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Sullivan et al.

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(54) **CENTRIFUGAL PUMPS, CASINGS AND VEHICLES USING THE SAME**

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F04D 29/42 (2006.01)

(52) **U.S. Cl.**
CPC ***F04D 29/428*** (2013.01); ***F04D 29/4293*** (2013.01)

(58) **Field of Classification Search**
CPC F04D 29/428; F04D 29/426; F04D 29/126; F04D 29/4293; F04D 1/006; F04D 13/14
See application file for complete search history.

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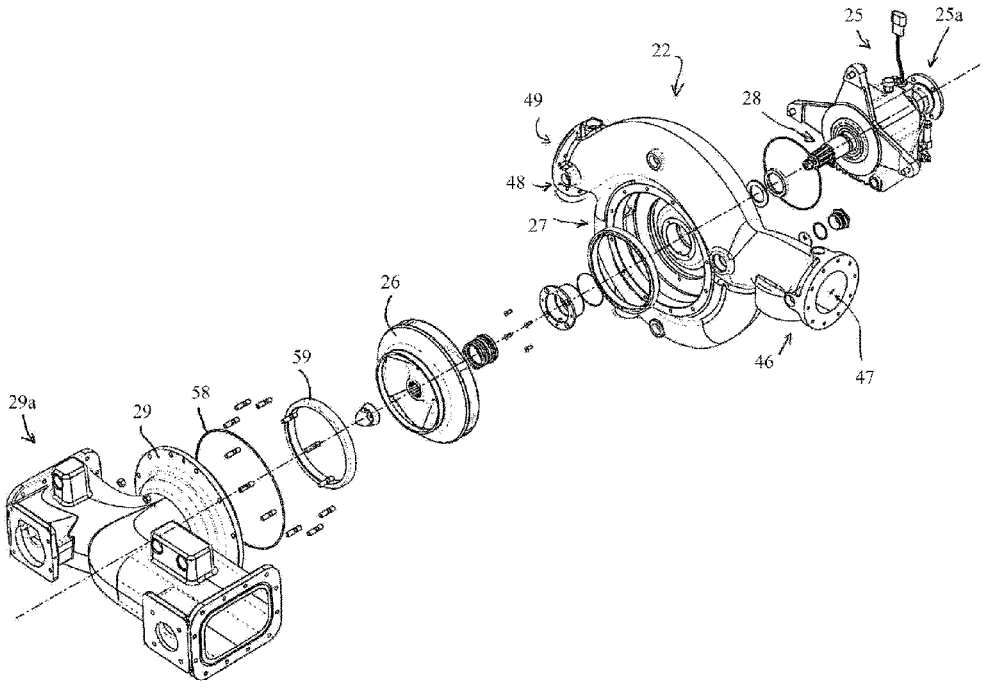
(57) **ABSTRACT**

Single suction centrifugal pumps, pump casings, pump systems and vehicles for using pumps which include a single piece casing having a first cut-water fluid flow path, a first discharge nozzle, and a second discharge nozzle, the first cut-water fluid flow path communicating with the first discharge nozzle and the second discharge nozzle and the nozzles being situated at opposing ends of the pump such that center outputs of the nozzles are offset from a horizontal centerline of the casing and the first nozzle is positioned a greater distance from a lower casing wall of the pump as compared to the second nozzle so that the casing may be connected to output piping for both sides of the vehicle and at a low profile within the vehicle.

