Feb. 12, 1929. 1,702,222

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PROPELLING AND MANEUVERING SYSTEM FOR VESSELS

Filed March 19, 1927 3 Sheets-Sheet 1

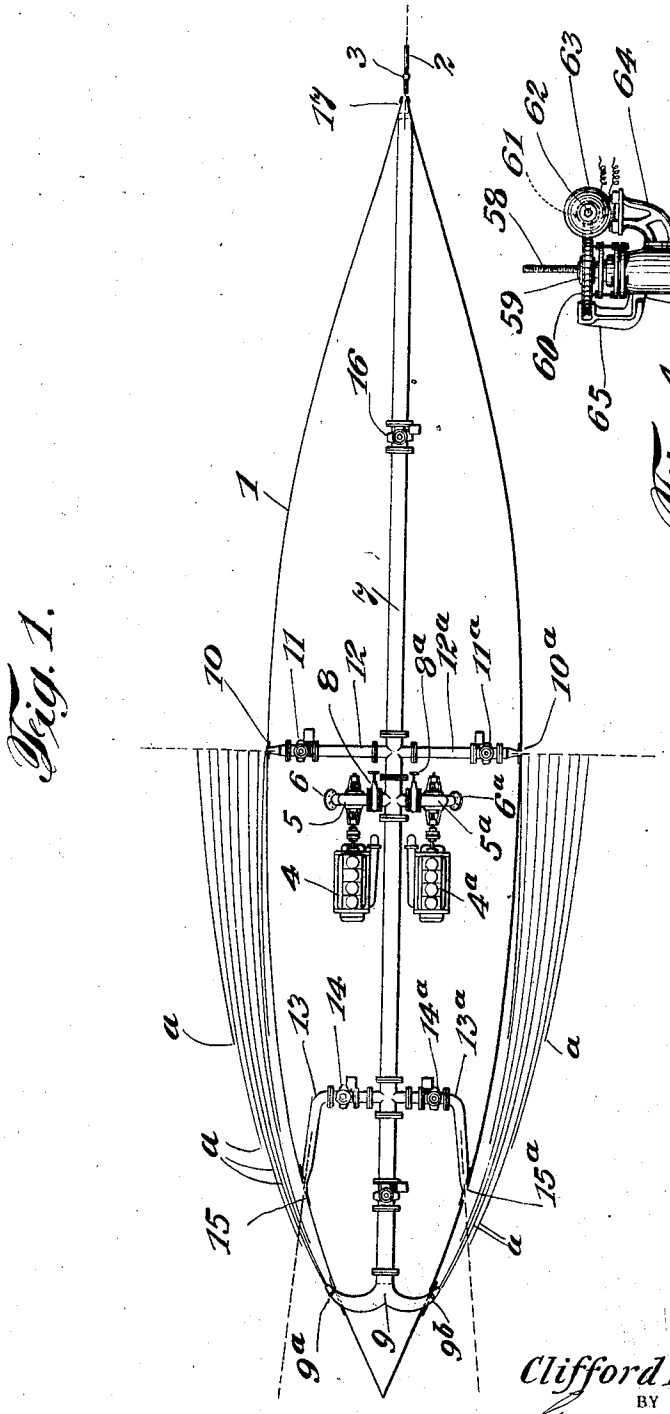


Fig. 1.

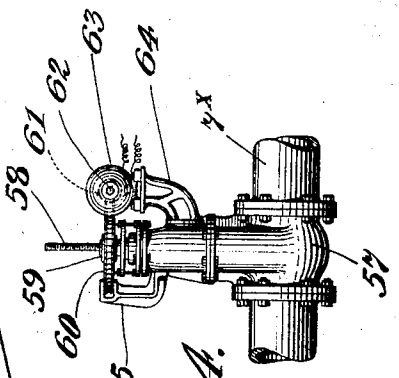


Fig. 4.

