Sept. 9, 1969 L. CASTOLDI 3,465,705

WATER JET PROPELLING APPARATUS FOR BOATS

Filed March 20, 1968 2 Sheets-Sheet 1

Fig. 1

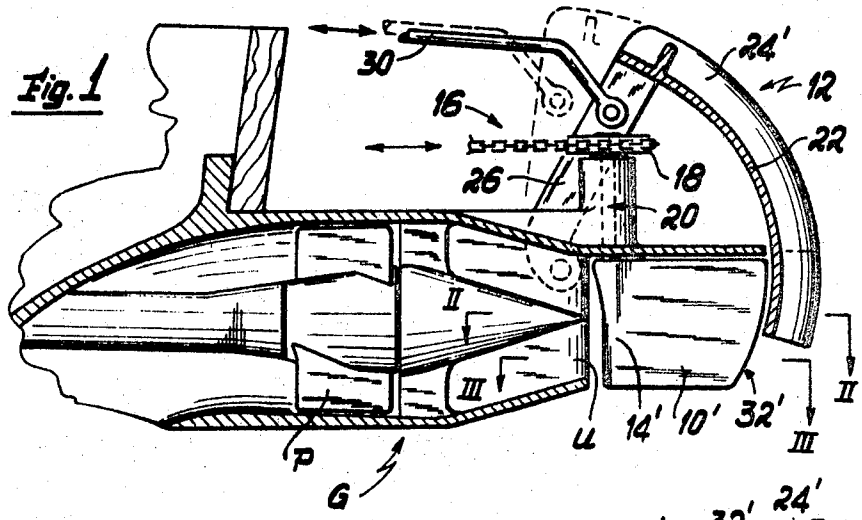
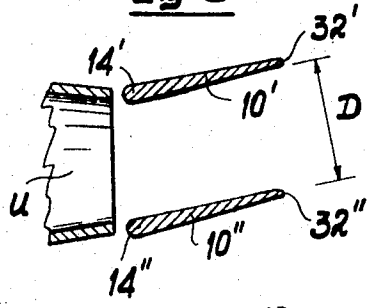


Fig. 3



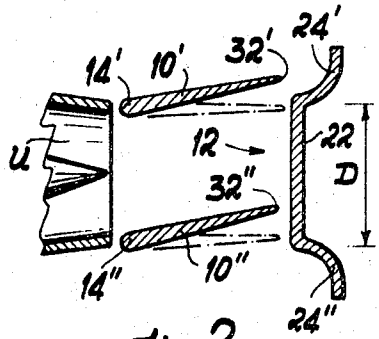


Fig. 2

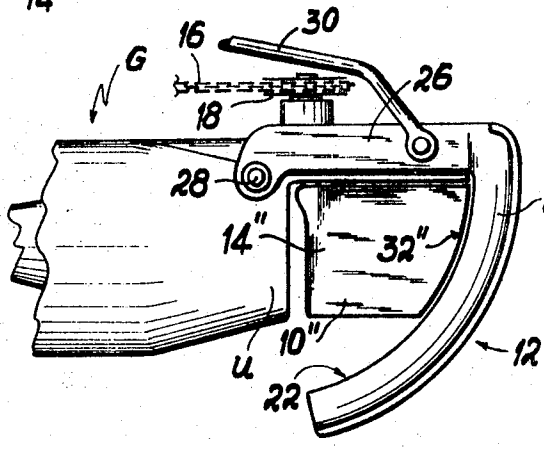


Fig. 4

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Sept. 9, 1969 LUIGI CASTOLDI 3,465,705

WATER JET PROPELLING APPARATUS FOR BOATS

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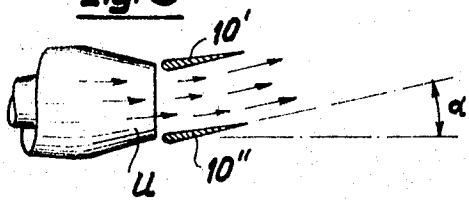
Fig. 5



