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Hager et al.

[11] **3,834,345**

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[54] **MARINE DRIVE SETTING APPARATUS**

[75] Inventors: **James R. Hager,** Fond du Lac; **Hugh E. Riordan,** West Bend, both of Wis.

[73] Assignee: **Brunswick Corporation,** Skokie, Ill.

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[52] **U.S. Cl.** .... **115/41 HT,** 115/41 R

[51] **Int. Cl.** **B63h 5/12**

[58] **Field of Search** .... 115/41, 34 R, 34 A, 35, 115/17, 18; 114/144 R, 144 A, 235 B; 244/76 R, 76 C, 77 R, 77 F, 77 DZ

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Primary Examiner—Trygve M. Blix
Assistant Examiner—Charles E. Frankfort
Attorney, Agent, or Firm—Andrus, Sceales, Starke and Sawall

[57] **ABSTRACT**

Apparatus for power positioning and holding of an outboard marine drive includes a manual trim angle selection input signal generator. A position sensitive signal generator in the form of a Hall cell or a resistor is secured on the gimbal ring unit with a movable element set in accordance with and by the movment of the marine drive. A comparator provides a pair of output signals in accordance with the relative magnitude of the two signals and depending upon whether drive is to be raised or lowered. The output signals are similarly connected through amplifying and switch isolating circuitry to actuate an electric motor and hydraulic pump unit to raise or lower the stern drive unit the position sensor and the manual input are nulled. A slight dead band maintains stable operation as the stern drive is moved to a new trim position. A fail-safe circuit prevents malfunctioning if the sensing system open circuits.

