April 7, 1964 J. E. POTTHARST, JR 3,127,741

JET PROPULSION CONTROL SYSTEM

Filed Sept. 28, 1961 5 Sheets-Sheet 1

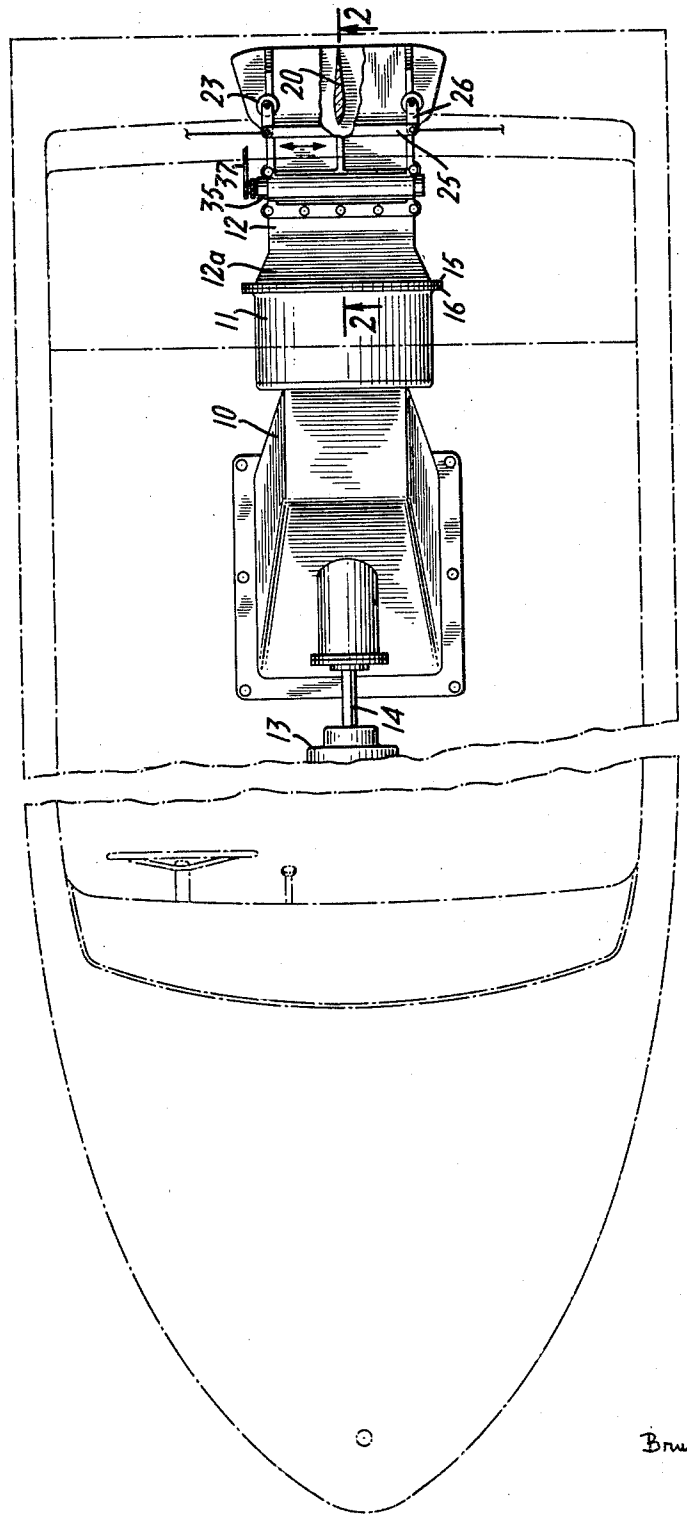


FIG. 1

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JET PROPULSION CONTROL SYSTEM