23 Claims, 9 Drawing Sheets



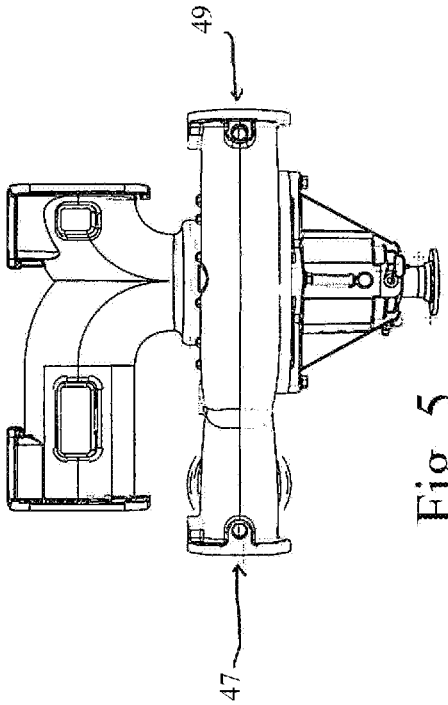


Fig. 5

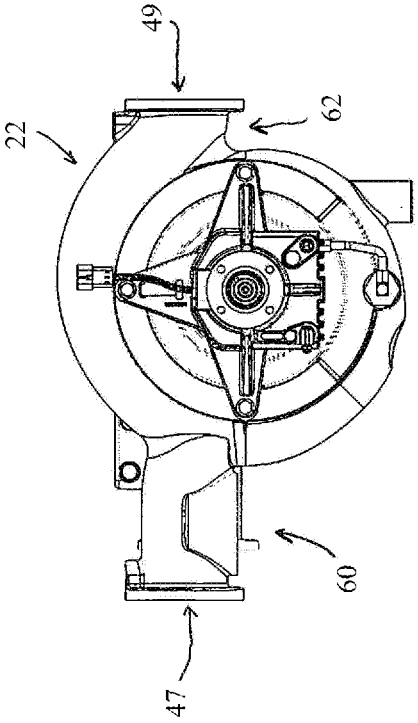


Fig. 4

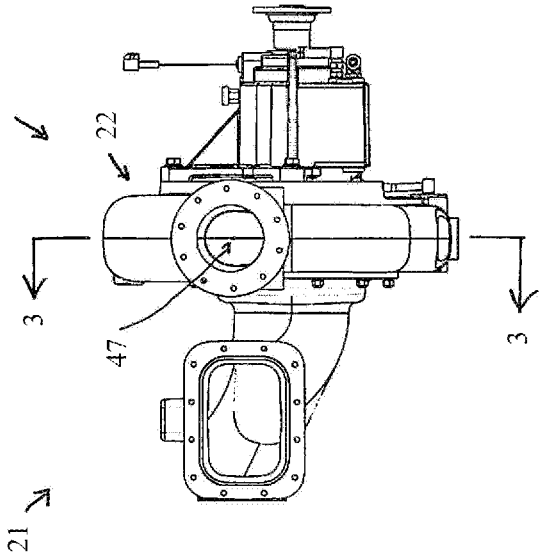


Fig. 1

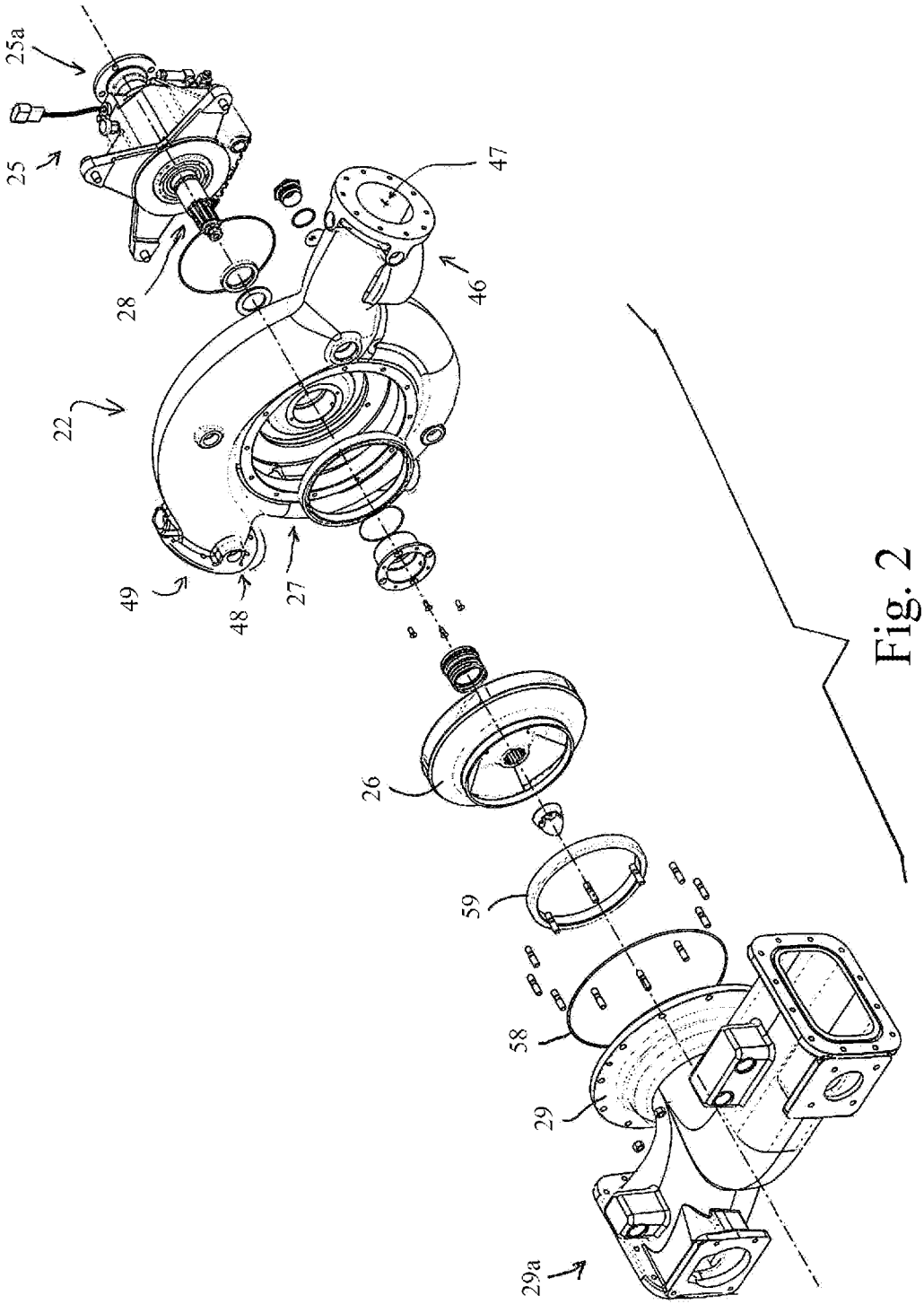


Fig. 2

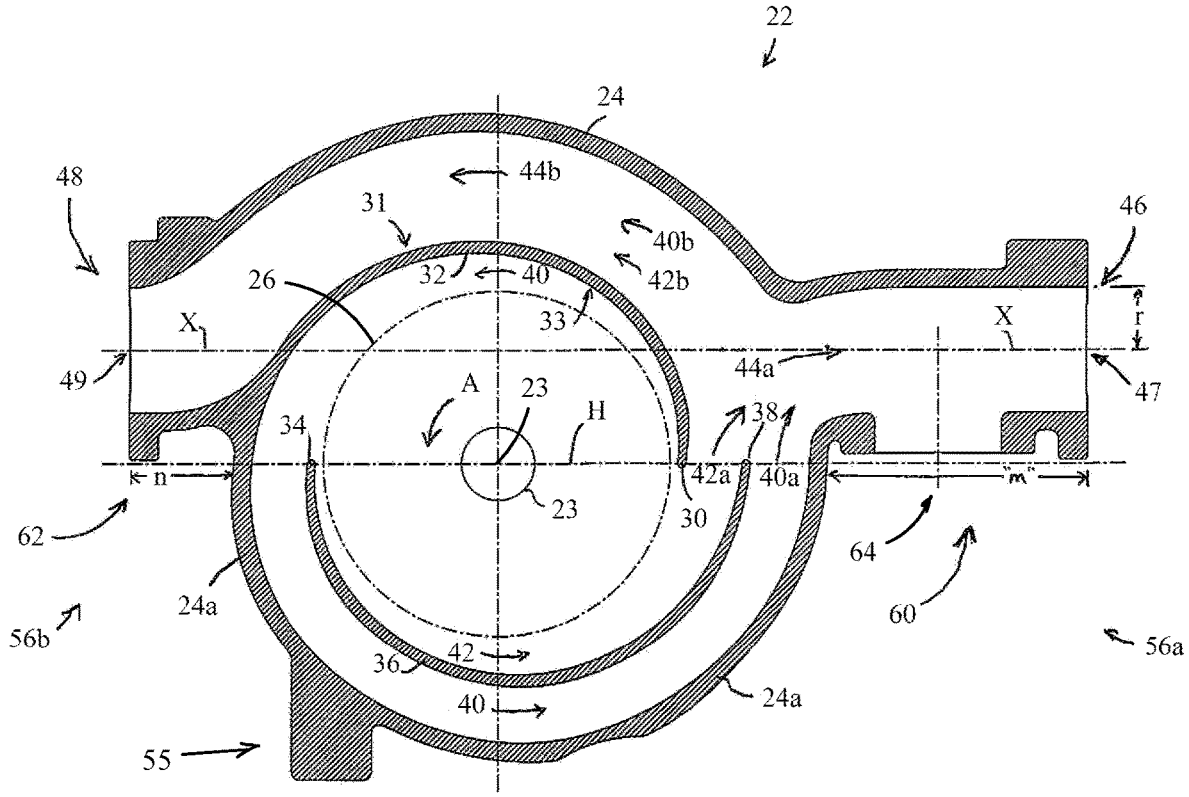

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Fig. 3

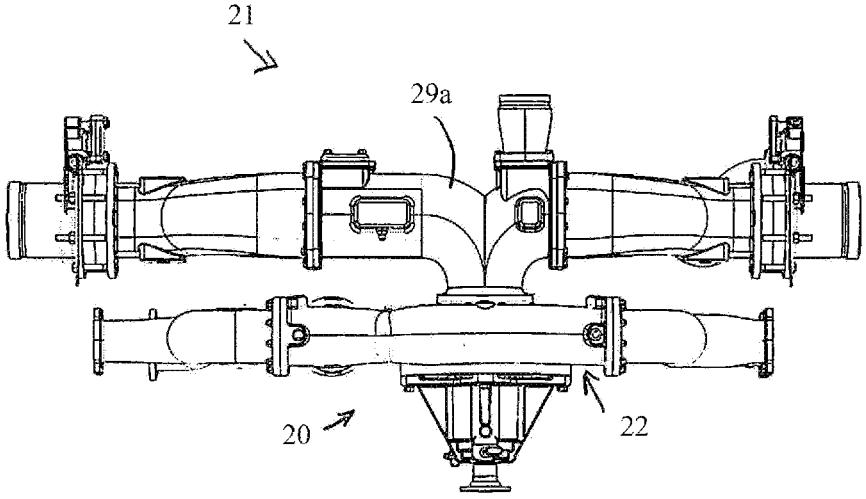

Fig. 6

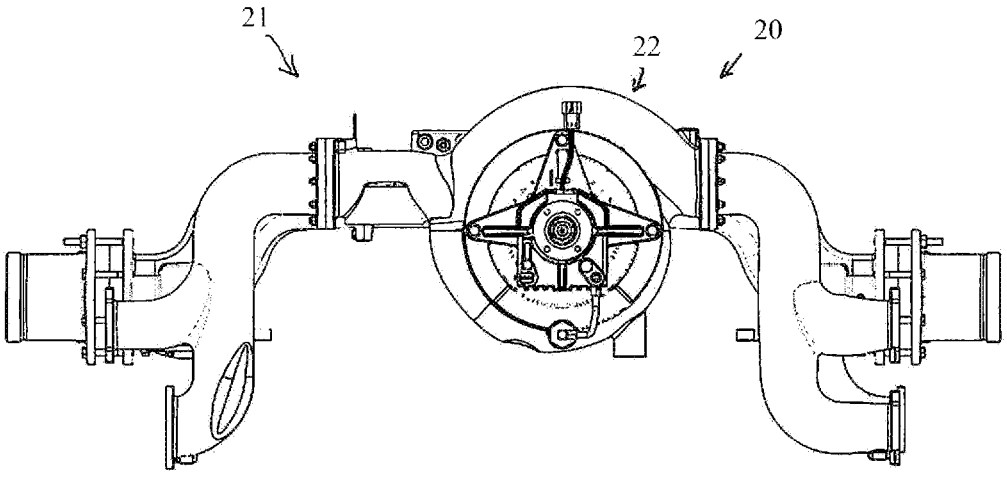

Fig. 7

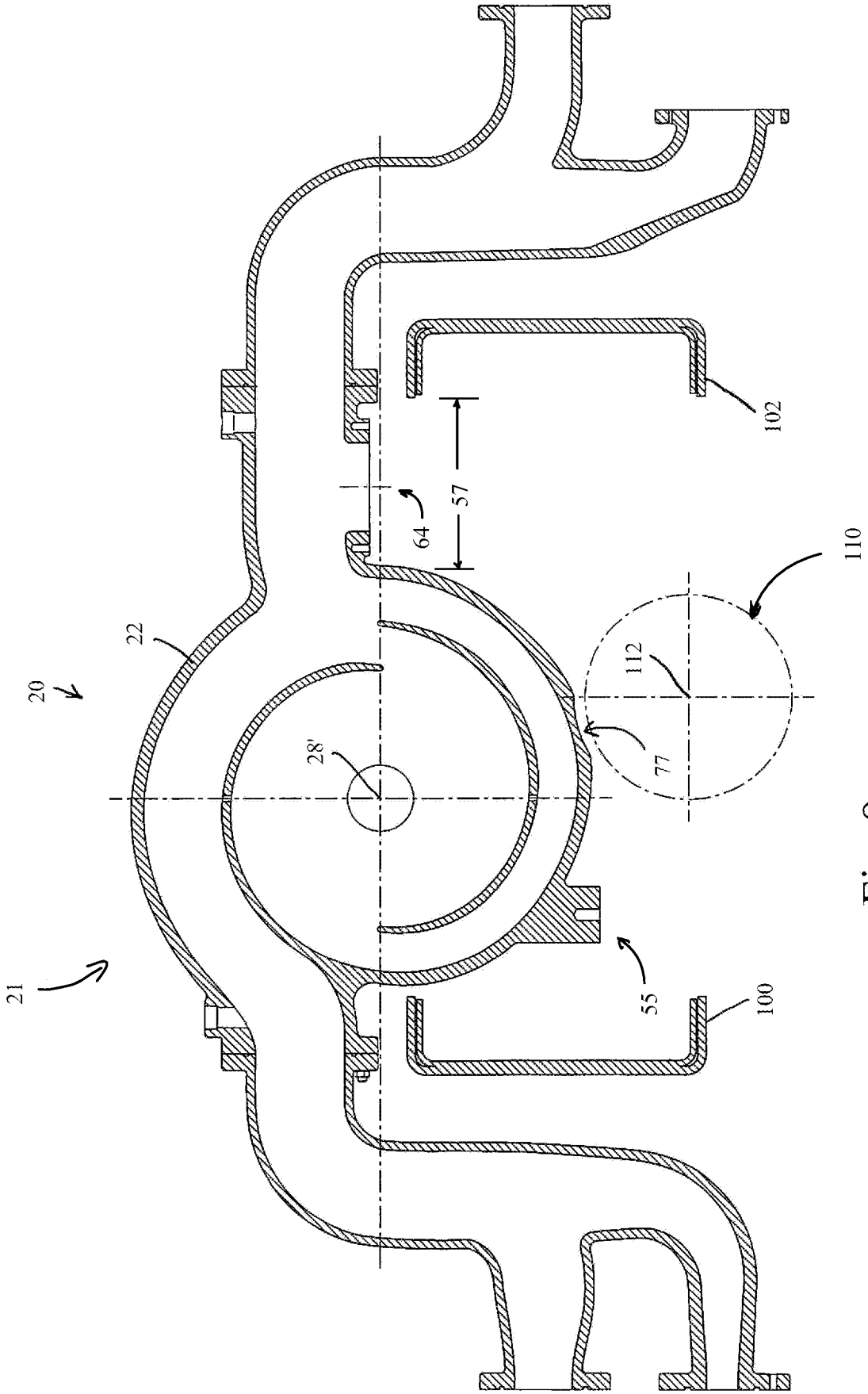

Fig. 8

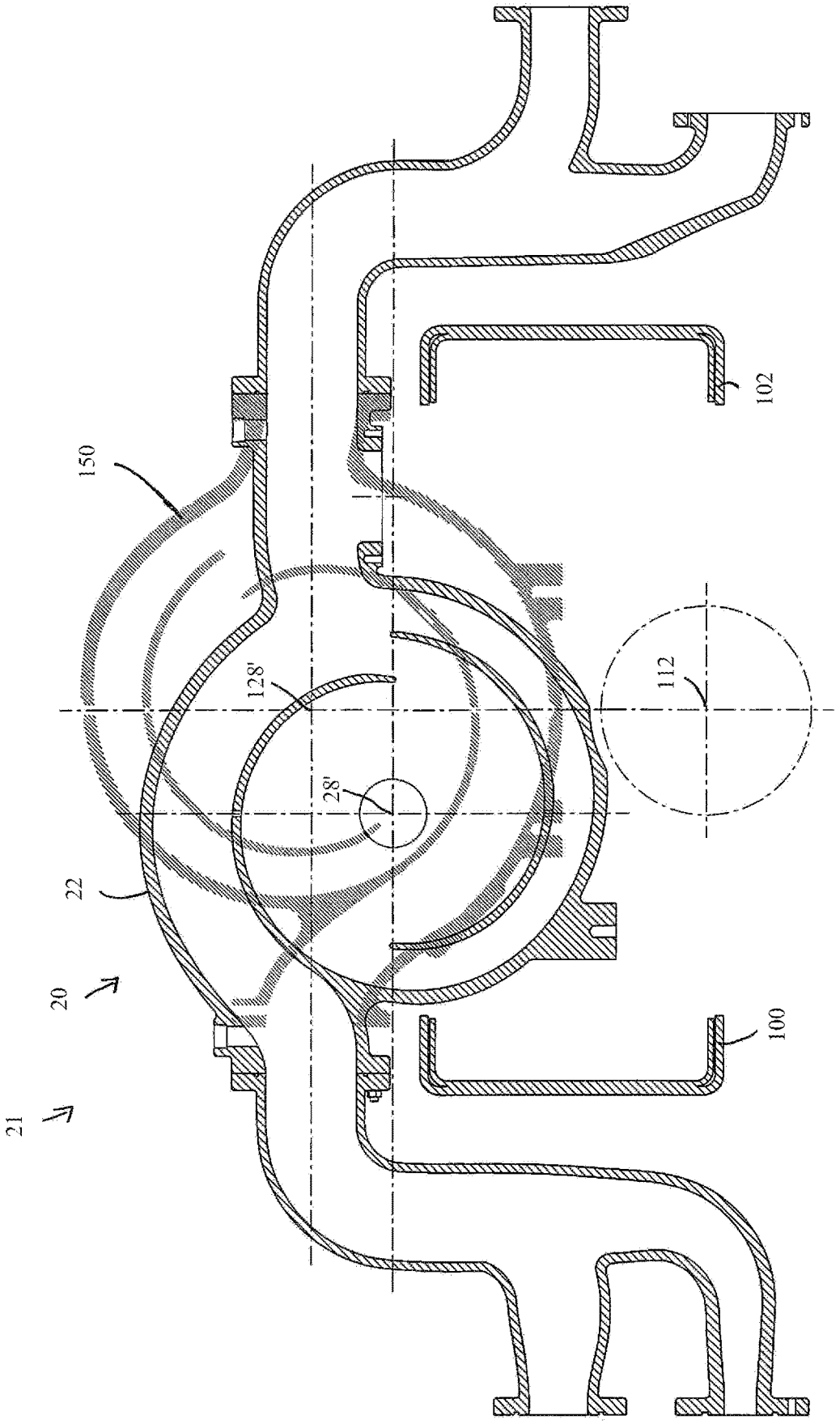

Fig. 9

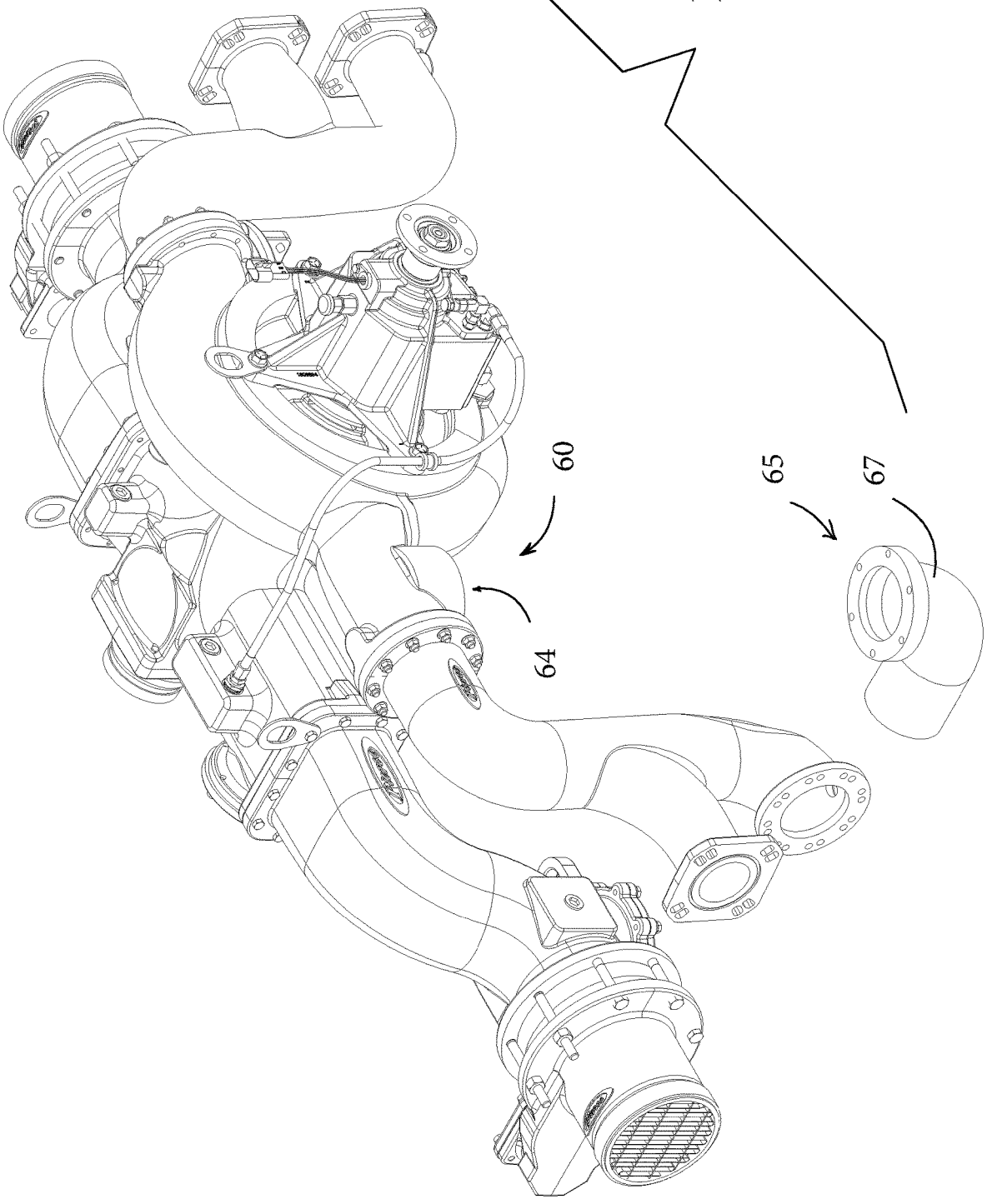

Fig. 10

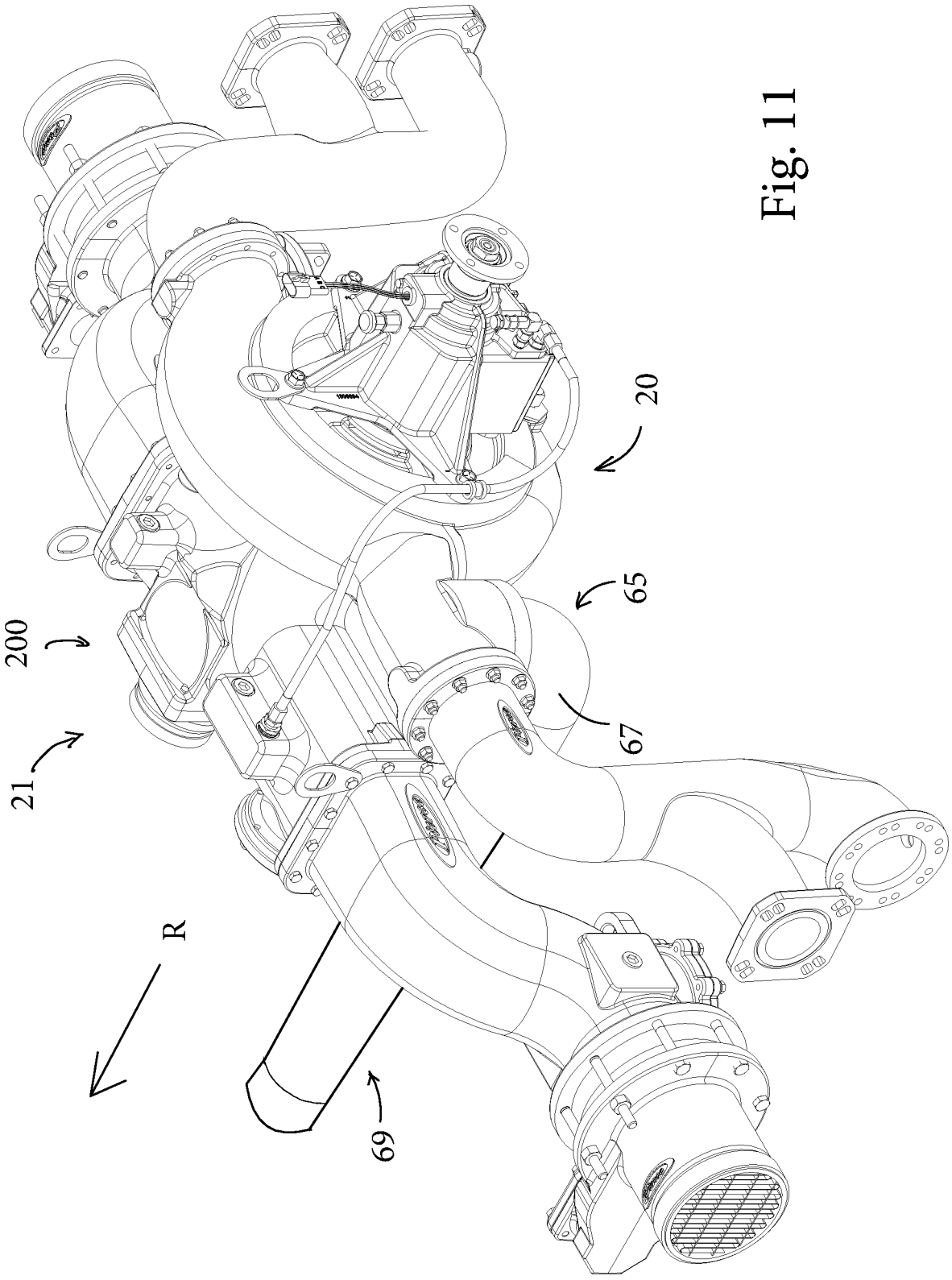

Fig. 11

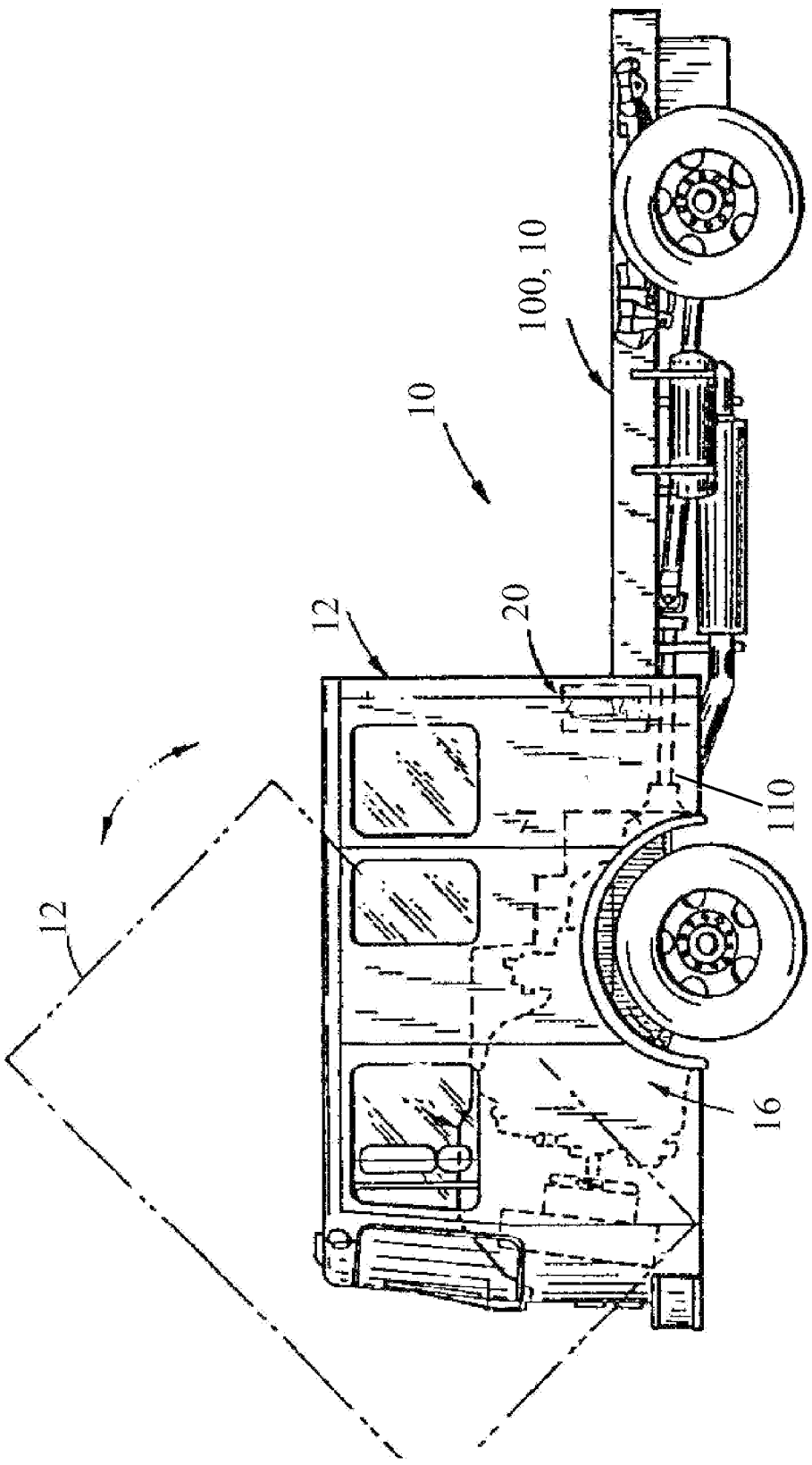

Fig. 12

CENTRIFUGAL PUMPS, CASINGS AND VEHICLES USING THE SAME

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of and priority to, U.S. Provisional Patent Application Ser. No. 63/228,434 filed Aug. 2, 2021 for CENTRIFUGAL PUMPS, CASINGS AND SYSTEMS, incorporated herein by reference in its entirety for continuity of disclosure.

BACKGROUND OF THE INVENTION

Centrifugal pumps have been commonplace for ages and have been used in numerous applications. A relatively recent development has been a powerful firefighting type of pump having a low profile while still allowing discharge at opposite ends of the pump, such as that found in Seitz et al. U.S. Pat. No. 7,517,186. While this and other examples have benefits, there is room for improvement.

SUMMARY OF THE INVENTION

In one aspect the invention pertains to a single piece pump casing which allows the pump to be placed in a relatively low position upon a chassis of a firefighting vehicle to allow improved storage, function and spacing under a cab portion of the vehicle and functionality of the vehicle while also allowing discharge flow from the pump at opposite sides of the vehicle. The pump casing has a first cut-water fluid flow path, a second cut-water fluid flow path, a first joint-water path and a second joint-water path, the first cut-water fluid flow path and the second cut-water fluid flow path communicating with the first joint-water path and the second joint-water path, the first joint-water path communicating with a first discharge