A marine jet drive apparatus includes a power trim unit coupled to a jet deflector for remote trim positioning of the jet and for controlling steering deflection of the jet to either side. An auxiliary rudder also coupled to the jet deflector to vary the effectiveness of the auxiliary rudder with the trim positioning. The main jet deflector is a tubular extension of the jet nozzle and is mounted for trim positioning. The main jet deflector is a tubular extension of the jet nozzle and is mounted for trim rotation about a transverse axis by a gimbal ring. A powered trim control link is connected to the ring for setting of the jet with respect to the horizontal. The jet deflector is pivotally mounted within the gimbal ring to create a vertical steering axis for angular positioning of the jet deflector through the normal 40° to 50° for conventional type steering. The rudder has an upper portion projecting between a pair of depending walls of the jet deflector and with the opposite sides slidably engaging the opposing portions of the walls. As the trim position of the jet deflector changes, the sliding coupling automatically moves with respect to the pivot axis of the auxiliary rudder and varies the effective center of rotation of the coupling with respect to the axis of the deflector and the rudder axis.

27 Claims, 7 Drawing Figures
MARINE JET DRIVE WITH POWER TRIM CONTROL AND AUXILIARY RUDDER STEERING

BACKGROUND OF THE INVENTION

This invention relates to a marine jet drive having a power trim control and a combined deflector and rudder steering control apparatus and particularly to such a drive employing a novel coupling between a steering jet deflector means and auxiliary rudder means.

Jet drives for small recreational boats and the like have been more recently developed to replace the conventional outboard motor and/or conventional propeller driven stern drive units. Jet drive units have certain distinct advantages from the standpoint of safety as well as maintenance as a result of significant reduction in the required moving parts and the like. A particularly satisfactory jet drive system is shown in the co-pending application of the present invention entitled "Marine Jet Drive Propulsion Apparatus" which was filed on Dec. 21, 1972 with Ser. No. 317,200, now U.S. Pat. No. 3,857,355, and which is assigned to the same assignee as the present application. As more fully pointed out in that application, marine propulsion jet drive apparatus generally includes a pump means for establishing and projecting of a water jet which is emitted through the boat transom as a powered jet stream which establishes foward boat motion. A suitable gate means is employed to deflect the jet stream downward and forwardly of the boat to produce a reverse or backward boat movement. Steering is accomplished by deflection of the jet stream laterally from side to side. The steering may be effected by either providing complete movement of the nozzle, or by a fixed nozzle with a suitable steerable jet stream deflecting means. Thus, the above application particularly discloses a highly improved steering means mounted within the aft end of the jet emitting housing and the jet nozzle to effect a continuous steering action.

Although steering systems have been provided, jet propulsion drive systems have presented rather significant difficulties in the adequate maneuverability and steering of the boat at relatively low speeds and in the event of total loss of jet power at high speeds. Thus, low speed is, or course, created by use of a reduced power jet which, however, results in a significant reduction in the steering capabilities. Generally, adequate low speed steering requires creation of short bursts of power by operator to provide corresponding high powered pump thrust to effect turning of the boat. It has been suggested that the steering can be further improved by the introduction and employment of a relatively fixed rudder attached directly to and movable with the steering deflector and/or nozzle. Although the additional rudder connected to and depending downwardly from the jet steering deflector contributes to the steering capabilities and to effecting adequate steering at high speed in the event of loss of power, Applicant has discovered the effectiveness is significantly limited relative to a completely separate boat rudder by the relatively more limited rudder maneuverability or rotation resulting from its being fixed to the main deflection system. Current jet propulsion drives have a turning angle of about 40° to 50° of the total steering motion. Thus, one-half of the total angular displacement provides for steering to the left and the opposite provides for steering to the right. The rudder being affixed to the conventional steering drive mechanism has a similar steering angle. Although the low speed steering is improved by the addition of the rudder, Applicant has found that jet drive steering remains quite difficult at low speeds, particularly for the week-end boater.

To provide separate steering mechanism, of course, requires separate steering controls which even further complicate the normal operation of the boat drive.

SUMMARY OF THE PRESENT INVENTION

The present invention is particularly directed to an improved marine drive steering mechanism including a jet drive with a novel power trim and with a novel auxiliary rudder coupled to the main steering means such as a steerable jet deflector means with amplification response means which increases the auxiliary rudder movement in response to the conventional movement of the main steering means. In accordance with a highly improved and novel feature of the present invention, the degree of amplification may be changed and particularly in an automatic manner with an adjustment of the jet trim angle relative to the boat to change the effectiveness of the auxiliary rudder. Thus, in accordance with one important feature of this invention, a coupling is provided between the main drive jet steering means and the auxiliary rudder means which varies the effectiveness of the auxiliary rudder with the trim positioning of the main drive jet steering means.

