April 2, 1968 F. B. EASTON 3,375,789

SPLIT CASE SUBMERSIBLE PUMP

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FIG. 2

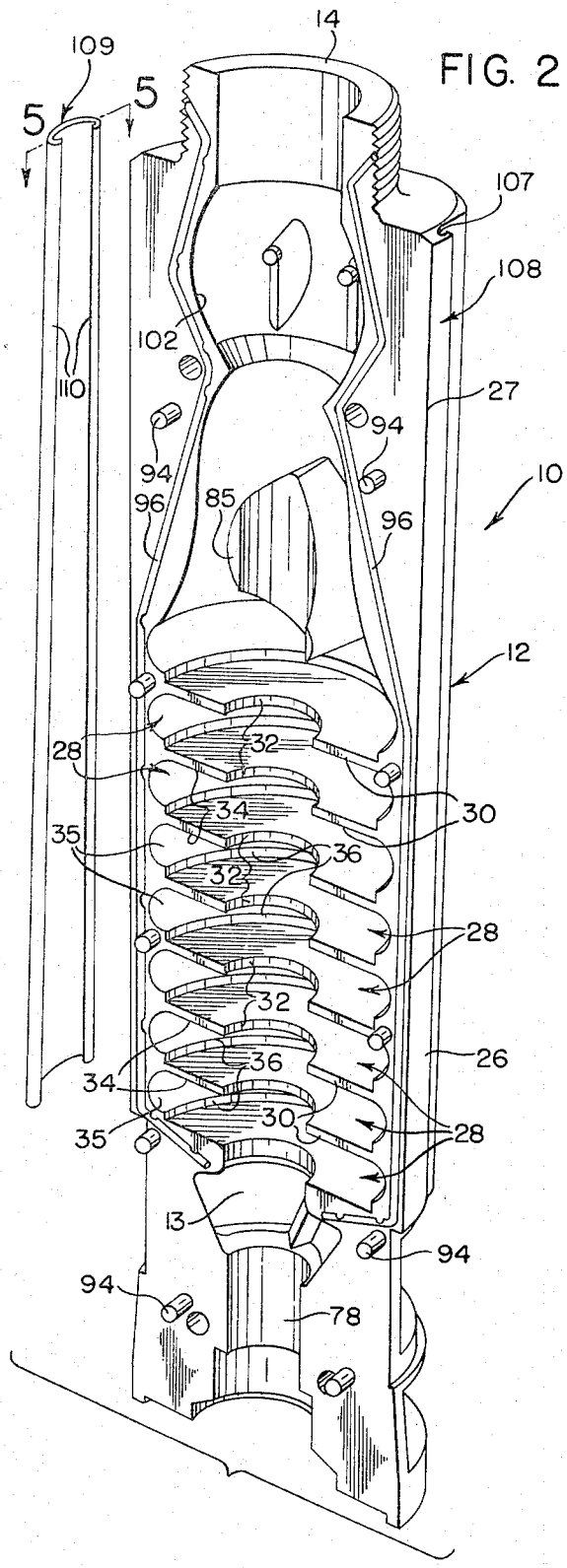
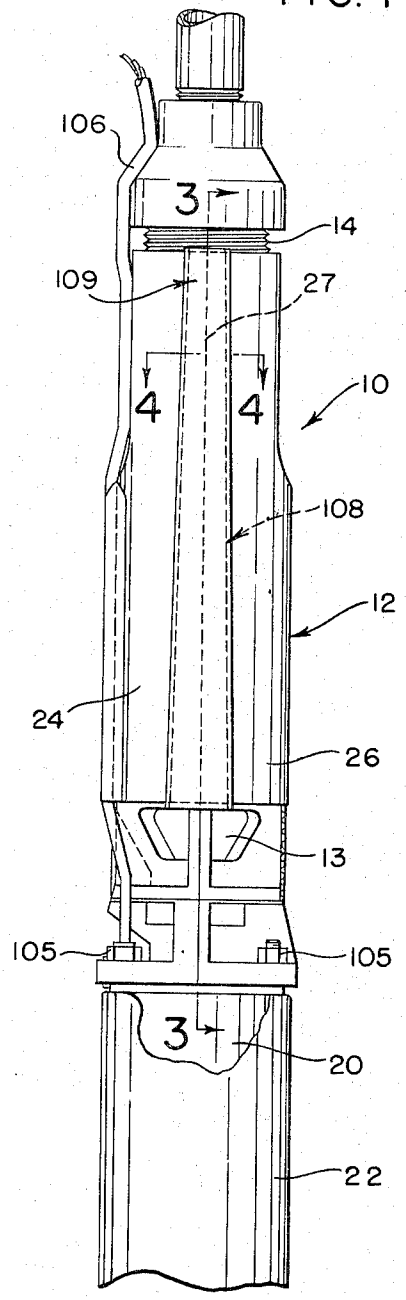


FIG. 1



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FIG. 3

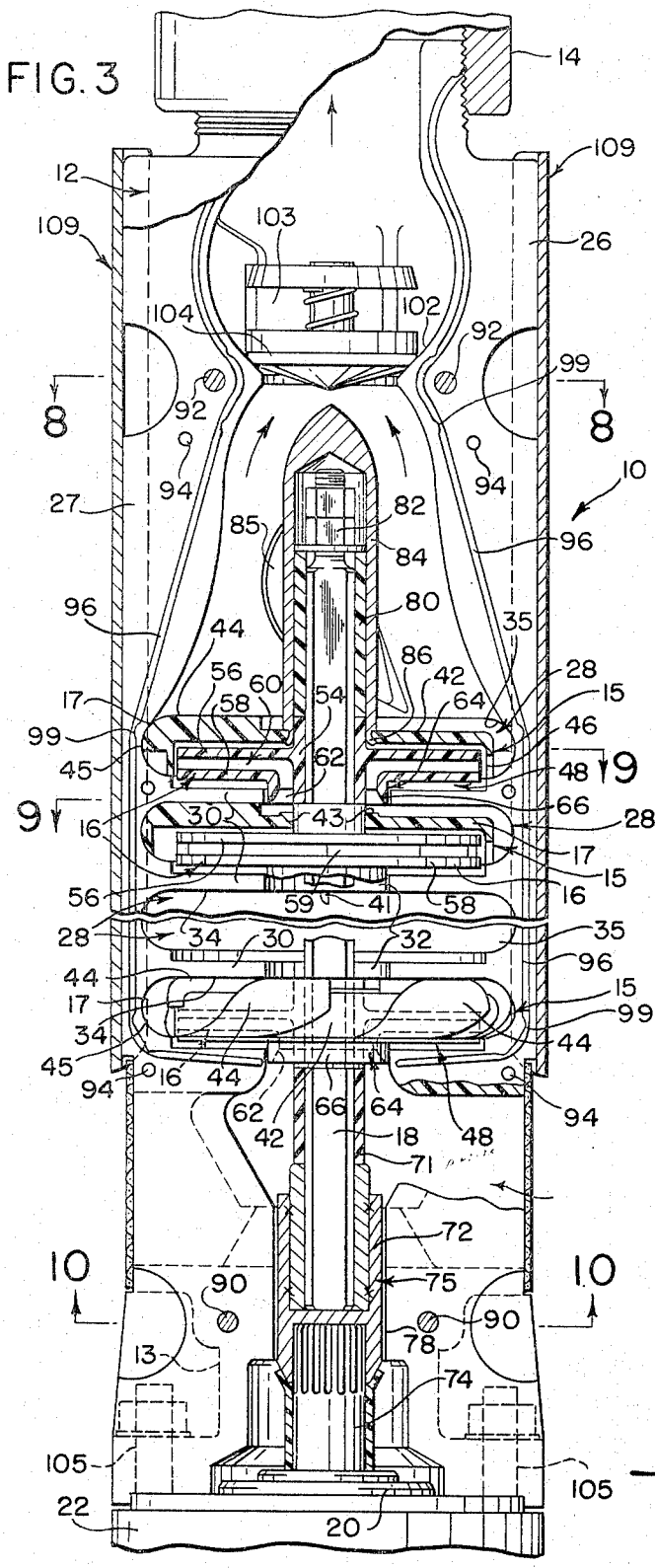
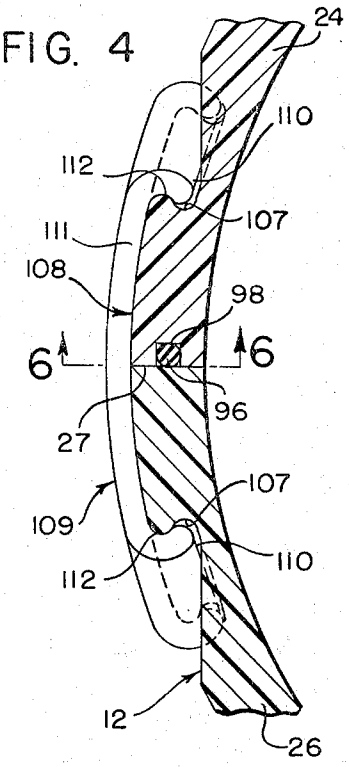