29 Claims, 8 Drawing Figures

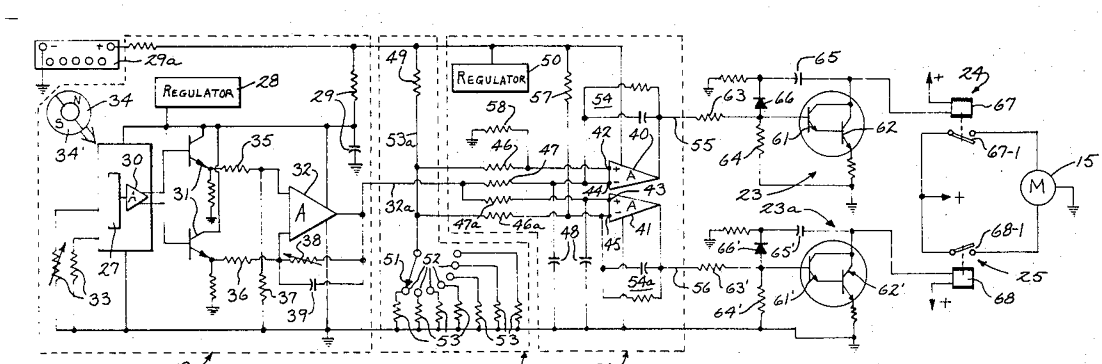


Fig.1

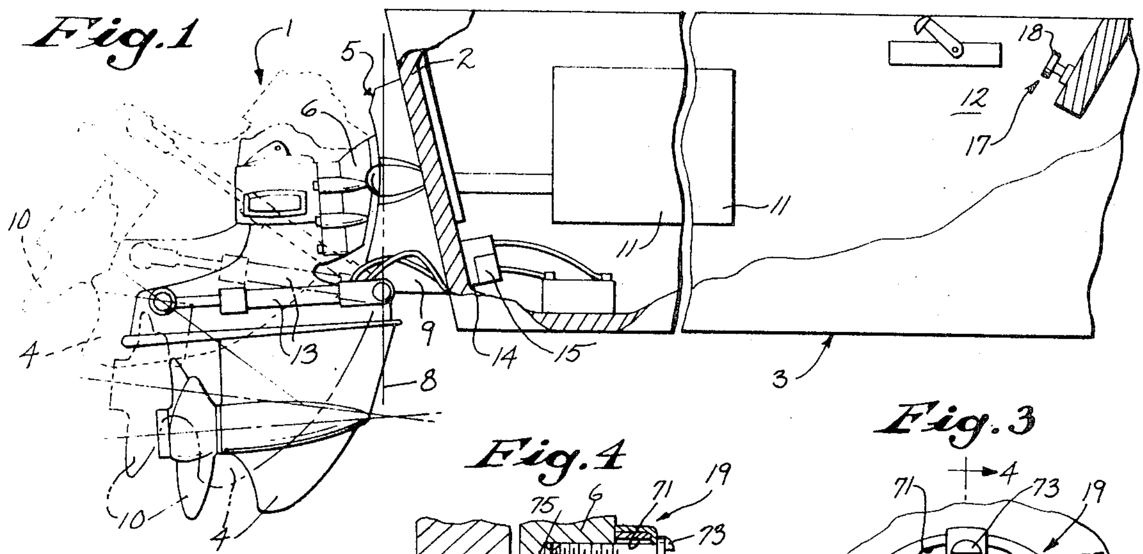


Fig.2

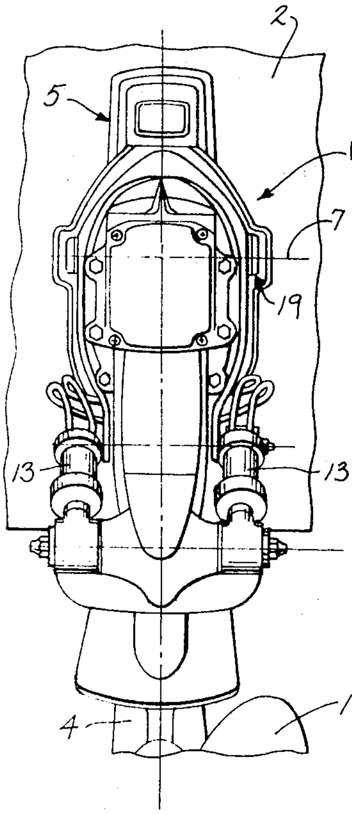


Fig.4

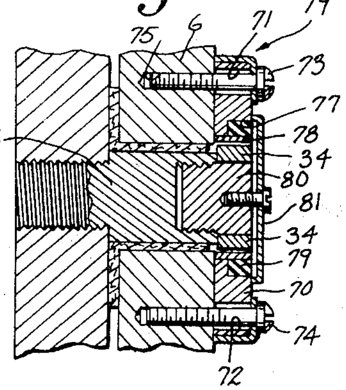


Fig.3

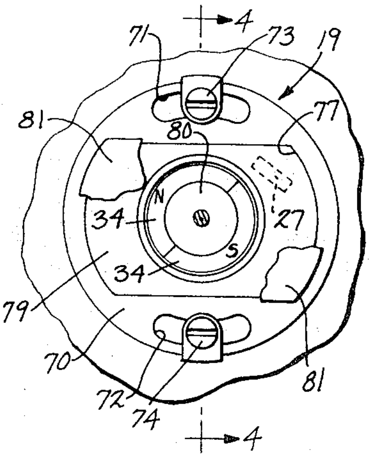
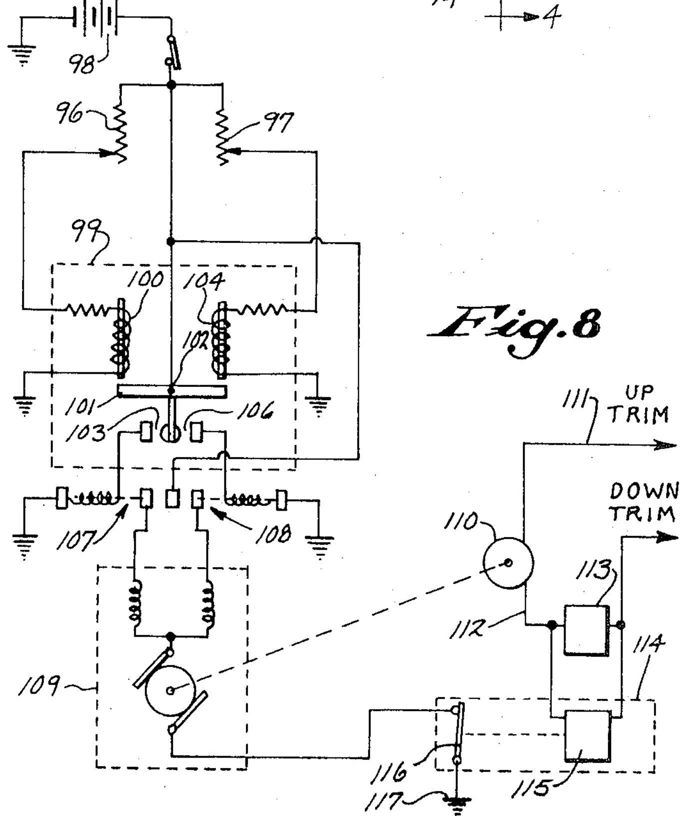