More particularly, in accordance with the present invention, the auxiliary rudder is coupled to the main jet deflector through a suitable mechanical coupling which amplifies the movement of the auxiliary rudder according to the angular steering displacement of the main jet steering means. For example, the steering axis of the auxiliary rudder may be mounted aft of the steering axis of the main jet deflector. Consequently, any angular motion of the deflector is transmitted as a greater angular movement to the auxiliary rudder means. This then does provide increased or accentuated effects by the auxiliary rudder which will improve the low speed steering response and maintain steering control if the jet thrust is reduced or lost.

In accordance with the highly significant novel aspect of the present invention which includes variable amplification features, the main jet steering deflector is mounted for trim rotation about a transverse axis. In a particularly novel construction, a deflector is gimbal mounted with a power trim control coupled to the gimbal ring for preselecting and setting of the deflector with respect to the horizontal. The coupling between the deflector and the auxiliary rudder provides automatic variation in the relative offsetting of the axis of the auxiliary rudder with respect to the axis of the deflector in accordance with the trim setting. This then creates a means which automatically varies the amplification of the auxiliary rudder drive with the power trim setting. Preferably the system is established so as to maintain maximum amplification at relatively low speeds and a minimum or zero amplification at high speeds.

More particularly in a preferred and particularly novel construction of the present invention, the jet stream deflector unit is mounted to the jet drive by a suitable gimbal ring permitting the angular orientation thereof about a transverse axis or trim setting. A power trim unit, such as a hydraulic power cylinder, is coupled to the gimbal ring for remote, powered trim con-
The gimbal ring also provides a vertical steering axis mounting for angular positioning of the deflector through the normal 40° to 50° for conventional type steering. The auxiliary rudder is mounted centrally beneath the deflector unit, with a vertical steering axis, which is generally aligned with but slightly offset aft of the true vertical steering axis of the jet stream deflector. The rudder depends downwardly as well as extending forwardly and rearwardly. The main deflector generally includes a forward directed nozzle means for effecting reverse movement of the boat. In accordance with the present invention, the rudder structure includes a portion projecting upwardly and connected by an interfering surface on the rudder and the deflector such as a pair of coupling brackets attached to the forward directed nozzle means in sliding engagement with the opposite sides of the rudder portion. As the trim position of the deflector unit changes, the sliding coupling automatically moves with respect to the pivot axis of the auxiliary rudder and varies the effective center of rotation of the coupling with respect to the axis of the deflector unit and the rudder axis. Trimming between full up and full down results in a significant change in the angular rotation of the rudder for any given steering rotation of the deflector unit. Greater amplification will normally be selected to occur at the full down trim position which is used at low speeds. Consequently, the rudder contributes to an effective increase in steering movement at low speeds and significantly improves the steering capabilities for jet drive systems for docking, maneuvering, low speed maneuvering and the like. Conversely, when the operator trims up in accordance with the increased speeds, the amplification is reduced and may reach or approach zero to maintain normal response provided by the conventional nozzle deflector drive which will produce adequate steering even if there is a loss of jet power.

The present invention thus provides a significant improvement in the low speed steering capability of marine jet propulsion apparatus without adversely effecting the response of the steering system during normal higher speed running operation.

**BRIEF DESCRIPTION OF THE DRAWINGS**

The drawings furnished herewith illustrate the best modes presently contemplated by the inventor for carrying out the subject invention and in which the above advantages and features are clearly disclosed as well as others which will be readily understood from the following description of such illustrated embodiments.

In the drawings:

**FIG. 1** is a side fragmentary elevational view of a boat provided with marine jet propulsion drive means having an auxiliary rudder coupled to the main steering mechanism in accordance with the present invention;

**FIG. 2** is an end elevational view of the jet drive apparatus illustrated in **FIG. 1**;

**FIG. 3** is an enlarged vertical section of the jet drive in **FIG. 1** and more fully illustrating the level trim position of the apparatus;

**FIG. 4** is a reduced top view of the jet drive assembly including the jet deflector positioning control;

**FIG. 5** is a schematic illustration of a linkage more clearly illustrating the kinematic theory of the rudder control as shown in **FIG. 1–3**;

**FIG. 6** is a schematic side elevational view of an alternative jet drive, without the power trim in **FIG. 1–3**, and employing an auxiliary rudder in accordance with the present invention which provides a single amplified steering characteristic; and

**FIG. 7** is a top view of the structure shown in **FIG. 6** to more clearly illustrate the functioning of the embodiment shown in **FIG. 6**.