FIG. 4



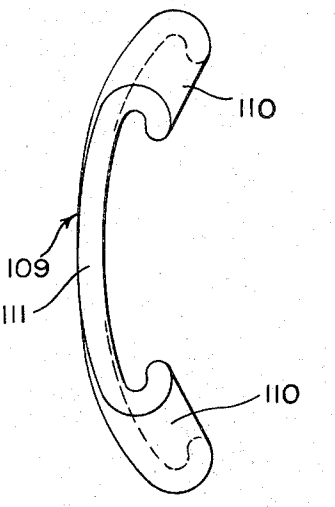


FIG. 5

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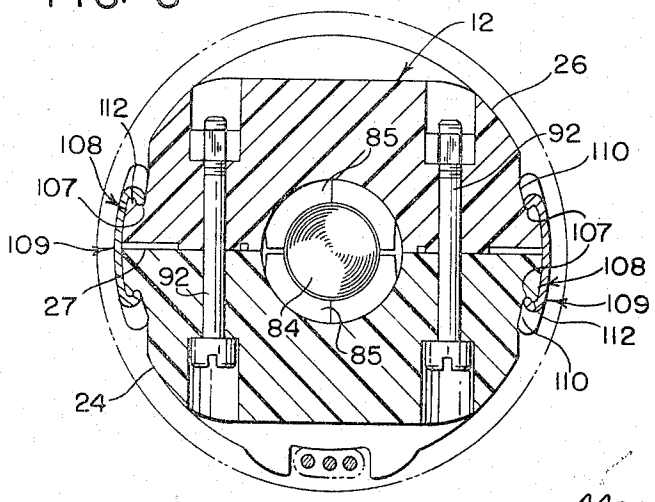
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FIG. 8



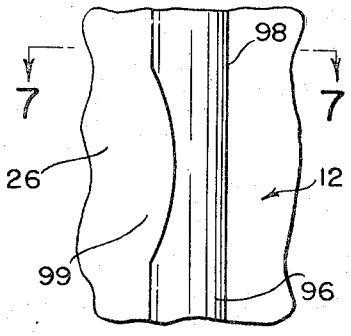


FIG. 6

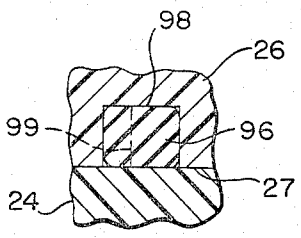


FIG. 7

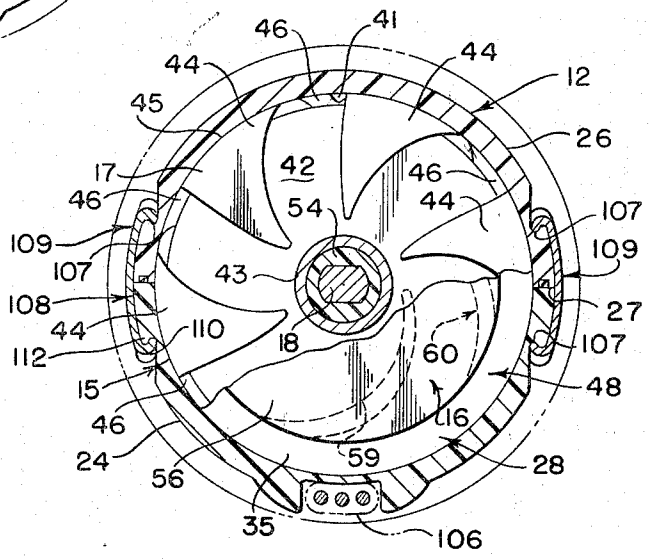


FIG. 9

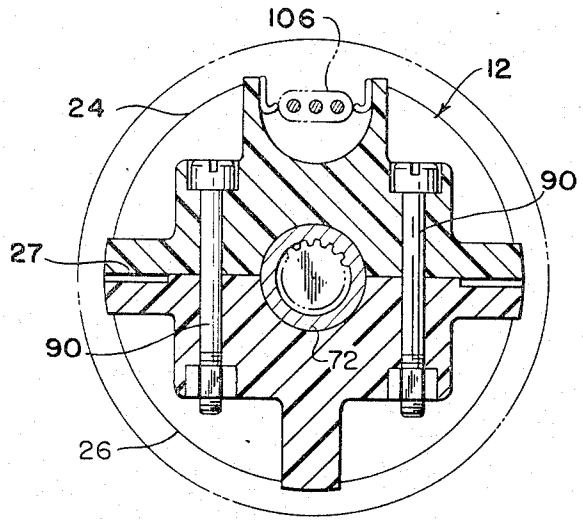


FIG. 10

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FIG. 11

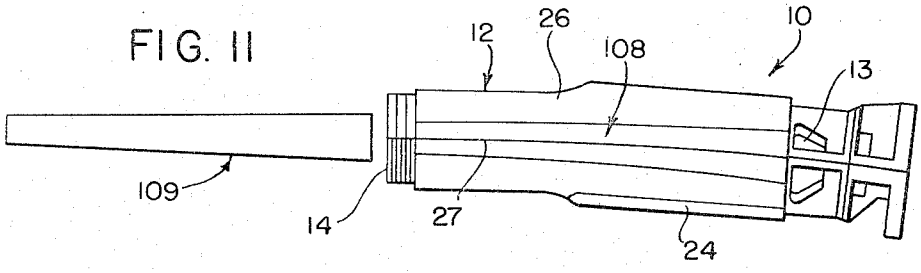


FIG. 12

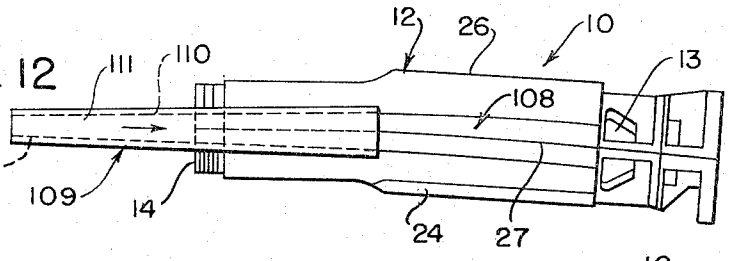


FIG. 13

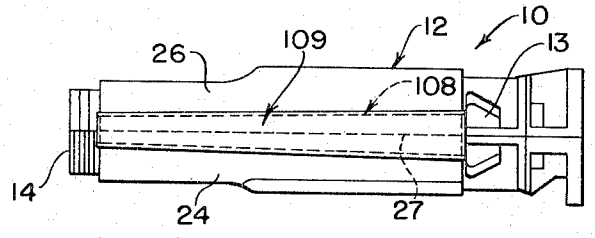
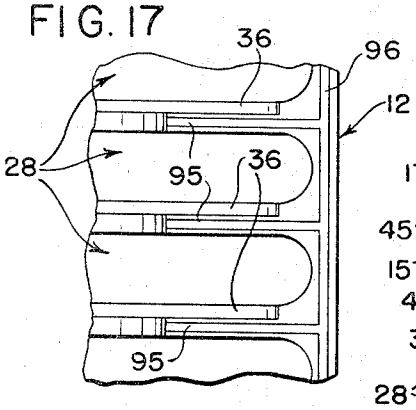


