June 8, 1943. J. H. HAMMOND, JR 2,321,025

PROPELLER CONTROL MECHANISM

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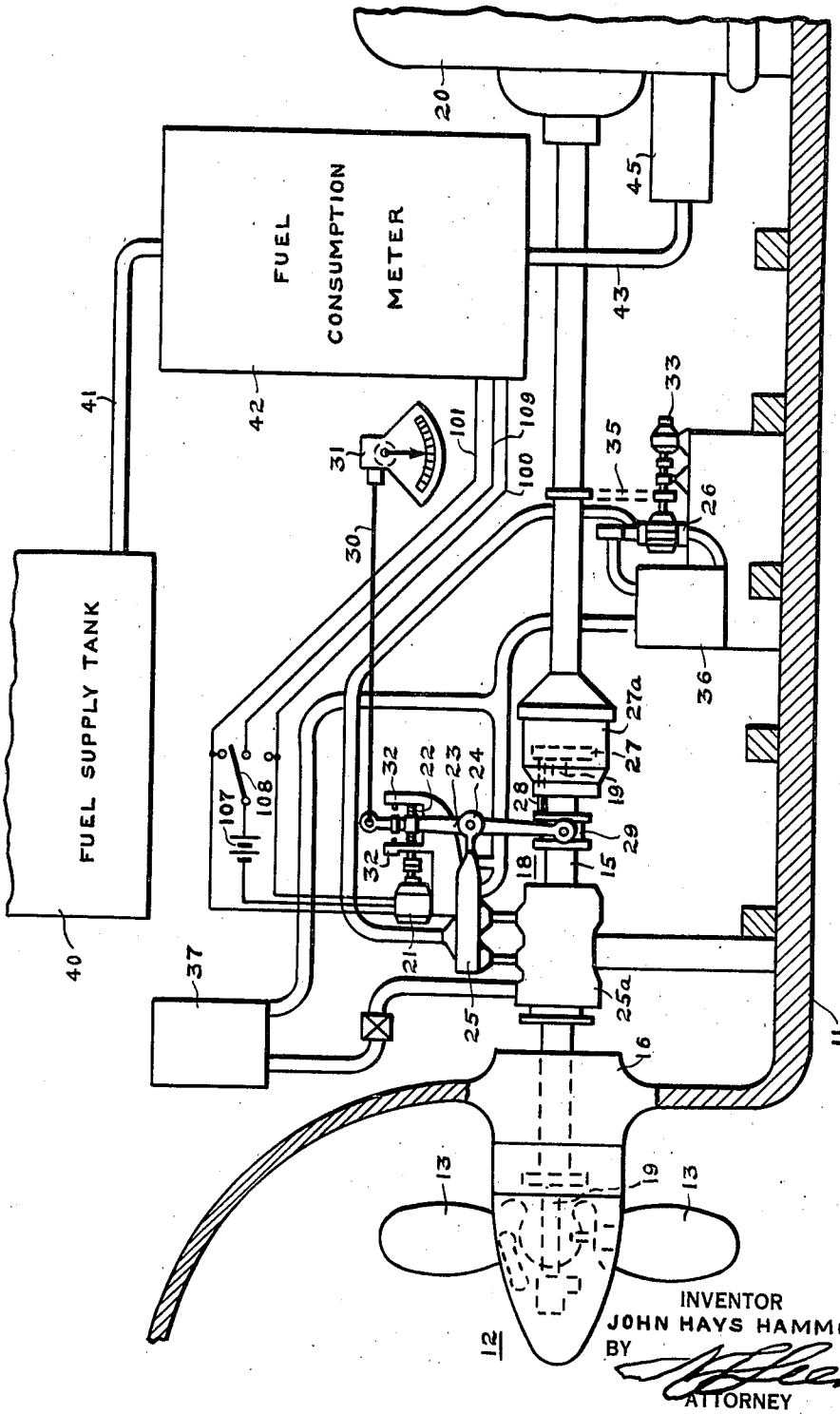


Fig. 1.