**DESCRIPTION OF ILLUSTRATED EMBODIMENTS**

Referring to the drawings and particularly to **FIG. 1**, a marine jet propulsion apparatus 1 is mounted to a boat 2, of which only the fragmentary portion is illustrated. The propulsion apparatus 1 includes an internal combustion engine 3 mounted within the boat 2 and connected to drive a pump unit 4 which projects outwardly through an opening 5 in the boat transom 6. The pump unit 4 has an inlet opening 7 in the lower portion of the boat 2 and is adapted to draw the water upwardly through the boat, to pressurize the water and deliver the pressurized water as a driving jet 8 through a discharge control steering deflector unit 9 mounted aft of the transom 6. A forward mounted steering wheel 10 is shown connected by suitable steering cable 11 to the deflector unit 9 for selectively pivoting thereof about a generally vertical axis 12 for lateral deflecting of jet 8 and turning of the boat to the right or left as shown in **FIG. 4**. In this embodiment of the jet drive, the steering deflecter unit 9 is mounted on the aft side of the transom 6 to a pump nozzle housing 13 by a gimbal ring 14, which permits angular orientation of the deflector unit 9 about a lateral axis 15. A suitable powered operator 16 is attached by a linkage 17 to the gimbal ring 14 for providing selective trim control to change the jet stream 8 relative to the attitude of the boat 2. A remote control unit 18 is provided at the steering location in the boat to control the operator 16 and automatically rotate the attached steering deflector unit 9 about the axis 15 in a predetermined manner to provide a remote, powered trim control. An auxiliary rudder 19 is pivotally mounted immediately beneath the steering deflector unit 9 and is connected to the bottom, aft end of the deflector unit 9 through a novel coupling mechanism 20 constructed in accordance with the present invention to provide controlled, amplified auxiliary steering. The coupling of the rudder to the deflector unit 9 automatically varies with the powered trim setting, adjusting the amplification of rudder movement with deflector movement and thereby producing highly improved low speed steering characteristics without adversely affecting high speed steering, as more fully developed hereinafter.

More particularly, as most clearly shown in **FIG. 3**, the illustrated pump unit 4 is mounted with the impeller axis and, consequently, the axis of the jet nozzle housing 13 angularly oriented in a predetermined manner with respect to the bottom of the boat 2 and the true horizontal position, as more fully disclosed in applicant's previously referred to co-pending application. The pump unit 4 may, of course, be of any suitable design which will transfer the necessary volume of water at a greatly increased momentum and discharge the water through rear nozzle housing 13 which is generally cone-shaped and terminates in the outer end in a relatively small cylindrical nozzle 21 to form the jet 8. The steering deflector unit 9 includes a deflector 22 having an inner deflector end portion 23 concentric of the discharge nozzle 21 of the pump nozzle housing 13 and
having a tubular portion 24 forming a control extension thereof. The outer periphery of the nozzle 21 is fitted with a ring 25 having a spherical outer surface portion 26 which is close fitting to a corresponding spherical surface on portion 23 of the deflector unit 9 to reduce leakage loss when a reverse gate 27 is closed, as subsequently described.

The gimbal ring 14 encircles the telescoped portions 21 and 23 of the nozzle and deflector. The ring 14 is secured to the top wall and to the bottom wall of deflector portion 23 by similar bearing and pivot pins 28 and 29 which point inwardly in diametrical alignment to define the vertical steering axis 12. The gimbal ring 14 is pivotally mounted on the horizontal and lateral pivot axis 15 by suitable pivot pins 30 and 31 (FIG. 2), similar to pins 28 and 29, on the nozzle housing 13, which is provided with suitable support arms 32. This provides for the steering and trim positioning of the deflector 22, as follows.