FIG. 17



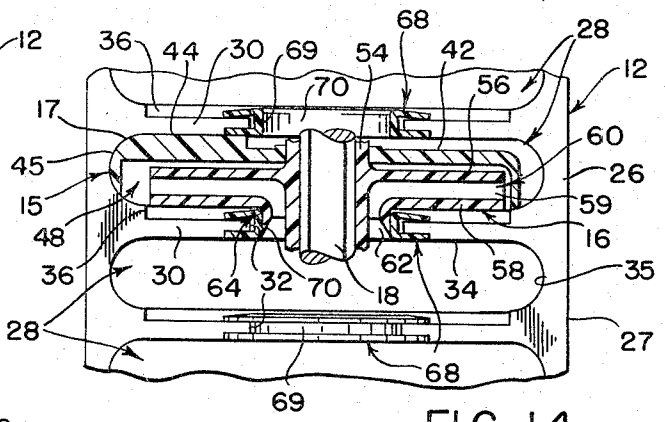


FIG. 14

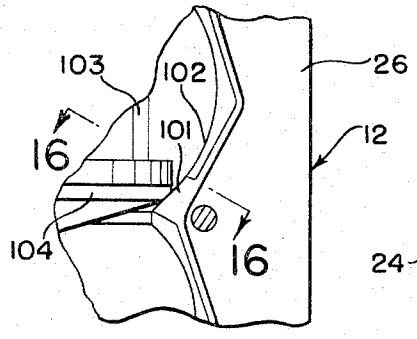


FIG. 15

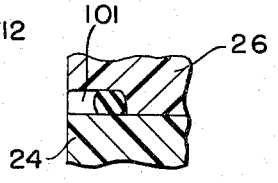


FIG. 16

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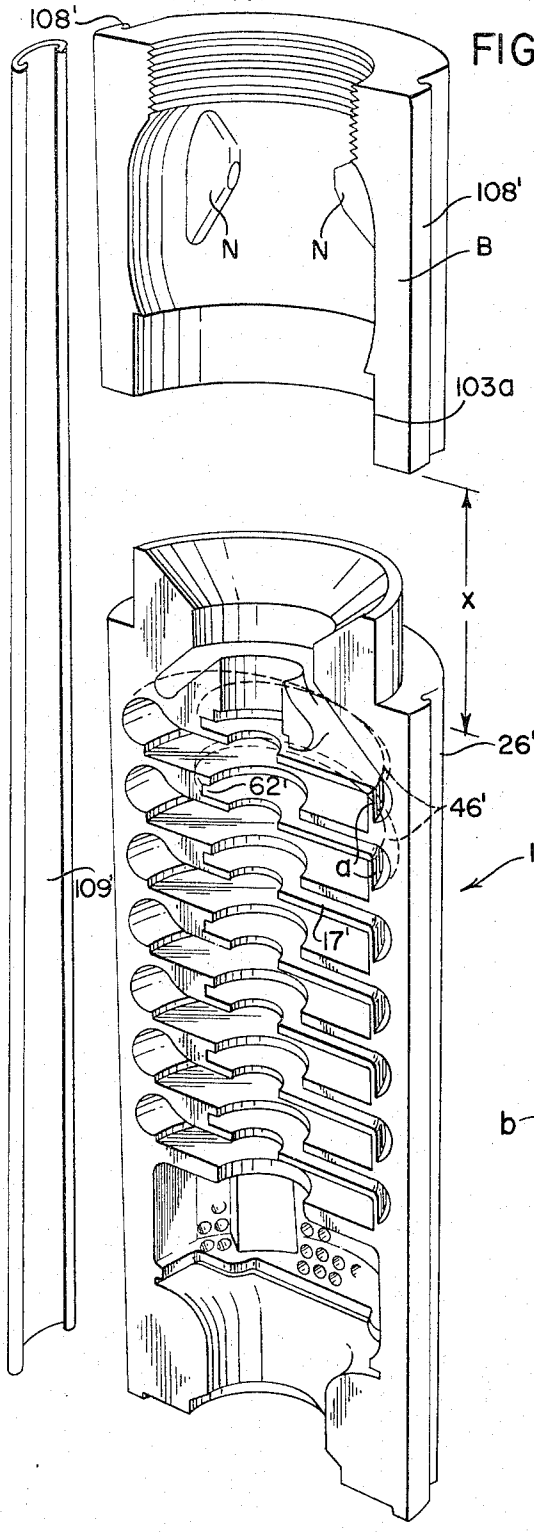


FIG. 18

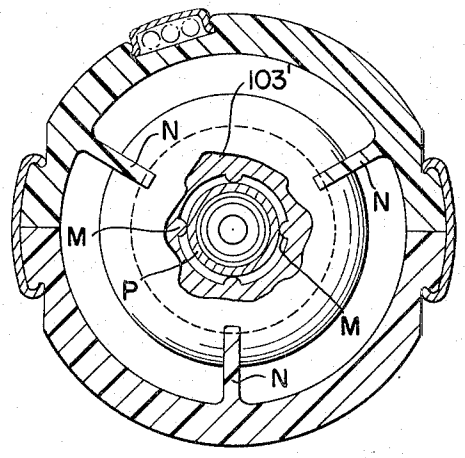


FIG. 20

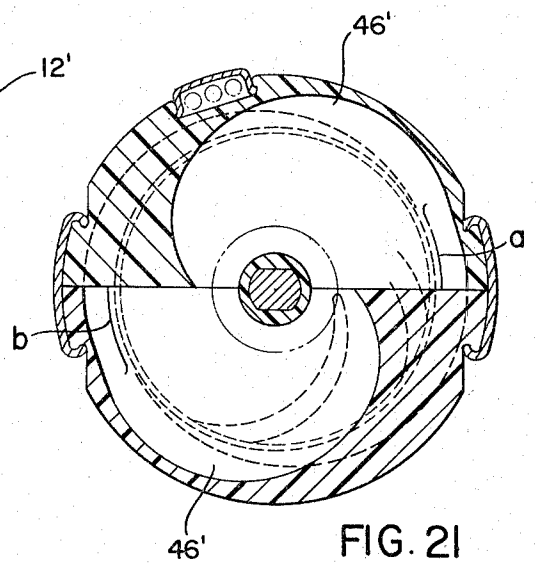


FIG. 21

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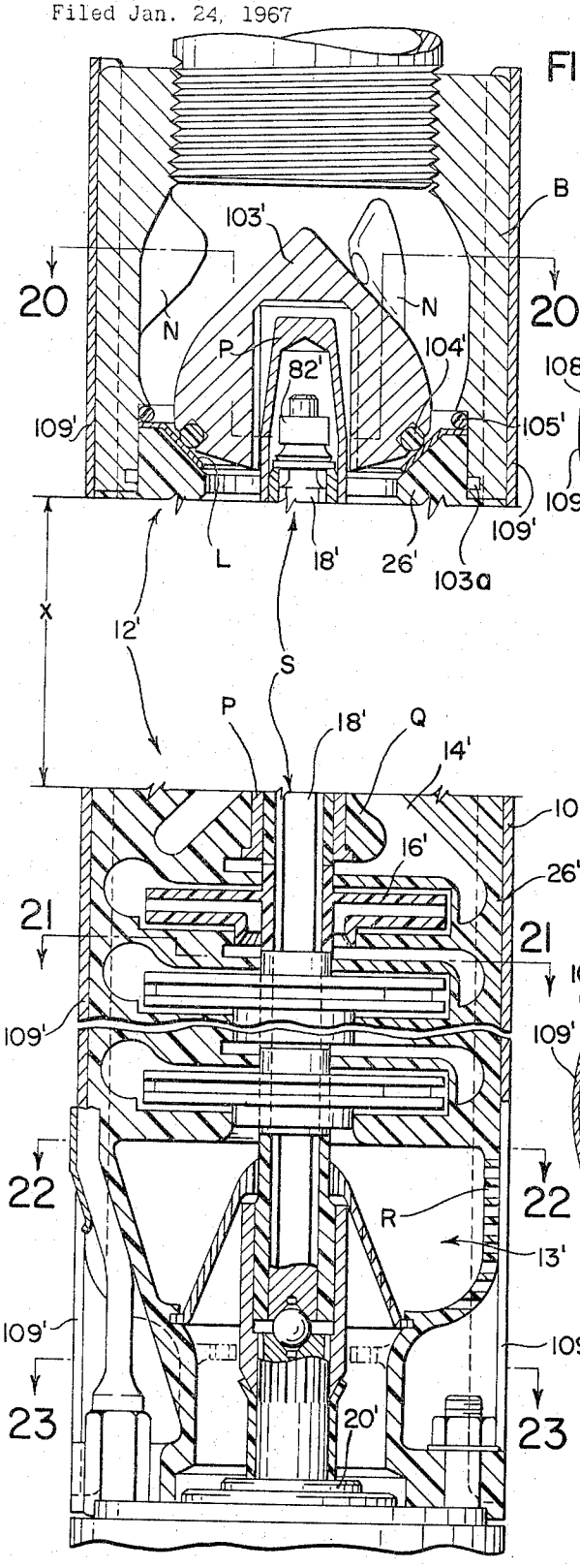
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FIG. 19