Fig.8



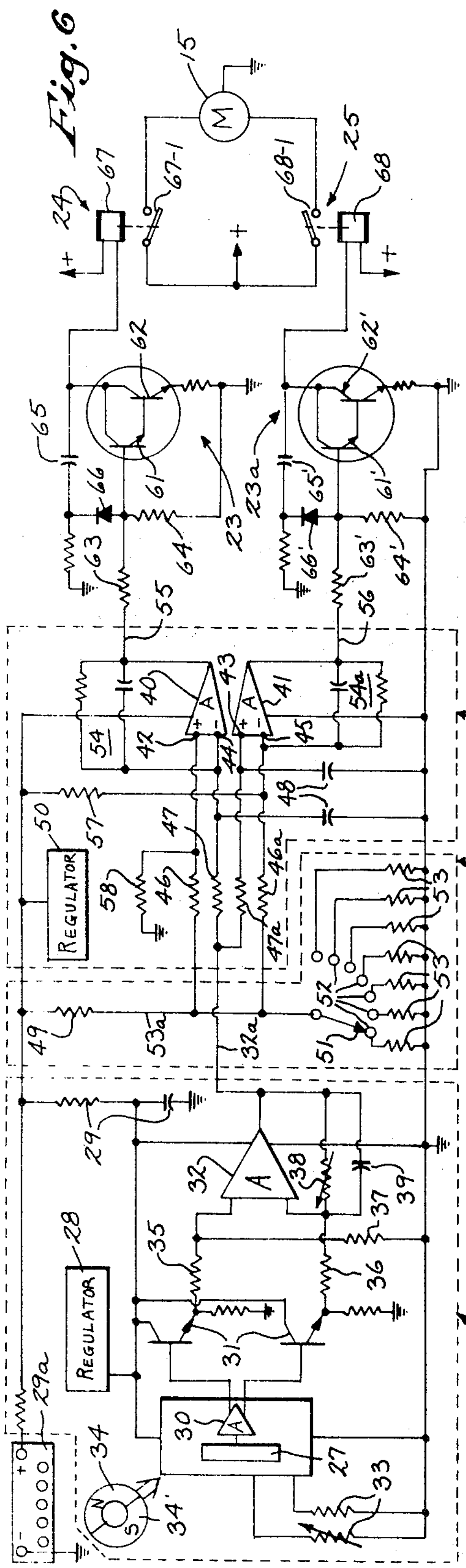


Fig. 6

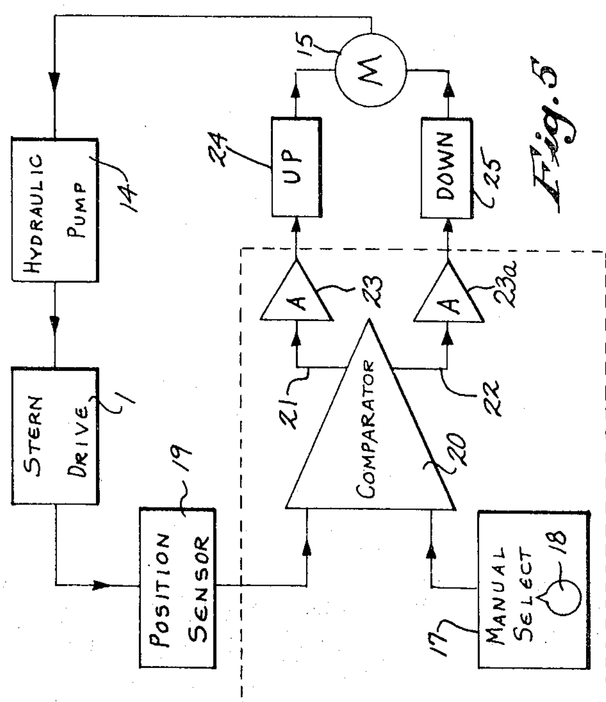


Fig. 5

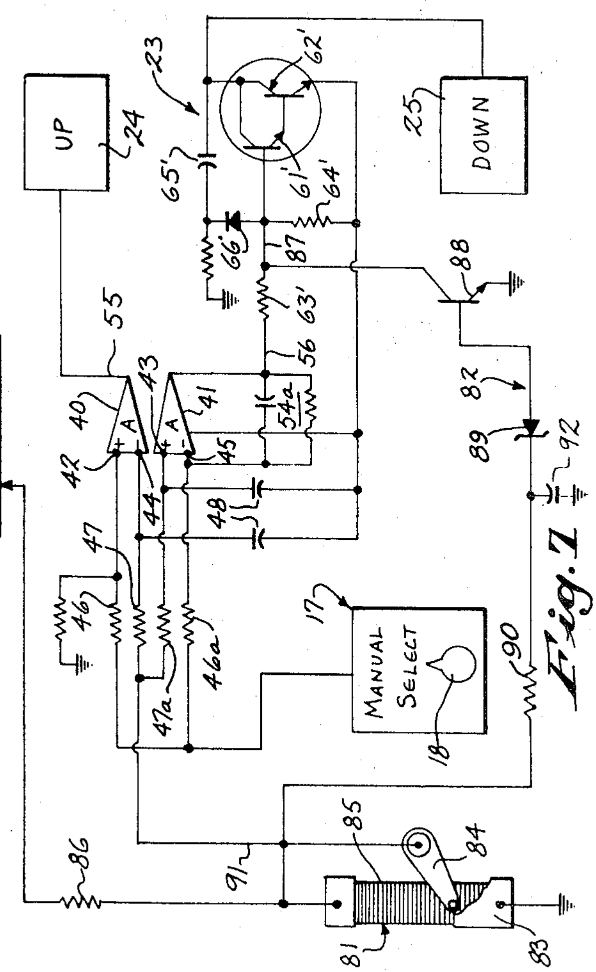


Fig. 7

MARINE DRIVE SETTING APPARATUS

BACKGROUND OF THE INVENTION

This invention relates to automatic positioning drives for angular positioning of an outboard drive unit.

Outboard propulsion drive units are widely employed for marine drives particularly of the smaller pleasure boats and the like. Such units are preferably connected to the transom of the boat and mounted for angular orientation about a vertical axis for steering purposes and about a horizontal axis to permit optimum location of the propulsion unit in the water for optimum driving conditions. Hydraulic systems have been advantageously applied to power trim positioning of the outboard propulsion units. For example, U.S. Pat. Nos. 3,434,448 and 3,434,449 disclose hydraulic systems wherein a piston and cylinder means is coupled to a stern drive for selectively positioning and holding of the stern drive unit in various angular orientation about a horizontal axis. The hydraulic system is driven from a suitable electric motor driven pumping unit having an appropriate hydraulic control system for raising and lowering of the stern drive unit. Generally such systems have employed a manual control at the steering station which the operator continuously operates until such time as the motor is at a desired position. The prior systems have therefore relied on the operator sensing an optimum condition. Alternatively, meters have been electrically coupled to the stern drive unit and positioned in accordance with the angular drive trim position. The variable resistor unit is connected in the circuit of a meter mounted adjacent to the operator and provides a visual indication of the angular setting trim position.

Although the prior art devices have permitted power trim positioning systems, they have relied upon the direct attention of the operator either through a subjective sensing of optimum motor positioning, visual viewing of the motor position or of a meter with adjustment of the trim until an optimum condition is believed to have been established. Thus, the operator's attention is, in essence, divided between the setting of the trim control and the operation of the propulsion unit. Further, in such systems, the set trim position changes during operation such as a result of interaction with the water and/or objects in the water or as a result of minor hydraulic leakage. For example, rapid acceleration or running over a stump or the like may cause the marine propulsion unit to move from the set position without necessarily returning to the set position after the disturbing forces are removed. The operator must, therefore, provide a more or less continuous attention to the trim run position of the propulsion unit. This may require the operator's attention under conditions representing a hazardous diversion from the driving of the boat.

SUMMARY OF THE PRESENT INVENTION

The present invention is particularly directed to a power lift system for automatically setting the marine propulsion unit in a selected trim position as a result of a single angle selection input, with the system holding the trim position for all normal operating conditions. Generally, in accordance with the present invention, the automatic trim system includes a manually actuated signal generator for producing a signal related to a desired trim angle. An automatic sensing unit is coupled to a power unit and generates an output signal proportional to the angle position with respect to a reference. The two signals are connected to a comparator, the output of which provides an output for raising and lowering of the propulsion unit. The comparator preferably provides a pair of on-off signals for selectively raising and lowering of the marine propulsion unit. Thus, the one signal actuates a power lift mechanism to raise the stern drive and the opposite signal correspondingly actuates the power lift unit to lower the marine propulsion unit. The drive unit is thus automatically positioned until a null signal condition is established, at which time the drive unit is held in the preset desired position. If the trim angle should be changed due to any operating condition, the system will automatically reposition the drive unit to the preset condition.

In accordance with a further novel aspect of the invention, the apparatus is provided with a time delay which will be sufficient to keep the system from self-correcting itself under minor disturbances such as those associated with wave bounce and the like. The apparatus may further include a pressure responsive cutout which opens the drive position circuit if a high pressure is applied to the propulsion means, such as encountered if passing over a log. This permits the standard "log jumping" with subsequent automatic reconnection of the trim control. Further, electronic circuitry can be employed to minimize the power consumption by the control system and thereby adapt the unit to the usual marine drive system.

The system, in accordance with a particularly novel aspect of the present invention, includes a dead band selected in accordance with the coasting characteristics of the drive unit including the hydraulic system. The dead band is selected to prevent overlap between adjacent selected angles.