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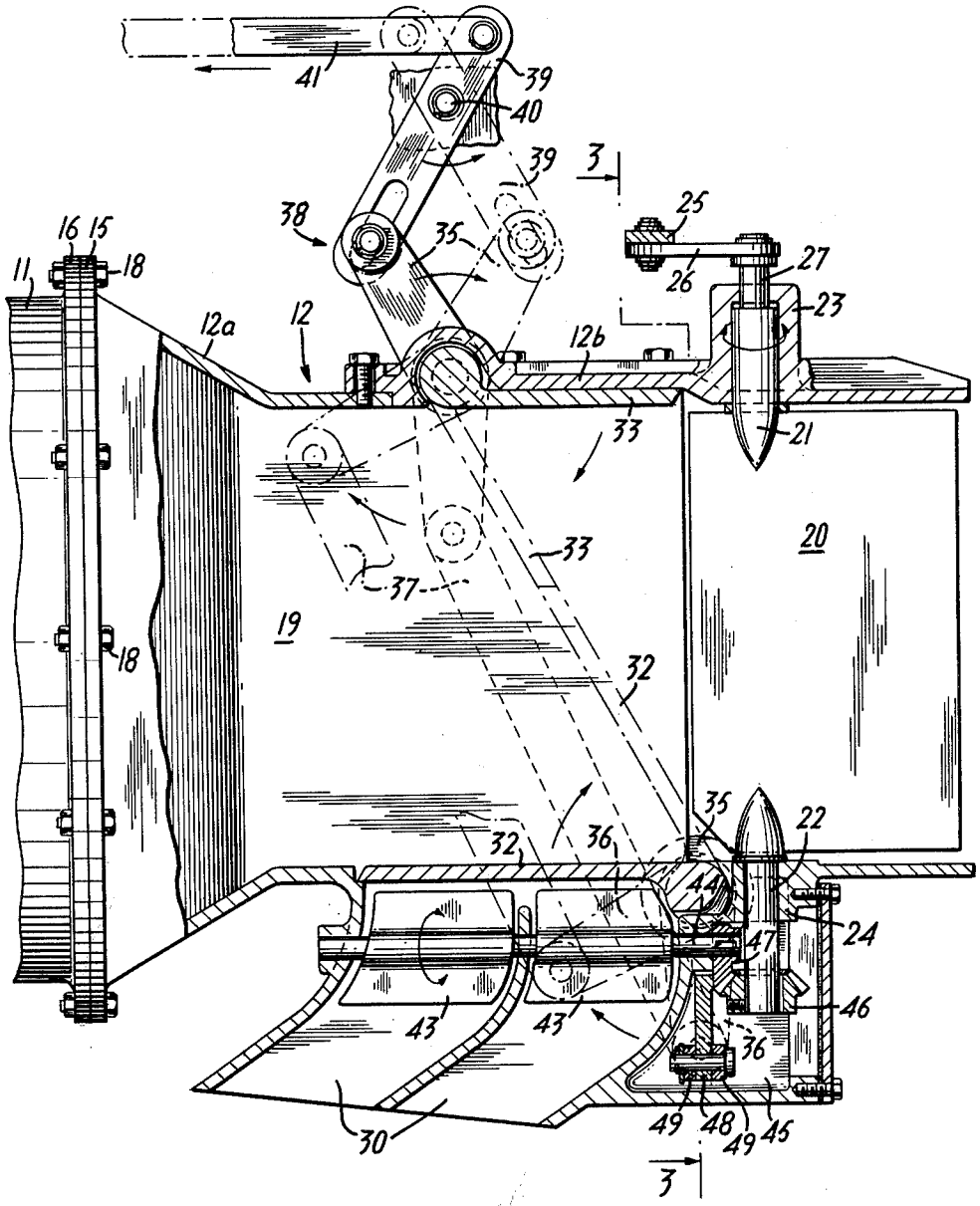