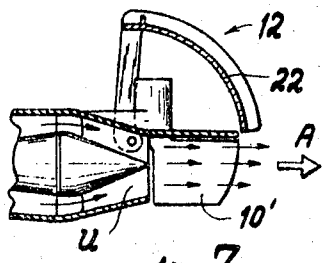


Fig. 7

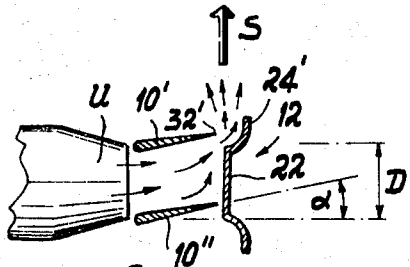


Fig. 6

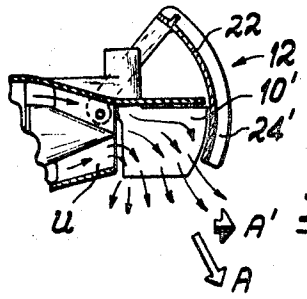


Fig. 8

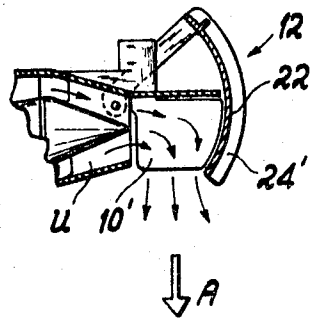


Fig. 9

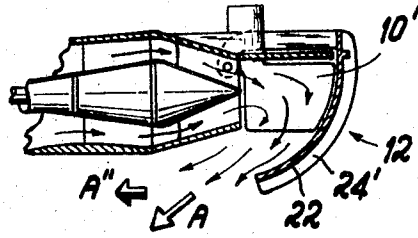


Fig. 10

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WATER JET PROPELLING APPARATUS FOR BOATS

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Claims priority, application Italy, Mar. 29, 1967,
14,288/67
Int. Cl. B63h *11/02*
U.S. Cl. 115—12 6 Claims

ABSTRACT OF THE DISCLOSURE

A water jet propelling apparatus, for boats, comprising a water pump to force water through a nozzle directed astern of the boat for propelling the boat in a straight forward course, rudder blades located at either sides of the jet for laterally deviating same under steering control, and a jet reversing gate which can be lowered under reverse control for reversing the thrust, said gate having laterally deflecting parts associated to its sides and positioned so that a portion of the jet, when laterally deviated by steering of said rudder blades, impinges on said deflecting part, forms a lateral jet projected toward the side at which said rudder blades have been steered, and provides a lateral thrust causing the boat to rotate about its yawing axis and boosting the steering control thereof.

BACKGROUND OF THE INVENTION

This invention relates to a water jet propelling apparatus and especially to a class suitable to be fixedly secured to the transom of the boat hull. The invention is mostly applicable for shallow draught boats.

Water jet motors and units are now being widely applied to the field of medium and in particular of small boats. In this method of propulsion, the boat's engine drives a water pump which forces water, at suitably high volume and pressure, through a nozzle directed astern of the boat. In the nozzle, the mass of water is accelerated and the thrust reaction drives the boat forward. The boat can be steered by directing the jet of water. Such water jet motors, both inboard and outboard, are well known and further discussion thereabout is unnecessary.

This invention is particularly concerned with various problems concerned with steering and controlling of boats provided with water jet propelling motors of the inboard type. Steering of boats provided with water jet motors of outboard type does not generally involve serious problems because the motor-water pump-nozzle assembly consists of one unit steerably secured to the boat's transom, and the water jet is directed by controlledly rotating the entire unit about a nearly vertical axis. To move the boat backward, a reversing gate is generally mounted so that it can be controlledly moved and positioned to cause the jet to impinge thereon and then be forwardly deflected thereby, the rotation of the unit about said axis allowing boat steering in reverse. On type of such outboard water jet motor has been detailedly described in the U.S. Patent No. 3,082,732, for example.

Such simple mode of steering the boat can obviously, not be used when the boat is provided with a fixed or

inboard type water jet propelling apparatus. Such type of apparatus, while highly desirable for its reliability of service and several other well known reasons, requires sidewards deflecting means linked to the steering wheel for controlledly deflecting the water jet to either sides. Many arrangements of parts have been heretofore proposed, but several deficiencies in the present day water jet propelling inboard motors and units exist. Said deficiencies are, among others:

(a) Provision of one or more steering plates or rudders in the stream of water jet, within or astern of the nozzle; such provision leads to disturbance and turbulence of the jet, spoiling the propelling thrust thereof;

(b) Generally poor steering response at low boat speed and in the occurrence of small forward thrust; such poor steering is particularly objectionable because short radius steering is especially desirable when low speed maneuvers, such as to dock or moor, are to be performed;

(c) Poor or even null steering of the boat in reverse;

(d) Problems related with linking between steering wheel and water jet sideward deflecting means, in relations with steering response and sensitivity of the boat to steersman's action. In general, too many revolutions must be imparted to the steering wheel for promoting a low speed short radius turn. A link which would not lead to said deficiency should lead to a seriously objectionable overcontrolling of the boat when accelerated to high speed.