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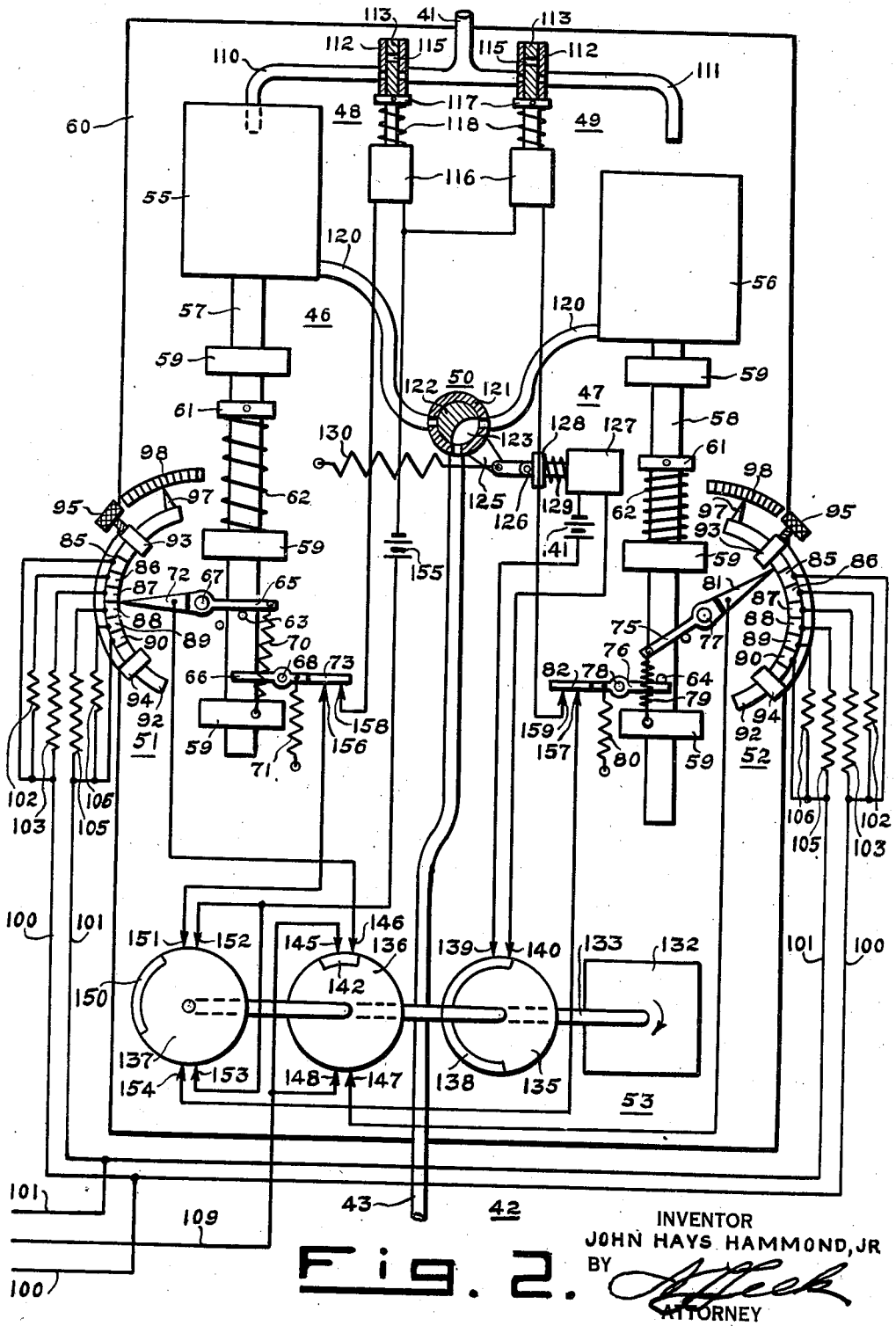


Fig. 2.

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PROPELLER CONTROL MECHANISM

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7 Claims. (Cl. 170—135.6)

This invention relates to variable pitch propeller systems and more specifically to a system for automatically varying the pitch of a propeller in accordance with a characteristic of the prime mover.

The invention further relates to means for controlling or measuring the fuel consumed by the prime mover which directly controls means for varying the pitch of the propeller blades in such a way that the rate of fuel consumption is maintained at a constant value.

The invention also provides means for varying the rate of change of pitch of the propeller blades in accordance with the rate of change of fuel consumption.

The invention also consists in certain new and original features of construction and combinations of parts hereinafter set forth and claimed.