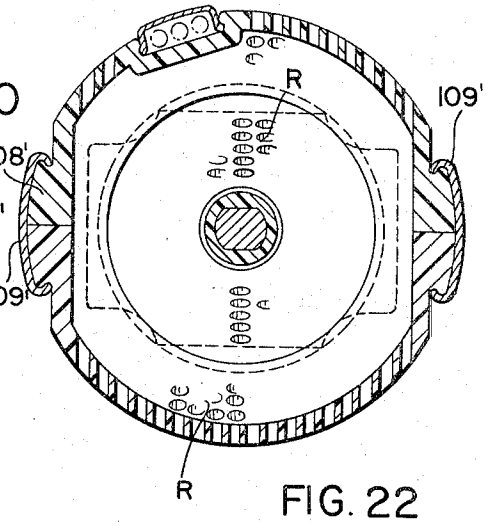


FIG. 22

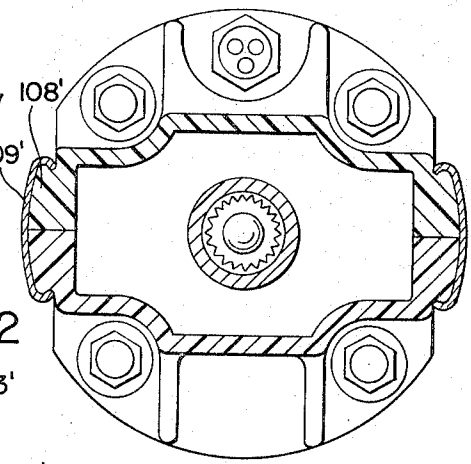


FIG. 23

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FIG. 24

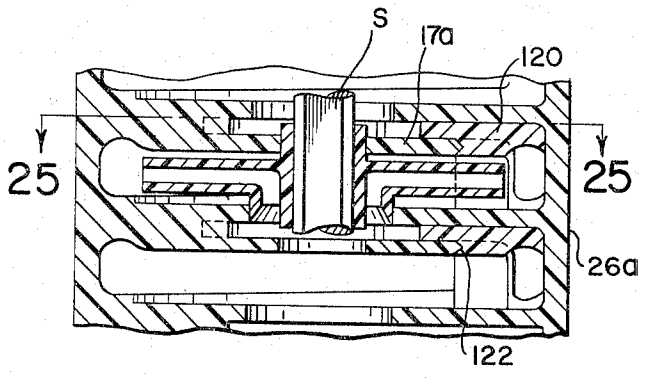
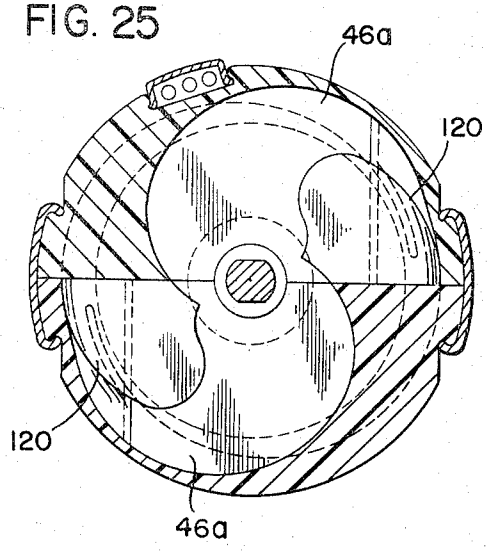


FIG. 25



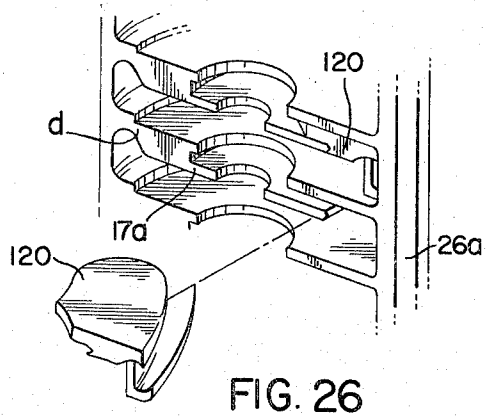


FIG. 26

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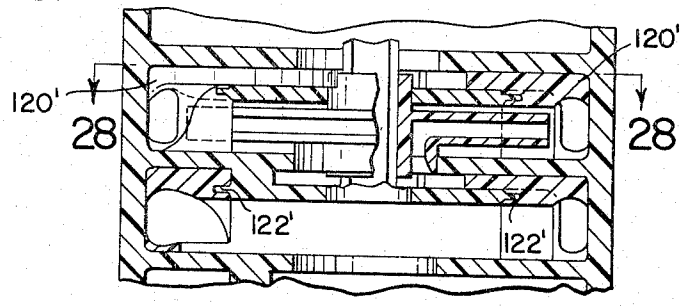
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April 2, 1968 F. B. EASTON 3,375,789

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FIG. 27



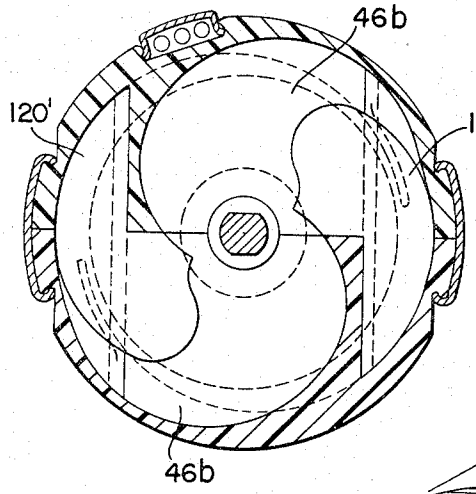


FIG. 28

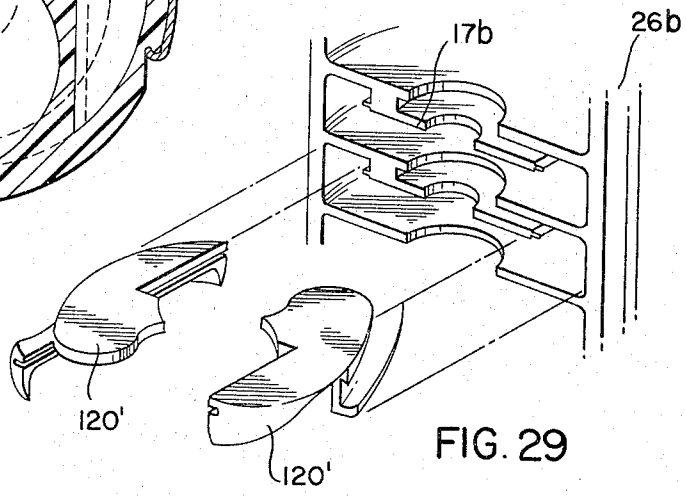


FIG. 29

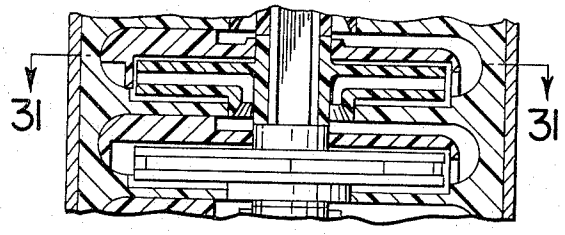


FIG. 30

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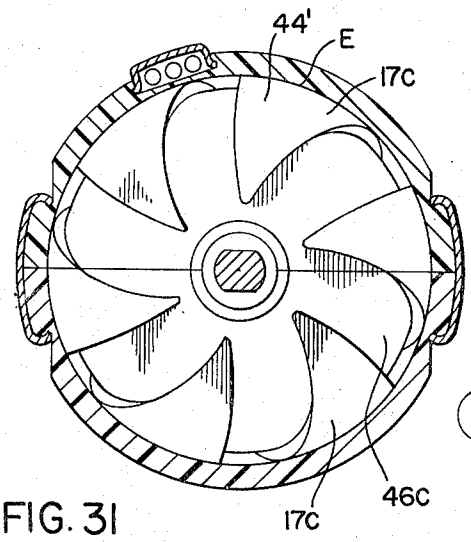
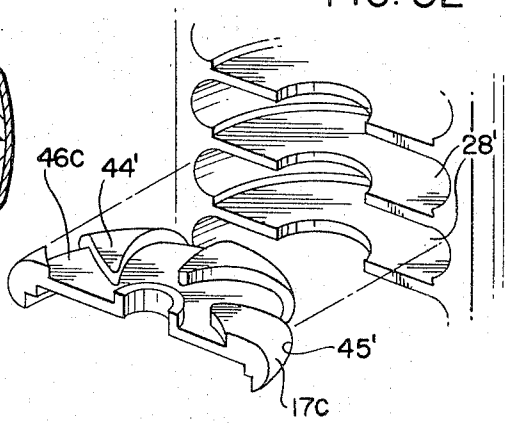