In accordance with a further novel aspect of the present invention, the position sensor is a Hall cell sensor including a Hall cell transducer in combination with a magnetic member, with the cell and magnetic unit mounted for relative movement as a part of the drive unit. The Hall cell sensor transduces the sine wave of flux density to a related sine wave of voltage in response to the relative angular orientation of the Hall cell and the magnetic unit. The output is amplified and preferably buffered with a pair of emitter follower transistors to produce a double-ended output sufficient to drive an operational amplifier, the output of which is connected as an input to a comparator amplifier. The sensor circuitry includes filtering means to attenuate any radio frequency signal resulting from the ignition system of the marine propulsion unit and an offset adjustment means to adjust the offset of the Hall device. The system is preferably powered from a suitable voltage regulator means.

The Hall cell amplifier and emitter follower circuit may advantageously be formed as an integrated circuit unit with the Hall cell mounted in fixed relation to the propulsion drive unit. A doughnut shaped magnet is secured to the movable portion of the stern drive, for example, to the pivot shaft mounting and is rotated about the Hall cell to impress an operative flux upon the Hall cell which varies as a sine wave with the rotation or angular orientation of the propulsion drive unit. The comparator and drive circuitry may be separately mounted in a suitable control mounted inboard of the motor of the boat. Thus, in the preferred circuitry an operational amplifier means including a separate pair of operational amplifiers is connected as a comparator to compare the output of the Hall cell sensor and a preset DC signal. The output of one operational amplifier is connected to selectively drive an up switching amplifier and the output of the other operational amplifier is connected to drive a down switching amplifier. The outputs of the switching amplifier are connected through suitable relays or other switching means to reversibly drive an electric motor. The electric motor, in turn, is coupled to reversibly drive a hydraulic pump unit for corresponding raising and lowering of the propulsion drive unit until such time as the position sensing signal is nulled with the input signal. The control circuitry may further include a stabilizing network to eliminate the effects of vibration and to insert the desired angular dead zone which will permit the drive unit to coast past the equilibrium position by approximately one degree in either direction without re-energization of the system.

Further, as previously noted, the Patent **3,641,965** discloses a resistive sensor for providing an output signal proportional to the angular orientation of the drive unit. As noted therein, relatively simple and inexpensive linear resistors are preferably employed. However, the output as noted is linear with the position and, consequently, such an inexpensive resistor does not provide the required sine wave signal compatible with a system employing a Hall cell sensor. Applicant has found, however, that for the limited angular positioning required of a marine propulsion unit, a linear resistor in series with an appropriate fixed resistor generates a variable voltage which approaches a sine wave voltage versus angular displacement and is such as to permit highly satisfactory operation as the input to the Hall cell signal processing circuit. The resistive sensitive system may be desirable to minimize the expense and to avoid certain temperature stabilization required with Hall cell units.

As the sensing systems are preferably mounted to the propulsion unit there is a danger that the circuit will become open circuited due to wear or water contamination, corrosion or the like, particularly where the resistive sensing network is employed. Under such conditions the voltage may rise to provide a turn-on signal to the power lift means tending to lower the propulsion drive unit to its maximum down position with no means for the operator to return it to a higher position. This can obviously create an extremely dangerous operating condition particularly when the boat is under power. The present invention desirably provides a safety circuit to positively prevent the operation of the lowering power circuitry under open circuit conditions. The safety circuit in accordance with a further novel aspect of the present invention may employ a Zener diode means or the like connected to sense the input voltage from the resistance position sensor and actuate an interlock switch such as a transistor in response to an open circuit condition. The interlock switch positively prevents energizing of the lowering circuitry. The same voltage signal holds the lifting circuit in the preferred construction. The safety circuit preferably includes an integration means such as a resistor-capacitor to produce a delay in the actuation of the fail-safe circuit and thereby permit a momentary open circuit condition. Thus, in the resistance sensor element, the wiper may momentarily create an open circuit condition when moving from one winding turn to the next and erroneously operate the safety circuit if a delay means is not introduced.

The present invention thus provides a reliable automatic drive for accurately locating the positioning of an outboard marine propulsion drive unit.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawings furnished herewith illustrate preferred constructions of the present invention in which the above advantages and features are clearly disclosed as well as others which will be readily understood from the following description:

In the drawings:

FIG. **1** is a side elevational view of an inboard-outboard drive unit mounted on the transom of a partially shown watercraft, with various trim positions shown in phantom line illustration;

FIG. **2** is a fragmentary rear view of the watercraft and stern drive unit shown in FIG. **1**;

FIG. **3** is an enlarged fragmentary side elevational view of the stern drive unit shown in FIG. **1** more clearly illustrating the Hall cell mounting;

FIG. **4** is a vertical section taken on line **4—4** of FIG. **3**;

FIG. **5** is a block diagram of an automatic trim control system constructed in accordance with the present invention and applied to control a stern drive unit such as shown in FIG. **1**;

FIG. **6** is a schematic circuit diagram of a system corresponding to that shown in FIG. **5** and employing a Hall cell position sensor mounted as a part of a stern drive unit shown in FIG. **1**;

FIG. **7** is a schematic circuit similar to FIG. **3** illustrating an embodiment employing a resistance sensor and a novel fail-safe circuit; and

FIG. **8** is a schematic circuit of a simple differential relay embodiment.

DESCRIPTION OF THE ILLUSTRATED EMBODIMENT

Referring to the drawings and particularly to FIG. **1**, an outboard propulsion unit or assembly in the form of a stern drive unit **1** is shown mounted on the transom **2** of a partially shown watercraft **3**. The stern drive includes a lower drive unit **4** and a bracket mounting assembly **5** for movably mounting and supporting of the drive unit from the transom **2**. The bracket assembly **5** includes an intermediate gimbal ring **6** which pivotally supports the drive unit **1** upon a generally transverse horizontal axis **7** for selective tilt movement of the unit in a generally vertical plane. The gimbal ring **6** is in turn pivotally supported on a generally vertical axis **8** by the outer transom bracket **9** to provide for and permit movement of the drive unit **4** in a generally horizontal plane for purposes of steering the movement of the watercraft **3**.