Although the novel features which are believed to be characteristic of this invention will be particularly pointed out in the claims appended hereto, the invention itself, as to its objects and advantages, the mode of its operation and the manner of its organization may be better understood by referring to the following description, taken in connection with the accompanying drawings forming a part thereof, in which

Figure 1 illustrates diagrammatically the system as applied to a fuel consumption meter of the prime mover, and

Figure 2 is an enlarged view of the mechanism of the fuel consumption meter.

Like reference characters denote like parts in the several figures of the drawings.

In the following description and in the claims parts will be identified by specific names for convenience, but they are intended to be as generic in their application to similar parts as the art will permit.

Referring to the accompanying drawings, and more particularly to Figure 1, the hull of a marine vessel is indicated at 11. This vessel is shown as driven by means of a propeller 12 which is provided with adjustable blades 13. The propeller 12 is attached to the end of a hollow shaft 15 which passes through an outboard bearing 16. The shaft 15 is driven by a prime mover 20 which may be of any desired type but is preferably of the Diesel engine type and is provided with a governor, not shown, for maintaining a constant speed of rotation.

The blades 13 are connected to a variable pitch mechanism 18 which may be of any well known and standard construction such as that manufactured by the Escher-Wyss Company of Zurich, Switzerland, the details of which form no part of the present invention and are accordingly not specifically set forth herein. This mechanism, in general comprises a rod 19 slidable longitudinally within the shaft 15 and connected to control the pitch of the blades 13. The rod 19 is actuated by a piston 27 in a fluid pressure cylinder 27*a*. Fluid for actuating the piston 27 is supplied by a pump 26 through a control valve 25 and a distribution valve 25*a* which communicates with the cylinder 27*a* through ducts, not shown, in the shaft 15.

A motor 21 rotates a worm 22 which operates to move the upper end of a floating lever 23, which, in turn, is pivoted to the end of a valve rod 24 which controls the valve 25. The piston 27 is connected by a rod 28 to a collar 29 which is slidably mounted on the shaft 15 and engages the lower end of the lever 23 so that the position of this end of the lever corresponds to the pitch of the blades 13.

The upper end of the lever 23 is connected by a wire 30 to an indicator 31 which shows the pitch at which the blades 13 are set. Stops 32 are provided for limiting the maximum and minimum pitch of the blades 13. The fluid pump 26 is driven either by a motor 33 or a belt 35 from the shaft 15. A reservoir 36 and a supply tank 37 are provided for the necessary fluid.

It is to be understood that other pitch control devices may be employed in place of that referred to above, for varying the pitch of the propeller blades 13 in response to actuation of the motor 21. A particular type is shown for purposes of illustration only.

The engine 20 is supplied with fuel from a supply tank 40, the fuel from which passes thru a pipe 41 to a fuel consumption meter 42, to be described, from which it passes thru a pipe 43 to the fuel pump 45 of the engine 20.

Referring to Figure 2 the fuel consumption meter 42 is shown in detail as comprising in general two fuel weighing devices 46 and 47, two control valves 48 and 49, a distribution valve 50, two pitch control mechanisms 51 and 52 and a time controlled switching device 53.

The fuel weighing devices 46 and 47 comprise two fuel tanks 55 and 56 which are mounted on two shafts 57 and 58 which are slidably mounted in brackets 59 attached to a base plate 60. Secured to each of the shafts 57 and 58 is a collar 61 between which and the corresponding bracket 59 is a compression spring 62. Mounted on the shafts 57 and 58 are pins 63 and 64 respectively. The pin 63 cooperates with two levers

65 and 66 which are pivoted at 67 and 68 to the base 60 and tend to be rotated in a clockwise direction by springs 70 and 71. Secured to but insulated from the levers 65 and 66 are two contact arms 72 and 73.

The pin 64 cooperates with two levers 75 and 76 which are pivoted at 77 and 78 to the base 60 and tend to be rotated in a counter-clockwise direction by springs 79 and 80. Secured to but insulated from the levers 75 and 76 are contact arms 81 and 82 respectively.

Each of the contact arms 72 and 81 selectively engages a set of six segments 85—90, mounted on but insulated from an arc shaped member 92, which is slidably mounted in brackets 93 and 94 attached to the base 60. The brackets 93 are provided with clamping screws 95 for holding the members 92 and contacts 85—90 in any desired position. Pointers 97 are attached to the members 92 and register on scales 98 secured to the base 60.

