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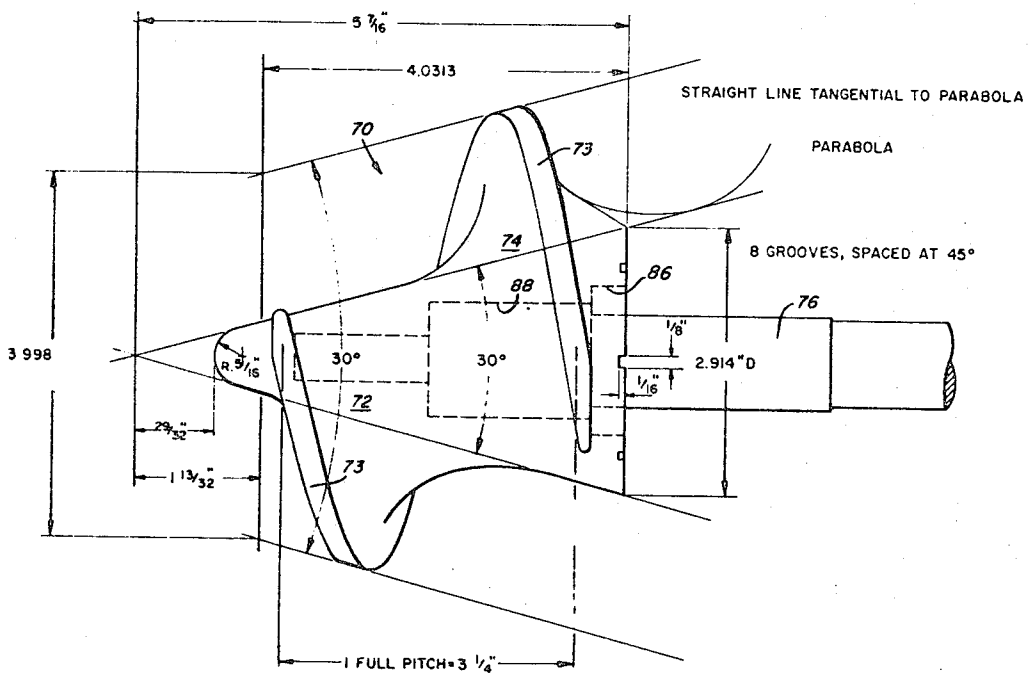
[54] **PUMP CONSTRUCTION**
12 Claims, 12 Drawing Figs.

[52] U.S. Cl. **415/72,**
415/215, 416/175, 416/203
[51] Int. Cl. **F01d 5/00**
[50] Field of Search. 415/72,
215, 198, 214, 219; 416/175, 176, 177, 203

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ABSTRACT: A rotary pump assembly is described comprising a pump housing having a suction side and a discharge side each of a predetermined geometric form, with an impeller rotatably mounted therein for cooperating with the pumping action which is from approximately 35 to 85 percent auger action, and the remainder being centrifugal pumping action. The pump housing and impeller are substantially wholly made of a fully cured urethane elastomer.