The drive unit **4** more particularly includes the usual propeller **10** which is drivingly connected to an engine **11** mounted inboard of the watercraft **3**. The propeller **10** is selectively rotatable in opposite directions in accordance with operation of suitable reversing gear positioning means not shown to provide for a corresponding forward and reverse thrust respectively for the watercraft **3**. Further, the drive controls include a suitable remote speed and directional control unit connected by an electrical, mechanical cable system or the like not shown to permit convenient location of the operation, for example, adjacent a forward control station **12** of the watercraft **3.** In addition, hydraulic power means are provided for supplying hydraulic liquid to a pair of cylinder-piston means **13** connected to the opposite sides of the stern drive unit **1** functioning as hydraulic shock absorbing means as well as stern drive angular positioning or trim positioning power means. Thus, as more fully described in the previously referred to U.S. Pat. Nos. 3,434,448 and 3,434,449, the piston-cylinder means **13** are connected to a hydraulic gear pump **14** which is reversible driven by a reversible electric motor **15** to selectively supply liquid to the opposite sides of the cylinder-piston means **13,** thereby permitting the powered extension and retraction thereof with a corresponding angular orientation or positioning of the stern drive unit **1** about the horizontal axis **7.** As the above mounting and positioning of the stern drive may take any desired form and construction, no further description thereof is given other than that necessary to clearly describe the present invention.

In the operation of a watercraft which is driven from an outboard propulsion means such as a stern drive unit, the watercraft is preferably started with the drive unit **1** in the lowered depending full line position shown in FIG. **1.** This aids the movement of the boat to the plane position. However, when the boat is on a plane, it is desirable to re-position the drive unit **1** further outward for maximum efficiency and speed as disclosed in the previously referred to U.S. Pat. No. 3,641,965. Under normal operating conditions various trim angles might be desirably employed. Further, the drive unit **1** may be raised upwardly to maximum position for trailing or low power operation. The present invention is particularly directed to provide an automatic drive and positioning control system which will permit selection of a given angle and the holding of such given angle automatically and in response to the operator merely actuating a suitable input positioning device to a selected angle position without the necessity for continued attention and monitoring of the system. Thus, generally, in accordance with the present invention, a trim angle selection unit **17** is provided adjacent to the operating station **12** and may conveniently be in the form of a multiple switch unit adapted to select any one of a plurality of preselected angles between a reference zero position and a maximum raised position. Thus, for example, a highly satisfactory automatic control system has been constructed providing for the selection of the seven different angles of 0°, 3.5°, 7.0°, 10.5°, 15°, 22° and 44°. Although pushbuttons, levers or position selection means can be used, a satisfactory selection unit **17** has been constructed with a rotary switch having an input knob **18** that could be moved to any one of the angle positions. The trim control system further includes a stern drive position sensitive signal means **19** coupled to the unit **1** and the signals of the selection unit **17** and signal means **19** are compared and processed to automatically and directly establish the angular movement and positioning of the stern drive unit **1** and is continuously operative to maintain such trim angle position.

Referring particularly to FIG. **5,** a block diagram of the automatic trim control system of the invention is illustrated in which the manual input control **17** is shown providing one input to a comparator amplifier **20,** the opposite input of which is connected to the position sensor **19.** The output of the position sensor is a signal directly related to the angular positioning of the drive unit **1** and of a character related to the signal from the unit **17.** The comparator **20** compares the two signals and provides a lift signal or a drop signal at a pair of corresponding lines **21** and **22,** depending upon the relative magnitude of the two input signals. Thus, if there is a difference between the selected angle and the actual angle, a signal will appear at one or the other of the two output lines. These signals are similarly processed and in particular the control signal is amplified through similar amplifiers **23** and **23*a*** and connected to actuate an up-relay **24** or a down-relay **25.** The relays **24** and **25** in turn connect power to the electric motor **15** to reversibly operate the electric motor in accordance with the operation of the relays to thereby reversibly drive the hydraulic pump **14.** The control system will automatically establish the trim angle and will reset the trim angle if it is changed for any reason under operation; for example, due to rapid acceleration, running over a stump or the like. The operator can select any one of the given angles without a great deal of attention or distraction from the normal operation of the watercraft.

Referring particularly to FIG. **6,** schematic circuit diagram of an automatic trim control system is shown employing a Hall cell position sensing unit coupled to the stern drive unit, as shown in FIGS. **1–4** and functioning as a position sensor.

The Hall sensor **19** preferably is constructed as an integrated Hall cell circuit unit having a Hall cell **27** connected to a closely regulated power supply **28.** A resistor-capacitor network **29** connects the supply **28** to the battery **29a** and functions as a low pass filter to attenuate radio frequency that might be produced by the ignition system, not shown. Thus, in a practical application, the Hall cell was connected to a 5.6 volt regulated voltage.

The output of the Hall cell **27** is connected to a differential amplifier **30** which produces a double-ended output, each of which is coupled through a buffering emitter transistor **31** to a second amplifier **32** to provide an amplified voltage signal related to the Hall cell voltage at the output line **32*a*.** A pair of resistors **33** one of which is made adjustable, is connected to the input of the differential amplifier **30** to adjust the offset of the Hall device **27.** The several circuit elements of the sensor **19** are, as noted, preferably formed as a single integrated circuit.

The output of the Hall cell **27** is controlled by an annular permanent magnet **34** which as shown diagrammatically in FIG. **6** is polarized diametrically of the magnet on a line generally normal to the diametrical line through the Hall cell. The magnet **34** is mounted for angular rotation about its own axis and is angularly oriented with respect to the Hall cell **27,** as more fully shown in FIGS. **3** and **4.** The effective component of the flux impressed upon the Hall cell **27** changes or varies in accordance with a sine wave function as the angular orientation or position of the magnet **34** with respect to the Hall cell **27** changes. The Hall cell **27** thus transduces the sine wave of magnetic flux to a corresponding sine wave voltage signal.