FIG. 2

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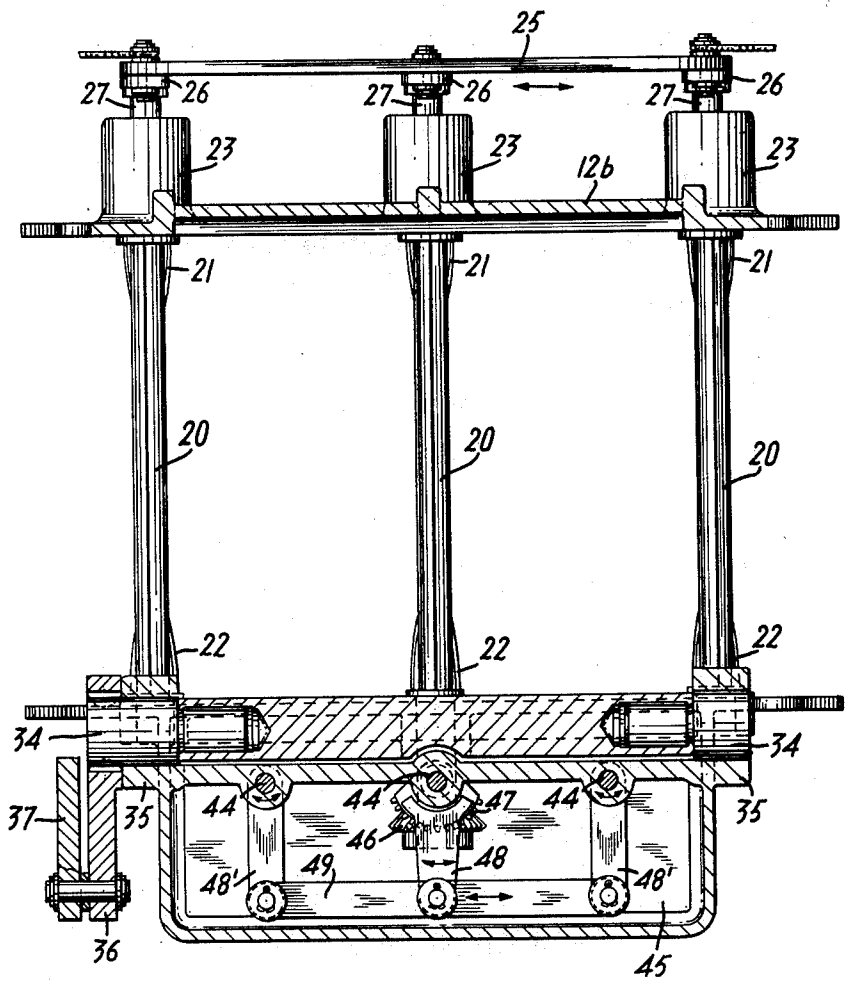
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JET PROPULSION CONTROL SYSTEM

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FIG. 3



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JET PROPULSION CONTROL SYSTEM

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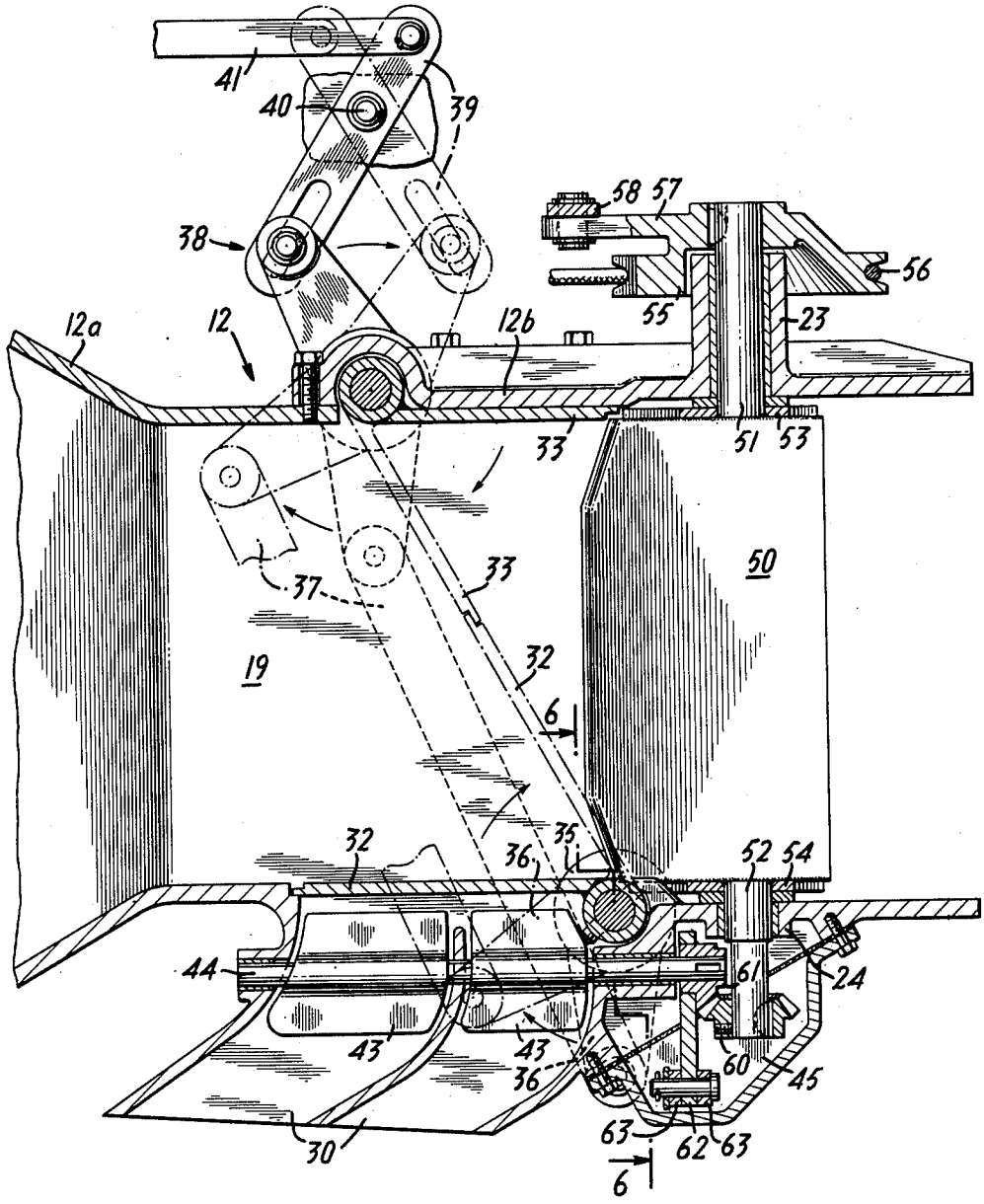


