

[54] **GUIDE VANE FOR SUCTION SIDE OF MARINE JET PROPULSION SYSTEM**

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[51] Int. Cl. **B63h 11/08**

[58] Field of Search **115/11, 12, 14, 16; 60/35.5; 103/87**

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[57] **ABSTRACT**

In a jet boat having a jet nozzle, an impeller pump discharging water through the nozzle, and a flow channel delivering water from below the boat to the impeller, the improvement wherein a fixed guide vane is disposed in the flow channel to divide the flow channel into upper and lower flow portions. At boat speeds greater than the impeller entrance velocity, the fixed guide vane causes an automatic adjustment of volume rates of flow of water through each flow channel portion so that a volume rate of water equal to the flow capacity of the impeller flows freely and smoothly through the flow channel, such water being distributed uniformly around the entrance of the impeller.

10 Claims, 9 Drawing Figures

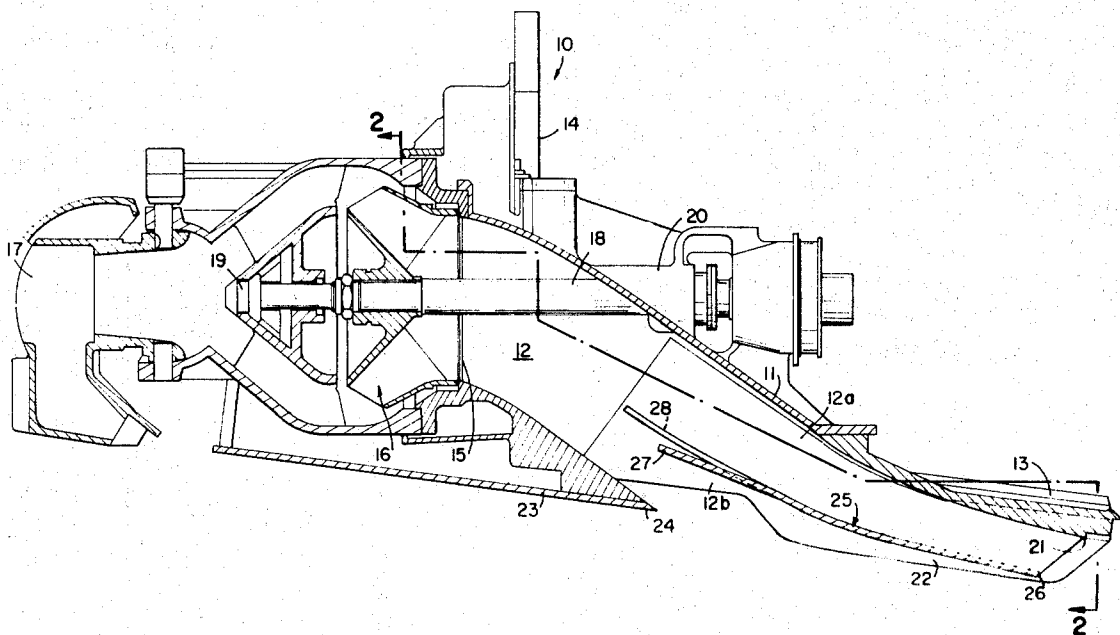


FIG_2

FIG_3

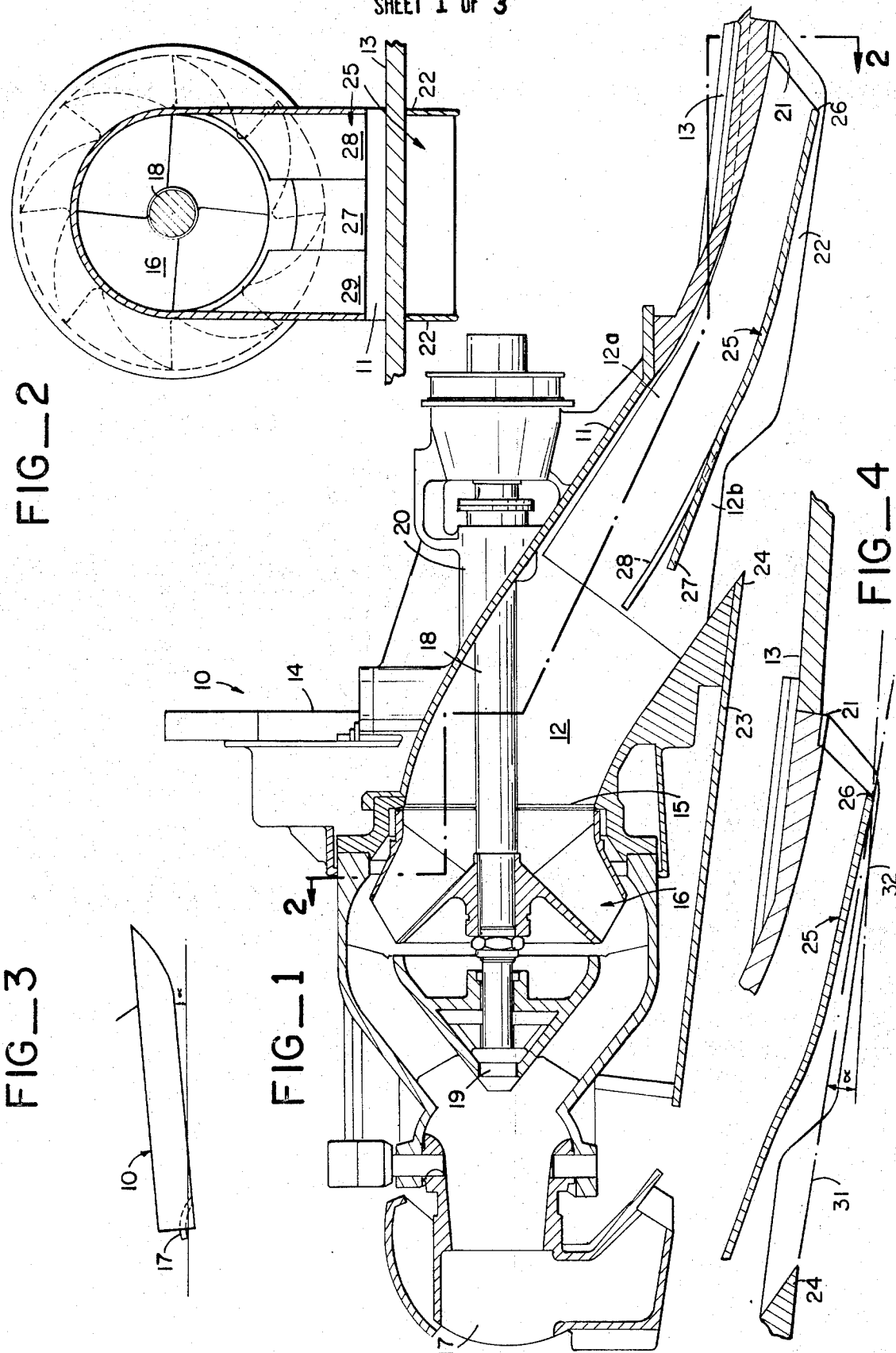


FIG_6

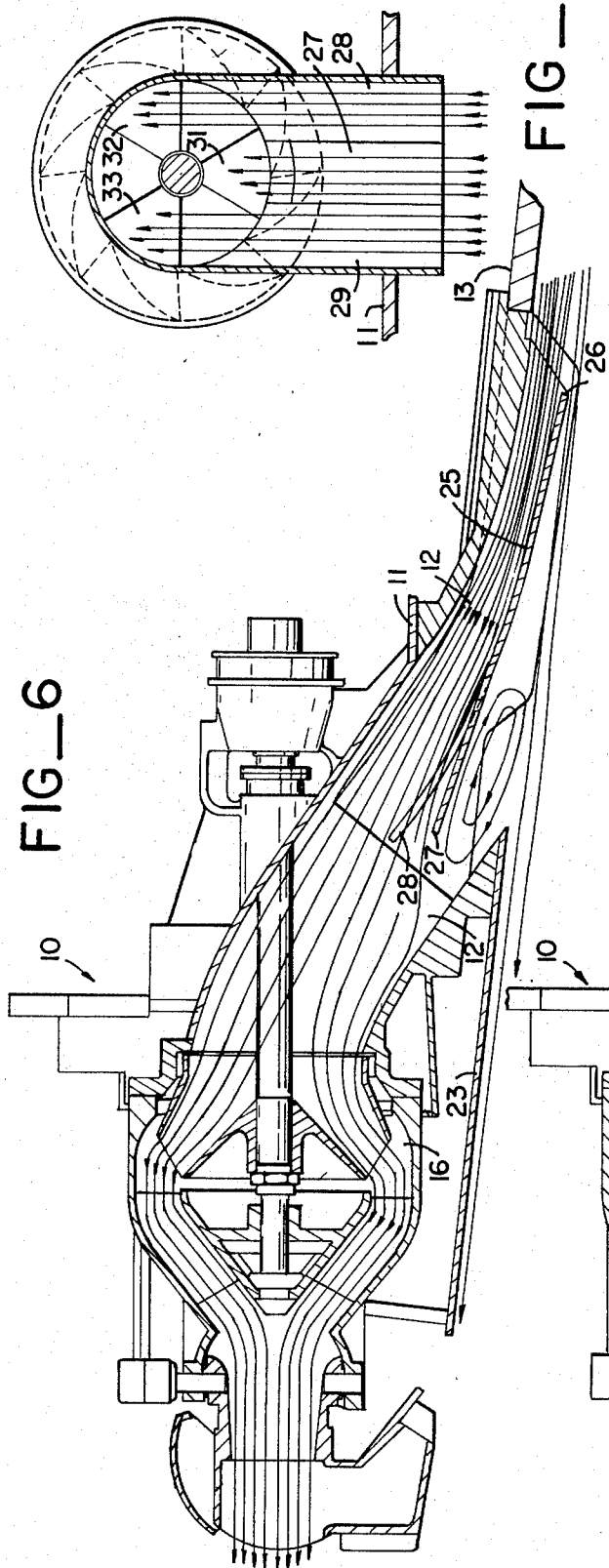


FIG_7

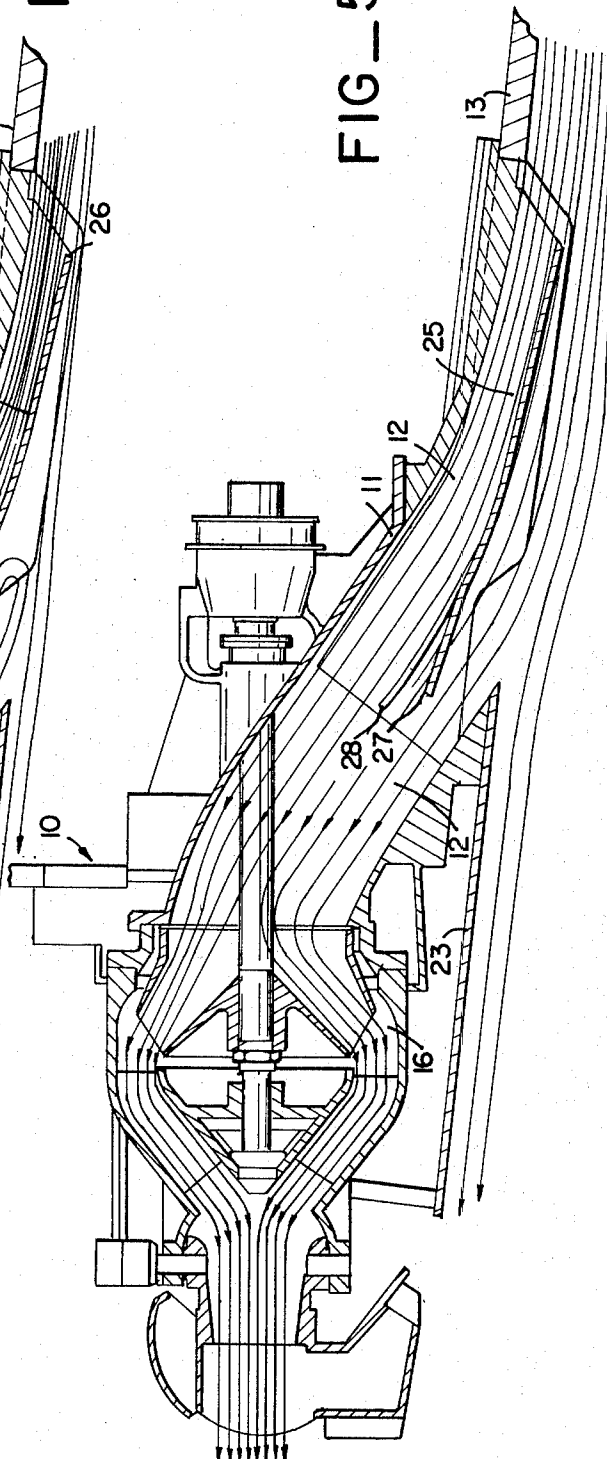


FIG_5

FIG-8
PRIOR ART

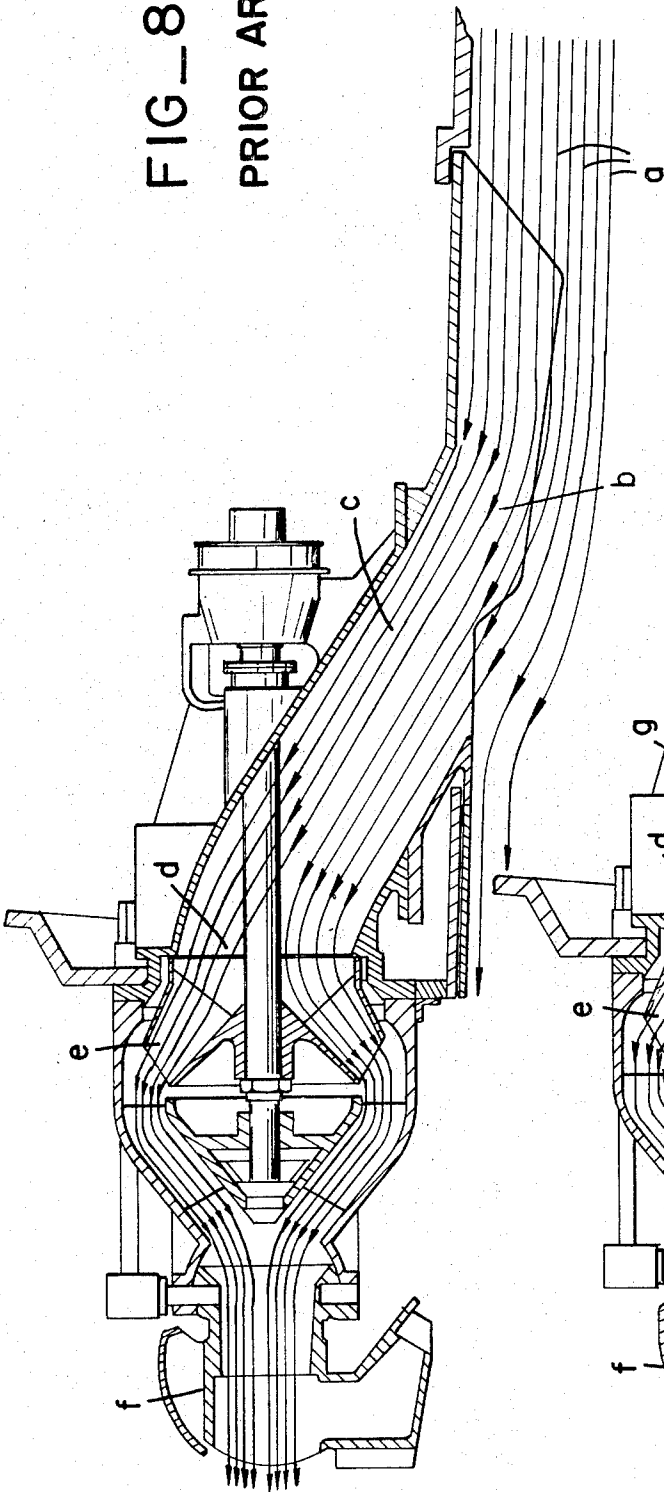
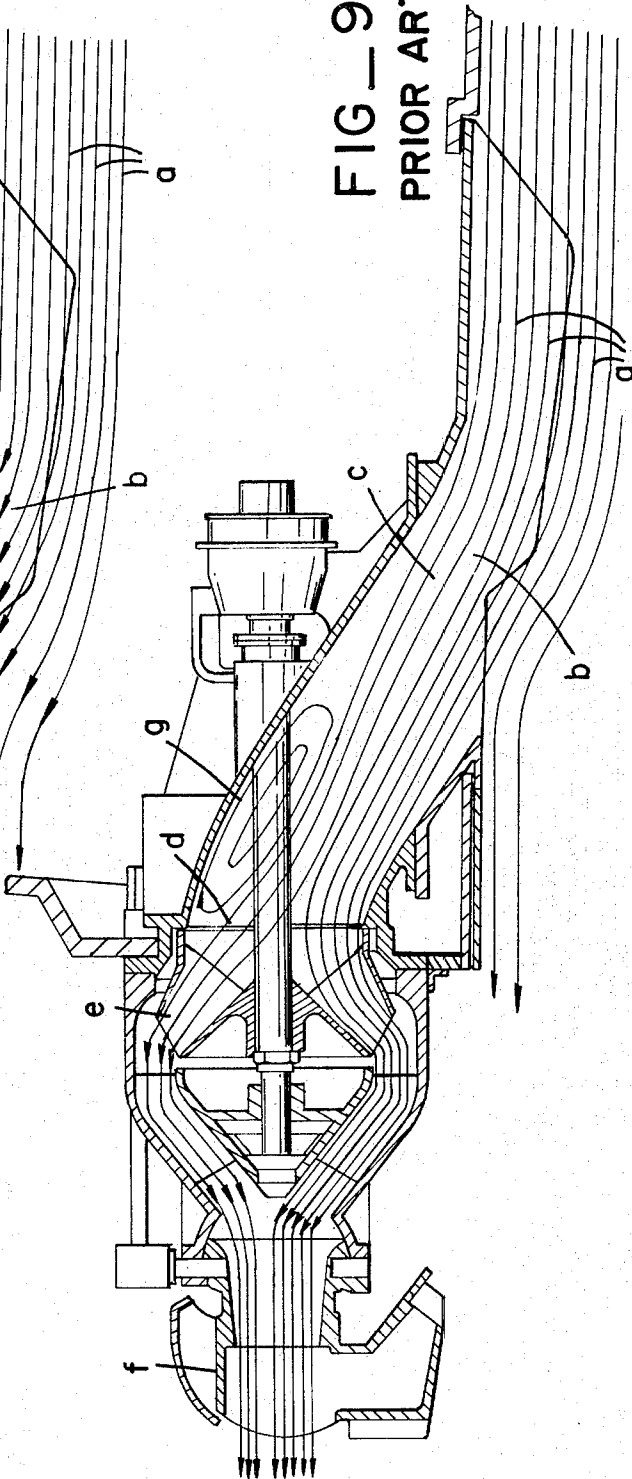