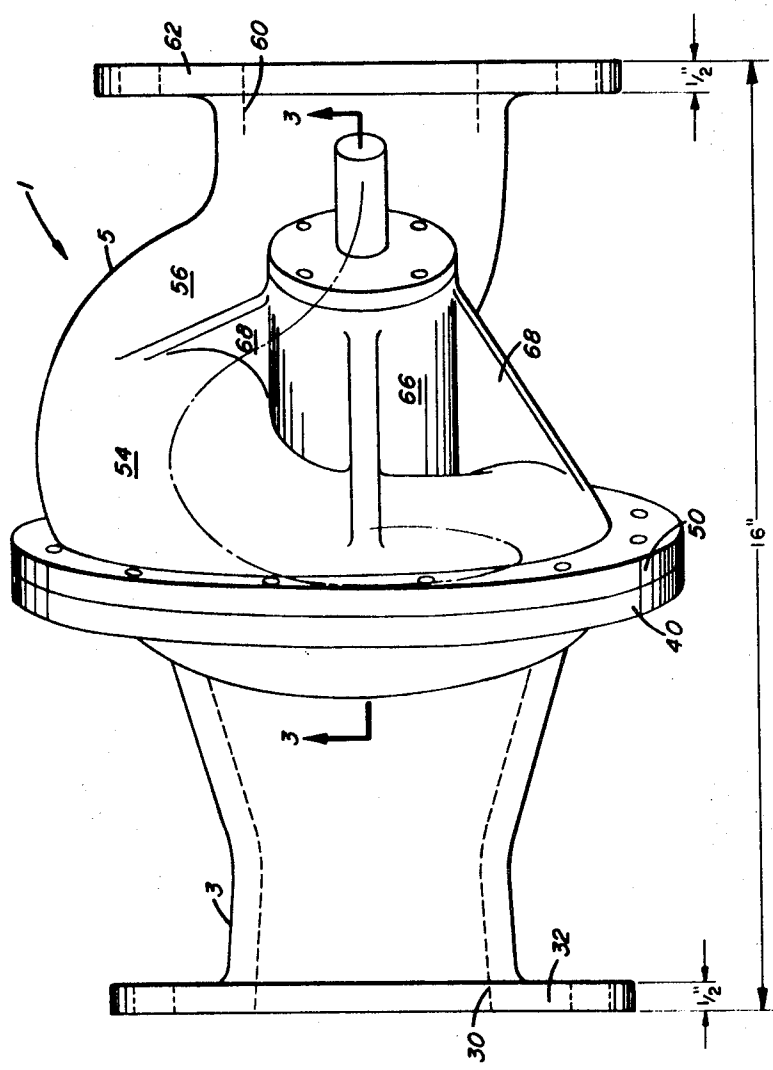


FIG. 1

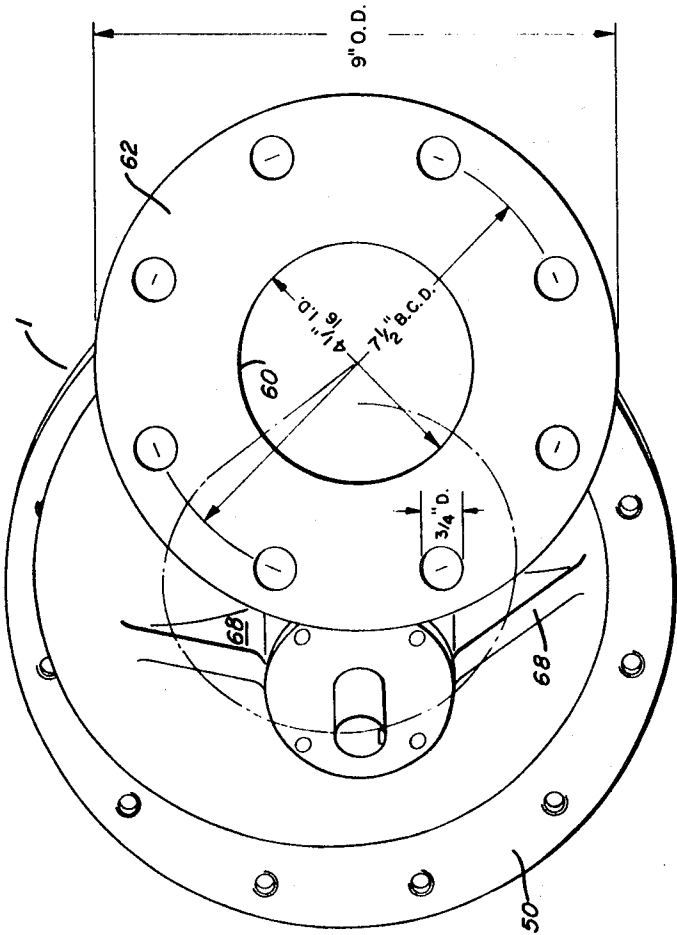