The gimbal bearing pins 28 and 29 permit the rotation of the deflector 22 about vertical axis 12 through the aligned pivot pins relative to the gimbal ring 14 and the trim pivot support 15. As shown in FIGS. 2 and 4, a steering lever arm 33 is integrally formed to the upper wall of the nozzle unit and projects inwardly toward the pump housing 12. The remote control steering wheel cable 11 is connected through a suitable universal linkage 34 for selective turning of the arm 33 and, consequently, the interconnected deflector unit 9 about the axis 12 of fixed pivot pins 28 and 29 to thereby effect a lateral steering of the boat in accordance with conventional practice. Thus the linkage 34 includes a ball coupler 35 connected to the lever arm 33, as most clearly shown in FIG. 3, and to a laterally extending link 36. The outer end of the link 36 is connected by a similar ball pivot coupler 37 to a rotating arm or crank 38 secured to the outer end of a steering shaft 39. The remotely controlled steering cable 11 is coupled to rotate the steering shaft 39 and linkage for steering movement of deflector unit 9. The universal linkage 34 including ball couplers 35 and 37 transmits the turning force on crank 38 while permitting the trim positioning of the deflector unit 9 by powered rotation of the ring 14 about the axis 15.

In the illustrated embodiment, as most clearly shown in FIGS. 3 and 4, the power trim operator 16 includes a reciprocating shaft or rod 40 mounted within the mounting flange portion of the pump housing 13. Link 17 has a bifurcated inner end 41 secured to the end of rod 40 by a pivot pin 42 and an outer end secured to the upper side edge of the ring 14 as by a hub and bolt connection 43. Thus, the operator 16 is controlled by control unit 18 to extend and retract rod 40 and thereby pivot the ring 14 about the trim axis 15 as defined by the mounting pins 30 and 31.

The trim positioning of deflector unit 9 also varies the coupling mechanism 20 through the position of the lower housing wall of the deflector 9, which is illustrated so formed to define a reverse jet nozzle 44.

The deflector steering unit 9 includes the tubular portion 24 which is somewhat larger than the pump jet nozzle 21 and, as shown, the inner diameter is similarly shaped to the outer diameter of nozzle 21 to form a continuation thereof.

The bottom wall of the deflector 22, adjacent its outer discharge end, is provided with an opening with the reverse nozzle 44 extended downwardly and forwardly toward the boat 2. The nozzle 44 generally terminates just above the bottom plane of the boat 2. The reversing gate 27 is pivotally mounted by a pair of side arms 45 to the opposite sides of the nozzle portion 24 of deflector 22 and is selectively positioned in the raised position, shown in full line, or dropped in overlaying relation to the end of the deflector nozzle portion 24. In the lowered position, the gate 27 blocks the jet 8 and thereby causes all or a part of the drive jet to pass downwardly through the opening and reversing nozzle 44 to effect a reversed or neutralized thrust. The illustrated cover gate 27 is generally formed as a part of a segment with the side arms 45 extending downwardly and interconnected by pivot pins 46 to the side of the deflector portion 24.

The jet unit is selectively trimmed upwardly to the desired positioning to effect proper hull trim for speed. This may, of course, be provided through an automatic trim control such as shown in the co-pending application of Hager et al. entitled MARINE DRIVE SETTING APPARATUS which was filed on Feb. 5, 1973 with Ser. No. 329,726 and which is assigned to the same assignee as the present application. Alternatively it can be provided through a suitable manually controlled system such that the boat operator may continuously adjust the trim position until the proper feel is obtained.

Thus the present invention provides improved performance resulting from the proper trim positioning of the jet 8.

In addition, the deflector unit 9 and the rudder 19 are especially interrelated and coupled by the coupling mechanism or unit 20 to provide optimum movement of the rudder 19 with the selected positioning or trim of deflector unit 9.

As most clearly shown in FIG. 3, the pump housing 13 is provided with a bottom generally horizontal mounting wall 47 which extends beneath housing 13 and terminates inwardly of the gimbal ring 14. A rudder mount plate 48 is secured to the underside thereof as by a plurality of bolt elements or the like, with a depending portion 49 extending downwardly to define an extension of the upper edge portion of the rudder 19. Thus the back edge of the rudder plate extends beyond the mounting plate and generally in alignment with the steering axis for the deflector. The rudder mount plate 48 is provided with a bearing hub 50 at the outer end within which a pair of suitable flanged sleeve bearings 51 and 52 are secured. The rudder 19 is provided with an upper portion which telescopes over the hub 50. A pin member 53 passes through the bearings 51 and 52 and into appropriate openings in the rudder 19 in alignment with the bearing members. A laterally extending attachment pin 54 secures the pivot shaft 53 to the rudder 19 and pivotally mounts the rudder within the bearings 51 and 52.