FIG-9
PRIOR ART



GUIDE VANE FOR SUCTION SIDE OF MARINE JET PROPULSION SYSTEM

BACKGROUND OF THE INVENTION

This invention relates to jet-powered boats wherein water is drawn in through an opening in the bottom of the hull, delivered through a flow channel to an engine-driven impeller pump to be accelerated thereby, the water then being expelled through a jet nozzle in the rear to drive the boat forward.

The water flowing through the flow channel and entering the impeller pump has flow characteristics which depend upon the speed of the boat in the water. When the boat is standing still and the pump is being driven, the pump sucks the water into the flow channel and the water flows uniformly therethrough, the water being distributed uniformly to the impeller entrance. As the boat moves forward, the forward motion rams water into the entrance channel. When the boat reaches a speed equal to the velocity of the water flowing into the impeller entrance the flow pattern at the impeller entrance is very uniform, assuming that proper attention has been given to the design of the shape of the flow channel. However, when the boat reaches higher speeds, then the forward motion of the boat attempts to ram more water through the flow channel than can be handled by the pump and the flow pattern at the impeller entrance becomes non-uniform, thereby decreasing to a considerable degree the efficiency and performance of the pump.

The effect of boat speed on the flow pattern of water in a conventional jet drive system can best be illustrated by reference to FIGS. 8 and 9. In these figures, water (indicated by flow lines *a*) flows along the under-surface of the hull and enters the inlet *b* of the water flow channel *c*, and flows therethrough to the inlet entrance *d* of impeller pump *e*. The water is discharged from impeller pump *e* through the jet nozzle *f* to drive the boat forwardly.

For simplicity of explanation, it will be assumed that at a fixed pump speed, the rate of water delivered by the pump will remain the same. Assume also that the boat is initially anchored or otherwise held against forward motion, and the engine is driving the pump at full speed. With no forward motion of the boat, the suction created by the pump will be the only force drawing water into the flow channel *c*. The water in the flow channel *c* and at the impeller entrance *d* will have a velocity determined by the fixed size of the flow channel and the capacity of the pump at its rated speed. The flow pattern will be uniform as illustrated by the distribution of the flow lines shown in FIG. 8.

If the boat is now released, the water jet will propel the boat forwardly. As the boat gathers speed, the water entering the flow channel *c* will enter partially due to pump suction and partially due to the forward motion of the boat in the water which rams water into the flow channel. The flow pattern of the water through the system will remain substantially uniform, as in FIG. 8, as the speed of the boat increases and the boat reaches a speed wherein the velocity of the boat in the water equals the velocity of the water entering the impeller pump. At this speed, the forward motion of the boat is a sole force causing water to enter the flow channel.

As the speed of the boat continues to increase, the forward motion of the boat seeks to ram more water

into the flow channel and into the impeller pump than the pump can handle. As a consequence, the flow pattern in the flow channel starts to adjust itself, in order to deliver to the impeller entrance only the amount of water the pump can handle.

For example, if the boat is running at twice the speed of the average velocity of the pump entrance, water will flow through the flow channel at boat speed but will only flow through approximately half the area of the flow channel. The remainder of the flow channel would be filled with water which the pump cannot handle and which acts to block the flow channel. Such condition is illustrated in FIG. 9. Typically the water will attempt to flow through the channel in a straight line, and thus the upper portion of the flow channel will be blocked, as shown by the water block *g* in FIG. 9. As a result, the impeller will have delivered to it water at twice the velocity it requires, and the water will be delivered to it over half the area of the impeller entrance — usually the lower half of the impeller entrance. This unbalanced distribution of high-speed water causes the impeller to become inefficient. The inefficiency increases as the speed of the boat increases beyond the pump entrance velocity and markedly limits the maximum speed of the boat for a given amount of force delivered to the pump by the boat engine.

SUMMARY OF THE INVENTION

The main object of the invention is to improve the flow conditions through the flow channel to the impeller pump inlet at boat speeds higher than the impeller entrance velocity.