FIG. 1A

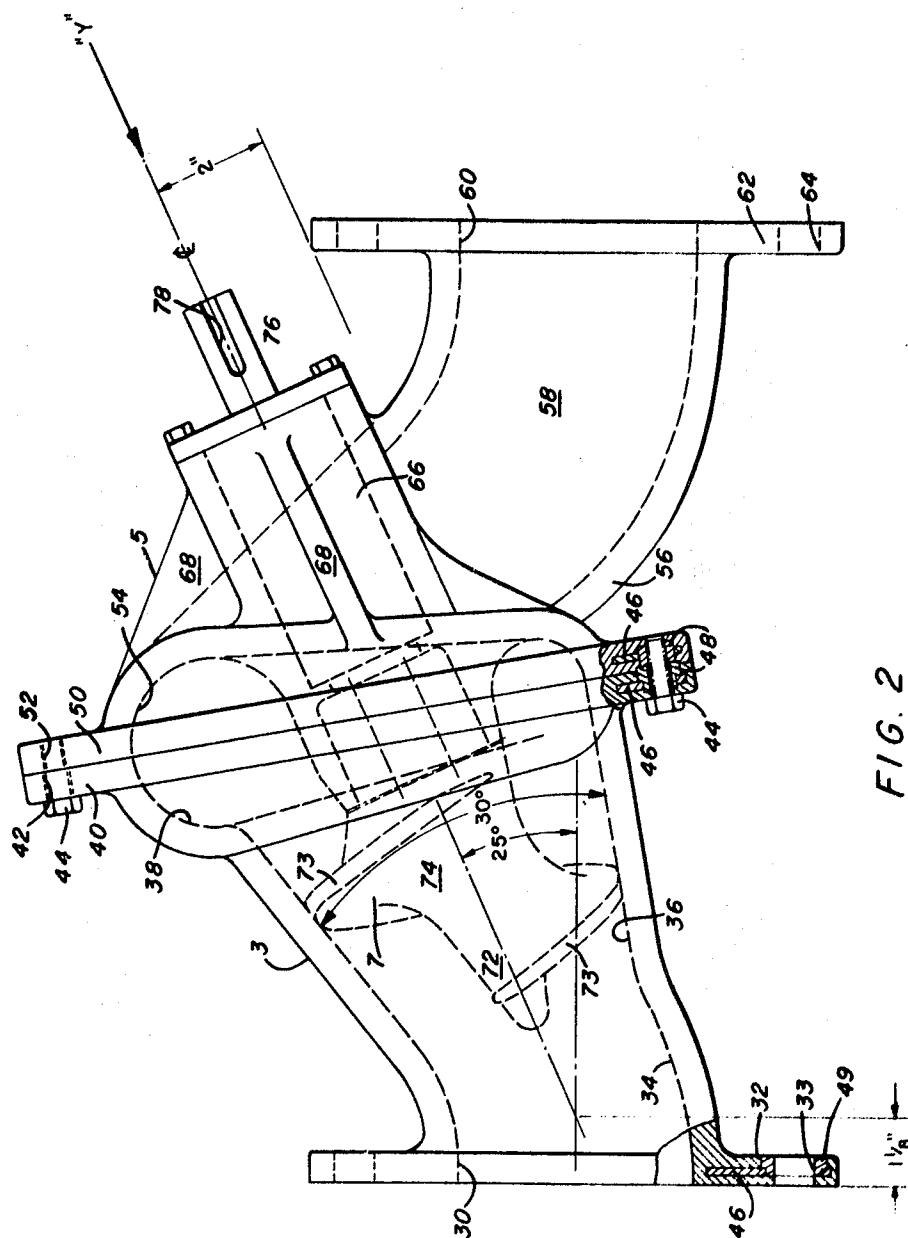
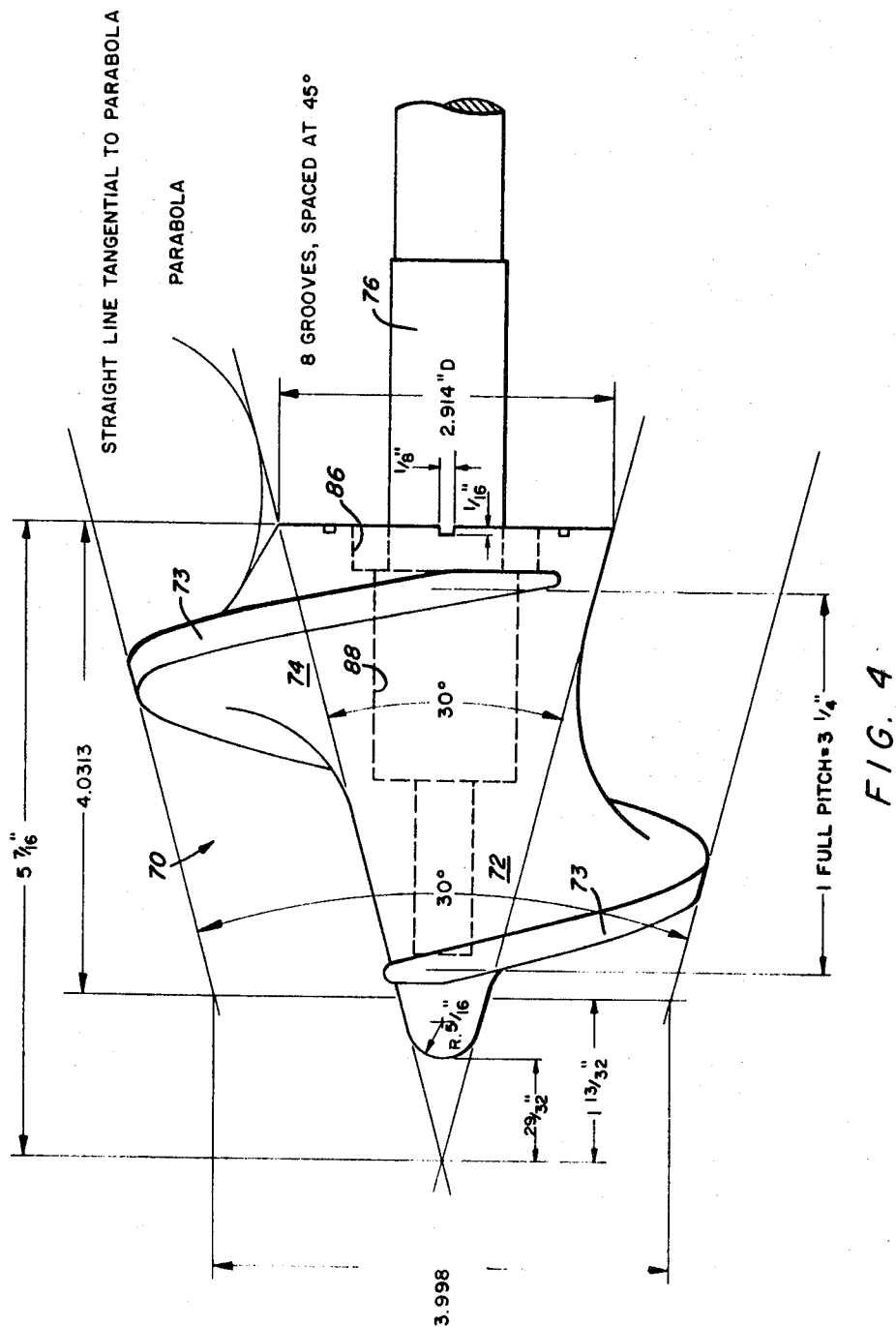


