

FORM 1

58513/86

COMMONWEALTH OF AUSTRALIA

PATENTS ACT 1952

APPLICATION FOR A STANDARD PATENT



I/We, _____
SECTION 34(4)(a) DIRECTION SEE FOLIO 6
of NAME DIRECTED Baker Hughes Incorporated
5100 Susan Lane, Houston, Texas 77027-5115 USA

hereby apply for the grant of a standard patent for an invention entitled:

CENTRIFUGAL ELASTOMER ELASTOMERIC IMPELLERS AND VANE CORE EXTRACTION FOR MAKING SAME

which is described in the accompanying complete specification

Details of basic application(s):

Number of basic application	Name of Convention country in which basic application was filed	Date of basic application
743067	US	10 JUN 85

My/our address for service is care of CLEMENT HACK & CO., Patent Attorneys, 601 St. Kilda Road, Melbourne 3004, Victoria, Australia.

DATED this 10th day of June 1985

BAKER INTERNATIONAL CORPORATION

CLEMENT HACK & CO.

TO: The Commissioner of Patents.

[Handwritten signature]

APPLICATION ACCEPTED AND AMENDMENTS

ALLOWED 15-6-90

LODGED AT SUB-OFFICE
10 JUN 1986
Melbourne

Forms 7 and 8

AUSTRALIA

Patents Act 1952

DECLARATION IN SUPPORT OF A CONVENTION OR NON-CONVENTION APPLICATION FOR A PATENT OR PATENT OF ADDITION

Name(s) of Applicant(s)
Title
Name(s) and address(es) of person(s) making declaration

In support of the application made by BAKER INTERNATIONAL CORPORATION

for a patent for an invention entitled CENTRIFUGAL ELASTOMER ELASTOMERIC IMPPELLERS AND VANF CORE EXTRACTION PROCESS FOR MAKING SAME

I/we, CARL ALLEN ROWOLD, c/o Baker International Corporation, 500 City Parkway West P. O. Box 5500 Orange, California 92667 USA

do solemnly and sincerely declare as follows:-

- 1. ~~I am/we are the applicant(s) for the patent, or am/are authorised by the abovementioned applicant to make this declaration on its behalf.~~
- 2. The basic application(s) as defined by Section 141 of the Act was/were made in the following country or countries on the following date(s) by the following applicant(s) namely:-

Country, filing date and name of Applicant(s) for the or each basic application

in United States of America on June 10, 1985
by John Hyll (serial no. 743067)
in _____ on _____ 19____
by _____

- 3. The said basic application(s) was/were the first application(s) made in a Convention country in respect of the invention the subject of the application.

Name(s) and address(es) of the or each actual inventor

- 4. The actual inventor(s) of the said invention is/are John Hyll 8849 Summer Meadow Dr., Sandy, Utah 84092 USA

See reverse side of this form for guidance in completing this part

- 5. The facts upon which the applicant(s) is/are entitled to make this application are as follows:-
The applicant is the assignee of the actual inventor, the applicant in paragraph two above.

DECLARED at Salt Lake City, Utah USA this 17th day of May 1986

BAKER INTERNATIONAL CORPORATION
By: Carl Allen Rowold
Title: Chief Patent Counsel

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(54) Title
CENTRIFUGAL ELASTOMERIC IMPELLER AND METHOD FOR MAKING SAME

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(56) Prior Art Documents
US 3189671
US 4634344
AU 542020 67763/81 F04D 7/06 29/42

(57) Claim

1. A vane core assembly for use in forming a vane passage in an injection-formed, elastomer-covered, closed-shroud impeller, said vane core assembly comprising:
a first core element having a first length sized to extend from a central opening in said impeller to an outer periphery of said impeller;

a second core element detachably mated with said first core element, said second core element having a second length sized to extend from said central opening of said impeller to said outer periphery of said impeller;
and

a third core element detachably mounted to said second core element, said third core element having a length sized to extend from said central opening of said impeller short of said impeller outer periphery, said third length being dimensionally less than said first length and said second length;

wherein said third core element is detachable from said

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(10) 595204

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second core element by manipulation of said second and third core elements through said impeller's central opening while said second and third core elements are positioned within said impeller.

6. A vane core assembly for use in forming a vane passage between a pair of adjacent vanes in an injection-formed, elastomeric-covered, closed shroud impeller; said vane passage having a central opening proximate an inlet of the impeller, and a peripheral opening proximate an outer periphery of said impeller, a width of said central opening being at least twice as large as a width of said peripheral opening and a length of said peripheral opening being substantially greater than a length of said central opening, said vane core assembly comprising:

a first vane core element having a first length dimensioned to extend substantially from said central opening to said peripheral opening of said vane passage;

a second vane core element detachably mounted on said first core element; said second core element being dimensioned to extend substantially from said central opening to said peripheral opening of said vane passage;

a third vane core element, detachably mounted by attachment means on a proximal end of said second core element; whereby said third core element is positionable within said central opening; said third core element having a length less than said first length whereby when said vane assembly is positioned within said vane passage said third core element extends between said central opening and a location short of said peripheral opening;

wherein said attachment means are configured to be accessible from said impeller inlet when said vane core assembly is within said vane passage whereby said third core element is rendered manually detachable from said second core element by manipulation of said second and third core elements through said impeller inlet while said second and third core elements are positioned within said impeller.

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Form 10

COMPLETE SPECIFICATION

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Related Art:

This document contains the amendments made under Section 49 and is correct for printing

TO BE COMPLETED BY APPLICANT

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Australia.