This object is accomplished by providing the flow channel with a guide vane across the channel to divide the channel into upper and lower flow portions. As the speed of the boat increases beyond the impeller entrance velocity the volume rate of water flow through the upper flow portion increases and the flow through the lower flow portion decreases.

When the boat reaches its maximum designed speed, all of the water required for the impeller pump is delivered through the upper flow portion. For illustration, the maximum designed speed of the boat might be twice impeller entrance velocity. In such case, the inlet opening of the upper flow portion would have an area of one-half that impeller entrance. As a consequence, water flow into the upper flow portion at twice the velocity of the impeller entrance but through an opening one-half that of the impeller entrance. Thus, the volume rate of flow entering the upper flow channel portion is matched to the volume rate of flow of water through the impeller. This matching eliminates water blockages in the flow channel to the impeller and allows water to enter the upper flow portion freely and to flow smoothly and uniformly to the impeller entrance. The guide vane is shaped to guide the water flowing through the upper flow portion so that the water is delivered to and distributed equally around the impeller entrance instead of such water being delivered primarily to the lower half of the impeller entrance as is usually the case in normal entrance design.

The guide vane is also preferably designed to provide for an increasing cross-sectional area to the upper flow portion in order to slow down the velocity of the water in the flow channel to a velocity closer to the impeller entrance velocity, again increasing efficiency of the system by such matching.

Other objects and advantages will become apparent in the course of the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

Referring now to the drawings, which form a part of the application and in which like parts are designated by like reference numerals throughout the same,

FIG. 1 is a sectional view, in elevation, of a portion of a jet-powered boat, the section being taken along the longitudinal centerline of the boat, illustrating the jet, impeller pump, flow channel and the flow channel guide vane;

FIG. 2 is a sectional view, taken on line 2—2 of FIG. 1;

FIG. 3 is an illustrative view of a jet-powered boat, planning in the water;

FIG. 4 is a detail view illustrating the location of the guide vane relative to the rear edge of the flow channel inlet;

FIG. 5 illustrates the water flow through the jet system of FIG. 1 at boat speeds up to impeller entrance velocity;

FIG. 6 illustrates the water flow through the jet system of FIG. 1 at a boat speed greater than the impeller entrance velocity;

FIG. 7 is a sectional view, substantially the same as FIG. 2, and illustrates the water distribution to the impeller entrance at a boat speed greater than the impeller entrance velocity;

FIG. 8 illustrates the water flow through a prior art jet system, without the guide vane of the present invention, at boat speeds up to the impeller entrance velocity;

FIG. 9 illustrates the water flow through the prior art system of FIG. 8 at boat speeds above the impeller entrance velocity.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, FIG. 1 illustrates a boat 10 having a jet-drive housing 11 forming a water flow channel 12 therein, the housing extending through the bottom of the hull 13 and the rear transom 14. Water from below the boat flows through the flow channel 12 to the impeller entrance 15, the cross-sectional area of flow channel 12 being approximately the same as that of the impeller entrance 15, the impeller 16 then forcing the water through the rearwardly projecting jet nozzle 17. The impeller 16 is mounted on drive shaft 18, the latter being journaled in rear and forward bearings 19 and 20 and adapted to be driven by a conventional marine engine (not shown).

The forward inlet edge 21 of housing 11 is substantially flush with the bottom of hull 13, and the casing is provided with vertical side plates 22 depending below the hull. An afterplane plate 23 extends rearwardly from the rear inlet edge 24 of housing 11.

A guide vane 25 is mounted in the housing 11, extending from side to side of the flow channel 12 therein. The guide vane thus dividing the flow channel 12 into upper and lower flow portions 12a and 12b. The guide vane 25 projects forwardly from the inlet of the flow channel 12 with the front edge 26 of the guide vane being spaced below the forward inlet edge 21 of casing 11. The guide vane 25 extends rearwardly a substantial distance into the flow channel 12, and the rear portion of the guide vane is longitudinally divided into

a number of guide surfaces, three being shown in FIGS. 1 and 2. The central guide surface 27 is downwardly inclined relative to the side guide surfaces 28 and 29.

As will be noted from FIG. 1, the spacing of guide vane 25 below the upper inner surface of housing 11 increases rearwardly to provide a rearwardly increasing cross-sectional area to the upper flow portion 12a, thereby enabling a reduction of velocity in the flow of water therethrough. The rear edges of the guide surfaces terminate a substantial distance from the impeller entrance, to provide space in the flow channel 12 for water to flow through the lower flow portion 12a to the impeller, and to provide space in flow channel 12 for water velocity reduction when water is flowing only through the upper flow portion 12a to the impeller.