The rudder 19, otherwise, is a plate-like member which extends rearwardly of the pivot mounting toward the reverse nozzle 44 and depends downwardly therefrom, with the lowermost end somewhat below the normal boat level in the illustrated embodiment of the invention. The plate-like rudder 19 also includes a forwardly extending plate-like triangular portion located below wall 49 of the member 48 and with the leading edge adjacent the boat extending upwardly toward the boat.
The rudder 19 is shown with the pivot pin 50 essentially aligned with the nozzle pivot pins 28 and 29 in a neutral position. The rudder axis 55 is angularly oriented with respect to the horizontal such that the two axes are parallel with the nozzle unit 9 trimmed down by a couple of degrees to the neutral position. In the neutral position, however, the deflector axis 12 is spaced forwardly of the rudder axis 55 by a small distance. In rotating with the deflector unit 9, as presently described, the coupling 20 moves arcuately through the steering range depending upon the trim position of the deflector unit 9, as shown in FIG. 3.

The rudder 19 is coupled to the deflector unit 9 through a sliding contact such that the lateral rotation of the deflector causes a corresponding deflection of the rudder 19 to provide angular movement for all trim positions. The force application point to the rudder 19, however, varies relative to the rudder axis 55 with the trim angle of the deflector unit 9. This changes the effective point of coupling to the rudder 19 with the trim angle and directly changes the amplification of rudder movement with the trim position. More particularly, the deflector unit 9 includes a pair of depending coupling projections or arms 56 and 57 extending downwardly from nozzle 44 to the opposite sides of the rudder 19. Semicircular bearing pads 58 are mounted within each of the walls 56 and 57 with the cylindrical surfaces in opposed bearing relation on the rudder 19. The pads 58 slidably engage the rudder 19 with essentially single point contact to minimize friction loading. As the deflector unit 9 is pivoted about its trim axis 15, the engagement point between the rudder 19 and the pads 58 moves generally along a circular path 59, with the center through that of the trim axis 15, as shown in FIG. 3. This, in turn, varies the effective turning radius applied to the rudder 19 for any given steering rotation of the deflector nozzle unit 9. In the neutral or zero trim position 60, the steering axis 12 is essentially parallel to and slightly offset from the rudder axis 55, and the rudder 19 will rotate essentially in accordance with the angular displacement of the deflector unit 9. With the deflector unit 9, however, trimmed up, as shown in FIG. 3, or down, the steering axis pivots relative to the trim axis and moves from alignment with the rudder axis. The rudder 19 and the deflector unit 9 will rotate relatively through different angles from each for any given angular steering displacement of the deflector, in accordance with the trim positioning of the deflector unit. Further, the angular orientation of the rudder axis and the angular orientation of the deflector when trimmed neutral results in the contact of pads moving arcuately on the rudder.

In particular, as the deflector unit 9 is trimmed down, the sliding pads 58 move downwardly on the rudder 19 toward the rudder pivot pin 53, such as to a maximum down position line 61. Simultaneously, the steering axis 12 rotates with the lower end moving forwardly of the rudder pivot axis 15 and the upper end moving rearwardly thereof. This effectively shifts the rudder axis 12, resulting in an amplified rudder movement such that the rudder 19 will move through a greater angle than the angle the deflector nozzle unit moves. Conversely, opposite or trimming up of the deflector unit 9 results in an opposite rotation of the steering axis 12. The sliding coupling pads 58 similarly move upwardly on the rudder 17 as to line 62 and simultaneously, the steering axis effectively moves closer to the rudder axis 55 with a resulting reduction in the movement of the rudder 19 for a given angular steering displacement of deflector unit 9. Thus, with the unit 9 trimmed up, a nearly equal rudder response is obtained while with unit 9 trimmed down a greater rudder response is obtained for the same angular steering movement of unit 9. In actual practice, the boat operator is provided with maximum auxiliary steering effect and sensitivity at down trim which will normally be used under low speed conditions or when just on plane.

This is highly desirable for docking and other low speed maneuvering. The increased amplification at full down trim also results in the elimination of hunting characteristics at slow maneuvering, as a result of additional steering provided by the amplified rudder movement. As speed is increased, the operator normally will trim up to effect maximum speed conditions, and at maximum speed he will normally be at least three-fourths full-up trim. The system is designed to locate the pad contact such as at 62a to effect a nearly zero amplification at such a full-up trim position to maintain a more normal steering sensitivity.