As illustrated in FIGS. **3** and **6,** for the lowermost position of the drive unit **1,** the Hall cell **27** is aligned with the periphery of the magnet **34** at essentially ninety degrees to the north and south poles. Although this is not the position of maximum flux and therefore signal level, it is the position of the maximum rate of signal change for any given small angle movement. This is particularly advantageous when applied to positioning of a marine drive unit, which is normally positioned between a vertical or 0° position and a raised 55° position. The angular positioning between approximately 0 and 15° is quite significant in the propulsion of an outboard unit and consequently maximum accuracy is desired in that range. The sine wave voltage signal provides maximum voltage change per degree at the zero crossover axis as a result of the maximum slope and almost linear characteristic of the wave at that point. This also permits use of a relatively narrow voltage range; for example, 2.5 volts for the 0° angle setting to 8.2 volts for a maximum or 55° angle setting. Although the voltage change per degree of angular movement in the upper range or last 15° is substantially less, the angular position is not as significant for operating the propulsion means and is therefore readily employed.

The output of the cell **27** is amplified and coupled through the emitter followers **31** to prevent loading of the sensor circuit. The amplified output is impressed upon a second amplifying stage **32** through series coupling resistors **35** and **36** and a resistor **37** to ground which sets the source impedance of the second amplifying stage. A paralleled RC feedback network includes a variable resistor **38** and a fixed capacitor **39**. The variable resistor **38** permits adjustment of the gain of the second amplifying stage while the feedback capacitor limits the band width of the operational amplifier and protects it from spurious oscillation.

The output is thus an amplified signal, taken with respect to ground, which is directly related to the angular orientation of the stern drive unit **1** with respect to the zero or reference position.

The output is applied as one input to the comparator **20**, which, as shown in FIG. **6**, is preferably an operational amplifier means including a pair of operational amplifiers **40** and **41** for driving of the respective switching amplifiers **23** and **23a**. Each of the amplifiers **40** and **41** is similarly constructed and includes a corresponding non-inverting input **42** and **43** and an inverting input **44** and **45**. The non-inverting input **42** and the inverting input **45** are connected through individual series coupling resistors **46** and **46a** to the ungrounded output of the angle selection unit **17**. Individual coupling resistors **47** and **47a** connect the inverting input **44** and the non-inverting input **43** to the sensor **19**. The sensor connected input terminals **43** and **44** of amplifier **40** and **41** are further connected to ground through suitable bypass capacitors **48** which, with the coupling resistors define low pass signal filters in the input circuit.

The selection unit **17** includes a voltage dividing network including a fixed resistor **49** connected to the battery **29*a*** with a regulated power supply **50** providing a regulated voltage to the selection unit **17** and the comparator circuit **20**. The opposite leg of the voltage dividing network includes the rotary switch assembly having a movable contact **51** selectively engaging one of seven different contacts **52**, related sequentially to the trim angles of 0°, 3.5°, 7°, 10.5°, 15°, 22° and 44° in accordance with the system heretofore discussed. Each of the contacts **52** is individually connected to ground via an angle related resistor **53** to complete the voltage dividing network, with the common connection or junction **53*a*** between the fixed resistor **49** and the movable contact **51** connected to the inputs **42** and **45** of the operational amplifier **40** and **41**. Thus, each of the resistors **53** provides a different voltage division of the regulated voltage with a corresponding fixed reference or set voltage input to the operational amplifier. The sensor and the reference voltages are thus applied to both operational amplifiers **40** and **41**, compared, and an appropriate output signal generated to null the system by repositioning of the stern drive unit.

The operational amplifier **40** includes a paralleled R-C feedback network **54** which interconnects the amplifier output line **55** to the non-inverting input **44**. A similar R-C network **54*a*** interconnects output line **56** of amplifier **41** to the non-inverting input **45**. The capacitors of the feedback networks **54** and **54*a*** limit the frequency response of the amplifier in order to prevent a frequency response high enough to cause positive feedback and unstable operation. The feedback resistors of the networks **54** and **54*a*** in combination with the input resistors set the gain of the amplifiers which is selected to be sufficiently high to maintain alternative full on and full off conditions at the lines **55** and **56** and provide a switching logic to the drive portion of the power tilt mechanism. A relatively low voltage appears at lines **55** and **56** with amplifiers **40** and **41** off and a relatively high voltage appears when such amplifiers are on. In a practical system, the voltage may change from 2.4 volts to 7 volts.

Thus, selection resistors **53** are selected to maintain the minimum voltage applied to the operational amplifier well below the low voltage operating limit at 0° centigrade, to thereby avoid possible erroneous operation with temperature. The stern drive unit is a relatively large load and will coast somewhat after a null condition is created. In accordance with an aspect of this invention, a dead band is introduced into the input circuit to allow for such movement. In the illustrated embodiment, a dead band bias voltage is established at the inverting input **45** of amplifier **41** and at the non-inverting input **42** of amplifier **40**. The input **45** is connected by a resistor **57** to the regulated power supply **50** while the non-inverting input is connected by a resistor **58** to ground. The resistors **57** and **58** are selected such that the reference voltage is offset slightly and results in a slightly premature cutoff or nulling of the corresponding amplifier. The dead band is selected in accordance with the coasting characteristics of the stern drive mechanism and in accordance with a practical construction permits the stern drive unit to coast past an equilibrium position by one degree in either direction without affecting the system.

For example, the reference voltages inserted by resistor **53** may be selected to vary the input voltage between 2.4 and 7 volts, with the resistors **57** and **58** causing the actual input voltage to be offset by 0.1 of a volt. Thus, if the selection unit is set to an intermediate position with four volts appearing at line **53a**, the voltage at the non-inverting input **42** of the raising operational amplifier **40** would be 3.9 volts while the voltage at the lowering operational amplifier would be 4.1 volts. If the sensor output voltage is, for example, below such level as a result of the drive unit **1** being located below the select angle, the amplifier **41** remains off. The amplifier **40**, however, is driven on because the inverting terminal **44** is at a lesser voltage than the non-inverting terminal **42.** The unit **1** is driven up and the sensor voltage increases until a voltage of 3.9 volts is impressed on both applifier **40** and **41.** Amplifier **41** is off and remains off. This, however, nulls the output of amplifier **40** which then cuts off and terminates the positive drive. The drive unit **1** continues to coast toward the set position and stops. If it coasts slightly past the set position corresponding to the reference voltage of the selection unit **17,** the offset of such voltage appearing at the opposite terminal prevents driving of the operational amplifier on, unless of course the coasting is excessive. In that case, the voltage output of sensor **19** compared to the set voltage differs by more than the offset voltage and reverses the drive.