nozzle and the second joint-water path communicating with a second discharge nozzle, the first discharge nozzle and the second discharge nozzle situated substantially at opposing ends of the casing, the first discharge nozzle defining a first center output point and the second discharge nozzle defining a second center output point, the first center output point and the second center output point defining a line offset from a horizontal center point of the casing. In aspects, the design allows for the pump to be positioned at a relatively low profile upon a chassis of a vehicle, allowing for space savings and flexible positioning, and allowing outputs to either or both sides of a vehicle. In further aspects a centrifugal pump includes an impeller contained within the casing.

In a further aspect the invention includes a single-piece casing for a single suction centrifugal pump where a first discharge outlet extends a greater distance from the lower casing wall compared to a second discharge outlet so that the casing may connect with piping and where the discharge outlets are offset above a horizontal centerline of the casing so the casing may be positioned low within a vehicle while avoiding contact with a main drive shaft of the vehicle. In aspects, the first discharge outlet is at a discharge arm which extends a greater distance from the lower casing compared to a discharge arm for the second discharge outlet and includes a third discharge opening to discharge fluid in a downward direction from the casing which allows for flexibility and space savings in configuration of discharge from the pump. In further aspects a centrifugal pump includes an impeller contained within the casing.

A further aspect includes a vehicle having a pump with features of discharge outlets offset from a horizontal centerline of a single piece casing of the pump while also having an extended discharge outlet so that the single suction centrifugal pump may be offset horizontally and in close spaced relationship with a main drive shaft of the vehicle. The pump may be offset horizontally and vertically to accommodate a lower profile, and which has an added benefit of also accommodating a downward discharge from the pump.

