*. Preferably there is used an alloy, cement, or bonding material having the characteristic of becoming liquid or thermoplastic under heat at a temperature that will not injure the glass when the bonding material is applied, although hydraulic cements may also be used. Among the desirable bonding materials are those low melting point alloys generally designated as "type metals" which have the desirable property of expanding slightly while cooling from a liquid to a solid phase. This property is valuable in the present invention because the irregularity in the surfaces have been specially designed to accommodate such an expanding material.

The preferred way of joining the metal quill to the hub 18 is to heat the quill and impeller to a temperature approximately that of the melting point of the particular composition used. A quantity of the composition slightly in excess of that required is placed in the socket 20 and the hot quill is inserted until shoulder 29 comes up hard against the end of the hub 18. The excess material will meanwhile escape through the vent, or riser 30. When the quill is in its inserted position, the crests 21 of the flutes on the socket will substantially register with the corresponding recesses or valleys 32 in the flutes of the quill. In a like manner, the valleys 22 in the socket 20 receive the crests 31 of the flutes on the reduced part 26. In this position, the extremity of the crests on the flutes on the quill or driving member D, radially overhang, or overlap the extremity of the crests of the flutes in the socket 20 of the impeller or driven member I.

As heretofore pointed out, there will be continuous spaces between the corresponding crests and valleys in the socket 20 of the impeller and reduced part 26 of the metal quill in the assembled relation, and the shoulder 29 will be bearing against the free edge of the hub 18. The alloy bonding composition will then fill the space between the corresponding crests and valleys of socket 20 and reduced part 26; and also fill the grooves 34 in the crests 31 of the flutes of the quill, and the grooves 23 in the crests 21 of the flutes in the socket.

While the tendency of the preferred alloys is to expand slightly on congealing, all such alloys and cements will shrink upon further cooling and, if the rate of shrinkage be different from the adjacent glass and metal parts, there will be a slight loosening of the joint. Such loosening is overcome in the preferred form of the invention by the special design of the side walls of the crests 21 and 31, as previously described. The shrinkage of the bond 33a which loosens the joint is primarily in a generally radial direction. Due to the above described configuration of the crests, it will be seen (Fig. 4*a*) that any contraction of the bond 33*a* radially with respect to the quill 26 and hub 18 will result in an increased clamping action of the solidified bond against the walls 21' and 31' of the various crests. In this manner a tight joint is ensured regardless of the rate of contraction of the bond.

It is pointed out there is an axial and circumferential bond 33*a* of bonding material throughout the entire confronting area between the socket in the hub and the reduced part of the quill.

It will be understood that the bond is not an adhesive bond between the metal of the quill 26 and the glass of the hub 18. The composition will be adhesive or "wet" only to the metal of the quill, and not to the glass. Because of the different rate of expansion and contraction between metal and glass, it is not practical to have a bond which is adhesive to both materials. However, the composition when "set" forms a slightly yieldable cushion sufficiently conformed to produce a good mechanical bond, but yieldable sufficiently to distribute torque. In other words, the composition forms a load distributing coupling effective to maintain shear stress in the glass well below its rupture value.

As a matter of fact, it is not essential to attain adhesion or "wetting" with respect to the quill, although this is preferable because of contraction in the quill upon cooling thereof. If a bonding material which is not adhesive to the quill is used, then it is desirable to use a material having a coefficient of expansion greater numerically than the coefficient of expansion of the material of the quill, so that the bonding material will shrink tight about the quill on cooling.

As a further variation, if a material is used which provides good adhesion to the quill, then it is not even necessary to form grooves in the quill.

In addition to this bond, there is the mechanical lock against rotation between the parts, caused by the radial overhang between the flutes. This mechanical lock is augmented by the expansion of the cement into the flutes, and the insertion of the tang 27 into the socket or keyway 28. From the foregoing it will be obvious that the driving stresses, when the parts are rotating are well distributed throughout the quill.