FIG. 4

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JET PROPULSION CONTROL SYSTEM

Filed Sept. 28, 1961 5 Sheets-Sheet 5

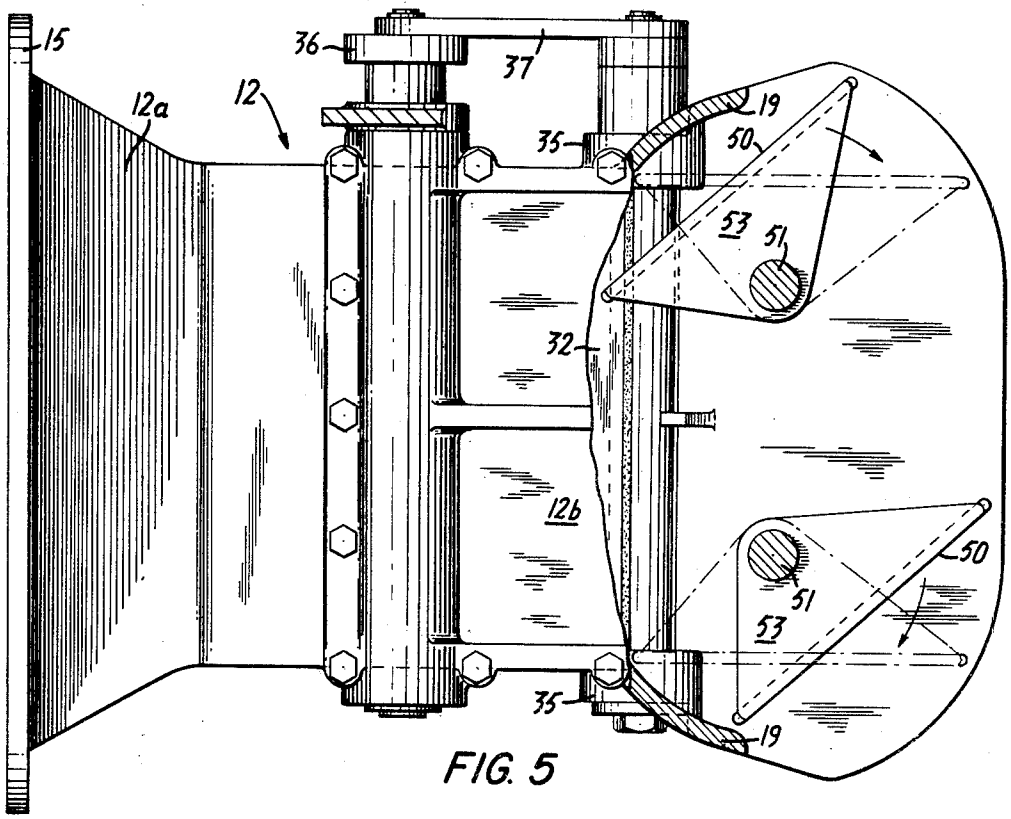


FIG. 5

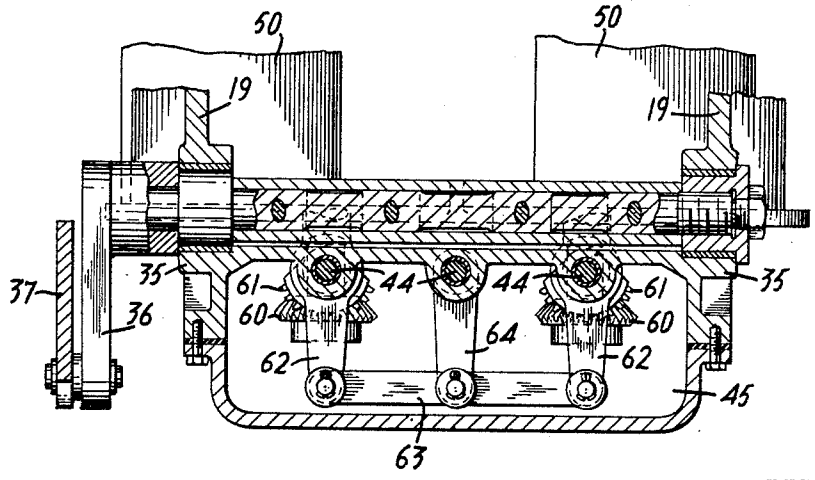


FIG. 6

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3,127,741

JET PROPULSION CONTROL SYSTEM

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Filed Sept. 28, 1961, Ser. No. 141,376
9 Claims. (Cl. 60—35.54)

This invention relates to a control system for a marine water jet propulsion unit.

The jet propulsion control system of the present invention includes an exhaust nozzle which communicates with the discharge of a water pump and discharges a jet stream of water at high velocity from the transom of the boat to impart forward thrust to the boat, adjustable steering rudders accommodated within the exhaust nozzle for steering the boat in the ahead direction, means upstream of the adjustable steering rudders for deflecting the jet stream of water flowing through the nozzle into a forwardly extending reverse passage for driving the boat in the astern direction, and adjustable steering rudders in the reverse exhaust passage connected with the ahead steering rudders for steering the boat when driven in the astern direction.

The jet propulsion control system of the present invention is designed for maximum efficiency while affording a high degree of maneuverability to the boat. Toward this end, the jet stream deflecting means comprises counterbalanced reversing gates which are moved in unison in opposite directions relative to the jet stream so that the jet stream produces opposite and counterbalancing forces thereon for ease of operation. Also, the ahead steering rudders are designed so that they are balanced in their straight-ahead