Complete Specification for the invention entitled:
CENTRIFUGAL ELASTOMER ELASTOMERIC IMPELLERS
AND VANE CORE EXTRACTION FOR MAKING SAME

The following statement is a full description of this invention including the best method of performing it known to me:-



CENTRIFUGAL ELASTOMER ELASTOMERIC IMPELLERS AND
VANE CORE EXTRACTION PROCESS FOR MAKING SAME

Background of the Invention

5 Field: The instant invention relates to elastomeric-covered shrouded impellers for centrifugal pumps.

10 Prior Art: Shrouded impellers in which the vanes and vane passages are enclosed between a pair of opposed shrouds or disks are relatively commonplace in centrifugal pumps. Shrouded impellers are available in both metal and elastomer-covered metal constructions. Metal impellers are typically utilized in non-abrasive, non-corrosive environments. Elastomer-covered impellers, because of expense and difficulty in making same, are typically utilized only where abrasive or corrosive resistance is required, for example, in slurry pumps handling abrasive or gritty solids in a liquid media or in dealing with corrosive liquids such as acids and the like.

15 An elastomeric-covered impeller is formed about a metal insert. The technique involves placing the metal insert within a mold and providing core elements which provide for the voids within the impeller after molding. Elastomeric material is forced generally under pressure into the molds so that those spaces which exist between the metal insert and the core elements are filled with rubber thereby forming the elastomeric-covered shrouded impeller.

20 A typical rubber-covered impeller is shown in FIG. 1 in an elevational view showing the peripheral edge of the impeller with vane passage openings shown at the periphery. The formation of the throat opening and vane passages in the molding process is relatively straightforward in this type of construction.

5 An elevational view of the vanes of a shrouded impeller along section lines 2-2 of FIG. 1 is illustrated in FIG. 2. The spacing between adjacent vanes is closer near the center of the impeller than around the outer edges of the vanes. In the orientation of the impeller illustrated in FIG. 2, the rotation of the impeller is counter-clockwise.

10 In the arrangement illustrated in FIG. 3, the vane core, which is a portion of the mold which forms the vane passage, has a uniform width "w" between the inner walls of the front and rear shroud. For the purposes of description herein of shrouded impellers, the front shroud is the shroud containing the inlet opening in the throat of the impeller. Thus, the vane core may be easily extracted by a force perpendicular to the central axis of the impeller.

15 A slight variation to the arrangement illustrated in FIG. 3 is that illustrated in FIG. 4 which is another prior art arrangement. The illustration of FIG. 4 shows some curvature of the inner walls of the front and rear shrouds. This wall curvature is to provide a flow channel from the inlet throat of the impeller into the vane passage which provides a gradual change of direction to accomplish the 90° change of direction from axial inlet flow to radial outlet flow. The vane passage of the impeller of FIG. 4 is formed by a pair of vane core members, A and B, whereby the width W_A and width W_B of each core member is smaller than the width "b" of the peripheral vane passage width. Extraction of these core members is perpendicular to the central axis of the impeller and is in the order of core A being first removed and then core B being later removed.

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30 In metal impellers with enclosed vanes the formation of shrouds with curved inner walls has been prac-

5 ticed for quite some time. Metal impellers are generally formed by sand casting, whereby the formation of curved interior walls of the forward and rear shrouds has been easily achieved since solid core members are not used in the casting process. Thus, the achievement of a channel connecting the inlet throat with the vane passage in a manner such that the channel encounters no sharp angle restrictions has been long practiced with metal impellers.

10 The presence of a right-angle corner such as that present in the construction illustrated in Fig. 3, may cause velocity loss as well as turbulence near the square corner and cause erosion of the elastomeric covering on the back shroud in the area directly opposite to the square corner on the front shroud.

15 Summary of the Invention

According to the present invention there is provided a vane core assembly for use in forming a vane passage in an injection-formed, elastomer-covered, closed-shroud impeller, said vane core assembly comprising:

20 a first core element having a first length sized to extend from a central opening in said impeller to an outer periphery of said impeller;

25 a second core element detachably mated with said first core element, said second core element having a second length sized to extend from said central opening of said impeller to said outer periphery of said impeller; and

30 a third core element detachably mounted to said second core element, said third core element having a length sized to extend from said central opening of said impeller short of said impeller outer periphery, said third length being dimensionally less than said first length and said second length;

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wherein said third core element is detachable from said second core element by manipulation of said second and third core elements through said impeller's central opening while said second and third core elements are positioned within said impeller.

According to the present invention there is further provided a vane core assembly for use in forming a vane passage between a pair of adjacent vanes in an injection-formed, elastomeric-covered, closed shroud impeller; said vane passage having a central opening proximate an inlet of the impeller, and a peripheral opening proximate an outer periphery of said impeller, a width of said central opening being at least twice as large as a width of said peripheral opening and a length of said peripheral opening being substantially greater than a length of said central opening, said vane core assembly comprising:

a first vane core element having a first length dimensioned to extend substantially from said central opening to said peripheral opening of said vane passage;

a second vane core element detachably mounted on said first core element; said second core element being dimensioned to extend substantially from said central opening to said peripheral opening of said vane passage;

a third vane core element, detachably mounted by attachment means on a proximal end of said second core element; whereby said third core element is positionable within said central opening; said third core element having a length less than said first length whereby when said vane assembly is positioned within said vane passage said third core element extends between said central opening and a location short of said peripheral opening;

wherein said attachment means are configured to be accessible from said impeller inlet when said vane core

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assembly is within said vane passage whereby said third
core element is rendered manually detachable from said
second core element by manipulation of said second and
third core elements through said impeller inlet while said
5 second and third core elements are positioned within said
impeller.

According to the present invention there is still
further provided a vane core assembly for use in forming a
vane passage in an injection-formed, elastomer-covered,
10 closed-shroud impeller, said vane core assembly comprising:

a first core element having a first length sized to
extend from a central opening in said impeller to an outer
periphery opening of said impeller;

a second core element detachably mated with said
15 first core element, said second core element having a
second length sized to extend from said central opening of
said impeller to said outer periphery opening of said
impeller; and

a third core element detachably mounted to said
20 second core element by a pneumatically operatable
separation means adapted for detaching said third core
element from said second core element, said third core
element having a length sized to extend from said central
opening of said impeller to a location within said impeller
25 short of said impeller's outer periphery opening, said
third length being dimensionally less than said first
length and second length, said third core element being
detachable from said second core element by manipulating
said separation means through said impeller's central
30 opening while said second and third core elements are
positioned within said impeller.