FIG. 2



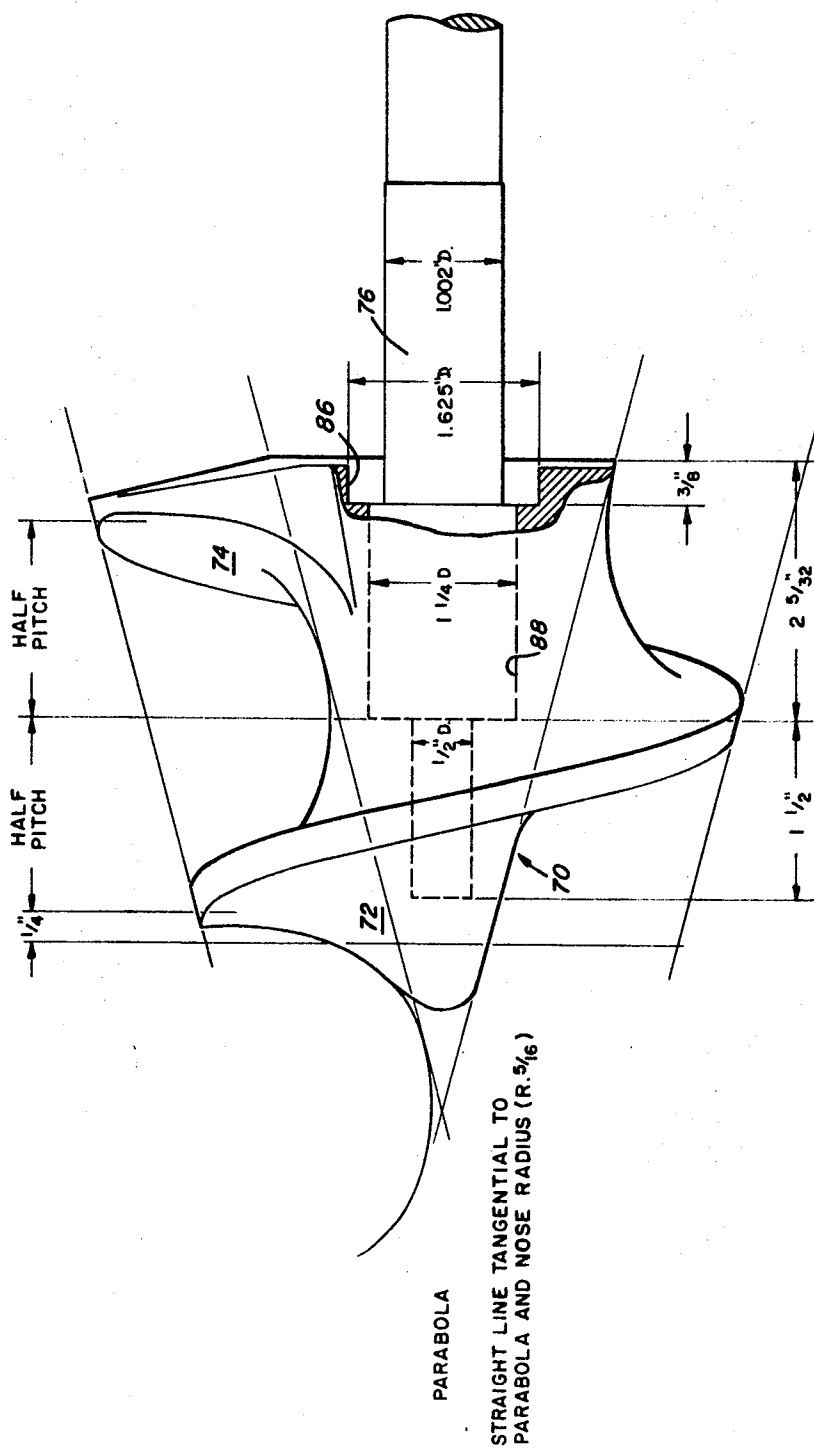


FIG. 5

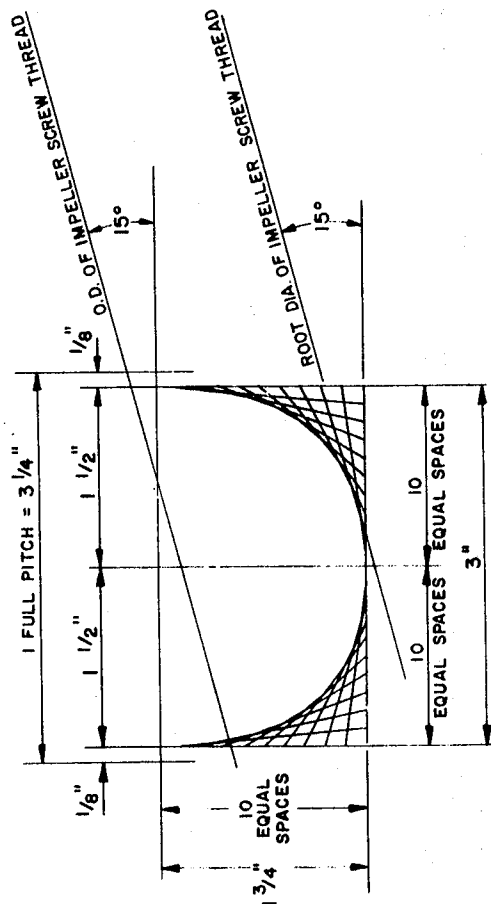


FIG. 6