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Filed March 19, 1927 3 Sheets-Sheet 2

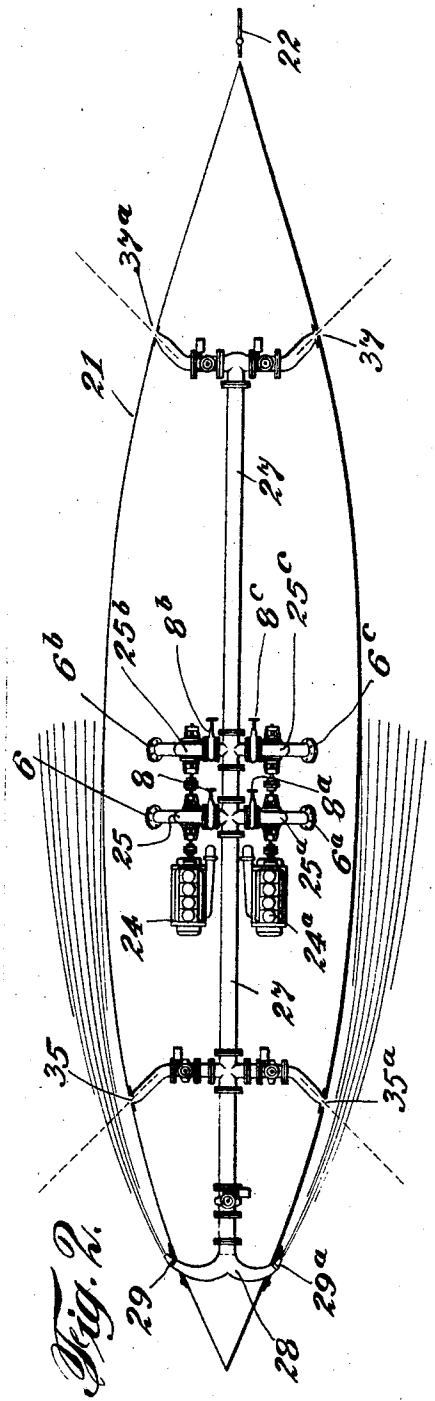


Fig. 2.

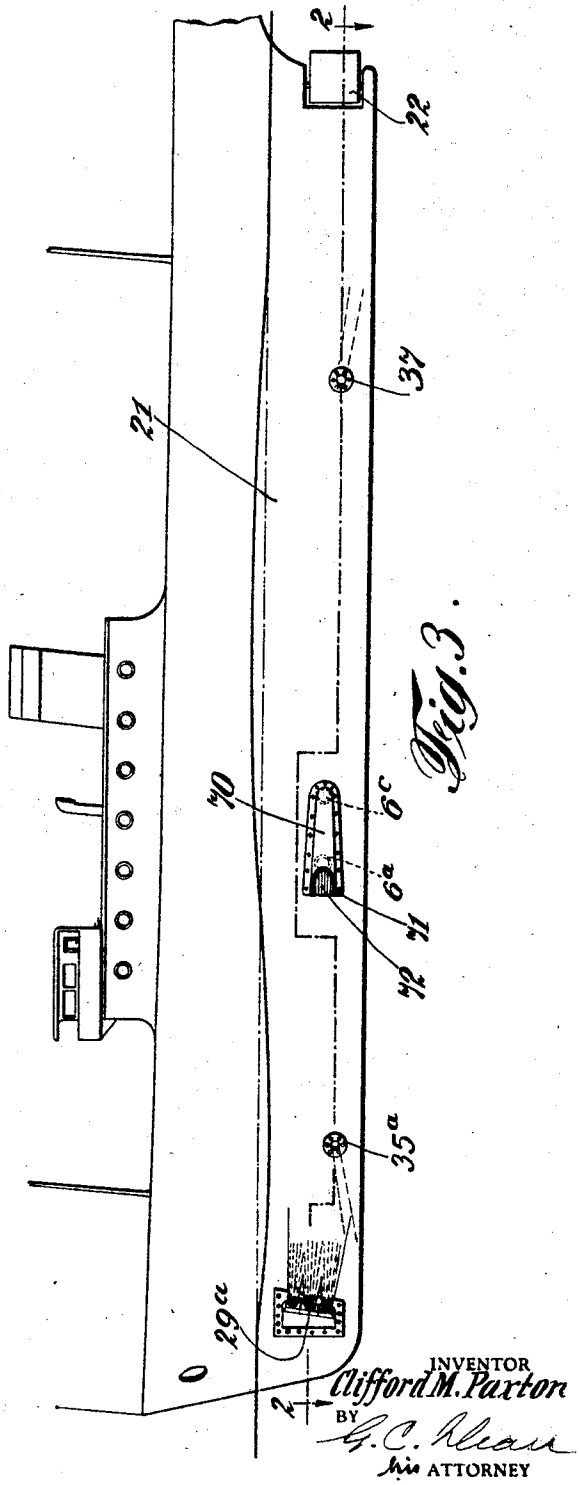


Fig. 3.