FIG. 31

FIG. 32



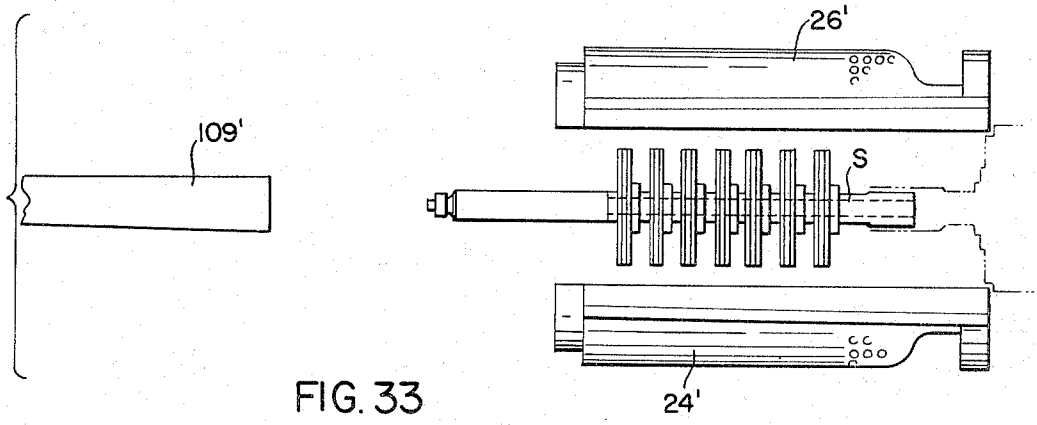


FIG. 33

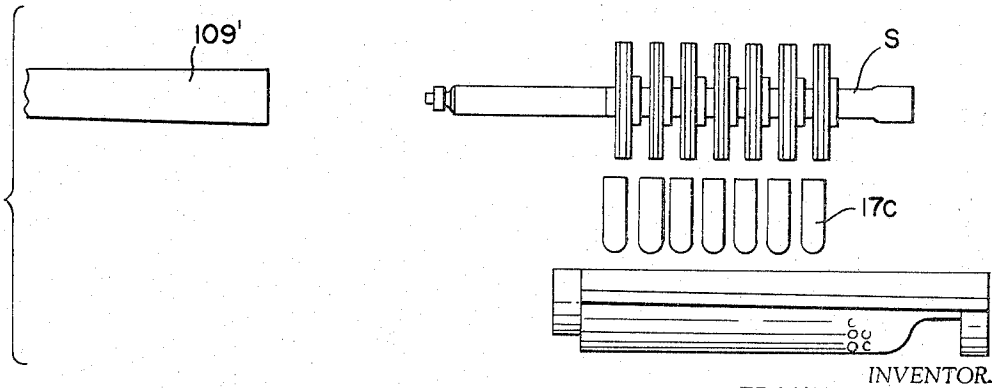


FIG. 34

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BY
Meyer, Tilberry & Body

ATTORNEYS

United States Patent Office 3,375,789
Patented Apr. 2, 1968

3,375,789

SPLIT CASE SUBMERSIBLE PUMP

Frank Bernard Easton, Salem, Ohio, assignor to Crane Co., New York, N.Y., a corporation of Illinois

Continuation-in-part of application Ser. No. 390,677, Aug. 19, 1964. This application Jan. 24, 1967, Ser. No. 611,453

20 Claims. (Cl. 103—102)

ABSTRACT OF THE DISCLOSURE

The disclosure pertains to the art of multistage centrifugal pumps and more particularly to such a pump having a casing formed of at least two longitudinal sections each molded from an epoxy or other plastic material. The casing sections are brought together to define pumping stages around a single rotatable spindle assembly of impellers. Fastener elements more rigid longitudinally than the casing sections secure the sections together in a manner designed to straighten the pump and align the stages with the impeller spindle axis.

This application is a continuation-in-part of U.S. application Ser. No. 390,677 filed Aug. 19, 1964, now abandoned.

This invention pertains to multistage centrifugal pumps and more particularly is applicable to a multistage submersible pump in which the entire pumping unit, including the motor, is completely submerged in a liquid which is to be pumped. Although the invention will be described with particular reference to such a pump, it is equally applicable to other types of pumps employing linear pumping stages whether submersible or not.

Multistage centrifugal pumps conventionally have a linear series of pumping units or stages each of which includes a diffuser with a rotatable impeller mounted therein driven from a common drive shaft. The shaft extends lengthwise in the pump and is supported at its opposite ends by bearings. With such a construction it is essential to maintain rigid manufacturing tolerances if the diffusers and impellers in each stage are to rotate freely relatively to each other; this problem is compounded in certain modular multistage pumps where one stage is stacked upon the next in a vertical array. As a result, manufacturing tolerances are multiplied and over the length of the pump, create a stacking limit condition restricting the number of pumping stages which can be put together without producing a binding condition in the uppermost stages. As a result, it frequently occurs that a costly and time consuming run-in period is required while the adjacent surfaces of the impellers and diffusers accommodate each other by mutual abrasion.

Another problem with multistage pumps is the requirement for precise alignment of the diffusers and impellers. This requirement is especially difficult to meet with pumps having parts which are molded separately and then assembled. In order to assemble the parts while preserving the axial alignment between the pumping stages and avoiding interference between rotating and nonrotating parts, particularly plastic parts, loose tolerances are permitted. This is objectionable because it results in a loss in pressure head due to a leakage between stages requiring an excessive number of stages to compensate.

Also, experience has shown that the stringent requirements for pumping stage alignment are not achieved with one piece plastic pump casings since it is difficult to prevent warpage upon removal of the casing from the manufacturing molds.

The present invention contemplates a new and improved multistage centrifugal pump having a molded casing structure adapted to overcome the above mentioned difficulties and others.

In accordance with the invention, a multistage pump is provided which includes a series of pumping stages. Each stage comprises an impeller which discharges into a volute passage for circulating fluid to the next stage. A drive member interconnects the impellers of each stage for transmitting a torsional driving force from one to the other. A pump casing is formed of at least two longitudinal sections which are fitted together around the stages in mating fashion on opposite sides of a mutual parting plane. And fastener elements, more rigid longitudinally than transversely, are engageable at the parting plane of two sections for holding them together and in substantial alignment with the axis of the impeller.

More particularly, where each volute passage is part of a diffuser which is separable as a unit from the pump casing, each longitudinal casing section includes a plurality of radially opening pockets defined by axially spaced arcuate segments, the pockets independently supporting each diffuser in proper relationship to each impeller.

In accordance with a further aspect of the invention, and particularly in order to achieve closer running clearances between the impellers and diffusers, the impellers are arranged on a common shaft as a single rotating spindle assembly and the diffusers are split with each half being molded or otherwise affixed integrally into the pump casing sections so that upon assembly thereof, the impeller spindle assembly is rotatably supported in precision alignment with a minimum of running clearance between the rotating and nonrotating parts.

Further in accordance with this aspect of the invention, where the mold draft necessary for withdrawal of the manufacturing molds in making the diffusers integral with the casing sections is not conducive to proper diffuser volute passage configuration, partial diffuser sections are molded integrally so that when assembled, the casing sections come together to firmly support the impeller spindle assembly and removable diffusers inserts are fitted with each partial diffuser section to complete the diffuser volute form.

A principal object of the invention is to provide a new and improved multistage centrifugal pump which is simple in construction, economical to manufacture and can be assembled from molded casing sections fitted together in complementary fashion.

Another object is to provide a pump casing as referred to above which maintains precise clearance and alignment between diffusers and impellers, thereby increasing pumping efficiency.

A further object is to provide that the diffusers are molded or otherwise affixed into the casing sections so that a single spindle impeller assembly may be used thereby by reducing the running tolerance between rotating and nonrotating parts.

Another object is the provision of a multistage centrifugal pump casing formed from duplicate sections capable of being molded by injection or compression molding techniques in a single mold.

Still another object is to provide a pump casing as referred to above in which any warpage due to the manufacturing process is corrected by straightening the casing as the sections are joined together.

Other objects and features of the invention will be more apparent from a consideration of the following description which proceeds with reference to the accompanying drawings wherein:

FIGURE 1 is a side elevational view of a submersible pump constructed in accordance with the invention;

FIGURE 2 is a perspective view of the right half of the

inventive pump casing and one fastener element therefor;

FIGURE 3 is a partial longitudinal sectional view of the pump taken along line 3—3 of FIGURE 1;

FIGURE 4 is an enlarged fragmentary transverse sectional view taken along line 4—4 of FIGURE 1;

FIGURE 5 is an enlarged end view of a fastener element in the unmounted condition as seen approximately along the line 5—5 of FIGURE 2;

FIGURE 6 is an enlarged fragmentary view of the longitudinal casing seal taken approximately along line 6—6 of FIGURE 4;

FIGURE 7 is a cross-sectional view taken along line 7—7 of FIGURE 6;

FIGURE 8 is a cross-sectional view taken along line 8—8 of FIGURE 3;

FIGURE 9 is an offset cross-sectional view taken approximately along line 9—9 of FIGURE 3;

FIGURE 10 is a cross-sectional view taken along line 10—10 of FIGURE 3;

FIGURE 11 is a pictorial view depicting the inventive pump casing in a greatly exaggerated wraped condition prior to assembly of the fastener elements;

FIGURE 12 is a sequential view depicting the relative position of the fastener elements and casing at an intermediate stage of assembly;

FIGURE 13 is a final assembly view showing the warped condition of the casing corrected;

FIGURE 14 is a fragmentary view of the casing showing the use of adjustable sealing members between pumping stages as an alternative to the preferred embodiment of the invention;

FIGURE 15 is an enlarged fragmentary view of an alternative arrangement of the longitudinal casing seal;

FIGURE 16 is a view taken along line 16—16 of FIGURE 16; and

FIGURE 17 is a fragmentary view of another alternative arrangement of the longitudinal casing seal.