The location of the guide vane 25 in and relative to housing 11 will depend to a large extent on the design of the particular boat, flow channel, impeller and engine with which it is to be used. For a given boat, the boat will have a maximum designed speed dependent on hull shape, size of power plant, size of impeller pump and nozzle. The hull shape and weight distribution will also determine the planing angle α of the boat. The forward edge 26 of the guide vane should be located relative to the forward edge of casing 11 so that the area of the inlet flow portion 12a is of a size that the volume rate of flow into flow portion 12a at maximum boat velocity is equal to the volume rate of flow through the impeller at maximum impeller capacity. As, for example, if the maximum boat speed is twice the velocity of flow into the impeller at that boat speed, then the inlet area of flow portion 12a should be approximately half the area of the impeller entrance. If the top speed of the boat is a greater multiple of the impeller entrance velocity, the inlet opening of the upper flow portion 12a would be correspondingly smaller.

The rear inlet edge 24 of the flow channel is positioned relative to the guide vane 25 as shown in FIG. 4. As there shown, a line 31 from the forward edge 26 of the guide vane to the rear inlet edge 24 is inclined to a line 32 through the forward guide vane edge 26 and parallel to the hull line of the boat by the planing angle α of the boat. With this location, and with no water flowing through the lower channel portion 12b, water passing just below the forward edge 26 of guide vane 25 will "kiss" the rear inlet edge 26 and flow along the undersurface of afterplane 23.

The effect of the guide vane 25 on water flow at different boat speeds is illustrated in FIGS. 5-7. FIG. 5 illustrates the water flow pattern at boat speeds equal to or less than the impeller entrance velocity. At such speeds, water will flow into the flow channel portions 12a and 12b partly from the suction force of the impeller pump and partly from the ram effect of the boat as it moves forwardly in the water. The water will be divided initially in proportion to the inlet areas of the upper and lower flow portions 12a and 12b but will flow freely through each portion, the water flows combining rearwardly of the guide vane and flowing uniformly to the impeller entrance. Since the restricted entrance to the upper flow portion 12a cannot supply all of the water required for the impeller, an upward suction force exists in the lower flow portion 12b so that the water passing underneath the front edge 26 of guide vane 25 will be drawn into the lower flow portion 12b to supply the impeller with the balance of the water required. As will be seen from a comparison with FIG. 8,

the flow patterns of water through the low channels to the impeller entrance are substantially the same for boat speeds equal to or less than the impeller entrance velocity whether the guide vane 25 is present or not.

As the boat speed increases above the impeller entrance speed, the velocity and volume rate of water entering the upper flow portion 12a increases. Such water is guided by the rear guide surfaces so that the water flowing past the center guide surface 27 will be directed to the lower central area 31 (FIG. 6) of the impeller entrance, while the water flowing past the side guide surfaces 28 and 29 will be directed towards the upper areas 32 and 33 above and on either side of the center of the impeller entrance. The guide surfaces are proportional relative to each other so that approximately equal amounts of water are delivered to the equally spaced-apart areas 31, 32 and 33 around the impeller entrance.

As the flow through the upper flow portion 12a increases, the water pressure therefrom at the rearward ends of the guide surfaces increases, thus reducing the flow of water through the lower flow portion 12b. Such water as does flow therethrough tends to distribute itself and fill in between the stronger streams of flow through the upper flow portion 12a, resulting in a uniform distribution of water to the impeller entrance.

FIG. 7 illustrates the flow pattern when the boat has reached a speed equal to twice the impeller entrance velocity. At this point, the water rammed into the upper flow portion inlet has a velocity twice the impeller entrance velocity. Since the upper flow portion inlet is half the impeller entrance, then the upper flow portion will supply all the water that the impeller can handle. By virtue of the guide surfaces 27, 28 and 29, this water is still distributed uniformly around the impeller entrance. The uniformity of the distribution is further enhanced by the reduction of speed of the water flowing through the upper flow portion 12a as such flow portion expands in cross-sectional areas.

At this point, the water pressure in the flow channel at the rearward end of the guide vanes resulting from the flow through the upper flow portion 12a has increased so that the total pressure at both ends of the lower flow portion 12b is the same. As a consequence, this "seals" the lower flow portion 12b against flow thereinto. The water flowing just below the forward edge of the guide vane then flows smoothly past the lower flow portion inlet and flows against the under surface of the afterplane 23.

Thus at increasing boat speeds above the impeller entrance velocity, there is an increasing volume rate of flow through the upper flow portion 12a and a self-adjusting rate of flow through the lower flow portion so that only an amount of water flows through the two flow portions which the impeller can handle.