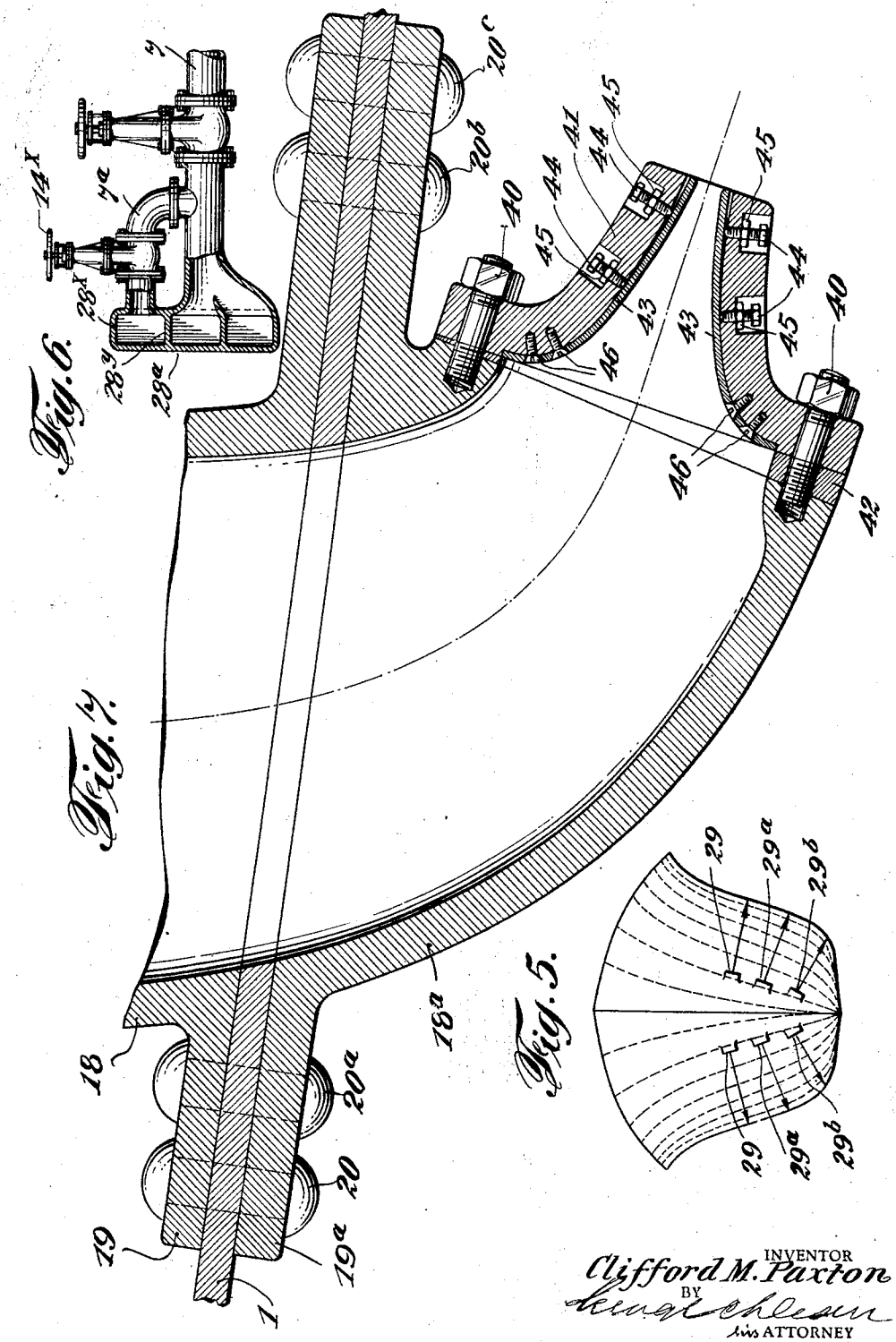
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PROPELLING AND MANEUVERING SYSTEM FOR VESSELS

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Patented Feb. 12, 1929. 1,702,222

UNITED STATES PATENT OFFICE.

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PROPELLING AND MANEUVERING SYSTEM FOR VESSELS.

Application filed March 19, 1927. Serial No. 176,600.