positions and unbalanced when they are turned in either direction from their straight-ahead positions. When they are turned in either direction from their straight-ahead positions, unbalanced forces acting on the rudders tend to return the rudders to their straight-ahead positions.

In a preferred embodiment of the present invention, the ahead steering system includes at least one pair of rudders which are located with their inner surfaces substantially in line with the walls of the jet stream passage upstream of the rudders. By virtue of this arrangement, in their straight-ahead positions, the steering rudders impose virtually no drag on the boat; moreover, the flow of the jet stream along the inner surfaces of the rudders maintains the rudders balanced in their straight-ahead positions. However, when the rudders are turned from their straight-ahead positions, the jet stream exerts unbalanced forces on the rudders which tends to return them to their straight-ahead positions.

These and other features of the present invention will be apparent by reference to the detailed description which follows and to the accompanying drawings in which:

FIGURE 1 is a plan view of a boat equipped with a jet propulsion unit embodying the control system of the present invention;

FIGURE 2 is a cross-sectional view taken on the line 2—2 of FIGURE 1, looking in the direction of the arrows;

FIGURE 3 is a cross-sectional view taken on the line 3—3 of FIGURE 2, looking in the direction of the arrows;

FIGURE 4 is a view similar to FIGURE 2 of an alternative embodiment of the control system;

FIGURE 5 is a plan view, partly broken away, of the embodiment shown in FIGURE 4; and

FIGURE 6 is a cross-sectional view taken on the line 6—6 of FIGURE 4, looking in the direction of the arrows.