According to the present invention there is still
further provided a vane core assembly for forming an
arc-shaped vane passage between a pair of adjacent vanes in
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an injection-formed, elastomer-covered, closed shroud
impeller, said impeller having an inlet which communicates
with said vane passages, wherein each of said vane passage
has a peripheral arcual opening having a length
5 substantially greater than its central arcual opening
length, wherein a width of said central opening of said
vane passage is substantially greater than the width of
said vane passage's peripheral opening and wherein said
10 central opening is transposed from a center line through
said peripheral openings, said vane core comprising a first
core element, a second core element, and a third core
element, said first core element and said second core
15 element having planar mating surfaces which are
substantially coextensive and a third core element which
detachably mates with a portion of a surface of said second
core element which is opposed to said surface of said
second core element which is in contact with said first
20 core element; said third core element being adjacent said
central opening to said vane passage wherein said first
core element and said second core element are dimensioned
to extend within said vane passage substantially from said
central opening to said peripheral opening; and wherein
25 said third core element is dimensioned to have a length
much shorter than a distance between said central opening
and said peripheral opening whereby when said vane core
assembly is positioned within said vane passage, said third
core element, being positioned within said central opening
30 and extending into said vane passage, does not extend
sufficiently to reach said peripheral opening; said first
core element and said second core element being retractable
from said vane passage along an arc-shaped path defined by
said vane passage, said third core element being detachably
secured to said second core element by an attachment means
configured to be accessible from said impeller inlet when

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said vane core assembly is positioned within said vane passage wherein said attachment means may be accessed and manipulated through said impeller inlet to effect a detachment of said third core element from said second core element while said second and third core elements are within said vane passage prior to a withdrawal of said second vane core element from said vane passage.

According to the present invention there is still further provided a vane core assembly for use in forming a vane passage between a pair of adjacent vanes in an injection-formed, elastomer-covered, closed shroud impeller, said vane passage having a central opening proximate an inlet of the impeller, and a peripheral opening proximate a periphery of said impeller, a width of said central opening being at least twice as large as a width of said peripheral opening and a length of said peripheral opening being substantially greater than a length of said central opening; said vane core assembly comprising:

a first vane core element dimensioned to extend substantially from said central opening to said peripheral opening of said vane passage;

a second vane core element detachably mounted on said first vane core element, said second vane core element being dimensioned to extend substantially from said central opening to said peripheral opening of said vane passage;

a third vane core element, detachably mounted by attachment means on a proximal end of said second vane core element; said third vane core element being positionable within said central opening, said third vane core element having a length less than a length of said vane passage; whereby when said vane assembly is positioned within said vane passage said third vane core element extends between said central opening and a location short of said peripheral opening;

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wherein said attachment means are configured to be accessible from said impeller inlet when said vane core assembly is within said vane passage whereby said third vane core element is manually detachable from said second vane core element by manipulation of said second and third vane core elements through said impeller inlet while said second and third vane core elements are positioned within said vane passage.

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Brief Description of the Drawings

FIG. 1 is an elevational view of the peripheral exterior of a conventional elastomeric-covered impeller;

5 FIG. 2 is a cross-sectional view of the impeller of FIG. 1 along section lines 2-2 illustrating the curved vanes and vane passages;

FIG. 3 is a cross-sectional view of the impeller of FIG. 1 along section lines 3-3 illustrating the flow channel from the inlet throat to the vane passage;

10 FIG. 4 is a cross-sectional view similar to FIG. 3 of an impeller having slightly curved shroud walls to provide an improved flow channel from the inlet throat to the vane passage;

15 FIG. 5 is a cross-sectional view similar to FIG. 3 of an impeller of the instant invention having radially curved shroud walls forming the vane passage and a cross-sectional view of the core assembly used to form the vane passage;

20 FIG. 6 is an elevational view of the vane core assembly member of the instant invention;

FIGS. 7, 8, 9 and 10 are perspective views of an impeller of the instant invention with vane core members illustrated in sequential steps of removal;

25 FIG. 11 is an elevational view of the peripheral surface of an elastomeric-covered impeller of the instant invention;

FIG. 12 is an elevational, facial view of a vane core element of the instant invention;

30 FIG. 13 is a plan view of the peripheral edge of the vane core elements of FIG. 12.

Detailed Description of the Preferred Embodiment

5 The instant invention involves a unique construction of shrouded, elastomeric-covered impellers. Such impellers come in particularly small sizes, for example, less than about 30.5 centimeters in diameter, and are provided with a channel comprising the inlet throat and the vane passage which is essentially curvilinear. Fluid entering the pump enters axially through an opening in the front shroud and, through the centrifugal action of the pump, parts in a direction perpendicular to the original axial flow. The change of direction for fluids in the instant impellers is very gradual and distinctly different from that in existing elastomeric-covered, enclosed impellers.

15 Theoretically, the curvature of the flow channel formed by the throat (inlet opening) through the vane passage to the peripheral exit for the impeller would ideally be a 90° arc of a circle. Such a construction would, of course, involve an impeller axial depth which was greater than about one-half the impeller diameter. While casting of metal impellers approximating such a construction in sacrificial molds is relatively straightforward, molding complexities are encountered in making a comparable elastomeric-covered shrouded impeller.

25 In the instant invention, a mold assembly involving a central core member and a vane core mold assembly of at least three elements is utilized to approximate an ideal flow channel from inlet to discharge for an elastomeric-covered shrouded impeller for a centrifugal pump.

30 The technique for making the impellers of this invention and the multiple-element vane core mold assembly for forming the sweeping channel connecting the throat and vane passage is unique. Further description of the instant invention may be facilitated by reference
35 to the attached drawings.