My present invention relates to systems of the above type, in which water jets are employed as a medium for moving the vessel. Preferably, the main propulsion of the vessel when under way is according to principles set forth in my Patent No. 1,543,026, granted June 30, 1925, and certain applications copending therewith as, for instance, Ser. No. 535,121, filed Feb. 9, 1922, and Ser. No. 32,531, filed May 25, 1925, Patent No. 1,662,206, granted March 13, 1928. As set forth in said prior applications and patent, the preferred method of propulsion is solely by means of sheet jets discharged rearwardly from points on the bow in advance of the region where the maximum bow wave tends to pile up when the ship is proceeding at speed and, while this system of propulsion may be employed in combination with a screw through which part of the power is applied, the jet system alone may be and preferably is utilized as the sole medium for applying the propulsive effort.

My present invention concerns more particularly means for flexibly applying the power to the jets both for propulsion and for maneuvering.

One feature relates to organizing a propelling and maneuvering system so that high speed, sources of power such as steam or internal combustion engines, or electric motors are utilized through a novel arrangement of pumps of the centrifugal type, for the purpose and with the result that motor or motors running at the most efficient speed will supply the maximum amount of water at the pressure desired for the jets. I find that where a powerful, high speed motor is directly connected with a single centrifugal pump designed to deliver the desired gallons per minute against the required pressure, the diameter for the impeller is likely to be so great that, at normal full speed, the water will be delivered at a velocity much higher than necessary. To meet this condition, I employ a plurality of pumps of proportionally smaller size so that the normal peripheral velocity of the centrifugal impellers and the resulting velocity of the water will be decreased to that required for the jets, while the number of the pumps will be multiplied to whatever extent necessary to deliver the required gallons per minute at the lower velocity.

Another feature is the use of a number of pumps operating in parallel relation to supply a distributing system including a pipe that leads to the main propelling jets in the bow, and that has branch pipes leading to maneuvering jets, the various branches of the system being equipped with valves and central control means whereby part or all of the water from the pumps may be diverted to one or two or more of the maneuvering nozzles, as may be desired. Centrifugal pumps particularly lend themselves to the widely varying volumes of discharge attendant upon such shifting uses of the water supply. When the back pressure becomes great enough, centrifugal pumps simply slip, whereas positive pumps of the gear pump type can operate to stall the engine with possible damage to the motor or pumps or the distributing system.

A feature of the maneuvering system is locating the maneuvering nozzles in proper relation to the lateral center of resistance of the boat to sidewise movement. Thus arranged, it is possible to maneuver the boat broadside at varying speeds, while increasing or decreasing the force of the stream discharged through the maneuvering jets.

The above and other features of my invention will be more evident from the following description in connection with the accompanying drawings, in which

Fig. 1 is a top plan view diagrammatically indicating a vessel equipped in accordance with one form of my present invention;

Fig. 2 is a similar view showing a modification;

Fig. 3 is an exterior side elevation of a vessel diagrammatically indicating a desired arrangement of main propelling jets, maneuvering jets and intake;

Fig. 4 is a detailed view indicating an electric motor means for operating the various valves shown in the preceding figures;

Fig. 5 is a diagrammatic end elevation of the bow of a vessel indicating a preferred arrangement for the subdivided sets of propelling jets shown in Fig. 3;

Fig. 6 is a detailed horizontal section of a preferred form of nozzle; and

Fig. 7 is a vertical section of a modified form of header that may be employed for triple bow jets.

In Fig. 1 the hull, 1, is shown as provided with an ordinary rudder, 2, diagrammatically indicated as being of the balanced type, the rudder post, 3, being intermediate the fore

and aft areas of the blade. The propelling system includes a motor, 4, and, if desired, a second motor, 4ª, each directly connected with centrifugal pumps as 5, 5ª, having intakes at 6, 6ª and discharging directly into a fore and aft distributing main 7, the discharge outlets being controlled by valves diagrammatically indicated at 8, 8ª. These valves are diagrammatically indicated and the actual construction may be and preferably is, arranged for electrical motor control after the manner indicated in Fig. 4, described hereafter. The main, 7, supplies a header, 9, for the bow jets, 9ª, 9ᵇ, which are rearwardly directed to afford induced stream line propulsion as indicated by the lines *a*, *a*, etc. Preferably, these jets are designed in accordance with the principles explained in my said prior patent, the showing of the stream lines in Fig. 1 being carried only to the dotted lines at the maximum cross-section.