The present invention is applicable to a marine jet propulsion unit of the type shown in FIGURE 1 in which water is drawn into an opening on the hull of the boat through an intake housing **10** and is discharged at high

velocity by a propeller type pump **11** through a housing **12** containing the control system of the present invention. The pump **11** is driven by an engine **13** through a drive shaft **14**. The high velocity flow discharged from the housing **12** imparts the necessary thrust to drive the boat at high speed.

The control system for the jet propulsion unit is shown in more detail in FIGURES 2 and 3 of the drawings. As shown in FIGURE 2, the housing **12** includes an upstream section **12***a* and a downstream section **12***b* bolted thereto. The upstream section **12***a* is provided with a flange **15** which is connected to a flange **16** of the pump housing by bolts **18**.

The housing **12** contains a water flow passage **19** therethrough which communicates at its upstream end with the discharge of the pump **11** and then tapers into a rearwardly extending exhaust nozzle. A plurality of rudders **20** are adjustably mounted in the discharge end of the passage **19** for steering the boat when the boat is driven in the forward direction. The water is pumped through the passage **19** at high velocity and expelled from the stern transom of the boat to impart a forward thrust to the boat. The pivotal adjustment of the rudders **20** deflects this stream of water and changes the direction of thrust, thereby affording steering control for the boat when the boat is driven in the forward direction.

In the embodiment shown in FIGURES 2 and 3 of the drawings, three rudders **20** are provided in the discharge end of the passage **19**. The two outboard rudders when adjusted to their straight-ahead positions are substantially in line with the side walls of the passage **19** and, therefore, are out of the path of the jet stream.

Each of the three rudders **20** is pivotally mounted on a vertical axis by a pair of pins **21** and **22**. The upstanding pin **21** is rotatably mounted in an upper bushing **23** of the housing section **12***b*, and the downwardly depending pin **22** is rotatably mounted in a lower bushing **24** of the housing section **12***b*. The three rudders **20** are adjusted simultaneously by the side-to-side actuation of a transverse link **25** which is pivotally connected to the forward ends of forwardly extending tiller arms **26** attached to vertical extensions **27** of each of the pins **21**.

The inlets of a plurality of reversing passages **30** communicate with the passage **19** upstream of the steering rudders **20**. Specifically, there are six separate reversing passages which, when the jet stream is deflected through them, direct six streams of water in a forwardly direction to impart a rearward thrust to the boat.

Two reversing gates **32** and **33** mounted within the passage **19** cooperate either to permit the water stream to flow rearwardly between the steering rudders **20** to impart forward thrust to the boat or deflect the jet stream into the reversing passages **30** to impart rearward thrust to the boat. When these gates are adjusted to drive the boat in the forward direction, the lower gate **32** closes the inlets to the reversing passages, and the gates **32** and **33** form walls of the nozzle passage **19**. When it is desired to shift the boat into reverse, both gates are operated simultaneously, the lower gate pivoting upwardly and the upper gate pivoting downwardly until they come into the edge-to-edge engagement shown in phantom lines in FIGURE 2 of the drawings. When adjusted to edge-to-edge relationship they cooperate to define a downwardly and rearwardly sloped wall which deflects the water stream into the reversing passages **30**.

As shown in FIGURE 3, the lower gate **32** is supported for pivotal movement by laterally extending journals **34** accommodated in bearings **35** of the housing **12**. The upper gate **33** is supported for pivotal movement in similar fashion.

The gates **32** and **33** are mechanically connected together by a parallelogram linkage arrangement so that they

can be operated simultaneously through a common actuator. Toward this end, a bell crank lever **35** is connected to the gate **33**, an arm **36** is affixed to the end of one of the journals **34** of the lower gate **32**, and a connecting link **37** pivotally connects the lower end of the bell crank lever **35** with the lower end of the arm **36**. The upper end of the bell crank lever **35** is connected by a pin and slot connection **38** to the lower end of a link **39** pivoted for rotation on a pin **40**. The upper end of the link **39** is pivotally connected to a reverse-ahead actuating lever **41**.

When the actuating lever **41** is moved to the left from the position indicated in FIGURE 2, the gates **32** and **33** are pivotally adjusted to their edge-to-edge positions shown in phantom lines in FIGURE 2 to deflect the water stream from the passages defined by the ahead rudders **20** into the reversing passages **30** to impart reverse thrust to the boat. During this operation, the lowering of the gate **33** tends to counterbalance the lifting of the gate **32** to make for ease of operation. In addition, the increased effort to lower the upper gate **33** against the force exerted by the jet stream as the effective surface area of the upper gate presented to the water stream increases is substantially counterbalanced by the force exerted by the jet stream tending to raise the lower gate **32** as the effective surface area of the lower gate **32** presented to the jet stream increases.