The segments 85 and 90 of each set are connected by flexible conductors to two conductors 100 and 101 which in turn are connected to the reversing windings of the motor 21 (Figure 1). The segments 86 and 87 are connected by flexible conductors to two resistors 102 and 103 which is turn are connected to the conductor 100. The segments 88 and 89 are connected by flexible conductors to two resistors 105 and 106 which in turn are connected to the conductor 101. The common lead of the reversing windings of the motor 21 is connected thru a battery 107 to the blade of a three position switch 108. The center contact of this switch is connected to a conductor 109, the lower contact to the conductor 100 and the upper contact to the conductor 101.

The fuel supply pipe 41 is connected to two branch pipes 110 and 111 which feed fuel at suitable times to the two tanks 55 and 56 respectively. The control valves 48 and 49 are located in the supply pipes 110 and 111 and control the flow of fuel to the two tanks 55 and 56 respectively. Each of the control valves 48 and 49 comprises a casing 112 in which reciprocates a valve stem 113 provided with a port 115. The valve stem 113 forms the core of a solenoid 116 and has secured thereto a collar 117. Surrounding the valve stem 113 and located between the solenoid 116 and the collar 117 is a compression spring 118 which tends to hold the valve in the closed position.

The two tanks 55 and 56 are connected by flexible tubing 120 to the distribution valve 50 which comprises a casing 121 in which is rotatably mounted a valve 122 provided with a port 123. The valve 122 is secured to an arm 125 the end of which is connected to the core 126 of a solenoid 127. Fastened to the core 126 is a collar 128 between which and the solenoid 127 is located a compression spring 129. A tension spring 130 is secured to the end of the arm 125, and tends to rotate the valve 122 in a clockwise direction.

The time controlled switch 53 comprises a driving mechanism 132 which rotates a shaft 133 in a clockwise direction at a predetermined uniform rate of speed, which for example may be one revolution in thirty minutes. Secured to the shaft 133 are three commutators 135, 136, 137 made of insulating material.

The commutator 135 is provided with a sector 138 of conducting material which at suitable times engages two contacts 139 and 140. The contact 139 is connected thru a battery 141 to one side of the winding of the solenoid 127, the other side of which is connected to the contact 140. The commutator 136 is provided with a sector 142 of conducting material, which at suitable times, engages four contacts 145, 146, 147 and 148. The contacts 145 and 148 are connected to the conductor 109. The contacts 146 and 147 are connected to the contact arms 72 and 81 respectively. The commutator 137 is provided with a sector 150 of conducting material, which at suitable times, engages four contacts 151, 152, 153 and 154. The contacts 152 and 153 are connected thru a battery 155 to one side of the windings of the solenoids 116. The contact 151 is connected to a contact 156 which normally engages the arm 73 and the contact 154 is connected to a contact 157 which normally engages the arm 82. Two contacts 158 and 159 which normally engage the arms 73 and 82 are connected to the other sides of the windings of the solenoids 116.

Operation

In the operation of this invention the pitch of the blades 13 is first set at the normal operating angle for the speed at which it is desired to operate the vessel. The setting of the propeller blades 13 is accomplished by moving the blade of the switch 108 into the lower or upper position which will cause the motor 21 to move the upper end of the lever 23 to the left or right to increase or decrease the pitch in a well known manner, the angle of pitch being indicated by the pointer of the indicator 31. The blade of the switch 108 is then moved to its center contact to make further control automatic in response to operation of the fuel consumption meter 42.

The operation of the fuel consumption meter may be considered as divided into two cycles of, for example, fifteen minutes each which are controlled by the timed switching device 53. During one such cycle the fuel is used from the tank 56, the consumption during a given interval is measured, and the pitch control motor is actuated by the control mechanism 52 to change the pitch in a manner to correct for any deviation in consumption from a predetermined value. During the next cycle the measurement and control are effected by the tank 55 and the control mechanism 51, while the tank 56 is refilled. The pitch is thus varied at intervals in accordance with the integrated fuel consumption which is a measure of the power being developed, and in a sense to maintain constant power.