In the present case, the said section is assumed to be the center of lateral resistance of the hull 1, to broadside movement; hence it is in this plane that I locate the broadside maneuvering nozzles 10, 10ª, having valves 11, 11ª, respectively, controlling supply of water jets through the lateral branch pipes 12, 12ª that connect with the main fore and aft pipe 7. Pairs of such nozzles may be located in parallel planes equidistant from said center of lateral resistance to suitably distribute the lateral thrust along the hull The center of broadside resistance may be and frequently is aft of the maximum or midship section, in which case broadside maneuvering nozzles would be located further aft.

The main, 7, also supplies water through branches 13, 13ª, controlled by valve 14, 14ª, to a pair of forwardly directed nozzles 15, 15ª. These nozzles are extraordinarily effective for stopping the ship when proceeding at speed, because their effective velocity and resultant nozzle reactions, are increased by the speed of the ship.

I prefer also to extend the main, 7, rearwardly through valve 16, to a stern jet, 17, which discharges against the rudder 2. The latter, being of balanced construction, lies directly across the path of this jet whenever the helm is put either to starboard or port, thereby directing the jet laterally at any desired angle and affording a very powerful turning effort regardless of whether the ship is running or stationary. This affords a powerful turning effect because the rudder intercepts and deflects the entire jet stream. By using the stern jet with the rudder properly set and with the reverse nozzles 15, 15ª, operating to balance the forward component of the rudder-deflected stream, the ship may be made to turn on its axis

In the above arrangement, the maneuvering jets operate on what may be termed rectangular coordinates, that is to say, a broadside movement is effected by one or more jets discharging at right angles to the axis of the ship, while the endwise movement is effected by effort applied parallel with the longitudinal axis of the ship. Thus it has only diagonal movements that require balanced action of broadside and endwise jets. This is in contrast to the arrangement shown in Fig. 2, which will now be described.

In Fig. 2, the hull 21, rudder 22, motors 24, 24ª, centrifugal pumps 25, 25ª, main 27, header 28, bow nozzles 29, 29ª and all controlling means, may be the same as before. In this case, the arrangement of maneuvering nozzles is analogous to that in Fig. 1, in that nozzles oppositely directed on opposite sides of the ship, as 35 and 37, operate in parallel planes at angles of 45° to the axis of the ship, while the other pair of opposite nozzles, 35ª, 37ª, operate in parallel planes which are at right angles to said first mentioned planes.

As the result, a simple broadside maneuver requires simultaneous or cooperative action of 35, 37ª on one side of the ship and 35ª, 37 on the other side of the ship, while straight forward movement requires cooperative action of 37, 37ª and straight rearward or stopping effort requires cooperation of 35, 35ª. The forward nozzles 35, 35ª and the rearward nozzles 37, 37ª may be and preferably are located equal distances fore and aft of the center of lateral resistance of the hull, to broadside movement, when stationary, thus giving a simple broadside movement when both jets on one side of the boat are supplied with discharge streams of the same volume and velocity, or, when diagonally opposite streams are discharged, the ship may be turned on its axis. Similarly when running, an extraordinary turning moment can be exerted by simultaneously discharging maneuvering streams through nozzle 35 or 37 or both, for turning to port; or through nozzle 35ª or 37ª or both, for turning to starboard.

When angles of 45° are employed, as in Fig. 2, and 35, 35ª are used jointly, 70% of the total reaction is applied to thrust the ship directly sternward when the ship is stationary or when the ship is in motion. The same thing is true of 35 and 37ª or of 35ª and 37 when they are used together in pairs for broadside movement to port or starboard, as the angles are uniformly 45°. This may not be always desirable, and a combination of angles may be employed if better suited to a given case. 45° is, however, a desirable arrangement in many cases and is used for illustration.

Thus the arrangement shown in Fig. 2 is a very flexible one, and to be preferred to that shown in Fig. 1, where the use of the rudder is sometimes necessary. In all cases it seems preferable to use the rudder for steering ordinarily, but in the case of Fig. 2, the ship may

be advantageously steered by means of the maneuvering nozzles. Thus a crippled rudder would not cripple a ship, and for making short turns at speed, as for instance to avoid collision, etc., the nozzles may be employed in conjunction with the rudder.