These and other aspects are more fully presented herein.

The above partial summary of the present invention is not intended to describe each illustrated embodiment, aspect, or every implementation of the present invention. The figures and detailed description that follow more particularly exemplify these embodiments and further aspects of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a side view of a pump system, pump, pump casing and related components in accordance with one aspect of the invention.

FIG. **2** is an exploded perspective view of FIG. **1**.

FIG. **3** is a section view taken along line **3-3** of FIG. **1** with portions removed for clarity.

FIG. **4** is a rear view of FIG. **1**.

FIG. **5** is a top view of FIG. **1**.

FIG. **6** is a top view of FIG. **1** with additional components in accordance with aspects of the invention.

FIG. **7** is a rear view of FIG. **1** with additional components in accordance with aspects of the invention.

FIG. **8** is a section view of the pump of FIG. **1** in accordance with further aspects of the invention and with portions removed for clarity.

FIG. **9** is a section view of the pump of FIG. **1** in accordance with further aspects of the invention and with portions removed for clarity and in comparison to an alternative design.

FIG. **10** is an exploded perspective view of the pump system, pump, and pump casing of FIG. **1** in accordance with further aspects of the invention.

FIG. **11** is a perspective view of the pump system, pump, and pump casing of FIG. **10**.

FIG. **12** is a side elevation view of a pump system and vehicle in accordance with further aspects of the present invention.

While the invention is amenable to various modifications and alternative forms, specifics thereof have been shown by way of example in the drawings and will be described in detail. It should be understood, however, that the intention is not necessarily to limit the invention to the particular embodiments or aspects described. On the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention and as defined by the appended claims.

DETAILED DESCRIPTION OF THE INVENTION