FIGURE 18 is an exploded perspective view of the right half of a pump casing modification in accordance with the invention in which the diffuser sections are molded integrally therewith;

FIGURE 19 is a partial, cross sectional assembly view of this pump modification;

FIGURES 20–23 are cross sectional views taken along the section lines where indicated in FIGURE 19;

FIGURES 24–26 show a further modification in which the diffuser sections are partly molded in the casing and partly formed by removable inserts;

FIGURES 27–29 show a further modification using removable inserts;

FIGURES 30–32 show still another pump modification where the diffuser sections are cemented into the casing sections; and

FIGURES 33–34 are exploded views of the pump assembly method according to the modification in FIGURES 30–32.

Referring generally to the drawings wherein the showings are for the purpose of illustrating certain embodiments of the invention only and not for the purpose of limiting same, FIGURES 1–3 show a pump **10** including an elongated casing **12** having an inlet **13** and an outlet **14**. A linear series of pumping units **15** in the casing **12** each include an impeller **16** and a diffuser **17**. Each impeller **16** is driven by shaft **18** from a motor **20** protectively encased in a sealed cannister **22**. Those familiar with pumps of this type will recognize that the embodiment shown relates to a submersible pump of a type commonly used in domestic water systems which have a storage tank above the ground and a well which extends down into the ground to provide a source of water. The submersible pump **10** is lowered, motor first, until it is completely submerged in the well water. The outlet **14** of the pump is connected to the storage tank and suitable above ground controls are provided for operating the system.

Referring now to the drawings in more detail, it is noted in FIGURE 1 that the casing **12** is actually divided into two half sections. A left hand section **24** mates with a substantially duplicate right hand section **26** with like parts of one section joining with like parts of the other in complementary fashion in a common parting plane at **27** through the axis of the pump. Where appropriate, the description will be only with reference to the right hand half section **26** and it will be understood that it applies equally to the other section **24** and like numerals will be used to indicate like parts in each section.

In accordance with the invention, the section **26**, as shown best in FIGURES 2 and 3, has a plurality of arch-shaped cavities or pockets **28** defined by axially arcuate segments or ribs **30** which project radially inwardly and terminate in semi-circular surfaces **32** aligned with the pump axis. Each rib **30** has a planar surface **34** facing the motor end of the pump which merges in a smooth curve with a surface **35** terminating in a shoulder **36** on the next adjacent rib **30**. Each diffuser **17** has a radially extending wall **42** with an inner hub **43** aligned with the pump axis. Vanes **44** which join to the wall **42** curve radially inwardly, as shown best in FIGURE 9, and are configured on the outer edge **45** so as to nest with the continuous surfaces **34**, **35** of the pockets **28** thus defining volute passages **46** which open into pumping chambers **48** surrounding each impeller **16**. Diffuser locating tabs **41** which project from the surfaces **35** engage the vanes and prevent rotation of the diffusers. Volute passages **46** thus provide fluid communication from one impeller to the next. It should be noted that each diffuser **17** is independently and removably supported within its associated pocket **28** isolated from the next diffuser in the series.

As shown in FIGURES 3 and 9, a more or less conventional impeller **16** is provided having a hub **54** received on the shaft **18** being adapted to rotate conjointly therewith. A front plate **56** is joined to a rear plate **58** by curved blades **59** defining radially outwardly curved passages **60** which communicate with an intake eye **62**. The rear plate **58** has an axially extending collar **64** which preferably has a machined outer surface **66** concentric with the arcuate surfaces **32** on the ribs **30**. The radial clearance spacing between the surfaces **66** and **32** is preferably only a few thousandths of an inch to provide a relatively effective fluid seal. As an alternative, the ribs **30** may be provided with loose fitting circular nibs **68**, as shown in FIGURE 14, having resilient side walls **69** for engaging the ribs **30** so as to provide a yieldable sealing surface **70** for sealing with the surface **66** of each impeller **16**. With this alternative sealing arrangement, axial alignment between stages is somewhat less critical since the nibs **68** can adjust to compensate for slight amounts of axial deviation. In a modification described hereinafter, precision clearance and alignment is more certain and nibs **68** may be eliminated.

Referring to FIGURE 3, the impellers **16** are stacked one upon the other on the shaft **18** in a linear series with the hub **54** of one impeller resting against the hub **54** of the next. The first stage impeller closest to the motor **20** rests against a spacer sleeve **71** for determining the proper longitudinal position of the whole impeller series with respect to the pockets **28**. Axially beyond the spacer sleeve **71**, the shaft **18** is provided on its end with a splined sleeve **72** coupled with a splined stub shaft **74** driven by the motor **20** by means of a coupling **75** rotatably received in bore **78'** of the casing **12**. At the opposite end, the shaft **18** carries a bearing journal **80** tightened down against the uppermost impeller **16** by means of nuts **82** threaded on the end of shaft **18**. A guide tube **84** supported in a contoured web **85** projecting from the casing sections **24**, **26** is provided on the upper end of the impeller assembly. The guide tube **84** is clinched over at the lower end **86** to hold the uppermost diffuser **17** in proper relation to the uppermost impeller **16**. When the two half sections **42**, **26** are assembled, the arcuate pockets **28** in each section are fitted around the diffusers **17** and

impellers **16** of each pumping stage. The diffusers are positioned to register with the diffuser locating tabs **41**. Bolts **90** hold the casing sections together securely in the region where the impeller assembly is coupled to the motor **20** and bolts **92** near the upper end of the casing insure a rigid joint where the contoured web **85** supportingly engages the guide tube **84** of the impeller assembly. Pins **94** extending between the upper and lower half sections **24, 26** may be used to insure proper longitudinal registration of the two sections. The motor **20** and cannister **22** are supported from the lower end of the pump casing by bolts **105** and a power cable **106** for motor **20**, suitably insulated with a water repellent material, connects to an above-ground control and source of electrical power not shown.

In accordance with one aspect of the invention, a seal is provided between the assembled half sections **24, 26** when the mating faces of the two sections are not smooth enough to seal or when the pressure is very high. The seal includes a pair of elastomeric cords **96** which are positioned in grooves **98** formed in the mating face of the section **26** on opposite sides of the pump axis as best shown in FIGURES 3, 4, 6, and 7. Each groove **98** receives a cord **96**. Both cords **96** form a sealing envelope in the parting plane **27** of the pump casing **12** around the pumping stages from the pump inlet **13** and the pump outlet **14**. Alternatively, the elastomeric cords **96** may include radially inwardly extending finger portions **95** received in grooves in the mating faces of ribs **30** as shown in FIGURE 17 thus sealing between each pumping chamber **48**. Shown greatly enlarged in FIGURES 6 and 7, small crescent shaped projections **99** periodically spaced along each groove **98** serve to hold each cord **96** in place by compressing a small portion of it. More importantly, the projections **99** prevent a longitudinal flow of liquid down the pump which would create a substantial leak at high pressures. For the same reason, the cords **96** may also have extensions **101** exposed in a surface ground area **102** of the casing as shown in FIGURES 15 and 16. A relief valve **103** in the outlet **14** has an O-ring **104** which sealably engages the surface ground area **102** as shown in FIGURE 3, but where in the alternative, extensions **101** are used, they cooperate with the O-ring to provide an effective seal in the pump seam at this location. A modified relief valve and seat arrangement will be described hereinafter which is designed to seat more uniformly and permit a shorter pump.

The manner in which the casing sections are secured together will now be described. In accordance with the invention, each casing section **24, 26** is provided with a longitudinal groove **107** on opposite sides of the parting plane **27**. As shown in FIGURES 1, 2, and 4, each groove **107** in each half section is inclined outwardly toward the motor end of the pump and away from the parting plane **27** providing a tapered, molded structure or guide **108** bisected by the plane **27**. A pair of tapered channels or fastener members **109** having clinched over edges **110** are slidably received in the grooves **107**. The back portion **111** of each channel **109** is transversely flexible and straddles the tapered guide **108**, thus holding the casing half sections together in clip-like fashion. The channels **109** have an additional function during the assembly of the half sections **24, 26** which will be more fully explained hereinafter. At present, and in this connection, it is noted that the grooves **107** are formed by arcuate shaped overhanging edges **112** of the guide **108** which face away from the parting plane **27** and the axes of the edges **112** coincide with the axes of the clinch bend edges **110** of each channel **109**.