Then there is the still further mechanical lock against axial, or longitudinal movement between the parts occasioned by the circumferential grooves 23 and 24. These three factors distribute the torsional stresses and strains over a greater area of the drive and driven members than is known to have been applied to any rotary joint.

The following compositions are given by way of example of suitable alloys for use as bonding materials:

	A	B
	Per cent	*Per cent*
Bismuth	48.00	------
Lead	28.50	86.50
Tin	14.50	0.50
Antimony	9.00	13.00

Another and important problem involved in the construction of pumps, utilizing glass or other ceramic or vitreous materials is found in the assemblage, mounting and adequate support for the pump casing within which is formed the pumping chamber. It is, of course, essential that the pump casing be held firmly and securely, while at the same time avoiding any tendency to produce localized strain therein, and also to afford protection from flying fragments, in the event that breakage should occur.

To this end there is provided a sectional metal housing or frame which furnishes a protective guard, as well as adequate support, this sectional housing being suitably clamped under predetermined uniform pressure.

In Fig. 1, the sectional metal housing or frame A provides a support for clamping the sections of the pump casing B together, and also provides the protective guard for the casing. All of the outer metal parts of the present structure, including the housing A may be made of cast iron, or other metal, not necessarily highly resistant to acid or acid vapors, and such metal parts may be plated with acid resisting material, such as cadmium, or covered with rubber base paints, or other suitable acid resistant coating.

This housing A is preferably formed in two major portions or sections, the inner of which consists of a frame section 50 which may be suitably braced or bolted if desired, to the motor M. One convenient and conventional mode of supporting the frame 50 would be by a spider or struts between the housing A and the motor, as illustrated for example in Fig. 9, but any convenient method may be used. The outer section of the housing A comprises an annular flanged member 51 having a flange 52 directed radially inward to embrace a face of the casing section 10, a projecting flange 53 disposed substantially at right angles to the flange 52 to encompass the periphery of the glass section 10, and an outwardly directed flange portion 54 which provides means for securing the section 51 to the section 50. The section or portion 50 is generally bell shaped to accommodate and encompass the glass casing section 11 and terminates in its outer peripheral edge with a thickened flange-like section 55, rabbeted, as indicated at 56, to receive the flange 53 of section 51, and thereby provide a mating relation between the two housing or main sections 50 and 51. The flange 54 is suitably drilled to receive threaded bolts 57 which may be threaded into the flange 55 of section 50.

It will be evident then that the pump casing section 11 may be mounted within the bell-shaped housing or frame section 50, the impeller being suitably assembled thereon, and then the pump casing may be completed by placement of the section casing 10 and securing thereof in place by the housing or frame section 51.

In order to avoid a metal to glass contact and insure distributed loading, corner strips 58—58 of resilient material are inserted circumferentially about the corners of the respective sections 10 and 11 of the pump casing, and the inner corners of the frame sections 50 and 51. Rubber or any other highly resilient material may be used for this purpose.

Of course, the elements of the stuffing box or gland between the impeller and the casing section 11 might readily be preassembled prior to placement of the pump casing within the metal frame but in order to facilitate such assemblage and to provide for adjustments of pressure against the gland, and to facilitate take-up occasioned by wear, temperature, or other conditions, the rear of the housing A, i. e., the section 50, is formed open, and adjustable means are provided for effecting a closure thereof. To this end an annular ring-like plate 59 is provided with a central opening 60 of a size large enough to surround the hub of the impeller and the drive shaft therefor with ample clearance. The purpose of this plate 59 is not only to close the opening of the section 50 but also to apply a yieldable pressure against the elements of the gland, and it will be observed that the sealing elements 17 are backed up with a follower 61, preferably of glass, or of material having the same expansion and contraction characteristics as the material from which the pump casing and impeller are made. This follower will be assembled within the gland and backed up by packing of resilient material, indicated at 62, which in turn is backed up by the plate 59. Studs 63 threaded into the section 50 extend freely through perforations circumferentially disposed in the plate 59, and carry at their outer ends take-up nuts 64. Interposed between the nuts 64 and the outer face of the plate 59 are springs 65. In the preferred embodiment of the invention, studs 63 are threaded for only a short distance at either end and the length and strength of the springs 65 are so chosen that they will never be fully compressed when nuts 64 are drawn up to their extreme limit of travel. Thus the pressure exerted on the follower 61 and packing 17 by ring plate 59 can never exceed a predetermined maximum pressure established by the characteristics of springs 65.