For example, assume the coast is 4° and thus in excess of 2° dead band. The sensor voltage is then 4.3 volts equal to 3.9 volt cutoff voltage and the additional 0.4 volts for the 4° coast movement. The non-inverting input **43** of the lowering amplifier **41** is now above the set voltage of 4.1 volts at the inverting terminal **45.** As a result, amplifier **41** turns on and reverses the drive to properly re-position the drive unit **1.**

Generally, the stern drive units of the assignee of this application are basically of two different varieties. One employs a relatively hydraulic cylinder means and moves at a relatively fast angular velocity, with a total angular displacement of about fifty degrees. The other system illustrated employs a somewhat larger hydraulic cylinder means moving at a somewhat slower angular velocity but with a total angular displacement of about 56°. This difference in velocity results in a somewhat different amount of average coast and generally it has been found that the slower dual drive will stop approximately three-quarters of a degree before the desired position whereas the single drive will stop at approximately the desired position with the 2° dead band.

The amount of coast also depends on the amount of power applied to the propeller. Thus, with the stern drive trimmed down and under full forward power, the total coast may be such as to move beyond the dead band zone. However, with the present invention, the system will correct itself once and come back within the desired position.

The total dead band zone of 2° in the system described is thus a compromise to adapt the unit to both systems while maintaining separation of the two adjacent trim settings at 3.5°.

The difference in total angular displacement also requires somewhat of a compromise if a single system is to be applied to all of the drives. Further, some margin of safety must be introduced into the system in order to compensate for normal manufacturing tolerances and the like as well as to allow a few degrees between the all down trim position and the all down mechanical stop. A practical system was designed for a variation in trim position between 0 and 44° nominal. As a practical matter, the actual positions may, as a result of normal manufacturing tolerances and the like, vary between 40 and 48° from unit to unit. If close tolerance components are employed for the highest value sensing resistor as well as the interrelated voltage dividing and sensing resistors of and for the voltage regulator diode and the like, the variation can be substantially reduced. Thus, if one percent tolerance parts were employed, the system could be designed for nominal displacement of approximately 47° with an expected total variation from unit to unit of about from 46 to 48°.

Alternatively, the control circuits could be constructed for each particular stern drive by a proper selection of the bias resistive network to the comparator. The highest value position resistor **53** as well as the compensating dead band resistors **57** and **58,** for example, could be properly selected for each design. This, of course, would require inventory of two separate control circuits, with the attendant expense and the like. The resistors **57** and **58** thus may be adjusted to provide a desired response to the inputs of sensor **19** and selective means **17** as applied to the amplifiers **40** and **41** of stage **20.**

Sensor assembly **19** and comparator **20** are powered from the regulated supply **50** to provide reliable logic response. The regulator **50** may be any suitable construction, such as a Zener diode unit with a temperature compensating diode and stabilizing capacitors to produce the desired regulated voltage. The regulator **50** produces the desired operating voltage such as 9.2 volts.

The amplifier output lines **55** and **56** are similarly coupled to high gain amplifying and switching stages **23** and **23***a* which function as power switches and are shown as Darlington switching circuits. As each of the output lines is similarly connected, that for the raising or up line **55** is described, with the corresponding elements for the lowering circuit being identified by similar prime numbers.

The illustrated amplifier **23** includes a pair of transistors **61** and **62** which are connected as a Darlington pair, with the input base connected by a coupling resistor **63** to the comparator output line **53.** A turn-on resistor **64** is connected between the base and the ground and emitter to complete the input signal circuit. The resistors **63** and **64** form a voltage divider which reduces the base voltage at the amplifier **23** below the switching level with the operational amplifier **40** off, and applying the relatively low voltage signal.

The output is taken at the collector with a negative feedback network including capacitor **65** which introduces a time constant in the system with a delayed turn-on and rapid turn-off to prohibit the system from correcting itself from each slight variation in position of the stern drive unit, such for example as associated with slight wave bounce. The switching and associated feedback circuit is more fully described in the copending application of James Hager and no further description is given herein.

The output switching as provided by the Darlington circuitry provides selective completion of the circuit to the relay **24,** which has a winding **67** connected in series with the output circuit of the Darlington transistor unit to the battery power supply. The Darlington pair normally presents a high impedance or open circuit condition to the relay winding. When the Darlington pair is turned on, as a result of the turn-on signal at the output line **55** of the amplifier **40,** the Darlington connected transistors rapidly switch to full on to establish a very low impedance path thereby completing the energizing circuit through the relay winding. This, in turn, closes the related relay contacts **67–1** to provide power to the motor for energizing of the electric motor in a lift direction and thereby driving the pump **14** to power the hydraulic system to correspondingly raise the drive unit **1.** As the drive unit **1** raises, the magnet **34** is correspondingly positioned and varies the effective flux supplied to the Hall cell **27** and correspondingly changes the voltage signal to the comparator **20** when the sensed signal corresponds in a predetermined manner to the set signal as determined by the positioning of unit **1**.

If for any reason the drive unit **1** moves from the set position, the Hall cell **27** generates an offset signal to operate the relay **24** or **25**. If the stern drive unit **1** is above the desired position, a signal appears at output line **56** which turns on the Darlington transistors **61'** and **62'** and completes the power circuit to the lower relay winding **68**. This, in turn, results in the closing of the associated contacts **68-1** to energize the electric motor **15** to operate in the opposite direction with the hydraulic pump **14** oppositely actuated to introduce hydraulic fluid into the piston-cylinder means **13** to lower the stern drive unit **1**.

When the unit is again in the preset position, the magnet **34** is relocated with respect to the Hall cell **27** to establish a null condition to turn off the trim drive and establish the stable condition.

The operator may therefore conveniently control the trim position before and during running.