Referring to FIGS. **1-12**, casings, pumps, systems and vehicles are presented in various aspects of the invention. A pump according to the present invention is generally depicted with reference to numeral **20**. In one aspect, pump **20** includes a casing **22** which in one aspect is a single piece metal casting. The casing **22** may be made of metals including iron or aluminum or other metals or alloys. Casing

22 includes an outer casing wall 24. Casing wall 24 in one aspect is curved or generally circular, and defines an impeller cavity 27 in which is positioned an impeller 26. Impeller drive shaft 28 runs through center opening 23 and cavity 27 and secures impeller 26 to drive the impeller 26. A drive box 25 houses the drive shaft 28 and is capable of housing bearings and seals and/or gears and lubricant and is driven by yoke 25*a* connected to a drive source to power pump 20. A suction head 29 overlays impeller 26. Fluid is introduced through head 29 (and other suction plumbing 29*a*) and into impeller 26 for subsequent discharge through discharge nozzles 46, 48. The fluid is used for firefighting purposes, for instance. Pump 20 further includes O rings 58, seal rings 59 and other common pump hardware as generally shown in FIG. 2.

With particular reference to FIG. 3, casing 20 includes a first cut-water wall 32 having a first cut-water 30 disposed at an end thereof. First cut-water wall 30 includes an impeller side 33 having a generally concave configuration, and a casing side 31 having a generally convex configuration. First cut-water wall 32 in part defines first cut-water fluid flow path 40. As fluid exits spinning impeller 26 the fluid travels along first cut-water fluid flow path 40. Subsequent flow of the fluid within path 40 is described further below.

Casing 22 includes second cut-water wall 36 having a second cut-water 34 disposed at one end thereof and a trailing end 38 disposed at another end thereof. Second cut-water wall 36 in part defines second cut-water fluid flow path 42. As fluid exits spinning impeller 26 the fluid travels along second cut-water fluid flow path 42. Subsequent flow of the fluid within path 42 is described further below.