It might be noted that the elements 17, in addition to functioning as a seal in a stuffing box or gland, may be formed of material effective to dispose of frictional heat and transfer same from the point of heat development. A suitable packing for this purpose may be prepared from asbestos fibres, lead shavings, and graphite.

From the foregoing it is evident that a controlled and predetermined pressure is exerted on the stuffing gland and transmitted through the stuffing box assembly, through the compression afforded by the springs 65.

Referring now to Figs. 6 and 7, it will be observed that the essential elements therein are substantially the same as illustrated in Figs. 1 to 5. However, the supporting housing or frame A for the casing B, instead of being bolted or otherwise secured to the motor M, is provided with a standard 66 having a substantial base 67 and arranged to encircle the neck or hub-like portion 68 of the housing A. Provision is made in the form of a threaded opening 69 for a set screw effective to secure the standard to the housing. Incidentally in Fig. 6 the discharge or outlet from the pump casing is illustrated at 70, and this same type of outlet or discharge may be used in several forms of the invention. The standard 66 may be formed with legs 71 and the upper portion of the standard made separable from the base and leg portions to facilitate assemblage. In this event bolts 72 entering the socket portions 73 may be utilized to secure the standard in position. This, however, is optional as obviously the standard may be made an integral structure.

It has been stated heretofore that variations are possible in the joint and bonding media between the drive shaft and hub of the pump impeller. Fig. 7 illustrates one such variation in which the hub 18^a of the impeller I is provided with circumferential inner grooves 23^a of substantially uniform depth throughout, such depth being equivalent to that of the longitudinally extending grooves or flutes 32a. In this arrangement it is contemplated that connection may be made directly to a drive shaft (not shown), or to a quill, but the tang 27 (Fig. 2) may be omitted in the form shown in Fig. 7.

Figs. 8, 9 and 10 illustrate a somewhat further modification or embodiment of the invention, in which the volute 75 and the closure plate 76 are arranged somewhat the reverse of the showings in Figs. 1 and 7, and in which the mode of clamping the frame sections and casing members 75 and 76 is different. In this embodiment, we find the volute 75 on the forward or outer portion of the pump casing, extending outwardly into an eye or inlet 77, and forming a pump chamber, when assembled for the impeller I. A discharge 78 extends radially outward instead of tangentially, but this arrangement of inlet and outlet can be varied to suit a particular installation. This arrangement of housing parts is particularly desirable since by merely removing the volute 75 access may be had to both the front and back of the impeller plate for cleaning and inspection without further dismantling the pump.

The housing or frame in this form of the invention is primarily for supporting purposes, and for holding the glass pump casing in a properly assembled, shock absorbing relation, there being no outer frame or housing about the main exterior of the glass pump casing.

The volute 75 is formed with an outwardly, radially extending flange 79, and the section 76 has a similar flange 80 which merges into a shoulder 81. When assembled the flanges 79 and 80 will be abutted, and the shoulder 81 will fit within the periphery of the bell of the volute 75. While no gasket is illustrated between the flanges 79 and 80 (Fig. 10), it will be evident that any suitable packing or gasket may be utilized, as desired, and the base of the flange 80 is channeled, as indicated at 82, for the reception of packing at that point.

The frame or housing for supporting the pump casing takes the form of an annular member 83 secured to struts 84 which extend rearwardly to the motor M and form a support for the pump assemblage. Metal clamping pads 85 which may take the form of a complete annular ring, but as illustrated are spaced pads, are arranged for placement exteriorly of the flange 79 and volute 75, as outer supporting or retaining means for the assembled sections 75 and 76.