BRIEF SUMMARY OF THE INVENTION

It is, therefore, an object of this invention to provide an improved water jet propelling apparatus which is not subject to the above and other objections and deficiencies.

More particularly, it is an object of this invention to provide a new and improved water jet propelling apparatus for boats, of the type comprising a not steerable nozzle fed by a water pump driven by a motor or engine which can be throttled by the helmsman and fixedly secured to the boat hull to provide a water jet directed astern of the boat in or parallel to the longitudinal plane of symmetry of the hull, rudder means for sidewardly deviating the jet in response to an action exerted on the steering wheel (or other steersman operated steering control means), and gate means for forwardly deflecting the jet in response to an action exerted on a reverse lever (or other steersman operatable reverse control means), and wherein the improvements comprises the provision of side-thrust boosting means associated with said jet deflecting means to boost under steerman control the side thrusts promoted by acting on the steering control means.

Another object of the present invention is to provide an improved water jet propelling apparatus as above, wherein said boosting means comprise further sidewardly deviating parts structurally associated with said gate means, whereby the amount of the further sidewardly deviated water from the water jet can be controlled by the steersman by acting on the reverse control means and on the motor throttle means, irrespectively of the actual longitudinal (forward or reverse) thrust reaction applied to the boat.

Yet another object of the present invention is to provide an improved water jet propelling apparatus as above, which is of simple and sturdy construction and reliable in operation.

These together with other objects and advantages which will become subsequently apparent reside in features, combinations and arrangements of parts and details of construction and operation as more fully described and claimed, reference being had to the accompanying drawings forming a part of this disclosure, wherein like numerals refer to like parts therethroughout.

BRIEF DESCRIPTION OF THE VIEWS OF THE DRAWINGS

FIGURE 1 shows a longitudinal sectional view of an apparatus improved according to the present invention, comprising the water pump, nozzle, jet deviating means, jet deflecting gate means and water deviation boosting means, for an inboard motor propelling unit;

FIGURES 2 and 3 fragmentary illustrate the nozzle and the steersman controlled water jet influencing means in longitudinal horizontal sectional views taken as indicated by II—II and respectively III—III in FIGURE 1;

FIGURE 4 is a fragmentary side view of the apparatus of FIGURE 1, with its water jet reversing gate means in its fully lowered position;

FIGURES 5 and 6 diagrammatically illustrate, partly in horizontal sectional view and partly from above, the nozzle and the water jet influencing means in their relationship shown in FIGURES 2 and 3, respectively, for better understanding of the operation of the new apparatus, together with FIGURES 7 to 10 inclusive, wherein the apparatus is shown in the sectional showing of FIGURE 1, but in rather diagrammatical manner and with the water jet reversing gate means in various positions from fully raised to fully lowered.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

For clearer understanding of the invention and consistency of terms, as this description proceeds and in the appended claims the following expressions will be made use of to mean:

"Deviation" and "to deviate" will indicate the sideward deviation (in a horizontal plane) of the water jet, such as exerted by conventionally arranged and operated rudder-like plate means adapted to impart a discrete lateral angulation to a water stream impinging thereon;

"Deflection" and "to deflect" will indicate an action leading to a substantial sideward modification (in a horizontal plane) of the path of the jet stream or of a part thereof, not exerted by said rudder-like means; and

"Reversion" and "to reverse" will indicate an action leading to a substantial forwardly modification of the water jet or of a part thereof, in a vertical plane, such as exerted by a conventionally arranged and operated reversing gate.

In FIGURES 1 and 4, there is shown a screw-propeller type water pump, generally indicated at P, conventionally drivenly connected to an inboard engine (not shown) and arranged within a suitably shaped duct formed within the casing of a water jet propelling apparatus, generally indicated at G, fixedly secured to the boat transom and having an outlet consisting of a nozzle U having a given width and cross-sectional area. Said pump, duct and nozzle means are quite conventional and can be constructed in several different manners, according to the art to which this invention appertains, together with the inlet or scoop vane or vanes (not shown) required for ensuring sufficient delivery of water to the pump.