First cut-water fluid flow path 40 and second cut-water fluid flow path 42 communicate to join into a first joint water path 44*a* and a second joint water path 44*b*. Casing 22 further includes a first discharge nozzle 46 and a second discharge nozzle 48. Both first path 40 and second path 42 communicate with first discharge nozzle 46 and second discharge nozzle 48. Both first joint water path 44*a* and second joint water path 44*b* communicate with first discharge nozzle 46 and second discharge nozzle 48. First discharge nozzle 46 and second discharge nozzle 48 are situated at or substantially at opposing ends 56*a*, 56*b* of casing 22. In further aspects discharge nozzles 46, 48 have a center output 47, 49 (particularly, first center output point 47 and second center output point 49) which define a center point of the respective nozzles. A horizontal centerline H aligns with a horizontal center of impeller drive shaft 28. The center output points 47, 49 define a line "X" which line X is offset from horizontal centerline H. Alignment of nozzles 46, 48 accommodates for efficient dual outlets to be extended to both sides of an emergency vehicle. An emergency response vehicle may be a fire truck such as, but not limited to, the vehicle 10 shown in FIG. 12. Vehicle 10 may include a fire truck which may include a tilt-forward cab 12 as well as various rear panels and compartments, a holding tank or tanks, discharge panels and various other components which are common to firetrucks or other emergency response vehicles. The invention is not limited to the vehicle 10 as shown, and may be include, and be used with, other emergency response vehicles and fire trucks or fire apparatus. Alignment of nozzles 46, 48 about the offset line X accommodates a lower profile pump 20 for space savings as referenced herein.

In one aspect nozzles 46, 48 have a terminal flow path radius "r" (i.e., a flow path radius at a terminal end of nozzle 46). In one aspect the radius "r" is 2 inches. In other aspects the radius "r" may be less than or greater than 2 inches. In further aspects, nozzles 46, 48 have a terminal flow path which is not necessarily circular in cross-section, and may have a rectangular, oval or other cross-section configuration. In aspects, line X (and corresponding output points 47, 48 of nozzles 46, 48) is offset from centerline H by a measure of at least "r" length. Having such offset of "r" dimension provides a feature for positioning casing 22 lower upon a vehicle, which results in increased spaced savings or space utilization of vehicle areas above and/or adjacent casing 22. Providing a greater offset of line X from horizontal centerline H allows for a lower placement of casing 22 compared to applications which do not have such configuration. In one aspect, casing 22 defines a center opening 23 which passes through the casing 22. The center opening 23 has a radius r' with a center point 23' of the center opening 23 defining a horizontal center point which lies along centerline H. In one aspect, line X is offset from centerline H by a measure of at least r' length. In a further aspect, line X is offset from centerline H by about 3 to 4 inches. In aspects line X is offset from centerline H by about 3.5 inches to assure a substantial benefit in space savings while still maintaining clearance from other components of the vehicle. Such offset allows casing 22 and pump 20 to be set lower within a vehicle. In one aspect, line X is offset from centerline H by over 3.6 inches, resulting in a corresponding lowering of casing 22 as compared to prior applications. Such lowering is a substantial lowering and increase in space utilization for a vehicle into which pump 20 is positioned. In aspect such substantial lowering accommodates more space within a cab portion of the vehicle which is positioned above the pump. Use of the offset and lowering of the profile position of the pump minimizes or eliminates the need to have a projection into the cab area to accommodate for pump clearance. This lessens or eliminates a "bump" which might otherwise be positioned at the floor of the cab.

In a further aspect casing 22 includes a foot 55 used to set upon or connect to a flange which in one instance is connected to rail 100. Connection of nozzles 46, 48 to discharge piping and connection of foot 55 to rail 100 provides a secure three-point contact to secure the pump casing 20. In one aspect foot 55 is configured with a planar lower surface such that when the planar lower surface is oriented horizontally, line X is also oriented horizontally or substantially horizontally. Plastic or rubber washers or bushings may be positioned at the respective connections of the casing 20.

In operation, fluid from path 40 continues to circulate through casing 22. Particularly, a portion of fluid travels along first cut-water fluid flow path 40*a* to exit at discharge nozzle 46, and a portion travels, or may travel, along first cut-water fluid flow path 40*b* to exit at discharge nozzle 48. Likewise, fluid from path 42 continues to circulate through casing 22. Particularly, a portion of fluid travels along second cut-water fluid flow path 42*a* to exit at discharge nozzle 46, and a portion travels, or may travel, along second cut-water fluid flow path 40*b* to exit at discharge nozzle 48. Joint water path 44*a* includes both first path 40*a* and second path 42*a*, and joint water path 44*b* includes both first path 40*b* and second path 42*b*. It may be appreciated that at least a portion of path 40 and at least a portion of path 42 define path 40*b* to create joint water path 44*b*. As such, both the impeller side 33 and casing side 31 of wall 32 in part define first cut-water fluid flow path 40. First cut-water wall 32 defines in part flow path 40 and defines in part second joint-water path 44*b*. Having joint-water path 44*b* allows pump 20 to efficiently deliver fluid to ends 56*a*, 56*b* in a

low-profile arrangement. While other pump designs may deliver fluid to both ends of a vehicle, joint-water path **44***b* contained entirely within casing **22** achieves an efficient low-profile arrangement. Having outputs **47**, **49** of discharge nozzles **46**, **48** arranged along a line X which is offset upward from a center point **23'** of the center opening **23** allows for a lower profile configuration. As a single casting, casing **22** also accommodates for efficient manufacture and assembly of pump **20** and positioning and connecting within a vehicle. In one aspect pump **20** includes a single impeller **26** (one and only one impeller in such aspect) and thus a single suction for efficient use and plumbing. In aspects, either of nozzles **46**, **48** may be closed to allow or force liquid to flow to the other open nozzle to allow a user to select which side (or both sides) of the pump (or fire truck) for discharge of liquid.

joint-water path **44***b* allows for efficient operation of pump **20** especially where an operator desires to vary the fluid output through respective discharge nozzles **46**, **48**. For instance, a user may close off (or partially close) fluid flow through nozzle **46** without disrupting radial balance of impeller **26**, since the entire output from flow path **40** and flow path **42** would then be directed through nozzle **48**. Likewise, if a user were to close fluid flow through nozzle **48** (or partially close the flow), the output from flow path **40** and flow path **42** would then be directed through nozzle **46**. If respective nozzles **46**, **48** were to be otherwise fed directly from respective flow paths without the combining of fluid in a joint water path, radial forces could disrupt the balance of impeller **26** impacting performance and pump life. Having water paths **40** and **44***b* contained within a single casing further allows for a low profile which would otherwise require additional or external plumbing about the pump casing to supply opposite sides of the vehicle. Other outlets or nozzles may also be provided on the casing **22**, including at discharge arm **60**.

In further aspects of operation, impeller **26** spins in a first direction represented by arrow A. While arrow A depicts a counterclockwise direction (when viewed opposite a suction side of the casing **20**), it may be appreciated that pump **20** may be designed for impeller **26** to spin in a clockwise direction. The first-direction spinning impeller **26** releases fluid (such as water or foam for fighting fires) into paths **40**, **42**. In aspects, pump **20** includes means for continuing transporting fluid in the first direction. Means for transporting is represented by reference numeral **44***b*, which may include means such as second joint-water path **44***b*, first cut-water fluid flow path **40***b*, and second cut-water fluid flow path **42***b*. In one aspect, means **44***b* has a generally arch-like configuration, or lies generally along a radius or modified radius. In one aspect means for transporting includes a joint-water path spanning substantially from a first end **56***a* to a second end **56***b* of the pump **20**. In one aspect means **44***b* spans from adjacent trailing edge **38** to first discharge outlet **46** and continues to span to second discharge outlet **48**. In one aspect means for continuing transporting is contained entirely within single piece casing **22**. Providing a simple single, non-split, casing design in which all water paths are located (including means for continuing transportation, such as path **44***b* which curves to either side of the casing) allows for ease of manufacture, assembly, hook-up, and use. It may be appreciated that connections to the nozzles of the pump may likewise be confined to a modest space to achieve an overall low-profile solution.