The unique channel arrangement associated with the instant invention is illustrated in FIG. 5. The throat inlet 10 connects to the vane passage, which in FIG. 5 is occupied by vane core mold members used in molding the appropriately shaped vane passage. As illustrated in FIG. 5, a very gradual change of direction occurs between fluid entering the throat and then changing directions at 90° to exit the vane core passage at the peripheral edge of the impeller.

The vane core passage 11 is formed between the front shroud interior wall 12 and the interior wall 13 of the rear shroud. The curved surface of the rear shroud 13 continues below the vane core passage 11 to form a cone-shaped projection 14 with its apex at the central axis of the impeller 15. A steel impeller skeleton is first placed in the mold before rubber is injected. In FIG. 5, the steel skeleton shroud members 16 and 17, respectively, form the front and rear shroud inserts about which the elastomer forms to form the elastomeric-covered impeller shrouds.

The interior wall of the front shroud adjacent to the throat inlet has a curvature as established by radius R. Radius R is generally determined by the diameter of the impeller and the amount of sweep desired. Furthermore, the curvature of the interior wall of the front shroud may be described by several different radii having different focal points.

The juncture of the inner wall 12 of the front shroud with the throat inlet wall 18 approximates a curvilinear relationship, that is, the curvature of the inner shroud wall 12 is such that the throat inlet wall 18 is substantially tangential to the curved wall 12 at the point of juncture.

The interior wall 13 of the rear shroud has a curvature such that at the apex of the cone 14 the curvature of the cone wall is such that an extension of such curved wall joins with the central axis 15 of the impeller in a curvilinear fashion, that is, the axis is substantially tangential to the extended curve of the curved wall of cone 14.

The center core plug 19 is substantially cylindrical in shape at the throat inlet area and has longitudinal grooves circumferentially spaced equidistantly about the plug near the distal end. These grooves accommodate the formation of extensions of the vanes into the inlet throat and are dished on the end to form the conical projection 14. The center core plug mates with vane core elements A, B and C at boundary or parting surface 20. Vane core member A joins at parting line 21 with vane core member B. Parting line 21 is, in fact, a planar surface as illustrated in other drawings, and is substantially perpendicular to the central axis 15. Vane core member A has a maximum width W_A , which must not be greater than its width at the exit of the vane passage. Since the extraction of the core is in a direction perpendicular to the central axis 15, no thickness of any core member can exceed the width of the core member at its exit point. The width of W_A must, of course, be less than the width of the exit as illustrated by letter "b". Preferably, the width W_A is significantly less than the exit width "b". The second vane core member B should have a sufficient thickness near its exit to be sufficiently durable that it is not easily broken. For example, if core member A were substantially as thick as exit width "b" then core member B may be substantially a knife edge at its upper portions and, therefore, would be easily broken.

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In the core mold arrangement illustrated in FIG. 5, the width of W, which is the combined widths of core members A, B and C, is greater than the exit width "b". In the case of core member B, the width W_B is not the maximum width of the element; however, the maximum width of core member B, which is near shoulder X, must be smaller than the exit width "b". Core members B and C are formed with a shoulder X so that again a sliver or knife edge is not required on core member C. Structuring core member C such that it is recessed slightly into core member B makes core member C an easier part to fabricate and assures a better seal at the sealing surfaces between core members so that the mold surface presented to form interior wall 12 is a continuous surface. Core member C and core member B are joined together by pins projecting from core member C which are recessed within bores in core member B. Conversely, the pins could be affixed to core member B and the bores recessed within core member C.

Since the surfaces at the joint between core members B and C are generally machined surfaces, the parts may tend to stick together after being subjected to the pressures within the mold during injection of the elastomeric rubber material. A pry slot 26 is provided for insertion of a screwdriver or the like to pry the cores B and C apart. Also air injection port 27 is provided in core member B so that air pressure may be introduced into bores 24 and 25 to eject pins 22 and 23 to separate cores C and B. Pry slot 26 and air injection port 27 are at a boundary surface between cores B and C and the center core plug so that the elastomer in liquid form, as it is filling the mold, cannot reach the slot 26 or port 27, so that these remain open and unfilled with rubber.

5 A frontal or elevational view of core member C is illustrated in FIG. 6. Core C has a substantially crescent shape; the central circle 28 illustrates the cylindrical wall of throat 10. FIG. 6 illustrates the central core plug 19 positioned in place with grooves 29 in the distal cylindrical surface of the plug spaced so as to form the interior tips of the vanes which protrude into the throat region. Thus, core member C at surface 30 forms a portion of the surface of a vane 31 while the surface 32 of the core C forms a surface of a vane 33. The juncture line X is illustrated showing a juncture surface between core B and core C. Surface 34 is the parting surface formed between core C and the central core plug 19. Pry slot 26 is shown in dotted lines as is injection port 27 which interconnects bores 24 and 25.

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FIGS. 7, 8, 9 and 10 illustrate sequentially the removal of vane core members A, B and C and central core plug 19.

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FIG. 7 is a perspective view of an elastomeric-covered impeller which has been molded and which has had the center core plug 19 removed. Also, three quadrants of the vane passage core sub-assemblies have been removed. In molding a complete impeller with four vanes and four vane passages, four vane core sub-assemblies similar to the sub-assembly shown in FIGS. 7 through 10 are utilized so that four vanes are formed and four vane core passages are formed in the impeller. In FIG. 7, cores A, B and C are still positioned within the impeller.

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In FIG. 8, vane core A has been removed. Core A has a rim 34 which is substantially as thick at its outer edge as the vane passage of the impeller. A quarter-circle, arc-like shoulder 35 is formed in the rim 34, said shoulder having a thickness substantially the same as the thickness of the rim 36 of vane core B.

Thus, vane core A and vane core B mate in concentric fashion as well as in a planar fashion where the tongue 37 of vane core A extends into the vane core passage.