Before the channels **109** are inserted, the back portions **111** are in a more severely bowed condition as shown in FIGURE 5, and upon assembly with the casing **12** are spread transversely to place a bending stress therein thus taking a much more flattened cross-sectional appearance complementary to the molded structure **108** as shown in FIGURE 4. Channels **109** and the molded structure **108** thus form complementary means on each casing section which when brought together define cooperating structure for aligning the pumping stages and securing the pump together. In the preferred form, the curvature of the back portion **111**, rather than being uniform, is more or less elliptical having a maximum radius at the center and decreasing on each side thereof to a minimum radius adjacent the clinch bend edges **110**. However, the channel members **109** must be as rigid as possible in an axial direction and are formed of a material having a much higher modulus of elasticity than the material from which the pump casing **12** is formed. For example, a suitable material which would resist the corrosive environments of the pump and also provide the necessary strength would be stainless steel.

Upon assembly, the impellers **16** and diffusers **17** are strung on the shaft **18** and this assembly is placed in one of the sections **24, 26** of the pump casing **12** such that each diffuser **17** is properly located around its associated impeller **16** in a pocket **28**. Upon assembly of the other casing half section, the guide tube **84** at the upper end of the impeller assembly is fitted between the mating complementary portions of the web **85** while the opposite end is fitted within the bore **78**. Prior to this, if found necessary, the sealing cords **96** and locating pins **94** are put in place. Bolts **90** and **92** are then inserted and tightened to maintain a slight pressure to hold the sections together. The casing **12** is then placed in a suitable holding fixture where it is to be straightened if necessary, as explained hereinafter.

Those acquainted with conventional submersible pumps will recognize that the basic pumping operation is such that liquid to be pumped is drawn in at the inlet **13** and is raised from one pumping stage to the next by the centrifugal action of the impellers **16**. The diffusers **17** conduct the fluid from one impeller to the next until it discharges under pressure through the outlet **14**.

As mentioned before, in the past a stacking limit problem has been encountered where each diffuser is stacked one upon the other. To overcome this difficulty in the present invention, the casing half sections **24, 26** are molded as a unit so that the pockets **28** are necessarily equally spaced. Thus when the diffusers **17** are assembled in the pockets **28**, each one will be independently supported and will not be affected by the stacking tolerances of the preceding diffusers.

The rigid alignment and close running clearance required between rotating and nonrotating parts has also been a problem in the past. Where the parts are formed from a thermosetting plastic material which can be molded under conditions of heat and pressure to take a permanent shape additional problems are encountered. Due to the molding operation, it is not uncommon for the plastic part to take a permanent set after being extracted from the mold in a slightly warped condition which upon assembly results in a misalignment. Oversized tolerances are thus required to compensate.

Referring now to FIGURES 11–13, prior to inserting the channel members **109**, the casing **12** is in a warped condition and instead of being straight, follows some independent path determined by the permanent set of the plastic material after removal from the mold. The condition of warpage is very slight in most cases but is greatly magnified in FIGURE 11 for purposes of illustration. To straighten the casing **12** and in accordance with the invention, both channels **109** are started in the grooves **107** on opposite sides of the casing **12** at the narrowest span of the tapered guides **108** as depicted in FIGURE 11. As the channels **109** are moved simultaneously in an axial direction, the clinch bend edges **110** bite into the groove **107** on each side of the guide **108** causing each channel back portion **111** to flex to a less bowed condition thus placing a clamping force on the casing sections **24, 26**.

In addition, as depicted in FIGURE 12, as the channel

members **109** are driven farther down the body of the pump casing **12** they begin to have an effect on its warped condition tending to bring the casing into true alignment. This results from the fact that the channels **109** are as rigid as possible in an axial direction and have a very high modulus of elasticity with respect to that of the thermosetting or thermoplastic material from which the casing **12** is formed. The result is that while the channels **109** may flex transversely to provide a clamping force, they are virtually rigid in a longitudinal direction so as to have a straightening effect on the casing **12**. When fully inserted as shown in FIGURE 13, the casing will be aligned and the bolts **90** and **92** may be tightened securely.

As previously noted, the curvature of the back portions **111** of the channels **108** is preferably not uniform, but is actually elliptical in shape. As a result, increased clamping forces for holding the casing together are developed when the channels are fully inserted. In addition, the clinch bend edges **110** have a radial center coincident with the center of the arcuate edges **112** of the tapered guides **108**. This insures continuous contact between the clinch bend edges **110** and the edges **112** so that the straight condition of the channels **109** is accurately imparted to the casing **12**.

FIRST MODIFICATION

Referring now to a modification of the invention in which similar parts will be identified by like numerals with the addition of a prime mark, FIGURES 18–23 show a modified version of the submersible pump described hereinbefore in which the major differences are (1) the diffusers are split in half and each half is molded integrally with the pump casing section, (2) the pump casing sections are joined throughout their length by channel members eliminating the need for transverse bolts and (3) modifications of the relief valve arrangement and an improved inlet and discharge flow configuration permit a shorter pump. The advantages arising from these and other modifications will be apparent from the description.

Referring now in detail to FIGURES 18–23, the pump casing **12'**, as shown by the exploded right half **26'** in FIG. 18, is shorter than the pump casing **12** (FIG. 2) by an amount X and is molded with diffuser halves **17'** formed integrally therewith. To permit mold withdrawal, the diffuser halves **17'** differ from the diffuser **17** described earlier in that only two cutwaters *a*, *b* (FIGURE 21) and volute return passages **46'** per pumping stage are permitted. In addition, the volute return passages **46'** are more of the side delivery type as depicted by the dotted lines in the upper two stages in FIGURE 18 in which the flow configuration diverges to the side from the cutwater *a*, widening out at the impeller intake **62'** of the next adjacent pumping stage. The chief advantage of forming the diffuser halves **17'** integrally with the casing sections is that a single impeller spindle S (FIG. 19) may be used without the diffusers being assembled around each impeller.

In accordance with this modification of the invention, the single impeller spindle S comprises an impeller shaft **18'** upon which a series of impeller **16'** are mounted and held as a permanent assembly by clinch nut **82'**. By single impeller spindle, the meaning is that the impeller **16'** and shaft **18'** constitute a single rotating body which permits the impellers **16'** to be center ground on the axis of shaft **18'**. As a result, the tolerances between the rotating and non-rotating parts may be held to within a few thousandths of an inch thus providing a freely running assembly with a minimum of leakage between pumping stages. In effect, closer tolerance means that a greater pressure head may be obtained with a fewer number of stages.

In the modification, better alignment of the stages is also obtained due to the fact that the channel members **109'** extend the full length of the pump thus eliminating the need for transverse bolts **90, 92** as shown in the previous embodiment (FIGURES 8 and 10). As shown in FIGURE 19, the channel members **109'** and tapered guides **108'** bridge across the pump intake screen thus holding the casing sections together securely in the regions of greatest stress where the impeller spindle S is coupled to the motor **20'**.

A further advantage in the modification is that the pump is shortened by the distance X while providing for the same number of stages. This is achieved primarily through a modification of the pump intake **13'**, outlet **14'**, and relief valve **103'**. Essentially the intake **13'** is shortened with the intake screen R molded directly in the casing halves.

At the outlet **14'**, the discharge configuration is through a vane head Q producing a more globular transition structure which also supports sleeve P. The relief valve **103'** is situated on sleeve P in close proximity to the last stage of the puump and is vertically slidable on guides M (FIG. 20) to a limited free open position permitted by stops N. An O-ring **104'** seals on a frustoconical continuous seat ring L which eliminates the possibility of slight leakage due to a discontinuity at the pump joint. The relief valve **103'** is also less susceptible to cocking on the seat L due to the function of guides M. The relief valve seals under the influence of the static pressure head acting on it from above. O-ring **105'** resiliently holds the seat L and seals at the joint between the casing **12'** and a relief valve bowl B. Return flow is trapped by O-rings **104', 105'** sealing on the continuous seat L.

To permit the use of a single manufacturing mold for making both half sections of the pump casing, the relief valve bowl B is formed separately and joined to the pump casing by the use of cement or by twist-lock lug-type fasteners **103***a*. Threads are thus eliminated which would require separate molds for each half **26'**.

SECOND MODIFICATION

Where a more perfect volute passage **46'** is required than can be obtained with the diffuser halves **17'** formed integrally with the pump casing, a further modification is shown in FIGURES 24–26. In this modification similar parts will be identified by the same numeral with a letter subscript. In FIGURE 24 the pump casing **26***a* is molded with integral diffuser partial half sections **17***a* to provide a more straight line withdrawal path for the molds. The partial half sections **17***a*, however, remain connected to the casing wall for substantial support and in this modification, the volute configuration **46***a* (FIG. 25) is, in part defined by removable diffuser inserts **120** positioned in the first and third quadrants of each pump stage.