For pump **20** to accommodate dual output at discharge nozzles **46**, **48**, pump **20** in one aspect includes joint-water path **44***b* which spans at least 45 degrees, and in some aspects at least 135 degrees, and even at least 180 degrees or greater than 180 degrees in further aspects. Having joint-water path **44***b* span at least 135 degrees accommodates for joint-water path **44***b* to wrap back or span to a significant degree, and accommodates a lower profile casing (and/or elimination of external conduit to supply fluid to opposite sides of the firetruck) and provides meaningful spacing of respective outputs or nozzles **46**, **48**. The joint-water path **44***b* spans in a curving manner along an arch generally defined by an arch line spanning from trailing edge **38** to discharge outlet **48**. In one aspect arch line is a curving centerline of joint-water path **44***b*. As shown in FIG. **3**, joint-water path **44***b* may commence adjacent trailing edge **38** and follow generally circumferentially in direction A to discharge nozzle **48**. In one aspect trailing edge **38** aligns substantially along reference line H. In one aspect cut-water **30** also substantially aligns along reference line H. In other aspects cut-water **30** and **34** are positioned in a spaced relation with respect to line H. Reference line H is a horizontal centerline running through impeller shaft **28**. In one aspect joint-water path **44***b* spans approximately 180 degrees from trailing edge **38** to reference line H. In one aspect joint-water path **44***b* spans greater than 180 degrees to accommodate configuration of discharge nozzles being positioned at substantially opposite ends **56***a*, **56***b*. In one aspect, due to the substantial offset of reference line X (defined by center points **47**, **49**), joint water path **44***b* avoids spanning across horizontal centerline H. In aspect joint water path **44***b* spans less than 180 degrees. In aspects, all liquid output from nozzles **46**, **48** occurs above horizontal centerline H.

In further aspects with respect to FIG. **3** first cut-water fluid flow path **40** is defined in part by lower casing wall **24***a*. The first discharge nozzle **46** is positioned at a first discharge arm **60** which extends outward from the lower casing wall **24***a*. Likewise, second discharge nozzle **48** is positioned at a second discharge arm **62** which extends outward from the lower casing wall **24***a*. In one aspect, discharge arms **60**, **62** are positioned above horizontal centerline H. In one aspect first discharge arm **60** extends from lower casing wall **24***a* a first distance "m" and second discharge arm **62** extends from lower casing wall **24***a* a second distance "n". In one aspect the first distance m is greater than the second distance n. In one aspect distance m is twice as great as distance n, and in other aspects distance m is greater than twice distance n. In a further aspect distance m is about 8 inches and distance n is about 3 inches. In further aspects distance m is greater than 8.2 inches and distance n is greater than about 3.3 inches. Other measures for distance m and distance n may be established or mixed and matched to provide efficiency of connection to discharge piping.

In one aspect first discharge arm **60** is positioned adjacent trailing edge **38** of second cut-water wall **36**, while second discharge arm **62** is position distal the trailing edge **38**. In further aspects, fluid travels upward at the exit (adjacent trailing edge **38**) from the first cut-water fluid flow path **40**.

As shown in FIG. **3** and as may be further appreciated with respect to FIG. **4** and FIG. **5**, reference line X is defined by center points **47**, **49**. Center points **47**, **49** in one aspect are aligned along line X in both a horizontal orientation (FIGS. **3** and **4**) and a casing bisecting orientation as shown in top view of FIG. **5**. FIG. **6** and FIG. **7** depict further views and aspects of pump **20**, casing **22**, system **21** and related configurations.

In a further aspect with reference to FIG. **8**, system **21**, pump **20** and casing **22** are presented within an emergency

response vehicle **10** application. An emergency response vehicle such as a firetruck apparatus **10** includes vehicle frame rails **100**, **102**. Between the opposing rails **100**, **102** is commonly positioned an engine **16** or power source (or the engine or power source is positioned at or adjacent rails **100**, **102**), and a horizontally centered drive shaft **110** defining a central drive shaft axis **112**. The drive shaft is used to power the vehicle. In aspects, pump **20** also receives power from shaft **110**. A single suction centrifugal pump **20** having casing **22** in which is positioned impeller **26** driven by an impeller shaft **28** is positioned between the rails **100**, **102**. The impeller shaft **28** defines a central impeller shaft axis **28'**. In one aspect, pump **20**, system **21** and casing **22** are positioned upon the emergency vehicle such that impeller shaft axis **28'** is horizontally and vertically offset from drive shaft axis **112**. Horizontally offsetting axis **28'** allows casing **22** to be lowered to a close or relatively close position with respect to drive shaft **110** and associated couplings (and with respect to rail **100**). Horizontally offsetting axis **28'** also allows casing **22** to be oriented closer to one of the rails **100**, **102**, creating a clearance or gap **57**. Clearance gap **57** accommodates fitting of plumbing to third discharge nozzle **64** of casing **22**. Third discharge nozzle **64** is positioned at right discharge arm **60**. Having a third discharge nozzle and associated opening **64** allows for additional flexibility on the discharge of fluid from the pump **20** and throughout the firetruck, including allowing for efficient filling of a tank or tanks positioned on or in the firetruck. Having a third discharge nozzle **64** and associated gap **57** allows for an elbow **67** or other fitting **65** to accommodate a third discharge line **69** to receive liquid from the pump casing **22**. In one aspect with respect to FIG. **10** and FIG. **11**, a fitting **65**, such as an elbow **67** or other fitting such as an adapter, extender, or other conduit projecting from nozzle **64**, is connected to casing **20** and receives in one instance plumbing for a third line **69**. The fitting **65** or elbow **67** extends downward from the casing **20** and between rails **100**, **102** to accommodate convenient connection of the third line **69** to an internal tank or to a third discharge outlet from the firetruck (in aspects the third outlet is positioned at a rear or front or other location of the vehicle). In one aspect elbow **67** is part of the third discharge line **69**. FIG. **10** shows elbow **67** in an exploded position from nozzle **64**. FIG. **11** shows fitting **65** and elbow **67** connected to the casing at nozzle **64** and third line plumbing **69** connected to fitting **65** and extending rearward generally in the direction of arrow "R". Plumbing **69** extending from the third nozzle **64** in this aspect runs parallel, at least in part, along rails **100**, **102**. A third line of discharge plumbing **69** is more easily connected to the pump **20** given the horizontal offset and gap **57**. The gap **57** provides clearance from rail **102**. The plumbing **69** may lead to a holding tank within the vehicle, or may terminate at an exterior panel of the vehicle. Fitting **65** and elbow **67** may be rotated to project opposite arrow "R" and in a front or forward extending orientation to service a forward area of the vehicle or to provide a discharge at a panel at a forward location of the vehicle. Elbow **67** includes a bolt pattern to receive bolts to be connected to a corresponding bolt pattern associated with nozzle **64**. The opening at nozzle **64** extends downward from the casing **20** so that the third line plumbing **69** is conveniently oriented for efficient extension of a discharge line below the nozzles **46**, **48** and between rails **100**, **102**. A cover or cap may be bolted at nozzle **64** if a third discharge line is not desired.

In one aspect lower casing wall **24***a* includes a dimple **77** for further clearance from drive shaft **110** and associated couplings. Also having nozzles **46**, **48** positioned such that line X is offset from horizontal centerline H allows for lowering casing **22** closer to axis **112** as compared to a prior arrangement as shown in FIG. **9**. Moreover, simultaneously providing discharge arm **60** with an enhanced length to couple with discharge piping while discharge arm **62** also connects with corresponding discharge piping, while simultaneously having nozzles **46**, **48** offset from horizontal centerline H while also simultaneously having impeller axis **28'** horizontally offset from axis **112**, accommodates an overall lowering of pump **20** and associated space savings.

In one example aspect of the invention, the foregoing features result in a combination where the impeller axis **28'** is vertically offset from axis **112** about 13 to 14 inches compared to an arrangement as shown in FIG. **9** where a prior pump casing **150** (represented in alternative cross section markings) had a much higher 17 to 18 inches of vertical offset from axis **112** (with a corresponding higher upper location of pump casing **150**). For example, impeller axis **128'** of casing **150** is located about 17 to 18 inches from axis **112**. Such feature is also achieved with casing **22** having a horizontal offset of about 4 to 5 inches from axis **112**, where the prior pump and casing **150** has an impeller axis **128'** aligned vertically with axis **112**. In another aspect impeller axis **28'** is vertically offset from axis **112** about 13.5 inches with a horizontal offset of about 4.5 inches; such dimensions are critical in one aspect for arranging casing **22** in a low profile and offset position within the vehicle and so that discharge outlets **46**, **48** connect to existing piping of the vehicle and/or result in minimal modification to typical receiving discharge piping. The outlets **46**, **48** in the example have a 4-inch diameter opening.