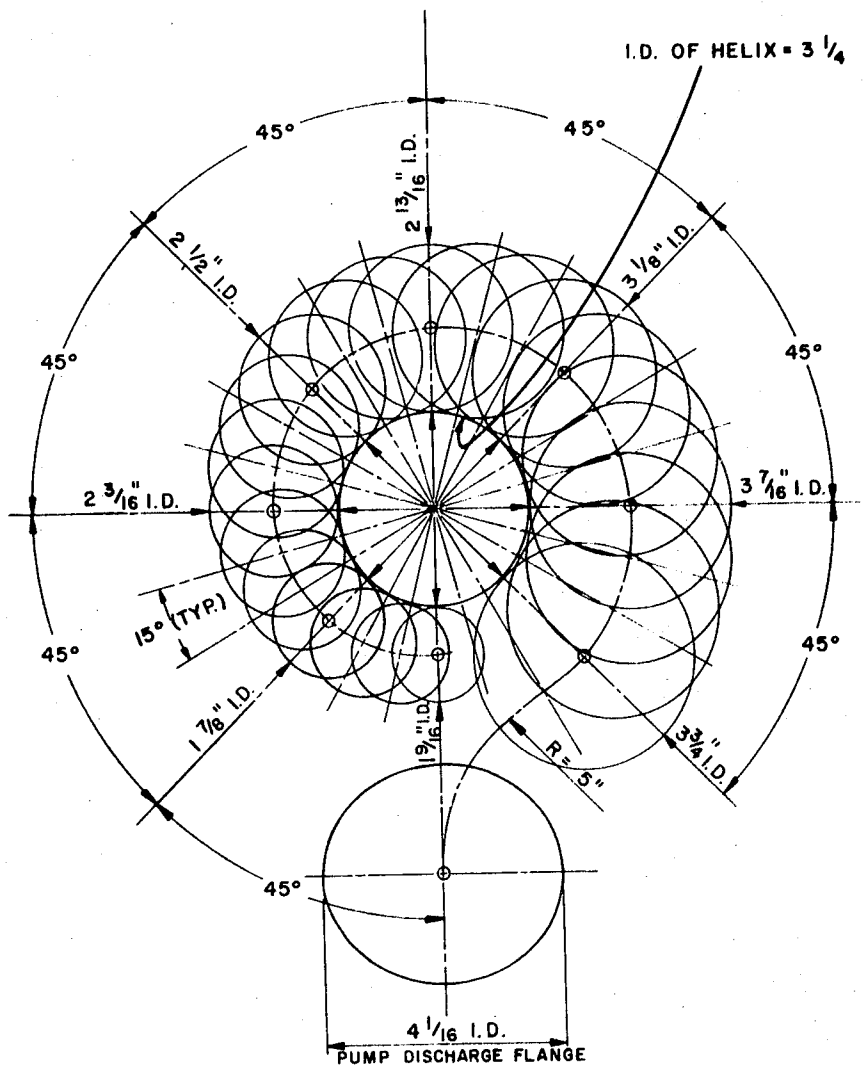
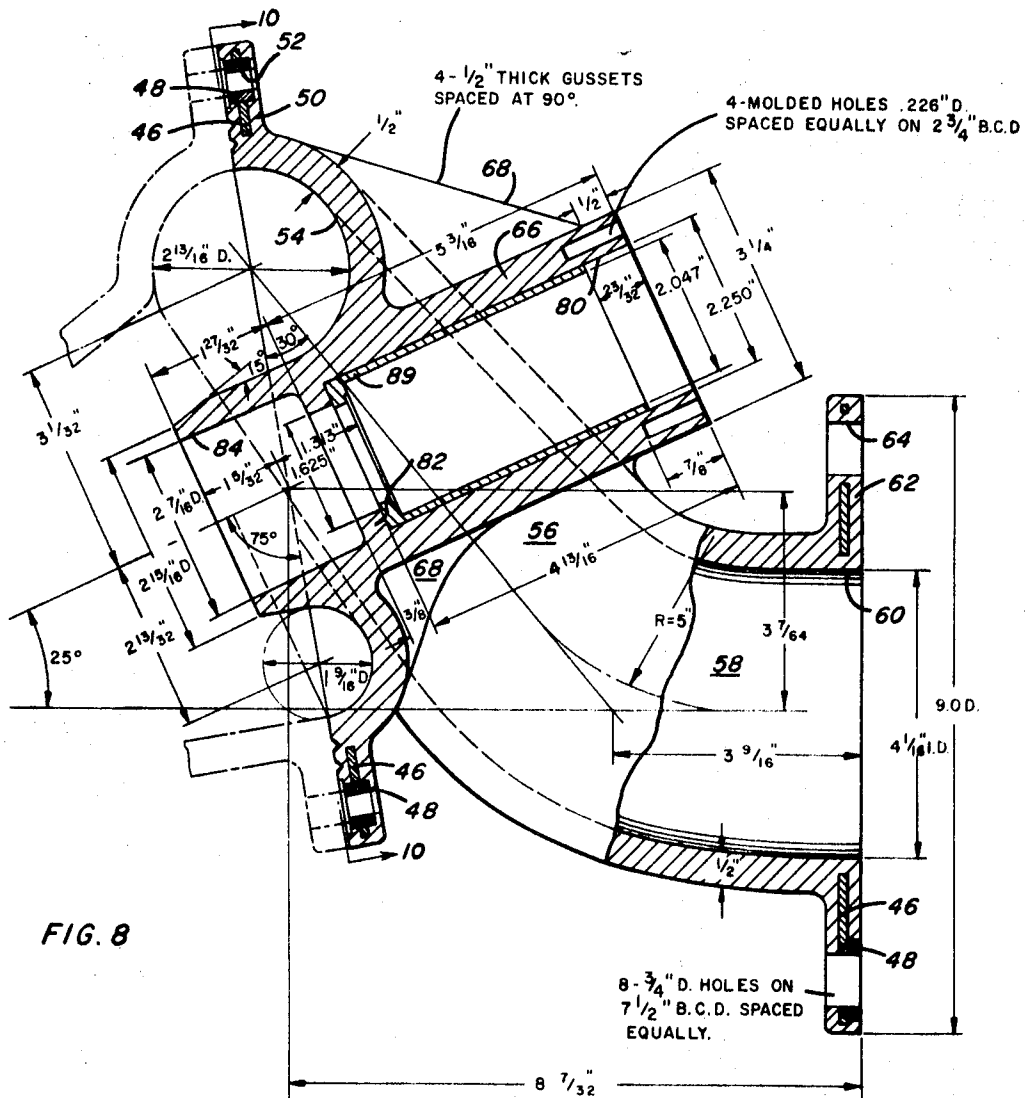
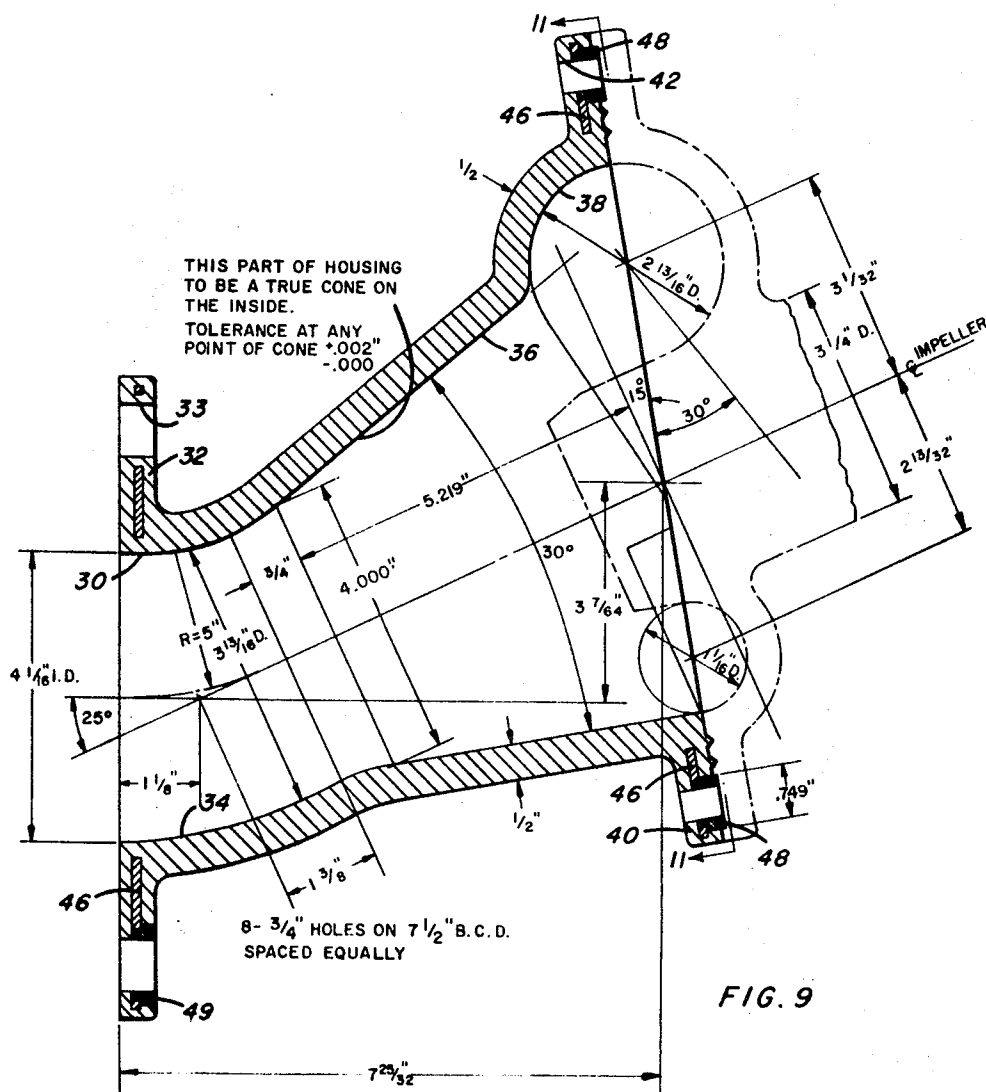