THIRD MODIFICATION

As an alternative, a further modification is shown in FIGURES 27–30 in which minimum width diffuser partial half section **17***b* are integral only at the center portion of each pump casing section **26***b* providing even greater freedom of mold withdrawal. The form of the volute passage **46***b* is not compromised due to the use of full sized inserts **120'** in each pumping stage. The inserts **120'** may be held in place relative to the diffuser section **17***b* by means of tongue and groove joints **122'**.

FOURTH MODIFICATION

Turning now to FIGURES 31–34, another modification is shown in which diffuser half sections **17***c* fit into pockets **28'** of each right and left hand section **24', 26'**, of the pump casing (FIG. 32) so that when the two casing sections are brought together (FIG. 31) the diffuser half sections **17***c* mate at the parting plane through the impeller spindle axis. The diffuser half sections **17***b* have the multiple volute passages **46***c* of the first embodiment (FIGURE 9) to provide maximum flow. Prior to insert-

ing each diffuser half section 17c in its pocket 28', an epoxy cement E is spread on the radial outer surfaces 45', of the diffuser vanes 44'.

The right and left hand pump casing sections 24', 26', are assembled around the impeller spindle S as shown in FIGURE 33. Assembly of the valve spindle P, relief valve 103' and valve bowl B may then take place. While the cement E is still wet the next step is to drive on the channel members 109' which takes any warpage out of the casing sections 24', 26' as discussed above, and aligns the diffuser half section 17c with the impeller spindle axis. Just prior to the setting up of the cement E, the impeller spindle S is given a few turns to assure freedom of rotating and nonrotating parts.

Where the casing half sections 24', 26' are molded out of much higher modulus of elasticity material and are therefore less flexible and less subject to warpage, a modification of the above assembly method may be used to achieve even closer mechanical alignment. In this method slightly larger than half section diffusers are glued in place and accurately prealigned by a full bearing-bore-diameter mandrel (not shown) until the adhesive has set. Assembly may then proceed as referred to above.

The joint between the right and left hand casing sections 24', 26' may be sealed in the manner disclosed in the first embodiment in FIGURE 3, for example, where an elastomeric cord 96 is used, however, since this requires that a groove 98 be formed in one of the casing sections to receive the elastomeric cord 96, a lap sanded joint is precluded. By lap sanded the meaning is that the two surfaces are worked with or without abrasives until a smooth surface-to-surface fit is achieved. Thus, as an alternative sealing arrangement and to eliminate sealing by means of an elastomeric cord, the mating surfaces of each casing section 24', 26' can be lap sanded and brought flush together. A polyester sealant may be applied if desired.

While the invention has been described with reference to several embodiments, any one of which may be used to practice the invention, obviously modifications and alterations other than those suggested will occur to those skilled in the art upon reading this specification and it is my intention to include such modifications and alterations insofar as they come within the scope of the appended claims except insofar as limited by the prior art.

Having thus described my invention I claim:

1. In a centrifugal pump having a series of pumping stages, the improvement comprising
   - a molded casing formed of at least two longitudinally mating sections and
   - complementary means including molded structure on each section on opposite sides of a mutual parting surface, which means when brought together, defining a longitudinal extending cooperating structure for securing the casing sections together and longitudinal extending
   - faster means having resistance to longitudinal deflection greater than said molded structure longitudinally engageable with said cooperating structure whereby said casing sections are secured in axial alignment with said pumping stages.

2. The improvement according to claim 1 including a series of impellers arranged on a common shaft as a single rotating spindle assembly and said casing sections being brought together to define said pumping stages around each impeller.

3. The improvement according to claim 2 wherein diffuser structure of each pumping stage is molded in each casing section and is brought together in mating complementary fashion closely circumjacent the rotatable impeller spindle assembly when assembling said sections.

4. The improvement according to claim 3 wherein the diffuser structure is separable in each casing section at least in part.

5. The improvement according to claim 4 wherein the separable diffuser structure is an insert defining, in part, a volute return passageway of the diffuser structure.

6. In combination with a centrifugal pump of the type having a plurality of linearly stacked pumping units each of which includes
   - an impeller member having an intake eye at its axis connected to radially outwardly extending discharge passages therein and
   - a diffusion member having radially inwardly curved vanes forming a pumping chamber around said impeller member and
   - drive means interconnecting each impeller member for transmitting a torsional driving force from one to the other,
   - a casing adapted to be assembled in surrounding relationship to said pumping units being formed of at least two longitudinal sections fitted together in mating complementary fashion on opposite sides of a mutual parting plane and each section being formed of a material having a relatively low modulus of elasticity
   - securing means for joining said sections in assembled fashion comprising a fastener member considerably longer than it is wide movable longitudinally relative to said mutual parting plane during assembly of said casing sections and being formed of a material having a higher modulus of elasticity than said casing sections so as to resist bending in a longitudinal direction during assembly whereby the linearly stacked pumping units are simultaneously aligned on a common axis with the casing sections.

7. The combination as set forth in claim 6 wherein each said longitudinal section includes a plurality of radially opening pockets defined by axially spaced segments having aligned arcuate openings circumjacent the intake eye of each impeller member, said pockets independently supporting each diffusion member in spacial relationship to each impeller member and the adjacent diffusion members.

8. The combination as set forth in claim 7 wherein each diffusion member is configured so as to nest in a pocket and defines with said segments a pumping chamber around each impeller member.

9. The combination as set forth in claim 7 wherein each impeller member has an axially extending hub defining its intake eye and said arcuate openings closely surround said hub to provide a fluid seal between said pumping chambers.

10. The combination as set forth in claim 9 and in addition comprising radially adustable sealing nibs mounted in said arcuate openings including an annular portion in sealing engagement with said hub and radially spaced from said openings.

11. The combination as set forth in claim 6 and in addition sealing means positioned between the mating surfaces of said sections and extending longitudinally along the outer boundaries of said pumping units.

12. In a submersible pump of the centrifugal type having a plurality of linearly stacked pumping units each of which includes
   - an impeller member having an intake eye at its axis connected to radially outwardly extending discharge passages therein and
   - a diffusion member having radially inwardly curved vanes forming a pumping chamber around said impeller member
   - drive means interconnecting each impeller member for transmitting a torsional driving force from one to the other, the improvement comprising
   - a casing adapted to be assembled in surrounding relationship to said pumping units being formed of right and left hand longitudinally extending molded sections fitted together in mating complementary fashion on opposite sides of a mutual parting plane, each said section having a plurality of radially opening pockets defined by axially spaced segments having

aligned arcuate openings circumjacent the intake eye of each impeller member, each diffusion member being shaped so as to nest in a pocket and define with said segments a pumping chamber around each impeller member and

securing means for joining said sections in assembled fashion.

13. The improvement as set forth in claim **12** and in addition sealing means positioned between the mating surfaces of said sections and extending longitudinally along the outer boundaries of said pumping units.

14. The improvement as set forth in claim **13** wherein said sealing means include radially extending portions at intervals therealong positioned between the mating surfaces of said segments for sealing between said pumping chambers.

15. The improvement as set forth in claim **13** wherein said sealing means include grooves formed in the mating face of one of said sections extending longitudinally along the outer boundaries of said pumping units and elastomeric cords received in said grooves sealably engaging the mating surface of said other section upon assembly.

16. The improvement as set forth in claim **15** wherein said elastomeric cords and grooves include means for sealing against the passage of fluid longitudinally within said grooves.

17. A two piece casing for a multistage submersible pump have a plurality of linearly stacked pumping elements each of which includes a diffuser and an associated impeller having an eye at its axis, said casing comprising,

right and left hand elongated casing sections, each molded as a separate unit and having axially spaced segments extending radially inwardly between adjacent pumping elements terminating in arcuate surfaces circumjacent the intake eye of each impeller, said sections being fitted together in mating complementary fashion on opposite sides of a common parting plane with said arcuate surfaces defining a series of bores adapted to be in substantial alignment with the impeller axes,

guide means on opposite sides of the casing at the joint thereof extending longitudinally on opposite sides of the common parting plane and

fastener means having a linear portion which is rigid in a longitudinal direction and flexible in a transverse direction received on said guide means for simultaneously joining said sections and aligning said bores.

18. A two piece casing as set forth in claim **17** wherein said guide means comprises,

linearly extending grooves, each inclined outwardly with respect to the parting plane and said linear portion of the faster means having longitudinally extending edges received in said grooves inclined in the same direction thereas.

19. A two piece casing as set forth in claim **18** wherein said grooves are defined by linearly extending arcuate portions formed in said casing sections facing away from the parting plane, the edges of said linear portion being turned inwardly beneath said arcuate portion into said grooves.

20. A two piece casing as set forth in claim **19** wherein said fastener means linear portion is bowed outwardly in a transverse direction to provide a clamping force acting through said arcuate portions.

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