In a further aspect the invention includes a firefighting vehicle **10** having a third discharge line **69** which initially extends downward from the pump casing. In further aspects the third discharge line **69** travels between and at least in part parallel with rails **100**, **102**. The third discharge line **69** may communicate with a holding tank on the vehicle **10** or may connect to a discharge nozzle positioned at an outer panel of the vehicle **10**. The outer panel of the vehicle **10** may be positioned at opposite sides of the vehicle, or at a front or back end or other panel area of the vehicle **10**.

In further method aspects **200** the invention includes discharging liquid through the pump **20** situated on a vehicle such that liquid is discharged simultaneously or selectively via a first discharge nozzle **46**, a second discharge nozzle **48** and/or a third discharge nozzle **64**, the third discharge nozzle **64** configured to accommodate discharge of the liquid downward through the nozzle **64** and from the casing of the pump **20**. In aspects the method includes discharge through a third line **69** which runs beneath nozzles **46**, **48** and in part parallel with rails **100**, **102**.

While the present invention has been described with reference to several particular example embodiments, those skilled in the art will recognize that many changes may be made thereto without departing from the spirit and scope of the present invention, which is set forth in the following claims.

What is claimed is:

1. A single piece pump casing comprising:

a first cut-water fluid flow path, a second cut-water fluid flow path, a first joint-water path and a second joint-water path, the first cut-water fluid flow path and the second cut-water fluid flow path communicating with the first joint-water path and the second joint-water path, the first joint-water path communicating with a first discharge nozzle and the second joint-water path communicating with a second discharge nozzle, the

first discharge nozzle and the second discharge nozzle situated substantially at opposing ends of the casing, the first discharge nozzle defining a first center output point and the second discharge nozzle defining a second center output point, the first center output point and the second center output point defining a line offset from a center point of a center opening passing through the casing.

2. The pump casing of claim **1** where the first discharge nozzle has a terminal flow path radius, the line is a horizontal line offset from the center point by at least the terminal flow path radius.

3. The pump casing of claim **1** where the center opening has a radius from the center point, the line is offset from the center point by at least the radius of the center opening.

4. The pump casing of claim **3** where the line is offset from the center point at least 4.5 inches.

5. The pump casing of claim **1** where the line is a horizontal line and is offset upward from the center point.

6. The pump casing of claim **1** configured to receive one and only one impeller.

7. The casing of claim **1** where the first cut-water fluid flow path is defined in part by a lower casing wall, the first discharge nozzle is positioned at a first discharge arm extending outward from the lower casing wall and the second discharge nozzle is positioned at a second discharge arm extending outward from the lower casing wall.

8. The casing of claim **7** where an entirety of the discharge arms are positioned above the center point.

9. The casing of claim **7** where the first discharge arm extends from the lower casing wall a first distance, the second discharge arm extends from the lower casing wall a second distance, the first distance is at least twice the second distance.

10. The casing of claim **1** where the second joint water path runs along an upper portion within the casing, the casing further comprising a third discharge nozzle opening downward.

11. The casing of claim **1** where the center point of the center opening in part defines a horizontal center line, the line is offset and substantially parallel the horizontal center line, and where fluid travels upward at exit from the first cut-water fluid flow path.

12. A single piece pump casing comprising:

a first cut-water fluid flow path defined in part by a lower casing wall, a first discharge nozzle positioned at a first discharge arm extending outward from the lower casing wall a first distance, and a second discharge nozzle positioned at a second discharge arm extending outward from the lower casing wall a second distance, the first cut-water fluid flow path communicates with the first discharge nozzle and the second discharge nozzle, the first discharge nozzle and the second discharge nozzle situated substantially at opposing ends of the pump, the first distance being greater than the second distance.

13. The pump casing of claim **12** where first discharge arm is positioned adjacent a trailing edge of a second cut-water wall, the second cut-water wall in part defining the first cut-water fluid flow path and a second cut-water fluid flow path.

14. The pump casing of claim **12** where the first distance is at least twice the second distance and where the first nozzle defines a center output point and the second nozzle defines a second center output point, the center output points defining a line offset upward from a horizontal centerline of the casing, and where fluid travels upward at exit from the first cut-water fluid flow path.

15. The pump casing of claim **12** further comprising a second cut-water fluid flow path, a first joint-water path and a second joint-water path, the first cut-water fluid flow path and the second cut-water fluid flow path communicating with the first joint-water path and the second joint-water path, the first joint-water path communicating with the first discharge nozzle and the second joint-water path communicating with the second discharge nozzle, and wherein all fluid exiting at least one of the first and second discharge nozzles exits at a position above a horizontal centerline of the casing.

16. A centrifugal pump comprising:

an impeller contained within a casing, the casing comprising a first cut-water fluid flow path, a first discharge nozzle, and a second discharge nozzle, the first cut-water fluid flow path communicates with the first discharge nozzle and the second discharge nozzle, the first discharge nozzle and the second discharge nozzle situated substantially at opposing ends of the pump and such that all fluid exiting at least one of the first and second discharge nozzles exits at a position above a horizontal centerline of the impeller.

17. A centrifugal pump comprising:

an impeller contained within a casing, the casing comprising a first cut-water fluid flow path, a first discharge nozzle, and a second discharge nozzle, the first cut-water fluid flow path communicates with the first discharge nozzle and the second discharge nozzle, the first discharge nozzle and the second discharge nozzle situated substantially at opposing ends of the pump and a first center output point of the first discharge nozzle and a second center output point of the second discharge nozzle defining a line offset from a horizontal centerline of the casing.

18. A centrifugal pump comprising:

an impeller contained within a single-piece casing, the casing comprising a first cut-water fluid flow path defined in part by a lower casing wall, a first discharge nozzle positioned at a first discharge arm extending from the lower casing wall a first distance, a second discharge nozzle positioned at a second discharge arm extending from the lower casing wall a second distance, the first cut-water fluid flow path communicates with the first discharge nozzle and the second discharge nozzle, the first discharge nozzle and the second discharge nozzle situated substantially at opposing ends of the pump, and the first discharge arm positioned adjacent a trailing edge of a second cut-water wall, the second cut-water wall in part defining the first cut-water fluid flow path and a second cut-water fluid flow path, the first distance being greater than the second distance.

19. A centrifugal pump system comprising the centrifugal pump of claim **18** and further including suction plumbing and discharge plumbing connected to the casing, the impeller connected to a drive shaft of a drive box or transmission to power the centrifugal pump.

20. The centrifugal pump system of claim **19** where the suction plumbing includes a first discharge line connected to the first nozzle and a second discharge line connected to the second discharge nozzle and a third discharge line connected to a third discharge nozzle of the pump casing, the third discharge line extending downward from the third discharge nozzle.

21. An emergency response vehicle for pumping water from opposite sides of the vehicle, the vehicle comprising:

opposing frame rails between which is positioned a drive shaft defining a central drive shaft axis and for powering the vehicle; and

a single suction centrifugal pump comprising a casing in which is positioned an impeller upon an impeller shaft having a central impeller shaft axis, the impeller shaft axis horizontally and vertically offset from the drive shaft axis, the casing having a first discharge nozzle and a second discharge nozzle.

22. The vehicle of claim 21 where the casing of the pump comprises a first cut-water fluid flow path which communicates with the first discharge nozzle and the second discharge nozzle, the first discharge nozzle and the second discharge nozzle situated substantially at opposing ends of the pump, and a first center output point of the first discharge nozzle and a second center output point of the second discharge nozzle defining a line offset from a horizontal centerline of the casing.

23. The vehicle of claim 21 where the casing of the pump comprising a first cut-water fluid flow path defined in part by a lower casing wall, the first discharge nozzle positioned at a first discharge arm extending from the lower casing wall a first distance, the second discharge nozzle positioned at a second discharge arm extending from the lower casing wall a second distance, the first cut-water fluid flow path communicates with the first discharge nozzle and the second discharge nozzle, the first discharge nozzle and the second discharge nozzle situated substantially at opposing ends of the pump, and the first discharge arm positioned adjacent a trailing edge of a second cut-water wall, the second cut-water wall in part defining the first cut-water fluid flow path and a second cut-water fluid flow path, the first distance being greater than the second distance.

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