FIG. 7





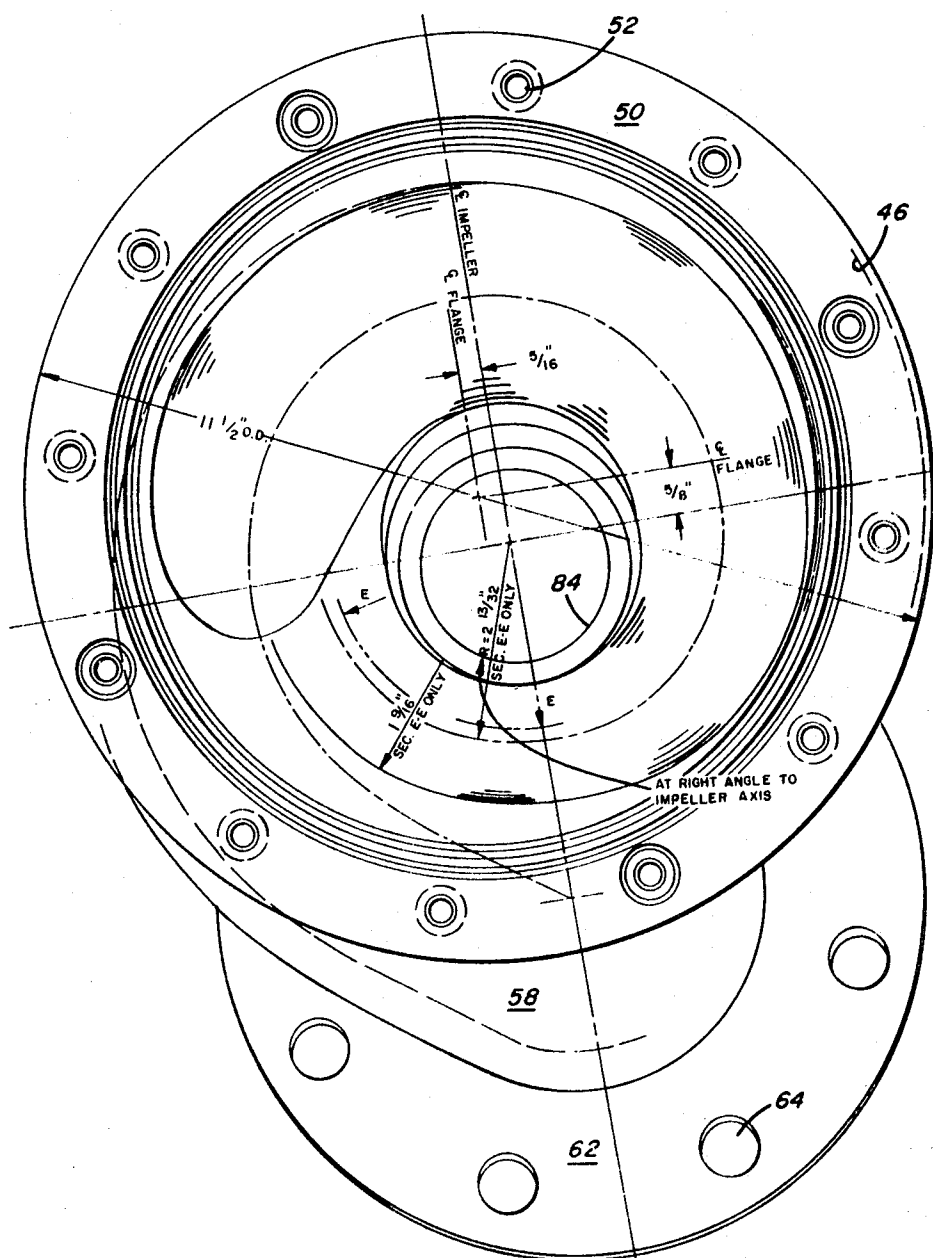


FIG. 10

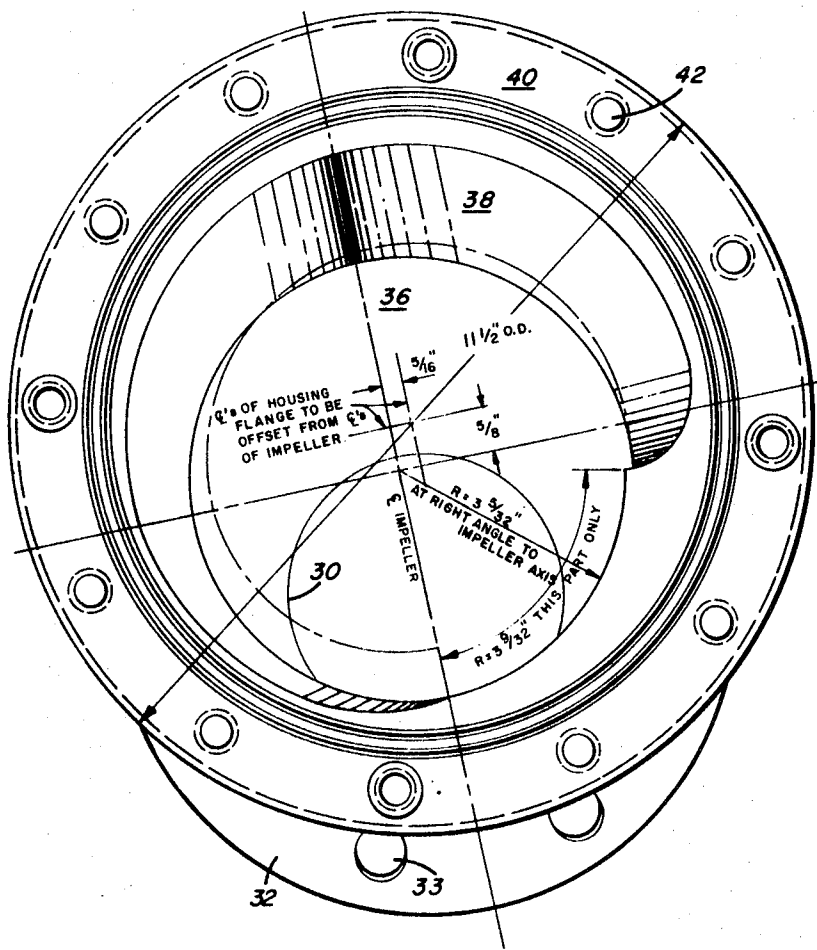


FIG. II

PUMP CONSTRUCTION

This invention relates to a rotary pump construction that is adapted for pumping a liquid, a liquid containing solid matter in suspension, a slurry, or the like. More particularly, the rotary pump construction being contemplated herein contains an impeller which is rotatably mounted and is designed to cooperate with a pump housing of a predetermined geometric form for providing a pumping action that is partly auger action and partly centrifugal action.

Rotary pumps are known which provide a pumping action that is entirely centrifugal in nature, while other rotary pumps are known which provide only a screw or auger type of pumping action. Generally speaking, centrifugal rotary pumps are probably most frequently used with liquids which are substantially free of solids, such as water, liquid fuels, oil and the like. Similarly, rotary pumps having a screw or auger type of pumping action are perhaps most often used with liquids containing solid matter in suspension, mining, excavating or dredging slurries, thick oils, liquid chemical substances, and the like. Problems that are frequently encountered in prior art pump constructions are those associated, for instance, with cavitation in the liquid being pumped, excessive wear and friction losses arising from abrasive materials in or carried by the liquid being pumped, corrosion from acid and/or alkaline chemical substances, rusting, heavyweight and its related high costs which arise from transportation and strength considerations, and so on. Many of such problems are significantly reduced in using a pump construction to be described below.

It is an object of this invention, therefore, to provide an improved rotary pump construction in which the pump housing and impeller have a specifically designed form for yielding a pumping action which is partly auger action and partly centrifugal action.

It is a further object of a preferred embodiment of the present invention to provide a rotary pump assembly in which both the pump housing and the impeller are substantially wholly made of a fully cured urethane elastomer, thereby offering a considerable saving in weight while still maintaining adequate strength properties for many pump applications.

It is also an object of another embodiment of the present invention to provide a pump construction in which the direction of inlet flow and outlet flow of liquid being pumped are coaxial.

These and other objects and features of this invention may be embodied in a rotary pump assembly for pumping a liquid, comprising: a pump housing having a predetermined geometric form and including a suction side and a discharge side; an impeller rotatably mounted in the pump housing for operating in cooperation with said housing to provide a pumping action which is partly auger action and partly centrifugal action, the auger action being in the range from approximately 35 to 85 percent of the total pumping action.

In another form, the present invention may be embodied in a rotary pump assembly for pumping a liquid, comprising: a two-part pump housing having a predetermined geometric form including a suction side and a discharge side, the suction side including a frustoconical section and part of a centrifugal scroll housing, the discharge side including a complementary part of the scroll housing and a spin-out section whose surface substantially conforms to a path followed by liquid being expelled from the scroll housing in an unconfined flow; an impeller rotatably mounted and adapted to be disposed partly in the frustoconical section for operating in cooperation with the latter to provide an auger pumping action and partly in the scroll housing to provide a centrifugal pumping action, the auger action being in the range from approximately 35 to 85 percent of the total combined pumping action, whereby the predetermined geometric form of the pump housing tends to minimize frictional and pumping losses which normally arise from redirecting the liquid flowing through the pump assembly.

The present pump construction will now be described in more detail, with particular reference being made to the accompanying drawings, in which:

FIGS. 1 and 1A are top and discharge end elevation views showing one form of the pump construction described herein;

FIG. 2 is a side elevation of the pumping construction of FIG. 1;

FIG. 3 is a fragmentary side elevation view taken in section along line 3—3 of FIG. 1 and parallel to the axis of the impeller housing to show the means by which the impeller is mounted. It is to be noted that the upper half of this drawing shows an impeller shaft seal suitable for light or noncorrosive service while the lower half of the drawing shows a double-face impeller shaft seal suitable for highly corrosive service;

FIGS. 4 and 5 are side elevation views showing the impeller of the pump construction of FIG. 2, with the impeller being viewed from directions 90° apart;

FIG. 6 is a drawing illustrating how to generate the parabolic cross section of the impeller screw thread as taken parallel to the axis of the impeller shaft;

FIG. 7 is a view taken in the direction "Y" of FIG. 2 and showing the development of the conical helix of the spin-out portion in the discharge side of the pump housing of FIG. 1;

FIGS. 8 and 9 are side elevation views taken in section and showing, respectively, the discharge side and inlet side of the pump housing of FIG. 1; and

FIGS. 10 and 11 are elevation views taken along lines 10—10 and 11—11 in FIGS. 8 and 9, respectively. It should particularly be noted that although certain numerical dimensions have been shown in the drawings, such numerals are not to be considered as limiting, but rather as being illustrative of one particular version of the present pump construction.

Turning now to the drawings and particularly to FIGS. 1 and 2, the present rotary pump assembly is designated by the numeral 1 and is made up of a two part pump housing. The inlet half or suction side 3 and the outlet half or discharge side 5 are each preformed to a predetermined geometrical form to be described more fully below and as illustrated in part in FIGS. 7—11. Although the rotary pump assembly 1 may be manufactured from a metal such as cast iron, for example, or other similar materials from which pumps are generally formed, it is preferable in this instance to mould the suction and discharge sides 3 and 5 of the pump housing using a fully cured urethane elastomer. Some of the properties and a suitable method of preparation of the fully cured urethane elastomer as utilized herein will be described shortly in more detail.