An approximate theory of the rudder motion is given with reference to the simplified illustration shown in FIG. 5 wherein the deflector unit 9 is diagrammatically shown by the line-like link 63 which is pivotally connected to a support as at 64. The steering rudder 19 is similarly illustrated by link 65 but with its pivot connection 66 in spaced alignment with the first pivot support 64. In addition, the rudder link 65 is coupled to deflector link 63 intermediate the length thereof through a sliding support or collar 67 pivotally affixed to link 63 as at 68 which positively causes the link 65 to pivot, with the sliding collar 67 accommodating and permitting the required movement along the link 65. The angular movement of the rudder link 65 with deflector link 63 will be directly related to the fixed position of the collar on link 63. As shown in FIG. 5, rotation of the nozzle link 63 about pivot point 64 through a first angle α from the reference pivot line 0-0 results in rotation of the link 65 about pivot point 66 through a significantly greater angle β. As the fixed position of the collar 67 with respect to point 64, shown as Y in FIG. 5, is varied on the link 63 and/or the spacing between the pivot points 64 and 66, shown as X in FIG. 5, is varied, the relative angular movements will also vary. Generally, the angle β that the link 65 will move through for the angle α which link 63 is moved through is given by the following equation: β = Arctan (y sin α/(y cosa) X)

where y equals the distance between the pivot connection 64 and the collar pivot 68 and X is the distance between the pivot connections 64 and 66. As the spacing between the pivot points 64 and 66 approaches the distance of the collar 67 from the pivot point 64 of link 63, the link 65 will move essentially through 90° for a very slight change in the angular movement of link 63 from the reference or base line position. The above equation precisely applies only where the pivot axes 64 and 66 for the respective links 63 and 65 are parallel and the distance between points 64 and 66 is less than the distance between points 64 and 68.

In the illustrated embodiment of the invention, the steering axis of the deflector unit 9 rotates around the trim axis 15 and thus is not truly parallel to the rudder axis 55 except in one distinct position. Consequently, the formula does not precisely apply for all positions.
However, the sliding coupling between the rudder 19 and the deflector unit 9 essentially functions in the same manner as the sliding collar 67 to vary the effective coupling therebetween. Thus, the pivot coupling provided by the sliding pads 58 is maintained at a constant distance from the steering axis 12 and thus is the same as the fixed distance Y of the sliding collar 67. The rotation of the steering axis 12, however, results in a position change between the steering axis 12 and the rudder axis 55 which is roughly equivalent to the approximates the distance between the pivot spacing of the links 63 and 65 along the illustrated reference line such that the basic response is essentially of the same character as shown in FIG. 5. Although the equation given will not exactly define the actual geometry of the preferred construction, except at the single neutral position where the steering axis and the rudder axis are, in fact, parallel, it clearly indicates the amplifying action. The present invention thus provides a highly desired automatic steering characteristic which varies with the required steering characteristic and permits the operator to continuously control the steering and trimming to provide the optimum speed and steering characteristics.

Although continuous trim control and varying amplification control is desirable, the system, can, of course, be usefully applied to a simple couple between a main steering deflector means and an auxiliary rudder such as disclosed in FIGS. 6 and 7 wherein a steering deflector 69 and a rudder 70 are diagrammatically illustrated. The steering deflector 69 is shown pivoted mounted in a conventional manner about the jet nozzle 71 of a marine jet propulsion unit with a fixed vertical steering axis 72. The auxiliary rudder 70 is mounted with a pivot support 73 mounted aft of the steering axis 72. The rudder 70 is coupled to the deflector 69 through a pair of depending arms 74 slidably engaging the opposite sides of the rudder 70. As illustrated in FIG. 7, the movement 75 is accentuated or amplified for any given movement 76 of the deflector 69.

Other means of variable amplification can, of course, be provided. For example, an adjustable rudder pivot support could be provided to more relative to the steering axis for varying the relative separation of the pivot axis with speed or the like.

Various modes of carrying out the invention are contemplated as being within the scope of the following claims, particularly pointing out and distinctly claiming the subject matter which is regarded as the invention.