In order to secure the parts in assembled relation, ears 86 are formed on the annular section 83 of the frame, these ears, together with pintles 87, forming hinges for clamps 88. The clamps 88 are provided with pressure adjusting screws 89 threaded into lugs 90 and effective, after assemblage of the parts as an adjusting means for holding the pump casing sections in proper relation under desired pressure. Gaskets 91 and 92 function in a manner similar to the gaskets 58—58 of Fig. 1 to resiliently protect the glass casing sections and prevent a metal to glass contact. It will be observed that the described structure is particularly adapted for quick and easy removal of the volute 75 since screws 89 need only be slightly loosened and clamps 88 swung back on their pintles 87 to completely release the volute 75 from the section 76.

The struts 84, in addition to supporting the pump on the motor, which incidentally is itself provided with supports indicated generally at 93 provide a means for mounting the face plate or pressure applying medium to the stuffing box. As shown in Fig. 9, the plate 59a is entirely supported by bolts 63a, circumferentially disposed in suitable openings adjacent the periphery of the plate 59a, being in turn mounted in lugs 94 which are formed on the respective struts 84, instead of being secured into the frame or housing proper. Pressure adjusting nuts 64a control the pressure applied to springs 65a in a manner similar to that illustrated in earlier figures of the drawings. The other features of the pump structure and of the joint are in all respects similar to those heretofore described in connection with other figures.

Having thus full described the invention, what we claim as new and desire to secure by Letters Patent of the United States is:

1. In a centrifugal pump of the type adapted to handle corrosive fluids, and wherein elements of said pump are subjected to a wide range of created temperatures, the combination of a rotatable glass impeller, a drive shaft for the glass impeller, a quill interposed between the impeller and the drive shaft, effective to distribute torque over a large area to the impeller, with mechanical means for connecting the quill to the drive shaft, and a firm connection including a mechanical interlock and a bond of plastic material distributed therein, between the impeller and the quill, effective to accommodate differential expansion between the impeller and its driving means.

2. In a centrifugal pump of the type adapted to handle corrosive fluids, and wherein elements of said pump are subjected to a wide range of created temperatures, the combination of a glass impeller provided with a glass hub, a drive shaft for the impeller, with torque distributing means bonded to the hub and mechanically connected with the drive shaft for driving the impeller, the bond between the torque distributing means and the hub including a mechanical interlock and a bond of plastic material distributed therein, said plastic material having the characteristic of accommodating differential expansion between the torque distributing means and the hub.

3. The combination with a rotatable, vitreous pumping member, of a non-vitreous drive shaft, torque distributing means interposed between said shaft and said member, and solidified plastic material interposed between said torque distributing means and said member providing a firm, resilient bond between said distributing means and said member, said torque distributing means and said vitreous pumping member having cooperating, inter-related portions bonded to each other in a mechanical interlock by said solidified plastic material.

4. A joint comprising a rotatable, metallic drive member, a rotatable, frangible driven member providing a socket for said drive member, said drive member having a portion disposed in said socket, said parts being so shaped and proportioned as to provide cooperating, inter-related parts forming clearances between the exterior of said drive member and the interior of said driven member when in assembled relation, and a plastic bond solidified within the clearance between the interior walls of the driven member and that portion of the drive member which projects thereinto, providing, when set, a firm, resilient bonded, mechanical connection between the drive and driven members.

5. A joint comprising a rotatable, metallic

drive member, a rotatable, frangible driven member having a hollow portion for reception of said drive member, said drive member being at least partially disposed in said hollow portion, means including longitudinally extending recesses on said drive member, and longitudinally extending recesses on said driven member staggered with respect to said first recesses, the crests between recesses on one of said members being of smaller dimension than corresponding recesses on the other member, to provide clearances between the exterior of said drive member and the interior of said driven member when in assembled relation, and a firm bond of cushioning material within the clearances between the interior walls of the driven member and that portion of the drive member which extends thereinto.