The size of the upper flow inlet has a limiting effect on the speed of the boat. For example, if the boat thus far described were to be driven at a speed greater than twice the impeller entrance velocity, then more water would be rammed into the upper flow portion than could be handled by the impeller. As a result, the water pressure forward of the impeller would increase and water would flow forwardly through the lower flow portion 12b and out the inlet thereof, thus exerting a drag on the boat. However, such a result would come from an improper initial design. With the guide vane located so that at maximum boat speed the volume rate of flow

through the upper flow portion is equal to the volume rate of flow through the impeller, no such back flow will occur.

Although the guide vane 25 is shown as having three guide surfaces thereon to distribute the water to the impeller entrance at three areas, the centers of which are spaced 120° apart, the guide surface could be designed with a different number of guide surfaces to accomplish equal distribution. For example, four guide surfaces could be used to form the water flowing through the upper flow portion 12a into four streams and could direct these to areas at the impeller entrance spaced 90° from each other. Similarly, five or more guide surfaces might be used to divide the flow through the upper flow portion into a greater number of streams, aimed at equidistant areas around the impeller entrance.

In the form of the invention illustrated, a single guide vane is used to separate the flow channel into two portions 12a and 12b. Both channels are needed and available for water flow at lower boat speeds. At a higher boat speed the water sealing of the lower flow portion eliminates such flow portion and all the water for the impeller flows through the upper flow portion 12a. If desired, two or more parallel guide vanes could be used, to divide the flow channel 12 into three or more flow portions. If designed in accordance with the present disclosure, the lower channels would progressively and automatically be eliminated as boat speed increased while yet being available for flow at lower boat speeds. Thus, without any moving parts, the guide vanes effect an automatic adjustment of the effective area of the flow channel for different boat speeds so that water can flow freely and evenly through the flow channel to the impeller entrance at the different boat speeds, thereby maximizing the efficiency of the jet system.

Having thus described the invention, I claim:

1. In a jet boat having a rearwardly projecting water jet nozzle, an engine-driven impeller pump discharging water into said nozzle and means forming a flow channel for water extending forwardly and downwardly from the inlet of said impeller pump, said flow channel extending through the bottom of the hull of said boat and having an inlet opening substantially flush with the bottom of said hull, said flow channel having a cross-sectional area substantially equal to the area of said impeller pump inlet, the improvement comprising:

vane means disposed in and across said flow channel to divide said channel into upper and lower flow portions, said vane means projecting outwardly and forwardly from the inlet of said flow channel a substantial distance beyond a line drawn between the forward and rearward edges of said flow channel inlet, and having a generally horizontal forward edge below the forward edge of said flow channel inlet, said vane means extending rearwardly a substantial distance in said flow channel.

2. In a jet boat as set forth in claim 1, wherein the angle between a line from the forward edge of said vane means to the rearward edge of said flow channel inlet and a line drawn parallel to the hull line of said boat and through the forward edge of said vane means is substantially equal to the planing angle of said boat.

3. In a jet boat as set forth in claim 2, wherein said vane means has a plurality of guide surfaces on the rearward portion of said vane means to direct streams of water flowing through said upper flow channel por-

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tion to preselected areas spaced around the impeller pump inlet.

4. In a jet boat as set forth in claim 1, wherein the rearward end of said vane means terminates a substantial distance from said impeller pump inlet.

5. In a jet boat as set forth in claim 1, wherein said upper flow portion of said flow channel between said vane means and the upper part of said flow channel progressively increases in cross-sectional area rearwardly from the flow channel inlet.

6. In a jet boat as set forth in claim 1, wherein said vane means has a plurality of guide surfaces on the rearward portions of said vane means to direct streams of water flowing through said upper flow channel portion to preselected areas spaced around the impeller pump inlet.

7. In a jet boat as set forth in claim 6, wherein said vane means has a central guide surface directing approximately a third of the water flowing through said upper flow channel portion to the lower area of said impeller pump inlet and two side guide surfaces each directing approximately a third of the water flowing through said upper flow channel portion to upper areas

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of said impeller pump inlet.

8. In a jet boat as set forth in claim 1, wherein said upper flow portion of said flow channel between said vane means and the upper part of said flow channel progressively increases in cross-sectional area rearwardly from the flow channel inlet and said vane means terminates at its rearward end a substantial distance from said impeller pump inlet.

9. In a jet boat as set forth in claim 8, wherein said vane means has a plurality of guide surfaces on the rearward portion of said vane means to direct water flowing through said upper flow channel portion to preselected areas spaced around the impeller pump inlet.

10. In a jet boat as set forth in claim 9, wherein said vane means has a central guide surface directing approximately a third of the water flowing through said upper flow channel portion to the lower area of said impeller pump inlet and two side guide surfaces each directing approximately a third of the water flowing through said upper flow channel portion to upper areas of the said impeller pump inlet.

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