In order to afford steering control for the boat driven in the astern direction, each of the reverse passages **30** contains a reverse rudder **43**, and these are mechanically coupled to the ahead rudders **20** so that both the ahead rudders and the reverse rudders are operated from the steering wheel of the boat. Since the six reverse passages **30** are arranged in two rows of three each, three parallel shafts **44** are provided, each carrying two reverse rudders, and the three shafts are connected by a parallelogram linkage enclosed within a sealed chamber **45** of the housing **12**. The shafts **44** are rotated in unison by a bevel gear **46** carried at the lower end of the pin **22** associated with the center rudder **20**. The bevel gear **46** meshes with a bevel gear segment **47** carried by the centrally located shaft **44** and this bevel gear segment carries a downwardly depending arm **48** which is connected by transverse links **49** to the lower ends of downwardly depending arms **48'** affixed to the shafts **44** on either side of the centrally located shaft. Thus, the transverse link **25** which pivotally adjusts the three ahead rudders **20** also pivotally adjusts the six reverse rudders **43**.

An alternative embodiment of the control system of the present invention is shown in FIGURES 4 through 6 of the drawings. In this embodiment, the extreme end of the nozzle passage **19** flares outwardly to accommodate two ahead rudders **50**. The rudders **50** are each pivotally mounted on a vertical axis by a pair of pins **51** and **52**. The rudders are connected to the pins by upper and lower laterally extending plates **53** and **54**, respectively. The upper end of each of the pins **51** carries a pulley **55** around which a steering cable **56** passes. The pulleys **55** are each provided with a forwardly extending tiller arm **57**, and the tiller arms of the two ahead rudders **50** are connected by a transverse link **58** so that the ahead rudders **50** move in unison.

In the rudder arrangement of the embodiment shown in FIGURES 4 through 6 the rudders in the ahead direction are out of the path of the water stream with their inner surfaces forming continuations of the side walls of the exhaust passage upstream of the rudders. A feature of this arrangement is that the rudders impose virtually no drag on the boat while, at the same time, the flow of the water stream along the inner surfaces of the rudders tends to maintain them balanced in straight-ahead positions. Another feature of the rudder arrangement is that when the rudders are adjusted in one direction of the other, one of the ahead rudders presents a greater surface area to the jet stream than the other, creating an unbalanced condition which tends to restore the rudders to the straight-ahead position. More specifically, when the

rudders are in the positions shown in FIGURE 5, the downstream end of the port rudder **50** presents a larger surface area to the jet stream than the upstream end of the starboard rudder **50**. Since the force of the jet stream on the port rudder tends to restore the rudders to the straight-ahead position, it is apparent that the unbalanced forces acting on the two rudders will tend to restore the steering wheel to the straight-ahead position. The effect, therefore, is very similar to that obtained with the conventional steering rudder of a propeller-driven boat.

Since in the embodiment shown in FIGURES 4 through 6 the vertical axes of the ahead rudders **50** lie in the same planes as the horizontal axes of the two shafts **44** outboard of the intermediate shaft **44**, the lower ends of the pins **52** both carry bevel gears **60** which mesh with bevel gear segments **61** affixed to the ends of the said outboard shafts **44**. As shown in FIGURE 6, each of the gear segments **61** has a downwardly depending arm **62** affixed thereto. These arms **62** are connected by links **63** to the lower end of an arm **64** affixed to the intermediate of the shafts **44**. Thus, as in the embodiment shown in FIGURES 1 through 3 of the drawings, the shafts **44** are all connected by a parallelogram linkage to rotate in unison in order to adjust the reverse rudders **43**. In addition, the reverse rudders are mechanically coupled to the ahead rudders **50**, and both are controlled through the steering cables **56** from the steering wheel of the boat.

The invention has been shown in preferred forms by way of example only, and many variations and modifications can be made therein without departing from the spirit of the invention. The invention, therefore, is not to be limited to any specified form or embodiment except insofar as such limitations are expressly set forth in the claims.