A rotary impeller assembly 7 is rotatably mounted (FIG. 3) within an impeller housing 66 which is moulded integrally with the discharge side 5 of the pump housing. As may readily be seen in FIG. 2, the suction side 3 of the pump housing contains an inlet opening 30 which is surrounded and defined by means of an inlet flange 32 extending radially outwardly and having a number of apertures 33 therethrough for facilitating the connection of the pump housing to a mating flange surface on a pipeline, for example, by means of suitable bolts or other fastening means not shown. The inlet opening 30 leads to a slightly curved inlet passageway 34 which in turn blends smoothly into a section 36 of the suction side 3 which contains and cooperates with a major portion of the impeller assembly 7 disposed closely therein. The inner surface of the section 36 of the suction side 3 of the pump housing defines a part of a true cone which coacts with a screw or auger portion 72 of a dual functioning impeller 70. The dual functioning impeller 70 and the generation or development of its working surfaces are shown in more detail in FIGS. 4—6. It is to be noted that the working surfaces of this impeller 70 are disposed to lie in a which is frustoconical conforming to the section 36 of the pump housing. Accordingly, a very slight clearance between the inner surface of the section 36 and the working surfaces, a parabolically shaped screw thread 73, of the impeller 70 is provided for satisfactory operation. The frustoconical section 36 of the suction side 3 stops at and blends smoothly into a first half 38 of a centrifugal scroll housing. A complementary

second half 54 of the centrifugal scroll housing is provided in the discharge side 5 of the pump housing. It is to be recognized, of course, that the inner surface of each of the first and second halves 38 and 54 of the centrifugal scroll housing are smoothly formed and define an inner surface of such scroll housing which is substantially continuous and free from any significant irregularities. In this way potential friction and pumping losses in this area of the pump housing are reduced.

The second half 54 of the centrifugal scroll housing is formed to blend smoothly into a specially designed "spin-out" portion 56 in the suction side 5 of the pump housing. This spin out portion 56 of the discharge side 5 in its turn leads and blends smoothly into a straightener portion 58 which communicates finally with a discharge or outlet opening 60 from the pump housing. It should particularly be noted here that the inlet opening 30 and the outlet opening 60 are each disposed in a plane perpendicular to a common axis passing through such openings. In other words, the inlet and outlet openings 30 and 60 are coaxial, thereby facilitating a straight-in-line installation in a pipeline. As previously noted, the impeller housing 66 is moulded integrally with the discharge side 5 of the pump housing, and furthermore, such impeller housing 66 is strengthened by means of a number of reinforcing webs 68. It is also to be noted that complementary connecting flanges 40 and 50 are formed as a part of the centrifugal scroll housing and extend radially outwardly thereof. These connecting flanges 40 and 50 are provided, respectively, with apertures 42 and 52 which are adapted to receive threaded bolts 44 or other similar fastening means. Similar flanges 32 and 62 are provided surrounding the inlet and outlet openings 30 and 60. If required, the flanges 32, 40, 50 and 62 may contain reinforcing means 46 as a part thereof as well as spacers 48 and 49, and sealing means where applicable.

As may be seen from FIGS. 2, 4 and 5 the dual functioning impeller 70 includes the screw or auger portion 72 and integrally formed therewith the impeller screw thread 73 and a centrifugal portion 74. The auger portion 72 is closely received in the frustoconical section 36 of the suction side 3 of the pump housing with the screw thread 73 cooperating therewith to provide a pumping action which initially is axial, while the centrifugal portion 74 is disposed to lie partly within the centrifugal scroll housing to provide a centrifugal pumping action. In other words, the auger section 72 of the dual functioning impeller 70 is disposed within the frustoconical section 36 of the pump housing, while the centrifugal portion 74 is disposed at least partly within the first half 38 of the centrifugal scroll housing. It will be recognized by those skilled in the art that liquid which is pumped by means of a centrifugal pumping action frequently contains a certain amount of inherent spin as it is discharged from a centrifugal scroll housing. This is particularly so if the liquid is discharged freely in an unconfined manner. In the present invention, the second half 54 of the centrifugal scroll housing is formed integrally with and blends smoothly into the spin-out portion 56 of a predetermined shape, whose geometric form is generated or developed as shown in FIGS. 7-11. By providing the spin-out portion 56, maximum advantage is made of the inherent spin in the liquid being discharged from the centrifugal scroll housing and, therefore, pressure and friction losses which would otherwise occur when the flow is redirected, are minimized. Thus it is possible to provide a pump construction whose inlet and outlet openings are coaxial, and still keep pumping losses to a minimum while redirecting or turning the flow of liquid being pumped. In addition, the provision of the spin-out portion 56 in the discharge side 5 of the pump housing enables wear caused by abrasive materials in the liquid being pumped to be reduced significantly. Accordingly, the term "predetermined" as applied to the form of the pump housing, refers to the shape or form of such housing which tends to reduce friction and other pumping losses. The term may apply to the smooth blending from one section of housing to another, as well as to the specific shape involved.

As may be seen in FIGS. 4 and 5, the dual functioning impeller 70 is provided with a recess 86 in the base of the centrifugal portion 74 thereof. A further recess 88 of narrower diameter than the recess 86 is provided centrally of the latter and is adapted to receive a steel impeller shaft 76. This impeller shaft 76 is suitably coupled to a motor drive shaft or similar driving means, and may be driven to turn the impeller at speeds up to approximately 3,900 r.p.m. The larger recess 86 is adapted to receive and retain a spacer 87 which surrounds and is tightly fitted on the impeller shaft 76. This spacer 87 (FIG. 3) serves also to facilitate the mounting, as desired, of a spring biased shaft seal assembly 110 for light or noncorrosive surface; or a spring biased shaft seal assembly 112 for highly corrosive service. The seal assembly 110 is shown in the upper portion of FIG. 3, while the seal assembly 112 is shown in the lower half. The impeller assembly 7 may be mounted as follows. The impeller housing 66 is bored at 80 from its outer end and at 84 from the other, and inner end. A radially, inwardly directed flange or shoulder 82 is provided between the boreholes 80 and 84. The borehole 80 may be considered to define a bearing cavity while the borehole 84 defines a sealing cavity. A tubular bearing sleeve 89 is provided within the borehole 80 and serves to mount radial bearings 90 and 92 which surround and rotatably carry the impeller shaft 76. These bearings 90 and 92 are disposed generally at opposite ends within the tubular bearing sleeve 89. A bearing spacer sleeve 90 may also be provided within the bearing sleeve 89, being disposed between and abutting against the radial bearings 90 and 92. A backing ring 106 is sealably retained by the shoulder 82 and serves to provide a sealing surface for the impeller shaft seal assemblies 110 and 112. A weeping hole 81 is drilled radially through the impeller housing 66 and the insert sleeve 89 adjacent to the shoulder 82. This weeping hole may be drilled before final assembly. A bearing backup ring 94 is disposed to surround the impeller shaft 76 and is also disposed adjacent the shoulder 82 and the backing ring 106. This bearing backup ring 94 may be shrink fitted or otherwise securely mounted on the impeller shaft 76. It will be observed, of course, that the impeller assembly 7 is mounted in place from within, i.e., from the centrifugal scroll housing end of the discharge side 5 of the pump housing. The impeller assembly 7 is held in place by means of a lock washer 96 and locking nut 98. The bearing cavity or borehole 80 in the impeller housing 66 is sealed off by means of an oil seal 100 which is carried on and forms part of a bearing housing cover 102. This bearing housing cover 102 is suitably apertured peripherally thereof to receive fastening means 104 that engage threaded boreholes 105 in the face of the outer end of the impeller housing 66 to close off the same.