5 In FIG. 9, vane core B is shown after it has been removed from the impeller. Vane core B has an outer rim 36 which is a quarter of a circle in its arc and mates with the quarter-circle shoulder 35 of vane core A. Vane core B has a tongue 38 which extends into the vane core passage. The edge surfaces of tongues 37 and 38 are illustrated in FIG. 5 and the tongues have a width, W_A and W_B , as indicated in FIG. 5.

10 FIG. 10 shows vane core C removed from the impeller. The substantially crescent-shaped vane core C is illustrated.

15 It is apparent from FIGS. 7 through 10 that similar vane core elements could be utilized to form any number of vane passages and vanes in an enclosed shrouded impeller. For example, an impeller could be formed having three, five, six, or any number of vanes and vane passages in which the rim portions of the cores A and B, respectively, would be one-third, one-fifth and one-sixth of a complete circle.

20 A facial view of core elements B and C is presented in FIG. 12. Cores A and B have substantially the same overall shape; i.e., core B may set in with core A. The flat planar surfaces of core A are parallel to one another while core B has one flat planar surface which mates with a flat planar surface of core A. The other facial surface is a curved surface such that the width between opposed faces of the tongue increases with distance from the rim. The sweep of surface is such that it continues with the surface of core C.

25 30 That edge of core C designated by the numeral 40 is that portion which mates with the center cylindri-

cal plug of the mold. Edge 41 of the tongue of core B forms one surface of a vane while edge 42 forms a surface of an adjacent vane. The space occupied by the tongues of cores B and C between adjacent vanes is a vane passage.

The view in FIG. 13 is an edge-on rim view of cores B and C illustrated in FIG. 12. The outer edge 43 of the rim has a certain width, which is the width also of the tongue member adjacent the rim. The tongue of core B increases in thickness with distance from the rim, as illustrated in FIG. 13. The joint 44 between core C and core B is at the shoulder joint between these two elements. The offset of the shoulder is about the same as the increase in thickness of the tongue of core B from the rim to the shoulder. Thus, surfaces 40 and 45 are part of core C. The depth of the shoulder 44 and thickness of core B may be viewed in FIG. 5. The thickness of edge 40 at its junction with shoulder 44 is about the same as the thickness of edge 41 at its juncture with shoulder 44. The mating surfaces between cores C and B are flat planar surfaces which have a substantially crescent-shaped outline.

In FIG. 11, an edge-on elevational view of an impeller of the invention is illustrated. The center of gravity of the impeller is shifted towards the inlet opening. A consequence of the increased width of the impeller and the shift in the center of gravity is to position the center of gravity farther from the external bearing supporting the impeller shaft. Also, because of the greater cantilever effects of the impeller upon the bearing, a larger shaft and bearing are generally required.

Elastomeric impellers of the type of the instant invention for an impeller of a given diameter will generally weigh more than conventional elastomeric

prior art impellers, assuming the same thickness of elastomeric covering. Such increase in weight further would require an increase in shaft and bearing size. Thus, increased shaft and bearing sizes required for construction of this type may have lead those skilled in the art away from making impellers of the type of this invention.

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It has been found, however, that the elastomeric-covered impellers of this invention provide a significant increase in hydraulic efficiency, a significant decrease in power consumption, and improved impeller life when compared with prior art-type impellers of similar diameters. Thus, a smaller diametered impeller of the instant invention may be effectively substituted for larger diametered impellers of the prior art type, so that no real increase in shaft size or bearing size actually occurs when determined by pump performance.

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Molding of elastomeric-covered impellers is done under very high pressure; i.e., injection pressures of 1500 psi. to about 2000 psi. with internal mold pressur spikes of upwards of 5000 psi. to about 6000 psi. Such high pressures require mold elements which are particularly rugged, especially for vane core elements which, in the instant invention, are cantilevered from an external rim member.

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Should deflection or displacement of any mold element occur, several adverse conditions may result, such as:

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1. The hydraulic passageways may be distorted and less efficient than desired;

2. The thickness of rubber deposited in a particular area may be less than desired, thereby diminishing the wear resistance life of the impeller; and

3. The balance and dynamics of the impeller may be adversely affected.

5 Because of these adverse consequences, the various mold elements must fit securely together and all elements must be sufficiently strong to resist any unbalance in pressure during the molding process.

Elastomeric-covered impellers of this invention have pumping efficiencies which are significantly improved over previous configurations of elastomeric-covered impellers. For example, small diameter impellers of from about 15 centimeters to 30.5 centimeters in diameter show improvements of about 30% in pump efficiency when compared to other similarly sized pumps with configurations such as those show in FIGS. 1 and 2.

15 Another measurement of improvement for the pumps of the instant invention is that power requirements to pump a certain volumetric rate of liquid to a certain head is accomplished with significantly less power consumption.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A vane core assembly for use in forming a vane passage in an injection-formed, elastomer-covered, closed-shroud impeller, said vane core assembly comprising:

5 a first core element having a first length sized to extend from a central opening in said impeller to an outer periphery of said impeller;

10 a second core element detachably mated with said first core element, said second core element having a second length sized to extend from said central opening of said impeller to said outer periphery of said impeller; and

15 a third core element detachably mounted to said second core element, said third core element having a length sized to extend from said central opening of said impeller short of said impeller outer periphery, said third length being dimensionally less than said first length and said second length;

20 wherein said third core element is detachable from said second core element by manipulation of said second and third core elements through said impeller's central opening while said second and third core elements are positioned within said impeller.

5 2. The vane core assembly of Claim 1 wherein said first core element includes an outer rim configured to co-act with an outer rim of a second first core element to thereby retain said first core element stationary vis-a-vis said second first core element.

3. The vane core assembly of Claim 2 wherein each said outer rim is adapted to position and hold in place its respective first vane core element vis-a-vis an adjacently positioned second first core element.

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4. The vane core assembly of Claim 2 wherein said second core element has an outer rim which co-acts with its respective first core rim to form a manually detachable union of said first core element and said second core element.