The above briefly indicated means are adapted to provide and issue a water jet astern of the nozzle, the axis of which is contained in or is parallel to (in the case that the boat is provided with two propelling devices, for example) the longitudinal vertical plane of symmetry of the hull. For simplicity, the invention will be herein described assuming that the propelling device is located in said plane.

It will be readily evident that such assembly, apart from the features and components which will be discussed hereinbelow, is capable of providing an undeviated and undeflected water jet adapted for forwardly propelling the boat along a straight course. The propelling power will be proportional to the product of the mass by velocity of the water jet. Such product will be hereinbelow indicated by the approximate but more evident expression "jet power." Such jet power can be conventionally controlled and modified by the steersman, by acting on the conventional engine controls, such as the throttle lever with which motorboats are conventionally provided.

Astern of the nozzle outlet, two rudder-like deviating blades **10'** and **10''** are arranged and pivotally supported for rotation about vertical or nearly vertical axes contained within or adjacent to the forward or leading edges forming portions **14'** and **14''** of rudder blades **10'** and respectively **10''**; said rudder blades are vertically arranged in parallel relationship at starboard and at port side, respectively, of the water jet issuing from the nozzle, at an interval D (FIGS. 2, 3 and 6) which is preferably slightly greater than the width of said jet, so that, when said rudder blades are parallel to said jet also, the accelerated water will not frictionally engage the infacing surfaces of said blades and the jet power will not be prejudiced.

Said rudder blades are suitably concurrently linked to the steersman controlled steering control means, such as a conventional steering wheel (not shown). The linking means can comprise, for example, a sprocket chain **16** in mesh with sprocket gears **18** secured to the upper end of each rudder shaft **20** (indicated by phantom lines in FIG. 1) rotatably supported on hubs secured to or integrally formed with the propelling apparatus casing, for example.

In FIGS. 1, 4 and 7 to 10 there are shown rudder blades **10'** and **10''** having a straight horizontal lower edge located at the lower level of the nozzle. If desired, such rudder blades can be shaped so that lower portions thereof will more deeply protrude into the water beneath the jet for acting in a quite rudder fashion into the water on which the sped-up boat can skid. Such downwardly protruding rudder portions can be made of rubber-like or resilient material. As shown in FIGS. 1, 4 and 7 to 10, a horizontal rearwardly protruding plate is arranged above the jet and the rudder plates, said horizontal plate being secured to or integrally formed with the said propelling apparatus casing.

The apparatus is further provided with a reversing gate assembly, generally indicated at **12**, having a vertical plane of symmetry common with the vertical plane of symmetry of the water jet producing assembly. As far as the water jet reversing to forward is concerned, the arrangement and the operation of said reversing gate is old and well known in the art, as described in the U.S. Patent No, 1,700,913 (gate **9**) for example. Said reversing gate **12** has generally a curved configuration in its vertical longitudinal sections, forming an arc having its centre in the axis of pivots **28** (FIG. 4) by which said gate is supported for rotation about said axis to the propelling apparatus casing, braces **26** being provided to connect the gate structure to said pivots.

Said reversing gate is arranged for rotation from its fully raised position shown in FIG. 7, wherein the water jet is undisturbed by the gate, to its fully lowered position shown in FIGS. 4 and 10 for reverse. It is suitably linked, by means of a connecting rod such as indicated at **30**, to conventionally constructed and arranged steersman controlled reverse control means, such as a reverse lever (not shown).

The said reversing gate **12** comprises a central portion **22** the forward-facing surface of which is symmetrical and perpendicular to the vertical plane of symmetry of the nozzle. Preferably, such surface has the shape of an arc of a cylinder having its axis common to the axis of pivots **28**.

Such shape is however not critical, the criticality residing in the symmetry of such surface, so that an undeviated water jet impinging (completely or partially) on said surface, will be reversed without promoting formation of unbalanced side thrusts, that is so that lowering of said reversing gate into an undeviated water jet will not lead to a modification of the boat straight course or heading, both forward or at reverse.