6. A joint comprising a rotatable, metallic drive member, a rotatable, frangible driven member having a hollow portion for reception of said drive member, said drive member being at least partially disposed in said hollow portion, means including relatively staggered longitudinally extending recesses on said drive and driven members and circumferential relatively aligned recesses on said drive and driven members, the crests between recesses on one of said members being of smaller dimension than corresponding recesses on the other member, to provide clearances between the exterior of said drive member and the interior of said driven member when in assembled relation, and a firm bond of cushioning material within the clearances between the interior walls of the driven member and that portion of the drive member which extends thereinto.

7. A joint comprising a rotatable, metallic drive member, a rotatable, frangible driven member providing a socket for said drive member, said drive member having a portion disposed in said socket, means providing clearances between the exterior of said drive member and the interior of said driven member when in assembled relation, the bottom of said socket being slotted to provide a key-way, and the end of said drive member being formed with a tang adapted to mate with said key-way, and a firm bond of cushioning material within the clearances between the interior walls of the driven member and that portion of the drive member which projects thereinto.

8. A joint comprising a rotatable metallic drive member, a rotatable frangible driven member comprising head and hub portions, a socket in said hub portion for said drive member, said drive member having a portion disposed in said socket, means providing clearances between the exterior of said drive member and the interior of said driven member when in assembled relation, the bottom of said socket being slotted to provide a key-way extending into the plane of said head portion, and the end of said drive member being formed with a tang adapted to mate with said key-way, and a firm bond of cushioning material within the clearances between the interior walls of the driven member and all portions of that portion of the drive member which projects thereinto.

9. A rotatable joint comprising mechanically interengaging members, one arranged to be driven by the other, and one of said members being formed of frangible material, and a load distributing bond between said members disposed in and about the interengaging portions of said members, and effective to provide a cushion coupling therebetween.

10. A rotary joint comprising a rotatable drive member, a frangible driven member, a laterally projecting frangible hub on one side of the driven member provided with a socket extending axially of said driven member, a portion of the drive member being disposed in said socket in spaced relation to the walls thereof, a cushioning bond of thermo-plastic material in the space between said portion and said socket walls formed of a material that has the property of expanding while cooling from plastic condition to congealed condition, the internal walls of said socket being equipped with flutes providing crests and valleys to provide a mechanical lock in addition to the bond to eliminate relative rotation between the drive and driven members, and the crests of the flutes having circumferential grooves effecting a mechanical lock with the bond to eliminate axial movement between the members.

11. A rotary joint comprising a rotatable metallic drive member, a rotatable glass driven member, one member being provided with a socket, the walls of said socket being equipped with flutes providing crests and valleys, a portion of said other member extending into said socket and being provided with flutes co-related to and spaced with respect to the flutes in the socket, the valleys of the flutes in the socket receiving the crests of the flutes on the other member, the crests of the flutes in the socket receiving the valleys of the flutes on the other member to effect a mechanical lock against rotary movement by the radial overhang of the respective crests on the members, the crests of the flutes on the respective members being provided with circumferential grooves aligning with one another to effect a mechanical lock against axial movement by the members, when filled with a bonding medium, and a bonding medium consisting of plastic material congealed in the space between the co-related flutes and grooves, on the members to provide a firm resilient bond between the members in addition to the mechanical lock between the crests and valleys.

12. In a pump of the type adapted to handle corrosive fluids, and wherein elements of said pump are subjected to a wide range of created temperatures, the combination of a joint comprising a drive member, a driven frangible pumping member provided with a socket, a portion of said drive member positioned in said socket, and a combined mechanical and cushioning, load distributing bond between said members effective to couple them together, said load distributing bond including mechanically inter-related elements on the drive member and in the socket, and a plastic material disposed in and about said elements.

13. A joint comprising a rotatable, metallic drive member, a rotatable, glass, driven member provided with a laterally projecting hub to receive said drive member, means providing clearances between the exterior of the drive member and the interior of the hub when in assembled relation and a cushioning bond of thermoplastic material in the clearances between the drive member and the interior of the hub, said material having the property of expanding while solidifying, whereby it is expanded into said clearances.

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