5. The vane core assembly of Claim 4 wherein said first and second core element rims have means for providing a nesting relationship between said rims so that said second rim nests within said first rim.

6. A vane core assembly for use in forming a vane passage between a pair of adjacent vanes in an injection-formed, elastomeric-covered, closed shroud impeller; said vane passage having a central opening proximate an inlet of the impeller, and a peripheral opening proximate an outer periphery of said impeller, a width of said central opening being at least twice as large as a width of said peripheral opening and a length of said peripheral opening being substantially greater than a length of said central opening, said vane core assembly comprising:

a first vane core element having a first length dimensioned to extend substantially from said central opening to said peripheral opening of said vane passage;

a second vane core element detachably mounted on said first core element; said second core element being dimensioned to extend substantially from said central opening to said peripheral opening of said vane passage;

a third vane core element, detachably mounted by attachment means on a proximal end of said second core element; whereby said third core element is positionable within said central opening; said third core element having a length less than said first length whereby when said vane assembly is positioned within said vane passage said third core element extends between said central opening and a location short of said peripheral opening;

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wherein said attachment means are configured to be accessible from said impeller inlet when said vane core assembly is within said vane passage whereby said third core element is rendered manually detachable from said second core element by manipulation of said second and third core elements through said impeller inlet while said second and third core elements are positioned within said impeller.

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7. The vane core assembly of Claim 6 wherein said first and second core element are configured to permit a sliding disengagement one from another whereby said first core element may be initially withdrawn slidingly from said impeller and said second core element may then be
5 subsequently withdrawn whereby said withdrawal of said first core element provides sufficient space within said vane passage to permit a separation of said second core element from said third core element prior to beginning a
10 withdrawal of said second core element from said impeller.

8. The vane core assembly of Claim 5 wherein said attachment means include at least one pin, releasably received within a pair of oppositely positioned recess wells defined respectively within said second and third
5 core elements.

9. The vane core assembly of Claim 8 wherein said vane core assembly includes a pry slot positioned proximate a boundary surface between said third and second core elements, said pry slot being dimensioned to receive a tool
5 and facilitate a pried separation of said third and second core elements.

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10. The vane core assembly of Claim 8 wherein said vane core assembly includes an air injection port; said port being adapted to receive pressurized air from proximate said impeller inlet and direct that air against said pin to effect a dislodging of said pin from one of its recess wells; whereby said second and third core elements are forcibly separated.

11. The vane core assembly of Claim 6 wherein said first core element and said second core element each include a planar mating surface whereby said respective mating surfaces are positionable coextensive one another to permit a sliding action of said first core element along said second core element.

12. The vane core assembly of Claim 11 wherein said assembly is configured to be withdrawn element by element from said vane passage substantially in a plane perpendicular to a central axis of said impeller and along a generally arc-like path corresponding to said vane passage.

13. A vane core assembly for use in forming a vane passage in an injection-formed, elastomer-covered, closed-shroud impeller, said vane core assembly comprising:

5 a first core element having a first length sized to extend from a central opening in said impeller to an outer periphery opening of said impeller;

10 a second core element detachably mated with said first core element, said second core element having a second length sized to extend from said central opening of said impeller to said outer periphery opening of said impeller; and



15 a third core element detachably mounted to said
second core element by a pneumatically operatable
separation means adapted for detaching said third core
element from said second core element, said third core
element having a length sized to extend from said central
opening of said impeller to a location within said impeller
short of said impeller's outer periphery opening, said
20 third length being dimensionally less than said first
length and second length, said third core element being
detachable from said second core element by manipulating
said separation means through said impeller's central
opening while said second and third core elements are
positioned within said impeller.

14. A vane core assembly for forming an arc-shaped vane
passage between a pair of adjacent vanes in an
injection-formed, elastomer-covered, closed shroud
impeller, said impeller having an inlet which communicates
with said vane passages, wherein each of said vane passage
has a peripheral arcual opening having a length
substantially greater than its central arcual opening
length, wherein a width of said central opening of said
vane passage is substantially greater than the width of
10 said vane passage's peripheral opening and wherein said
central opening is transposed from a center line through
said peripheral openings, said vane core comprising a first
core element, a second core element, and a third core
element, said first core element and said second core
15 element having planar mating surfaces which are
substantially coextensive and a third core element which
detachably mates with a portion of a surface of said second
core element which is opposed to said surface of said
second core element which is in contact with said first
20 core element; said third core element being adjacent said
central opening to said vane passage wherein said first
core element and said second core element are dimensioned



to extend within said vane passage substantially from said
central opening to said peripheral opening; and wherein
25 said third core element is dimensioned to have a length
much shorter than a distance between said central opening
and said peripheral opening whereby when said vane core
assembly is positioned within said vane passage, said third
core element, being positioned within said central opening
30 and extending into said vane passage, does not extend
sufficiently to reach said peripheral opening; said first
core element and said second core element being retractable
from said vane passage along an arc-shaped path defined by
said vane passage, said third core element being detachably
35 secured to said second core element by an attachment means
configured to be accessible from said impeller inlet when
said vane core assembly is positioned within said vane
passage wherein said attachment means may be accessed and
manipulated through said impeller inlet to effect a
40 detachment of said third core element from said second core
element while said second and third core elements are
within said vane passage prior to a withdrawal of said
second vane core element from said vane passage.