There is an important difference in the motor and pump supply in Fig. 2 from that in Fig. 1. In Fig. 1, the motor speeds and pump diameter are supposed to be such that when one motor is direct connected to one pump without any reducing gear, the revolutions per minute at normal full speed of the motor will give the pump impeller a peripheral speed required for supplying the water at velocities as well as in volumes corresponding to the requirements of the bow jets. In Fig. 2, however, it is assumed that the revolutions per minute of the motor will be much higher than in Fig. 1, with the result that a single pump impeller of size suitable for delivering the required volume of water would be operating at a peripheral speed in excess of pressure requirements. In the latter case, much power will be wasted in imparting too high peripheral velocity to the water in the impeller. This difficulty could be obviated by a speed reducing gear inserted between the high speed motor and the pump, thereby bringing down the peripheral speed of the impeller to the required velocity for the jet output; but one object of my invention is to avoid use of a change speed gear, where possible, substituting therefor a plurality or, if needed, a multiplicity of pumps of sufficiently small impeller diameter so that their impellers will have the proper peripheral speed notwithstanding the high revolutions per minute of the motor. In this way, the volume and velocity of all of the water delivered to the main 7 by the multiplicity of pumps may be suited to the jet requirements without the introduction of gearing. It thus results that a motor of high operating speed may be used with a multiplicity of pumps operating at the most efficient peripheral speed, subject only to practical limitation as to how many pumps it may be desirable to employ.

As an illustration, we may assume a motor normally developing 13,500 horse power at 2,000 revolutions per minute in a ship where proper fitting of the bow jets to the hull would require 50,000 gallons of water per minute delivered against a back pressure of approximately 350 pounds. With jets delivering water at this rate under the above pressure, an impeller supplying water at the same velocity that it leaves the jets should have a diameter of approximately 22 inches, but if an impeller of that diameter were made wide enough to supply the required volume, there would not be room enough around the shaft for the intake because a shaft to transmit such an amount of power would have to be, say, 6 or 8 inches in diameter. Hence the value of my present invention, which in the above case contemplates employing any required number of pumps each having a 22 inch diameter impeller and each having its volumetric capacity small enough so that its intake though necessarily small, will yet be large enough to afford an unthrottled supply adequate for volumetric requirements of the respective pumps.

In this arrangement, the multiplicity of pumps gives great flexibility for adjustment of water volumes and pressures to suit the number of jets in use or for varying the speed of the ship, and particularly for varying the volume or velocity of the water supplied to the jets when the ship is running light; for instance, the valves 8^b, 8^c, may be operated to shut off pumps 25^b, 25^c and both of the engines relieved of part of the load may be run at a higher speed so that the remaining two pumps will deliver water at greater velocity though the total volume will be less than was being delivered by the four pumps; or by shutting off pumps 25 and 25^b, one engine, 24, may be idle, while the other engine, 24^a, does all the work. In such case, pumps 25^a and 25^c will tend to deliver the same volumes of water as before, at the same pressure and velocity as before, providing the total jet outlet area is correspondingly reduced so as to maintain the same back pressure as before. If six pumps are employed in combination with three pairs of equal area bow jets, then cutting off one pair of bow jets, say the upper pair, and cutting off two of the pumps, one from each motor, will make it possible to have the volume and velocity of water discharged through the lower two pairs of jets, the same as before, or the load of the motors being reduced by removal of two of the pumps, the motors may be run at higher speed to give a higher velocity to the two lower jets, as, for instance, when the boat is running light draft. In the latter case, the boat speed may be correspondingly increased and yet the jets may be kept properly "fitted" for the higher speed of the boat, according to the principles explained in my above cited patent.

Subdividing the bow jets into a multiplicity of pairs, arranged at progressively greater depths in the water, as above described, is desirable for a further reason indicated in Fig. 5. Here it will be seen that the bow jets, 29, 29 of the upper pair, and 29^a, 29^a of the next lower pair, and 29^b, 29^b of the lowest pair may be arranged to discharge at different downward angles as indicated by the arrows. These arrows are supposed to indicate the axes of the respective jets and also what is known as the "diagonals". Diagonals correspond to the shortest lines of natural stream line flow of water rearward along the entrance section, when said water is displaced by the advancing hull. The ob-

ject of this arrangement is to accelerate the natural stream line flow without disturbing its natural diagonal direction any more than is necessarily involved in accelerating it by jets projected at an outward angle to the hull surface. The outward angle of discharge is absolutely essential for reasons explained in my prior patent and this necessarily causes some disturbance and distortion of the natural stream line flow, but by my present invention, having a plurality of jets differently directed to harmonize with the different directions of the diagonals at different depths around the hull, the natural stream line flow is accelerated with a minimum of disturbance. Naturally, the downward inclination of these lines will vary according to the shape of the underbody, but in ordinary types of displacement boat, the decreased width toward the bottom of the hull will result in stream lines requiring the lower level jets to be directed downward at greater angles than those at a higher level.