The condition of the apparatus shown in Figure 2 is that assumed by the mechanism at the beginning of one of these cycles with both control valves 48 and 49 closed. The tank 56 has just been filled with a predetermined amount of fuel (oil) and the valve 50 has just been operated by energization of the solenoid 127, so that fuel from the tank 56 passes thru the flexible tube 120, port 123 and pipe 43 to the fuel pump 45 of the engine 20. The pitch control mechanism 52 is in its inoperative condition, as the contact 147 is on the insulating position of the commutator 136. Fuel has been used from the tank 55, which is the measuring position and the pitch control mechanism 51 is in operative condition as the contact 146 is on segment 142. The variable pitch mechanism 18 does not operate, however, because the contact 72 is shown as on the insulation between the segments 87 and 88, a position indicating that the full consumption from the tank 55 during the preceding cycle corresponds to the predetermined value.

The two members 92 have been set to positions corresponding to the predetermined amount of fuel which should be consumed in the operating cycle under normal operating conditions, i. e., for a given power load at constant propeller R. P. M., as indicated on scales 98 by pointers 97. The members 92 are held in these positions by tightening screws 95.

As the shaft 133 rotates in a clockwise direction from the position shown, the segment 142 disengages the contacts 145 and 146 after a predetermined interval such as two minutes thus putting the pitch control mechanism 51 in an inoperative condition. On further rotation of the shaft 133 the segment 150 engages the contacts 151 and 152 thus closing a circuit from the battery 155 thru the solenoid 116 of the valve 48 which is thereby opened, allowing fuel to flow through the supply pipe 119 to the tank 55 which quickly fills up. As it does so the tank 55 together with the shaft 57 moves downwardly against the action of the spring 62. This motion continues until the pin 63 engages the lever 66, rotating it in a counterclockwise direction, thus opening the circuit between the contacts 156 and 158 which causes the solenoid 116 to be deenergized and the valve 48 to close under the action of the spring 118. The tank 55 is now full and contains a definite predetermined weight of fuel oil.

As the shaft 133 continues to rotate the segment 150 will move out of engagement with the contacts 157 and 151, thus opening the circuit of the solenoid 116 of the valve 48 and allowing the valve 48 to close. At the end of the cycle the segment 138 will move out of engagement with the contacts 139 and 140 thus deenergizing the solenoid 127. This will allow the valve 122 to be rotated in a clockwise direction under the action of the spring 130 which will disconnect the pipe 43 from the tank 56 and connect it to the tank 55. At the same time the segment 142 will engage the contacts 147 and 148 thus putting the pitch control mechanism 52 in an operative condition.

During the cycle in which the tank 56 is connected to the fuel pump 45, a certain quantity of fuel oil is consumed by the engine 20. This lightens the load on the shaft 58 which moves upwardly under the action of the spring 62 until a position of equilibrium is reached depending on the weight of fuel consumed during the cycle.

As the shaft 58 moves upwardly the pin 64 engages the lever 75 causing it, together with the contact 81 to rotate in a clockwise direction. If normal operating conditions were maintained during the cycle the amount of fuel consumed would be exactly equal to the predetermined amount, as indicated by the pointer 97 on the scale 98. Under these conditions the contact 81 rests on the insulation between the segments 87 and 88 at the end of the cycle when the contacts 153 and 154 are closed by the segment 150 and the pitch varying mechanisms 18 is not operated.

If, however, the operating conditions are unfavorable such as due to head winds or a heavy sea, the fuel consumption increases and more than the theoretical amount of fuel is consumed, thus decreasing the weight of fuel in the tank 56 so that the shaft 58 moves farther up, which in turn causes the contact 81 to engage segment 88, for example. This closes a circuit from the battery 107 thru the resistor 105 to the motor 21 causing it to rotate slowly in a direction to move the upper end of the lever 23 to the right, which allows fluid under pressure to pass from the pump 26 to the cylinder 27a by means of the ducts in the shaft 15. This fluid actuates the piston 27, which, by means of the rod 19 causes the propeller blades 13 to slowly decrease their pitch.

This operation of the motor 21 continues for a brief interval of time, which, for example may be two minutes, at the end of which the segment 142 will move out of engagement with the contacts 147 and 148 thus stopping the variable pitch mechanism 18, and completing the cycle of operation for the tank 56 and associated mechanisms.

If under favorable conditions the fuel consumption during the cycle should decrease, the weight of fuel consumed during this interval would be less and shaft 58 would not move up so far, so that the contact 81 would engage the segment 87, which would complete a circuit to the motor 21 to cause the blades 13 to slowly increase their pitch.