15. A vane core assembly for use in forming a vane
passage between a pair of adjacent vanes in an
injection-formed, elastomer-covered, closed shroud
impeller, said vane passage having a central opening
5 proximate an inlet of the impeller, and a peripheral
opening proximate a periphery of said impeller, a width of
said central opening being at least twice as large as a
width of said peripheral opening and a length of said
peripheral opening being substantially greater than a
10 length of said central opening; said vane core assembly
comprising:

a first vane core element dimensioned to extend
substantially from said central opening to said peripheral
opening of said vane passage;



15 a second vane core element detachably mounted on
said first vane core element, said second vane core element
being dimensioned to extend substantially from said central
opening to said peripheral opening of said vane passage;

20 a third vane core element, detachably mounted by
attachment means on a proximal end of said second vane core
element; said third vane core element being positionable
within said central opening, said third vane core element
having a length less than a length of said vane passage;
whereby when said vane assembly is positioned within said
25 vane passage said third vane core element extends between
said central opening and a location short of said
peripheral opening;

30 wherein said attachment means are configured to be
accessible from said impeller inlet when said vane core
assembly is within said vane passage whereby said third
vane core element is manually detachable from said second
vane core element by manipulation of said second and third
vane core elements through said impeller inlet while said
second and third vane core elements are positioned within
35 said vane passage.

16. A vane core assembly for use in forming a vane
passage in an injection-formed, elastomer-covered,
closed-shroud impeller substantially as described herein
with reference to and as illustrated in Figures 5 to 13 of
the accompanying drawings.

DATED this 9th day of January, 1990.

BAKER HUGHES INCORPORATED
By Its Patent Attorneys

GRIFFITH HACK & CO.
Fellows Institute of Patent
Attorneys of Australia.

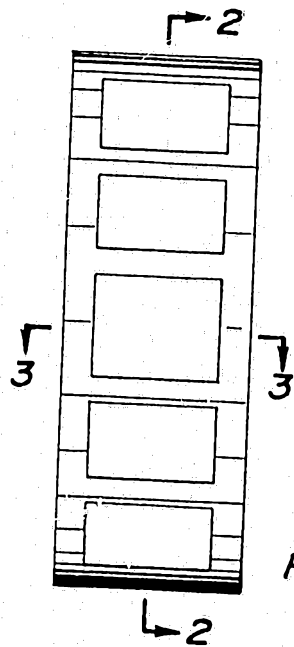


Fig. 1

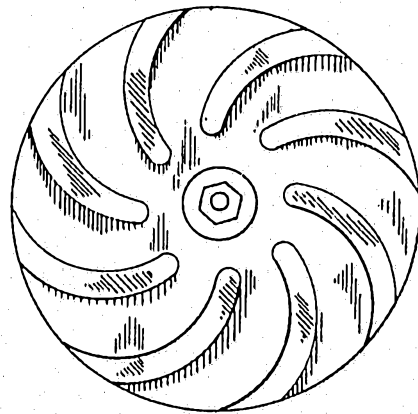


Fig. 2

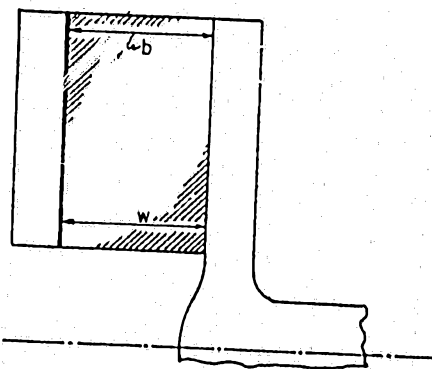


Fig. 3

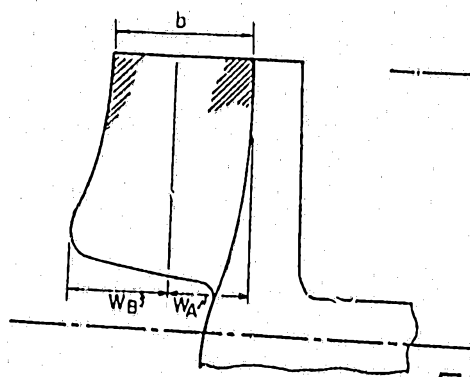


Fig. 4

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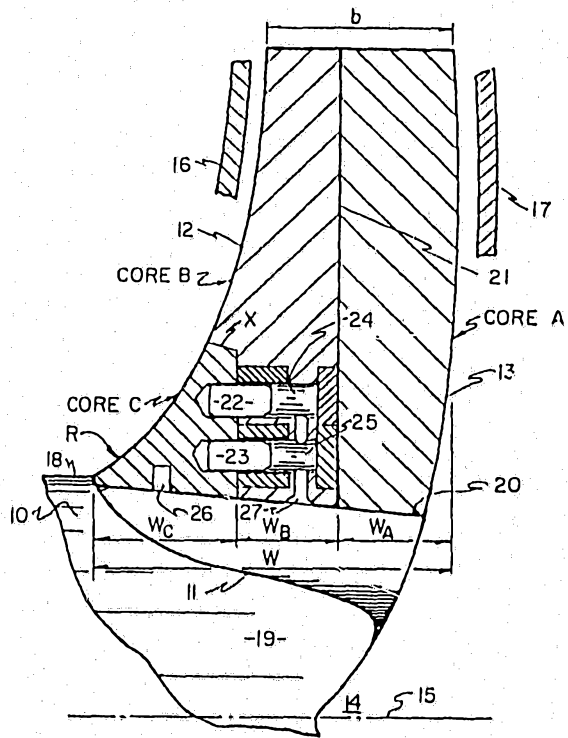