In Fig. 6, I have shown that where three pairs of jets are served by a single header, as 28^a, provision for cutting off one or more of the pairs, in this case the upper pair, may be made by providing a separate branch pipe, 7^a, controlled by separate valve 14^x. In such case, the upper part of the header 28^x will be segregated from the part supplying the lower jets, either by making it entirely separate from 28^a or, as shown in the drawing, by providing a partition, 28^y, cutting off all communication between 28^a and 28^x.

In Fig. 7, I have shown how a header, 18, may be made structurally rigid with the hull, 1, and at the same time structurally rigid with the exteriorly projecting nozzle portion, 18^a, by providing the interior and exterior parts with broad faced flanges 19, 19^a, fitting against the hull plates, 1, and secured by through bolts or rivets 20, 20^a, 20^b, 20^c. On the exterior header member, 18^a, is detachably secured by bolts 40, 40, a jet nozzle, 41. As explained in my prior patent, it is possible to replace one nozzle by another having a different shape or a different orifice area; also the angle of the discharge may be varied within wide limits, without changing the jet, merely by inserting wedge-shaped, gasket-like spacing members, 42, between the surfaces that are clamped by the bolts 40.

The width of the jet orifice and angle of discharge is made adjustable by providing interior plates or liners, 43, that are capable of adjustment inward and outward by means of set screws, 44, provided with lock nuts, 45. To permit such movement, the liners 43 are preferably of spring bronze shaped to fit the convergence of the interior surfaces of the nozzle, having their ends adjacent the nozzle free and the remote portions anchored to the nozzle, preferably rigidly as by screws 46, 46. Preferably, the spring set of these liners is such as to cause them to normally lie flat against the nozzle surface and they are further forced against such surfaces by the jet pressure when in operation. To effect desired narrowing of the slot outlet of the nozzle to reduce the cross-section of the jet without substantial reduction in its surface area, or for the purpose of increasing the velocity by varying the throttle or back pressure effect of nozzle, the set screws 44 are simply screwed inward a desired distance. Obviously, these set screws may be provided with worm or other gearing, whereby they may be operated from the deck or from the interior of the ship and hinged rigid plates may be used in place of spring plates.

In Fig. 4, as a suggestive illustration, I have indicated a form of power operated valve which it is understood will be used in place of the various valves diagrammatically indicated in Figs. 1, 2 and 3. In Fig. 4, the water supply pipe 7^x may be taken either as the main conduit or as any of the branches to be controlled by a valve. The valve casing, 57, contains a valve, not shown, which in this case is assumed to be an ordinary gate valve, although a balanced valve can be used provided the arrangement is such as not to involve too great frictional losses by reason of baffling and eddying of the water passing therethrough.

The valve stem, 58, is shown as screw-threaded and engaged by an internally threaded, rotary member, 59, having its periphery, 60, formed as a worm wheel operated by a worm, 61, on armature shaft, 62, of an electric motor, 63, supported on a bracket, 64. The worm wheel, 60, is free to rotate on the screw 58, to move the same up and down, longitudinal movement of the wheel being prevented by bracket 65. All parts are diagrammatically indicated, since the details of construction and operation of this valve are not essential to my present invention, which concerns only the employment of power operated valves suitable for control from a central station.

The intakes for the pumps are shown as drawing water through a scoop, 70, having a forwardly directed mouth, 71, which may be protected by a grating, 72. The scoop may be associated with the ship's hull and with the flanges of intakes 6, 6^a, 6^b, 6^c, by through riveting after the manner indicated for the discharge outlet at 19, 19^a, 20, 20^a, in Fig. 7. The scoops are supposed to be located deep down under the turn of the bilge, so that they can never come out of the water during rolling of the ship. While separate scoops may be employed for each intake, I have shown in Fig. 3 how two intakes as 6^a, 6^c can be served by one scoop. For such purpose, it is preferable that the scoop have its cross-sectional flow capacity at the mouth, equal to the combined demands of the two in-

takes, while the part extending to the rear intake, 6c, is of reduced cross-section adequate for supply of the intake 6c only.