1 claim:
1. A marine jet propulsion drive apparatus including a drive jet means for creating a jet for effecting propulsion of a vessel, comprising a main steering control means coupled to the drive jet means for lateral deflection of said jet means for steering purposes, trim means coupled to the drive jet means for generally vertical deflection of said jet means, an auxiliary steering means movable to assist the main steering control means, and a coupling means interconnecting the auxiliary steering means to the main steering control means for related angular movement and including connecting means whereby the angular movement of the auxiliary steering means is different from the main steering means, said coupling means being adjustable to selectively change the angular movement of the auxiliary steering means for a given angular movement of the steering control means with the adjustment of the trim means.
between said jet steering means and rudder means moving arcuately with the steering movement of the jet steering means and the rudder means.

11. The steering apparatus of claim 7 wherein said mounting means has a relatively fixed vertical pivot support for the rudder means and a gimbal mounting means for the jet nozzle means and the jet steering means so as to permit pivoting in both directions laterally about a generally vertical pivot support for steering of the boat and a generally horizontal pivot support to tilt upwardly and downwardly about a horizontal axis for trim positioning of the jet.

12. The steering apparatus of claim 11 wherein said vertical pivot support is horizontally offset with further effective degree of offset being controlled by the trim positioning of the jet nozzle means.

13. The steering apparatus of claim 11 including a pair of coupling member secured to the jet steering means and extending downwardly to the opposite sides of the rudder means and including means slidably engaging the opposite sides of the rudder means and adjustably coupling of the jet steering means and the rudder means at differently spaced relation to the rudder axis in response to the variation of the trim positioning.

14. The steering apparatus of claim 13 wherein said rudder means being located centrally of said nozzle means, and a pair of laterally spaced, semi-cylindrical pad means secured to the underside of said nozzle means in opposed facing relation of the opposite sides of the rudder means and slidably bearing on said rudder for the various trim positions.

15. The steering apparatus of claim 13 wherein said sliding engagement is selected such that the rudder means moves through a greater steering angle than that of the steering means in a lower trim position to provide improved steering response and moves through progressively smaller steering angles in response to increasing trim means for

16. A marine jet drive apparatus adapted to be mounted to the aft end of a vessel and including a jet nozzle means for establishing a controllable drive jet of water and having a deflection means for deflecting of said jet laterally and an auxiliary rudder means for steering, the improvement in the mounting and coupling of the deflection means and the rudder means to a single input steering control, comprising a gimbal means mounting the deflection means to swing in both directions laterally about a vertical axis for steering of the boat and to tilt upwardly and downwardly about a horizontal axis for trim positioning of the deflection means and thereby the driven jet, said tilting and swinging axis being approximately normal to each other, a rudder pivotal mount with a pivot axis generally parallel to the pivot axis of the deflection means at a preselected trim position, said rudder extending outwardly beneath said nozzle means, a pair of coupling members secured to the deflection means and extending downwardly to the opposite sides of the rudder means and including coupling means slidably engaging the opposite sides of the rudder means to couple the deflection means to the rudder means at differently spaced relation to the rudder pivot axis in response to the variation of the steering axis with respect to the rudder axis as a result of trim movement of the deflection means, said varying coupling creating variation in the degree of angular rudder movement for a given angular movement of the nozzle means in accordance with the trim setting of the nozzle means.

17. The jet drive apparatus of claim 16 wherein said pivot axis of the rudder pivotal mount is longitudinally spaced aft of the pivot axis of the deflection means.

18. The jet drive apparatus of claim 16 wherein said coupling means is selected such that the rudder means moves through a progressively greater steering angle than that of the deflection means for reduced trim positioning thereby providing improved steering response at a lower trim positioning.

19. The marine jet drive apparatus of claim 16 wherein the pivot axis of said rudder pivotal mount is tilted from the vertical with the jet apparatus mounted to a boat.

20. The marine jet drive apparatus of claim 16 wherein said pivot axis of the rudder is longitudinally spaced of the pivot axis of the jet with the preselected trim position at a neutral trim position.

21. The marine jet drive apparatus of claim 16 including a fixed pump nozzle and wherein said nozzle means includes a deflector nozzle extending outwardly thereof, said deflector nozzle having an enlarged end telescoped over the pump nozzle housing with opposed top and bottom pivot pins securing the deflector nozzle to a gimbal ring of said gimbal means, a rudder mounting wall integrally formed with the pump nozzle housing to locate the rudder pivotal mount in alignment with the gimbal ring pivot pins.