Fig. 5

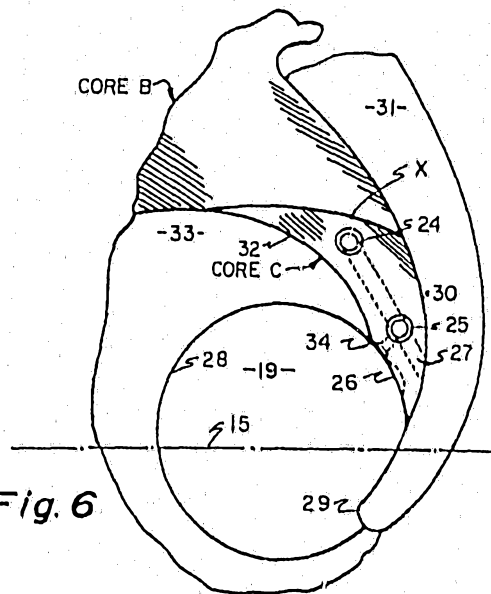


Fig. 6

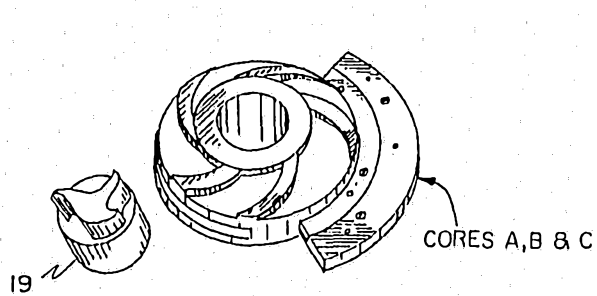


Fig. 7

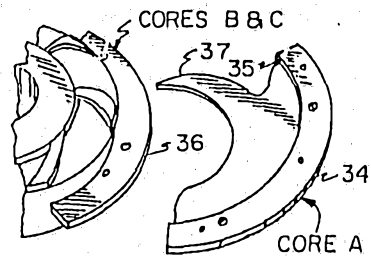


Fig. 8

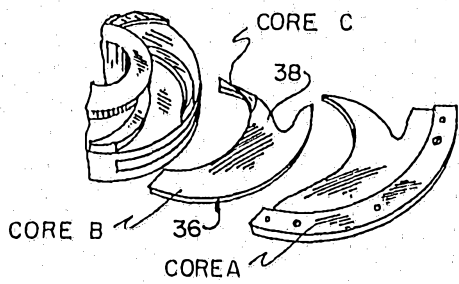


Fig. 9

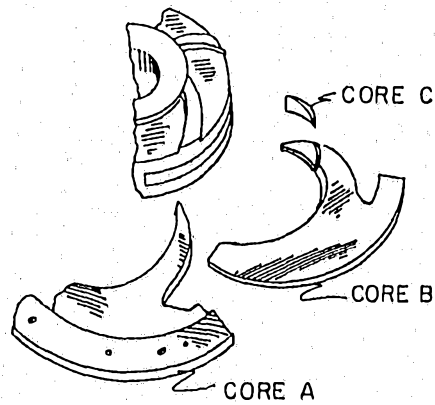


Fig. 10

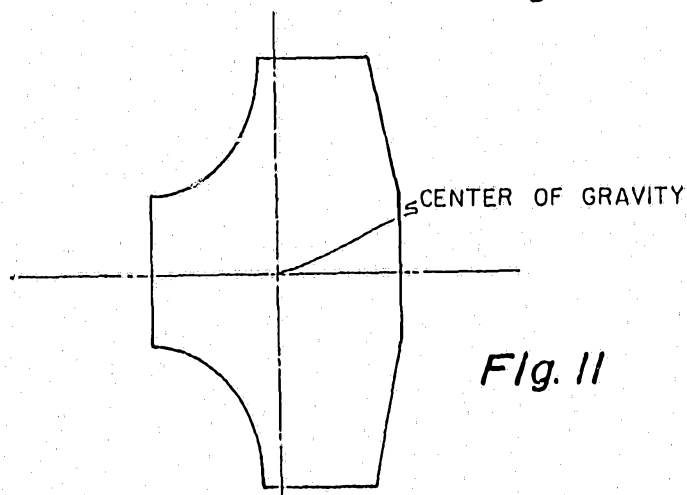


Fig. 11

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 34
 35
 36
 37
 38
 CORE A
 CORE B
 CORE C

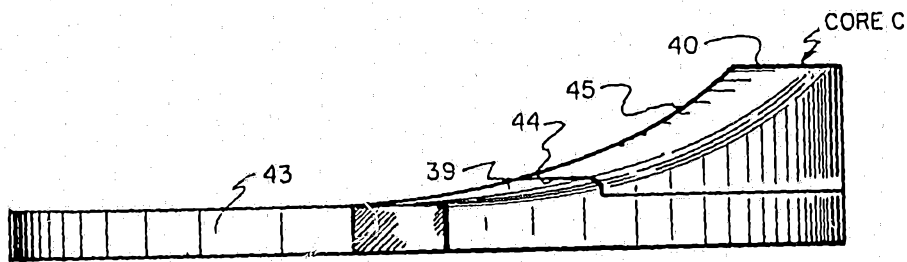
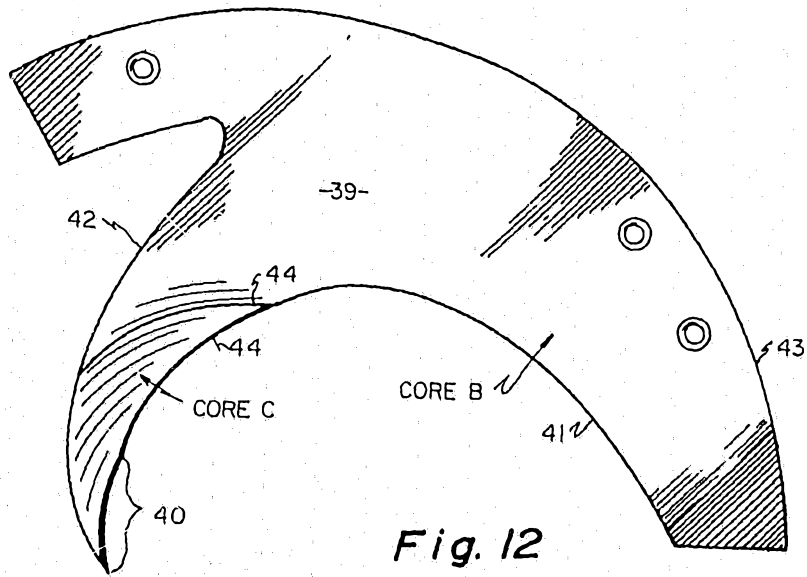


Fig. 13