The width or transverse dimension of said central portion **22** is equal to or slightly greater than the interval D between said rudder blades **10'** and **10''**. At both sides of said portion **22** two symmetrically shaped water deflecting surface forming parts **24'** and **24''** are arranged. Such parts are preferably but not critically fixedly secured to or integrally formed with said portion **22** and generally to and respectively with the reversing gate structure. Said parts **24'** and **24''** are shaped to provide, in their cross-sectional configuration shown in FIGS. 2 and 6, sidewardly water deflecting concave faces adapted to cause a substantial sideward deflection, preferably at or near to a right angle, of any water stream caused to impinge thereon. The said cross-sectional configuration is preferably but not critically uniform in the full height of the said parts and of the reversing gate.

In addition, the said rudder blades **10'** and and **10''** preferably shaped for nearly precisely confining the space therebetween and wherein the water jet is directed to impinge on the central portion **22** of the reversing gate, for preventing that a substantial part of the accelerated water impinges on said deflecting parts **24'** and **24''**, when said rudder blades are positioned in their central position, that is the boat is steered for straight course either forward and the reverse.

In view of above the trailing edges **32'** and **32''** of said rudder blades **10'** and respectively **10''** are shaped according to an arc of circular configuration, having its center in the axis of pivotal connection (at **28** FIG. 4) of the reverse gate, so that a small clearance is formed between said trailing edges and the forwardly facing surface of said central portion **22** of the reversing gate, as evident in particular from the showing of said FIG. 4.

OPERATION OF THE IMPROVED APPARATUS

From the above and by a consideration of the accompanying drawings the operation of the improved apparatus will be readily understood, as hereinbelow discussed. There will be considered first the aspects of the apparatus, which are common in the art, and its basic controls. Briefly recalling back to said aspects, the apparatus can be considered as comprising a motor driven water pump and nozzle means capable of providing a water jet adapted for propelling the boat in a forward straight course, jet deviating rudder means capable of modifying said course and jet reversing gate means capable of reversing said course, each said means being individually under steersman's control.

Therefore, there are three control means which can be individually acted upon by the steersman, to obtain three corresponding basic actions, as follows:

(I) Engine control (namely: the throttle lever) by which the steersman can control and adjust the power of the jet as actually issued from the nozzle; this is the basic speed control also;

(II) Steering control (namely: the steering wheel) by which the steersman controls the course and the heading of the boat, and causes the boat to perform turns of the desired radius, within certain limits; this control acts by laterally deviating the water jet, so that its reaction provides a transverse component of the propelling force, that is a side thrust; and

(III) Reverse control (namely: the reverse lever) by which the water jet is caused to partially or totally impinge on the reversing gate; the lowering of said gate can be adjusted so that the horizontal component of the jet reaction can be decreased down to zero and then reversed. This latter control may be assumed to be an ancillary speed control also, as being capable of adjusting the value of said horizontal component, which represents the actual propelling force.

The improved apparatus of the invention is designed to provide and make use of each of said basic controls and also of certain new coordinated maneuvres resulting from a new coordination of said basic controls.

INDIVIDUAL BASIC CONTROLS AND EFFECTS

Assuming that the reversing gate **12** will be fully raised as shown in FIG. 7, and the rudder blades **10'** and **10''** will be maintained parallel, the course of the boat will be "straight forward" as the water jet is undeviated and undisturbed astern of the nozzle. The speed of the boat is subject to engine control (I) adjustment only. The small arrows in FIG. 7 indicate the water stream from the nozzle, and the big arrow A vectorially indicates the jet power.

Acting on the steering control (II), the water jet is laterally deviated, principally by the inwardly deviated rudder blade (the rudder blade **10''** of FIGS. 3 and 5) and the boat is caused to take a turn the radius of which is nearly inversely proportional to the rudder blades' lateral inclination or rotation about their nearly vertical pivotal axes. The individual action on the steering control (II) is typical for controlling and adjusting the boat heading and course, when the boat travels at its cruising or higher speed, and in general when no sharp turns or abrupt maneuvres are to be performed at substantial speed.

In consideration of the possible performance of coordinated control maneuvres, which can be performed by the provision of the improved apparatus, as hereinbelow discussed, the follow-up linking of the rudder blades to the steering control means, namely a steering wheel, can be advantageously made so that a substantial and rather ample action is to be exerted on said steering means or wheel, for obtaining a rather small rudder blades' deviation, such as the one indicated by angle "alpha" in FIGS. 5 and 6 (10 to 12 degrees about). As a matter of fact, a prejudiciable overcontrolling of the boat can be prevented if the latter does not abruptly react to steering control and gentle turns can be more easily made at cruising and maximum speeds.