I claim:

1. A control for a marine jet propulsion unit comprising an exhaust passage for discharging a jet stream to impart forward thrust to the boat, means defining a reverse discharge passage for the jet stream to impart reverse thrust to the boat, a deflector gate movable from a position closing said reverse discharge passage to a position for deflecting the jet stream into the reverse passage, ahead rudder means for deflecting the jet stream discharged through the exhaust passage for steering the boat during forward propulsion, astern rudder means for deflecting the jet stream discharged through the reverse passage for steering the boat during astern propulsion and common actuating means for both the ahead and reverse rudder means.

2. A control for a marine jet propulsion unit comprising an exhaust passage for discharging a jet stream to impart forward thrust to the boat, means defining a reverse discharge passage for the jet stream to impart reverse thrust to the boat, and counterbalanced reversing gates movable in unison in opposite directions to the jet stream from open positions to positions in which they cooperate to deflect the jet stream into the reverse discharge passage, one gate moving against and the other moving with the jet stream.

3. A control for a marine propulsion unit as set forth in claim 2 including common actuating means for both reversing gates.

4. A control for a marine jet propulsion unit as set forth in claim 2 in which at least one of the reversing gates closes the reverse discharge passage when the boat is to be driven in the forward direction.

5. A control for a marine jet propulsion unit comprising a passage for discharging a jet stream to impart forward thrust to the boat, means defining a reverse discharge passage for the jet stream to impart reverse thrust to the boat, upper and lower pivotally mounted reversing gates, one movable downwardly and the other movable upwardly into edge-to-edge relationship to define a sloping deflecting wall, whereby the increased effort

to lower the upper gate against the force exerted by the jet stream as the effective area of the upper gate presented to the water stream increases is counterbalanced at least in part by the force exerted by the jet stream tending to raise the lower gate as the effective area of the lower gate presented to the jet stream increases.

6. A control for a marine jet propulsion unit comprising a passage for discharging a jet stream to impart forward thrust to the boat, steering rudder means for deflecting the jet stream at the end of the passage for steering the boat in the forward direction, a reverse discharge passage communicating with the passage upstream of the rudder means, a pair of counterbalanced reversing gates movable into cooperating position to define a deflecting wall for directing the jet stream into the reverse discharge passage to impart reverse thrust to the boat, rudder means in the reverse discharge passage connected to the rudder means at the end of the said passage, and common activating means for imparting movement to the reversing gates.

7. A control for a marine jet propulsion unit as set forth in claim 6 in which the reverse discharge passage is subdivided into a plurality of passages and including a rotatable shaft extending through a plurality of said reverse discharge passages, the shaft supporting a reverse rudder within each of the reverse discharge passages.

8. A control for a marine jet propulsion unit as set forth in claim 6 in which the rudder means for steering the boat in the forward direction includes connected rudders mounted so that the trailing end of one and the upstream end of the other turns into the jet stream for steering, the area of the trailing end being larger than the area of the upstream end to produce unbalanced forces which tend to return the rudders to the forward position.

9. A marine jet propulsion system comprising means defining an exhaust passage through which a jet stream is discharged to impart forward thrust to a vessel, said exhaust passage defining means including a pair of side walls, at least two steering rudders at opposite sides of said exhaust passage, the leading edge of each rudder in the straight-ahead position of the rudder being directly behind and in substantial alignment with a downstream edge of one of the side walls of the exhaust passages, means pivotally mounting each rudder on an axis intermediate the leading and trailing edge of the rudder, whereby the pivotal movement of the rudder in one direction moves the leading end of the rudder away from the opposite edge of the respective side wall and into the path of the jet stream, causing part of the jet stream to be deflected outwardly between the rudder and the downstream edge of the respective side wall, and the pivotal movement of the rudder in the opposite direction moves the trailing end of the rudder into the path of the jet stream, means for pivotally moving the rudders in unison from their straight-ahead positions to move the leading end of one rudder and the trailing end of the other rudder into the jet stream, the trailing end of the rudder presented to the jet stream being of greater effective area than the leading end of the other rudder presented to the jet stream, whereby an unbalanced force is exerted on the rudders by the jet stream which tends to restore them to their straight-ahead positions, walls defining a reverse discharge passage communicating with the exhaust passage upstream of the rudders, means for deflecting the jet stream into the reverse discharge passage for propulsion astern, and rudder means for deflecting the jet stream flowing through the reverse discharge passage and operatively coupled with said above-mentioned rudders.

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