It will be obvious that many features of my invention are not limited to the specific relation in which they are shown. For instance, the multiple pumps constructed as above described, would be applicable to jet propulsion or jet maneuvering where the effort is simply that of nozzle reaction, although it is also peculiarly adapted for the bow jet, stream line propulsion set forth in my prior patent first above mentioned. The plurality of differently directed bow jets located at different depths as indicated in Fig. 5 have their own specific novelty in connection with the stream line propulsion of said patent, even though they be not used in combination with the maneuvering jets or with the multiple pump feature. A boat may have the rectangular system of maneuvering jets shown in Fig. 1, combined with the diagonal system indicated in Fig. 2. Other like independent and dependent uses and relations and variations will be obvious to those skilled in the art.

While I have shown a plurality of pumps with separate intake pipes leading through the hull, it will be obvious for many purposes that a multiplicity of impellers each of the desired diameter capacity may be enclosed in a single casing. In such case, only the inlets to the impellers need be separate. The intake pipe for drawing water from the outside may be a single pipe or the discharge pipe leading to the distributing main may be a single pipe. The output from all of the impellers may be controlled by separate valves or by a single valve.

I claim:

1. A vessel having a propulsion system including means for maintaining rearwardly directed bow jets of the class described, in combination with sets of maneuvering nozzles on either side of the ship, and another maneuvering nozzle directed rearwardly and the ship being provided with a balanced rudder having its vertical pivotal axis in the path of discharge of said latter jet, together with forwardly and outwardly directed nozzles arranged to oppose the forward component of propelling efforts exerted by said rearward stream when deflected by the rudder.

2. A vessel having a propulsion system including means for maintaining rearwardly directed bow jets of the class described, in combination with a stern jet, sets of maneuvering nozzles on either side of the ship, and a jet supply system, including motors, each arranged to apply its power output through a plurality of centrifugal pumps having impellers of relatively small diameter, each having a valve controlled outlet and a main distributing conduit extending parallel with and adjacent the keel, into which all the pump outlets discharge independently.

3. A vessel having a propulsion system including means for maintaining rearwardly directed bow jets of the class described, in combination with sets of transversely directed maneuvering jets on each side of the ship, a jet supply system, including a single distributing conduit extending longitudinally of the ship to points adjacent the jets and branch pipes to the jets with valves controlling the individual branches and means for supplying water to said conduit including a plurality of internal combustion engines symmetrically arranged on opposite sides of the keel and parallel therewith, a centrifugal pump coaxial with and driven by each engine and separate valve controlled outlets from the pump into the conduit.

4. A vessel having a propulsion system including means for maintaining rearwardly directed bow jets of the class described, in combination with sets of transversely directed maneuvering jets on each side of the ship, a jet supply system, including a main distributing conduit and branch pipes to the jets with valves controlling the individual branches and means for supplying water to said conduit including a plurality of centrifugal pumps having independent valve controlled outlets into said distributing conduit and a plurality of independently operable driving units therefor.

5. A vessel having a propulsion system including means for maintaining rearwardly directed bow jets of the class described, in combination with sets of transversely directed maneuvering jets on each side of the ship, a jet supply system, including a conduit and branch pipes to the jets with valves controlling the individual branches and means for supplying water to said conduit including a plurality of internal combustion engines symmetrically arranged on opposite sides of the keel parallel therewith and each directly connected to a plurality of centrifugal pumps all discharging into said conduit.

6. A vessel having a jet propulsion system of the class described, including a nozzle having an elongated orifice for discharge of a jet having great surface area as compared with its cross-section, said nozzle being provided with means for adjustably varying the area of the jet orifice.

7. A vessel having a jet propulsion system of the class described, including a nozzle having an elongated orifice for discharge of a jet having great surface area as compared with its cross-section, said nozzle being provided with laterally movable means for varying the width of the jet orifice.

8. A vessel having a propulsion system including means for maintaining rearwardly directed bow jets, the jet nozzles being arranged in pairs at different depths, those at the same depth discharging at approximately the same angles and those at greater

depth discharging at angles having a greater downward component than those at lesser depth.

9. A vessel having a propulsion system including means for maintaining rearwardly directed bow jets, the jet nozzles arranged in pairs at different depths, said nozzles being arranged to discharge their jets to correspond with the diagonals of the hull at their respective depths.

Signed at New York, in the county of New York, and State of New York, this 17th day of March, A. D. 1927.

CLIFFORD M. PAXTON.