The well known effects of reverse control (III) will be apparent from FIGS. 7 to 10. Disregarding now any lateral deviation of the water jet, the effects of the adjustment (that is lowering) of the reversing gate **12** are evident: a small lowering of the gate (FIG. 8) such to provide a partial interception of the water jet, will downwardly direct the jet, so that its power A will be downwardly and rearwardly inclined, in the vertical plane, to provide a rearwardly directed horizontal component A' representative of the actual propelling force applied to the boat. Such force can be adjusted down to zero by further lowering the gate **12**, as shown in FIG. 9, so that no propelling power will be applied to the boat.

Therefore, the steersman can, by acting on the reverse control (III), adjust the boat speed and acceleration at values lower than the one provided by the undeflected actual water jet. In other words, the steersman can, without throttling the engine (without acting on the engine control (I)) adjust the propelling power from maximum to zero.

Still further lowering the gate **12** from the position of FIG. 9 towards the position of FIG. 10, the jet power A is further forwardly deflected to provide a forwardly directed horizontal component A'', that is to provide a reversed thrust adapted for moving the boat at reverse, for fast deceleration of the boat and any other known maneuvre requiring "engine at reverse." At reverse also the actual reverse thrust applied to the boat can be adjusted from maximum to zero by acting on the reverse control (III) only, that is by adjusting the reversing gate

12 in the desired lowered position from the position of FIG. 10 to that of FIG. 9.

COORDINATED CONTROLS AND EFFECTS

The effects of coordination of steering control (II) and of reverse control (III), and possibly of engine control (I), on a motorboat provided with the improved apparatus of the present invention, are mostly evidenced by the showing of FIG. 6, which can be considered jointly with any one of FIGS. 8, 9 and 10.

Assuming that the reversing gate **12** will be at least partially lowered to intercept at least a part of the water jet, and that the rudder blades **10'** and **10''** will be steered so that the outwardly deviated blade (the blade **10'** in FIGS. 2 and 6) will uncover the side edge (at the corresponding side) of central portion **22** of the reversing gate, a part of the water stream of the jet will be caused to impinge on the sideward water deflecting part **24'** associated to the gate. Such deflected part of the jet will form a lateral jet the power of which is represented by arrow S and the resulting thrust reaction (applied to said deflecting part **24'**) will apply to the boat a side thrust capable of rotating the boat about the yawing axis of the hull.

Said lateral jet will be anyway produced at the side at which the rudder blade have been laterally deviated, and therefore it will promote and expedite a modification of the boat heading concurrently with the heading modification promoted, at forward motion of the boat, by the steering control (II) which has allowed such lateral jet to be formed (by uncovering of part **24'** to water jet impingement) and, therefore, the effect of the coordinated actions on steering control (II) and on reverse control (III) can be properly termed as a "boosting" of steering control (II) on the boat forwardly moving at any speed from top speed down to zero.

The value of the side thrust obtained by above described coordination of controls is influenced by three parameters, each one of which is under full steersman control, that is:

(i) The water jet power, controlled by engine control. Irrespectively of the relative positions of rudder blades and of reversing gate, if only positioned for providing at least some lateral jet, the effect of such lateral jet is proportional to the power of the actually emitted water jet issued from the nozzle.

(ii) The amount of the side portion of the water jet, allowed to impinge on the deflecting part **24'** (or **24''**). Such amount is controlled by steering control (II) which governs the spacing at which the trailing edge **32'** (or **32''**, FIGS. 2 to 4) uncovers the deflecting part **24'** (or **24''**). Such amount is proportional to the amplitude of the steering control, and such proportionality is very desirable for proper steering of the boat. As a matter of fact, as the "boosting" of steering control is also proportional to the lowering of the reversing gate (as discussed below), for any given "boosting ratio" provided by gate adjustment, the response of the boat to steering control (I), either boosted or not (gate **12** fully raised, FIG. 7) will be satisfyingly proportional to the steering of rudder blades, that is to the steering control (II).