22. The marine jet drive apparatus of claim 16 including a fixed pump nozzle housing and wherein said deflection means includes a deflector nozzle extending outwardly thereof, said deflector nozzle having an enlarged end telescoped over the pump nozzle housing with opposed top and bottom pivot pins securing the deflector nozzle to a gimbal ring of said gimbal means, said pivotal mount being located immediately beneath the trim axis and angularly oriented with respect to the vertical plane therethrough, said deflector nozzle having reverse nozzle means secured to the outermost end of the bottom wall and having coupling arms curving downwardly and forwardly from said reverse nozzle means in laterally spaced aligned relation, said rudder means including a plate-like portion projecting between said coupling arms for imparting of pivotal nozzle movement to the rudder.

23. The marine jet drive apparatus of claim 22 including semi-cylindrical coupling pads secured to said arms in opposed facing relation and engaging said rudder plate-like portion at essentially opposed contact points to establish a low friction sliding coupling to the rudder means.

24. A controllable marine jet drive having a fixed pump housing unit for developing a drive jet operable to propel a vessel, comprising a jet deflection control means, a gimbal ring mounting means having first pivotal mounting means connected to the deflection control means for pivoting of the deflection control means about a first axis and having said pivotal mounting means for pivotal mounting to the pump housing unit for pivoting of the deflection control means about a second axis, said first and second axis being arranged to define perpendicular axis including a generally vertical steering axis and generally horizontal trim axis, a steering control means connected to the gimbal ring mounting means to pivot about the steering axis, and a trim control means linkage including a first link, a first pivot
connection including a pin and journal connected to the gimbal ring mounting means with a pivot axis parallel to the trim axis to pivot about the trim axis and a second reciprocating link pivotally connected to the first link vertically offset from the first pivot connection by a pin and journal connection means with a pivot axis parallel to the trim axis.

25. The controllable marine jet drive of claim 24 wherein said housing unit terminates in a jet nozzle, said deflection control means includes a tubular housing with an internal diameter generally corresponding to the jet nozzle and having a spherical enlargement portion concentrically aligned with the end of the jet nozzle and spaced radially outwardly therefrom, said first pivotal mounting means being connected between said enlargement portion and the gimbal ring mounting means to support said tubular housing.

26. The controllable marine jet drive of claim 25 including a partial sealing element secured to the jet nozzle and having a sealing lip in close spaced relation to said enlargement portion immediately adjacent the outermost end of the nozzle.

27. The controllable marine jet drive of claim 24 wherein said housing unit terminates in a jet nozzle, said deflection control means includes a tubular housing with an internal diameter generally corresponding to the jet nozzle and having a spherical enlargement portion concentrically aligned with the end of the jet nozzle and spaced radially outwardly therefrom, a partial sealing element secured to the nozzle and having a spherical sealing lip in close spaced relation to said enlargement portion immediately adjacent the outermost end of the nozzle, and said steering control means including a universal connection to the top of the enlargement portion to pivot the deflection means within the gimbal ring member.

* * * * *
It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, Line 44, before "course" cancel "or" and insert --- of ---;

Column 1, Line 47, after "by" insert --- the ---;

Column 1, Line 56, cancel "contribures" and insert --- contributes ---;

Column 1, Line 57, after "event" cancel "of loss";

Column 3, Line 65, after "in" cancel "FIG." and insert --- FIGS. ---;

Column 3, Line 67, after "trim" cancel "in FIG." and insert --- of FIGS. ---;

Column 9, Line 10, after "to" cancel "the" and insert --- and ---;

Column 9, Line 28, after "simple" cancel "couple" and insert --- coupling ---;

Column 9, Line 44, before "relative" cancel "more" and insert --- move ---;

Column 10, (CLAIM 6) Line 22, before "trim" insert --- the ---;

Claim 10, (CLAIM 7) Line 30, after "having" cancel "and" and insert --- an ---;

Column 11, (CLAIM 13) Line 18, after "coupling" cancel "member" and insert --- members ---;
PATENT NO. : 3,906,885  
DATED : September 23, 1975  
INVENTOR(S) : WILLIAM L. WOODFILL

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Page - 2 -

Column 11, Line 30, after "relation" cancel "of" and insert --- on ---;

Column 11, Line 32, before "for" insert --- means ---;

Column 11, Line 39, after "trim" cancel "means for" and insert --- positions ---;

Column 12, Line 63, cancel "axii" and insert --- axes---;

Signed and Sealed this
sixteenth Day of March 1976

[SEAL]

Attest:

RUTH C. MASON  
Attesting Officer

C. MARSHALL DANN  
Commissioner of Patents and Trademarks