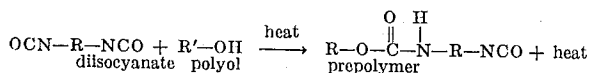
It is particularly to be noted that in a preferred embodiment of the present invention, both the suction side 3 and the discharge side 5 of the pump housing, as well as the dual functioning impeller 70, are substantially made of a fully cured urethane elastomer. In such an embodiment, only the smaller components such as spacers, reinforcing means in the flanges, the fastening means, the impeller shaft 76 and the means for mounting the impeller are formed of steel or other suitable metal. As a result of this construction the pump assembly 1 provides a very substantial saving in weight thereby making the same much easier to handle and costing less to transport. It has been found that a pump assembly made from a fully cured urethane elastomer has sufficient strength, abrasion resistance and load bearing capacity to enable its use in many pump installations. The urethane elastomer which is suitable here preferably has a Shore hardness of about 68D, an abrasion index in the range from 170-400, and a load bearing capacity of at least 1000 p.s.i.g. before rupture. To avoid failure of the urethane elastomer either by rupture or by cracking, the elastomer should have a relatively high Shore hardness in the range 85 A to 75D with about 68D being preferred, as indicated above. Below a Shore hardness of 85A the resin is too soft and will rupture readily. On the other hand, above a Shore hardness of about 78D the resin becomes too brittle and will

easily crack. Below an abrasion index of 170, as noted above, the urethane wears too easily and above an index of 400 the resin is again too brittle and will easily crack.

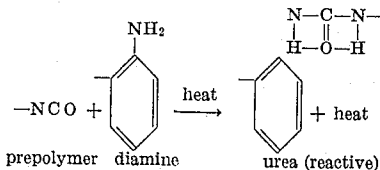
The fully cured urethane elastomer is suitably prepared from a prepolymer which in turn is suitably prepared by the reaction of a diisocyanate with a polyester or polyol and preferably a polyol. Thus, the liquid prepolymer is preferably prepared by reacting with heating a diisocyanate with a polyol. The prepolymer is then cured, preferably with a diamine curing agent and more preferably with an aromatic diamine curing agent such as dimethyl aniline and preferably 4, 4-methylene-bis (2-chloroaniline). The selection of the diamine curing agent and the prepolymer will depend upon the mechanical properties required in the resultant urethane elastomer.

A particularly useful urethane elastomer is prepared by curing a polyol prepolymer with about 95 percent of the theoretical of the diamine curing agent and completing the cure with excess moisture in a post curing step. This assures that neither the prepolymer nor the diamines are in excess and assures that no toxic material is found in the urethane elastomer. In particular, the reaction in the formation of the fully cured urethane elastomer is believed to proceed by means of the following reaction sequences.

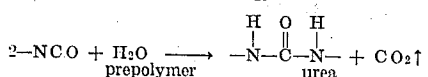
(1) PREPOLYMER FORMATION



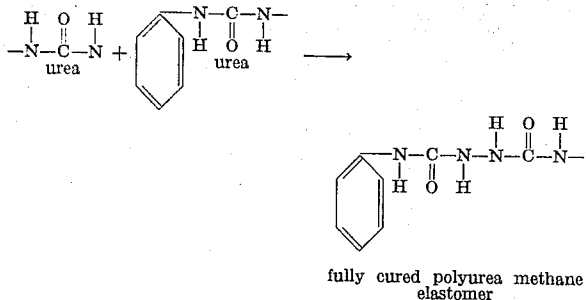
(2) CURING REACTION PREPOLYMER WITH DIAMINE



(3) POST CURING REACTION OF PREPOLYMER WITH WATER



(4) POST CURING REACTION



In the above sequences R and R' are organic residues.

The product is tough elastomeric nontoxic product having exceptional resistance to abrasion, corrosion and chemical environment. In particular, the polymer is unaffected by oil and grease and is water repellent. These are properties which are desirable in a wide variety of pumping applications.

We claim:

1. A pump construction suitable for pumping a solid-liquid mixture, comprising:

a pump housing having an inlet opening in its suction side and an outlet opening in its discharge side, including a frustoconical part whose smaller end is connected to said inlet opening and whose larger end is connected to a centrifugal scroll, said scroll being formed by complementary

portions of the suction and discharge sides and connected to a straightening diffuser elbow that leads to the outlet opening; and

a mixed flow impeller rotatably mounted to be disposed in the frustoconical part of the pump housing for effecting a transfer of kinetic energy to said mixture partly as a function of radial velocity and partly as a function of axial velocity; the housing and impeller being made substantially wholly of a fully cured urethane elastomer, the kinetic energy proportional to the axial velocity being in the range from 15 percent to 85 percent of the total of said energy transferred.

2. A pump construction adapted for pumping a slurry, a solid-liquid mixture or the like, comprising:

a pump housing having coaxial inlet and outlet openings, the housing including a frustoconical part having a small end connected to the inlet opening and a large end connected to a centrifugal scroll that is helically axially offset in a downstream direction of the pump, said scroll being connected to a diffuser section that includes an elbow of ever increasing inner cross-sectional area and having a curved axis, the discharge end of the elbow defining said outlet opening; and

a mixed flow impeller disposed in the frustoconical part and having a drive shaft rotatably mounted in a bearing housing provided on the pump housing, said impeller being adapted to be driven for effecting a transfer of kinetic energy to said slurry or solid-liquid mixture wherein the transferred kinetic energy includes a contribution that is proportional to the square of the axial velocity component of the material being pumped, said contribution being in the range from 35 to 85 percent of the total transferred kinetic energy.

3. The pump construction of claim 1 wherein the pump housing comprises at least two parts are connected together, in use, as one unit.

4. The pump construction of claim 3, wherein the pump housing is made of a fully cured urethane elastomer.

5. The pump construction of claim 2, wherein the pump housing is made of a fully cured urethane elastomer having a Shore hardness that is in the range of from 85A to 75D.

6. The pump construction of claim 1, wherein means are provided for driving said impeller at speeds up to 3,900 r.p.m.

7. The pump construction of claim 1, wherein at least one of the pump housing and mixed flow impeller is made of a fully cured urethane elastomer having a Shore hardness that is in the range from 85A to 75D.

8. The pump construction of claim 1, wherein said mixed flow impeller includes screw thread means thereon that has a root contour in the form of a parabola whose axis is disposed perpendicular to the axis of the impeller.

9. The pump construction of claim 1, wherein said pump housing is divided into two parts by a plane, said plane defining said two complementary portions of the volute with the complementary parts being disposed downstream of said impeller.

10. The rotary pump assembly of claim 2, wherein the impeller is an integral unit whose leading portion provides the transfer of kinetic energy as a function of axial velocity, and whose trailing portion is partly disposed in the centrifugal scroll housing to cooperate therewith for providing the transfer of kinetic energy as a function of radial velocity.

11. The rotary pump assembly of claim 1 wherein the suction and discharge sides of the pump housing are interconnected by mating flange means formed with and extending outwardly of the respective parts of the centrifugal scroll.

12. The rotary pump assembly of claim 2 wherein the impeller includes screw thread means thereon that has a root contour in the form of a parabola whose axis is disposed perpendicular to the axis of the impeller.