(iii) The "vertical" amount of the water jet reversed by the reversing gate, which is therefore proportional to the amount caused to impinge on either deflecting part **24'** or **24''**. Such vertical amount is adjusted by acting on the reverse control (III) and this adjustment is coordinated with the adjustment of actual horizontal component of the jet power, as discussed above, and it can be further coordinated with engine control (I).

Few examples of the effects which can be obtained by coordination of controls (I), (II) and (III) will make clearly apparent the principal features and advantages of the present invention:

By positioning the rudder blades as shown in FIG. 6 and the reversing gate as shown in FIG. 9, the boat is caused to turn about its yawing axis "on the spot," without any tendency to forward or backward motion, even if such turning of the boat on the spot is insisted to. The rotational speed of the boat about the yawing axis thereof can be adjusted at will by acting on the engine control.

The combination of positions of FIGS. 6 and 8 provides prompt and sensitive heading control by acting on the steering control alone at low speed, that is such combination is exceedingly desirable when maneuvering in a crowded harbor, when approaching to mooring or docking and so on, the raising of gate **12** allowing further prompt acceleration of the boat, if required, with concurrent zeroing of the steering control boosting effect. Conversely, the further lowering of the gate will lead to slowing down of the boat and even prompt deceleration, when desired (by applying the reverse) without spoiling the prompt response of the boat to the steering control.

The coordinated controls are very effective and useful when the boat is steered and maneuvres are to be made in current water such as in river or tidal streams, that is where the ground speed of the boat could be different from the water speed thereof. The heading can be easily controlled at low speed either moving upstream or downstream.

When the boat is steered in an emergency, such as in a collision route, a sharp turn can be promoted by prompt lowering of the reversing gate (down to provide fast deceleration, if required) subsequently to or concurrently with the action the steering control, and without reverse turning of the steering wheel, when the gate is lowered for deceleration, that is when the propelling assembly operates at reverse.

I claim:

1. In a boat having water propelling means including a nozzle adapted to provide a water jet projecting astern of the boat and motor-driven pump means for delivering a stream of pressurized water through said nozzle, in combination, steering means comprising a pair of steerable rudder blades located astern of said nozzle in the body of water surrounding said boat and respectively at opposite sides of the water jet issuing from said nozzle, said blades being pivotally supported in substantial parallel relationship with a given distance therebetween for pivoting movement to either side from a rest position in which said blades extend substantially parallel to a longitudinal plane of symmetry of said nozzle, said blades defining between rear edges and bottom edges thereof openings through which the water jet may pass in the surrounding body of water; means connected to said blades for simultaneously pivoting the same to either side of said rest position for controlled sideward deviation of the water jet passing therebetween; reversing gate means having a jet reversing surface laterally defined within side edges spaced in transverse direction from each other at a distance substantially equal to said given distance and water sidewardly deflecting surfaces respectively symmetrically located outwardly of said side edges for laterally deflecting a portion of the water jet when deviated laterally outside of said side edges upon pivoting of said blades to either side of said rest position; and means for moving said surfaces of said reversing gate means closely adjacent to said rear edges of said blades between an upper end position above said blades, a plurality of intermediate positions in which said surfaces move to an increasing extent over the opening defined by said rear edges of said blades so as to force the jet of water to flow at least in part in downward direction through the opening defined between said bottom edges of said blades, and a lower end position in which said reversing surface of said reversing gate means reverses the direction of said jet, whereby a portion of the water jet will be laterally deflected in said intermediate positions and said lower end positions of said reversing gate means when said blades are pivoted

to either side of said rest position to boost the steering action obtained by pivoting said blades.

2. A structure as defined in claim 1, wherein said water sidewardly deflecting surfaces consist of sidewardly and rearwardly facing surfaces pertaining to parts symmetrically located at both sides of said jet reversing surface.

3. The structure as defined in claim 2, wherein said parts are secured to said water jet reversing gate at both side edges of said water jet reversing surface thereof.

4. The structure as defined in claim 1, wherein said jet reversing surface of said reversing gate means is of cylindrical configuration, and wherein said gate means is turnable by said moving means about an axis substantially normal to a vertical plane of symmetry of said nozzle and located above the latter.

5. The structure as defined in claim 4, wherein said rear edges of said rudder blades are arc-shaped and

coaxially arranged with said cylindrical jet reversing surface and positioned to provide a small clearance therewith.

6. The structure as defined in claim 1, wherein said transverse dimension between said side edges of said jet reversing surface is slightly greater than said given distance.

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60—221