If conditions change more quickly so that somewhat more or less fuel is consumed during the cycle, the contact 81 will engage either of the segments 89 or 86. Under these conditions either the resistor 106 or the resistor 102 will be thrown in circuit with the motor 21. As resistors 106 and 102 have less resistance than resistors 105 and 103, the motor 21 will be caused to rotate faster, thus changing the propeller pitch more rapidly to take care of the more rapidly changing conditions.

If conditions change still more quickly so that considerably more or less fuel is consumed during the cycle, the contact 81 will engage either of the segments 90 or 85. In this case no resistance will be thrown in the circuit of the motor 21 and it will rotate at its maximum speed, thus changing the propeller pitch at a maximum rate. The stops 32 are provided so that the propeller pitch is prevented from exceeding certain limits beyond which it could not operate efficiently under any conditions.

As the shaft 133 continues to rotate the segment 150 will engage the contacts 153 and 154, thus closing a circuit thru the solenoid 116 of the valve 49 which will cause this valve to open and allow fuel oil to enter the tank 56. As the tank 56 fills with fuel it will move downwardly together with the shaft 58 until the pin 64 engages the lever 76, thus breaking the circuit to the solenoid 116 and closing the valve 49.

Further rotation of the shaft 133 will cause the segment 138 to engage the contacts 139 and 140 which will energize the solenoid 127 to rotate the valve 122 in a counterclockwise direction to disconnect the tank 55 from the pipe 43 and connect the tank 56 to said pipe. At the same time the segment 142 will engage the contact 145 and 146 to put the pitch control mechanism 51 in an operative condition to control the pitch of the blades 13 in a manner already described, but in accordance with the fuel consumption from the tank 55. This completes the cycle of operation for the tank 55 and its associated mechanism.

By the system above described the pitch of the propeller blades 13 is varied at predetermined intervals by amounts proportional to the integrated variation of fuel consumption from normal during this interval. This causes the

propeller to operate so as to maintain the average rate of fuel consumption of the engine 20 constant under varied conditions. The rate of change of pitch will vary in accordance with the rate of change of fuel consumption.

While the fuel weighing devices shown here are of the spring operated type it is to be understood that weight operated mechanisms may be used if found desirable. It is also to be understood that while weight operated means are shown for measuring the amount of fuel consumed the invention is not to be limited thereto but may employ other means for measuring the amount of fuel consumed, such for example as volume measuring devices which would operate the shafts 57 and 58.

Although only a few of the various forms in which this invention may be embodied have been shown herein, it is to be understood that the invention is not limited to any specific construction but may be embodied in various forms without departing from the spirit of the invention or the scope of the appended claims.

What is claimed is:

1. In a system for driving a vessel, a propeller having blades, means controlling the pitch of said blades, a liquid fuel actuated motor driving said propeller, a fuel line supplying liquid fuel to said motor, a fuel meter connected in said fuel supply line and including means measuring the rate of fuel flow therein to said motor, and means actuated by said last means to actuate said pitch control means so as to vary the pitch of said blades in a manner to maintain substantially constant fuel flow conditions.

2. The system set forth in claim 1 in which the propeller is driven at constant speed.

3. The system set forth in claim 1 in which the motor comprises an internal combustion engine.

4. In a system for driving a vessel, a propeller having blades, means controlling the pitch of said blades, an internal combustion motor driving said propeller and having means maintaining a constant speed of rotation, means measuring the fuel consumption of said motor over predetermined intervals of time, and means actuated at the end of each of said predetermined intervals of time and responsive to variations in said fuel consumption from a predetermined normal value during said intervals, to actuate said pitch control means so as to vary the pitch of said blades in a manner to compensate for said variation in fuel consumption.

5. The invention set forth in claim 4 in which the pitch control means is actuated for predetermined periods of time and at speeds determined by the amount of variation of fuel consumption from said predetermined normal value during the preceding measuring period.

6. The invention set forth in claim 4 in which the measuring device includes means measuring the loss of weight of fuel due to fuel consumed during the predetermined period of time, and the pitch control means is actuated at a speed determined by the direction and amount of deviation of said loss of weight from a predetermined normal value.

7. In a system for driving a vessel, a propeller having blades, means controlling the pitch of said blades, a liquid fuel actuated motor driving said propeller, means measuring the fuel consumption of said motor over predetermined intervals of time and means actuated by said last means in response to variations in fuel consumption during said intervals of time from a predetermined normal fuel consumption to actuate said pitch control means so as to vary the pitch of said blades in a manner to compensate for said variations in fuel consumption.

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