The Hall cell sensor **19** of FIGS. **5** and **6** is preferably constructed as a small compact and potted assembly which is mounted to the stern drive unit **1**, as most clearly shown in FIGS. **3** and **4**. A cup-shaped disc housing **70** includes a plurality of outer arcuate mounting slots **71** and **72** and is secured abutting the gimbal ring or member **6** by suitable cap screws **73** and **74** passing through the slots **71** and **72** and threaded into appropriately tapped openings **75** in the member **6**. The housing **75** includes a central opening aligned with the horizontal shaft **76** which is rotatably journaled in the gimbal ring and defining the tilt axis support of the drive unit **4**. The housing **70** includes a cylindrical recess or chamber **77** in the exterior face with a peripheral inner wall **78** of stainless steel or other similar non-magnetic material. The Hall cell **27** and associated circuitry of unit **19** shown for example in FIG. **6** is located within the recess **77** which is then filled with a suitable potting material **79** such as an epoxy resin to physically support the elements and protect them from the severe environmental conditions encountered in marine use. The Hall cell **27** is diametrically located with respect to the shaft opening **75**, as shown in FIG. **4**. The annular or doughnut shaped magnet **34** is secured to the shaft **76** by a clamping nut **80** and located within the central opening of wall **78** of the housing **70**, particularly in a common plane with the Hall cell **27**. The magnet is diametrically polarized to establish a radially outwardly directed flux which is impressed upon the Hall cell **27**. Thus, the non-magnetic inner wall readily transmits the flux to the potted Hall cell. As described in connection with FIG. **6**, a sine wave of flux is applied to the Hall cell in accordance with angular orientation of the drive unit with respect to the gimbal ring or member **6**. A cover **81** may be secured to the housing to enclose the potted recess and the magnet.

If desired, the system can be employed with a resistance sensing element, similar to that described in U.S. Pat. No. 3,641,965 in place of the Hall cell **27**. FIG. **7** is a schematic circuit corresponding to that of FIG. **6** with the substitution of a resistor position sensor **81** for the Hall cell unit **19** described above and additionally with a fail-safe circuit **82**. Corresponding elements of FIGS. **6** and **7** are correspondingly numbered and no further description of the circuit is given other than to clearly describe the revision to the basic circuit. The resistor position sensor **81** includes a resistor card **83** with a movable wiper **84** rotatably mounted to scan the card. A wound resistor **85** is mounted on the card and connected between the ground and the input terminal of the operational amplifier **40** functioning as the comparator. The wiper **84** in turn is connected to the corresponding input and thus selectively shorts a portion of the resistance from the circuit and simultaneously adjusts the voltage impressed on the input terminal. The wiper is coupled to rotate with drive unit **4**, for example, by connection to shaft **76** as disclosed in U.S. Pat. No. 3,641,965. A fixed resistor **86** is connected between the input terminal of the comparator forming the common connection to the position sensor and the regulated power supply. The fixed resistor **86** and the variable resistor **85** constitutes a variable voltage dividing network with the variation of the lower leg being directly related to the angular displacement. With the series resistances connected to the regulated voltage supply, a non-linear output with angular displacements is generated at the common junction. Applicant has found that the voltage output varies approximately as a sine wave with angular displacement, at least over the limited number of degrees encountered for marine propulsion units such as stern drives wherein the movement covers essentially fifty-five degrees of displacement. The voltage dividing network as described defines a curve which very closely approaches the sine wave curve and thus is completely suitable for direct substitution for the Hall cell circuit shown in FIG. **3**. Further, the variable resistor **85** is adjusted to create an offset signal corresponding to a zero degree positioning of the drive unit **1** to stimulate the offset adjustment of the Hall cell, with the sine wave generated from that zero reference position.

When a resistive sensor is employed, an open circuit condition may be caused by the wear of the unit, water contamination, corrosion and the like. If the sensing circuit does open, the voltage applied to the input of the comparator from the regulated voltage supply rises as the result of the very high impedance presented by a total or partial maximum open circuit between the input terminal and ground. This would, of course, create a maximum turn on lower signal at the sensing output line connected by resistors **47** and **47*a*** to the comparator **20** which in turn would lower the drive unit **1** to its lowermost position, with no means at the control of the operator for reversing or running the drive unit **1** to a lower position. Such a malfunction may create a particularly dangerous position under operating movement of the watercraft. To prevent this type of condition from arising, a safety circuit **82** is interconnected into the control system and in particular responds to an abnormal input voltage to positively prevent the lower system from being turned on.

The fail-safe circuit **82** in the illustrated embodiment of the invention is connected to the circuit of lowering amplifier **41** and particularly line **87** to the base of transistor **61'** and to the sensor signal line **32*a*** to the comparator resistors to hold line **87** at ground in response to an abnormally high input voltage at the sensor power terminal or line and thereby prevent turning on of the lower switch **23*a*** and the associated relay **68**.

More particularly, the fail-safe circuit **82** includes a single high beta transistor **88** connected between the line **87** and thus the base of transistor **61'** and ground.

A Zener diode **89** in series with resistor **90** connects the base of transistor **88** to the sensor line **91.**

A small capacitor **92** is connected between the resistor and ground which defines an integrating circuit holding the fail-safe circuit in the off condition for a momentary initial period of time with the input voltage above the 8.8 volts reference level. This is desirable to prevent actuation of the fail-safe circuit **82** during momentary or transient periods of abnormal voltages. Thus, in the usual wound resistor unit, the wiper **84** loses contact in moving from one winding turn to the next and would do so in the preferred linear resistor unit described. Zener diode **89** would be selected to provide a threshold detection of the voltage when it rises above a selected level greater than the voltage necessary to null the maximum voltage from the reference or selection unit **17.** When diode **89** contacts, current is supplied to the transistor **88** which shorts the input to the lower circuit to ground. Thus, with a 9.2 volt regulated supply and a maximum input reference signal of 7 volts, the Zener diode **89** may be conveniently selected to respond to a signal of 8.8 volts.

The fail-safe circuit may take any voltage sensitive form which will detect an abnormal high voltage on the input of the sensor circuit or the like and positively prevent the malfunctioning of the circuit to lower the stern drive unit **1,** particularly under running conditions. For example, a differential amplifying circuit may compare a fixed voltage with that at the sensor line and control a control switch in the lower drive circuit.

The circuit of FIG. **7** otherwise functions in the same manner as that previously described to provide an automatic raising and lowering of the drive unit to various trim positions as a result of the simple input selection by the operator.

Further, the relatively large number of selections which can be made permit the positioning of the drive unit in a proper position under essentially all possible operating conditions.

In addition to the electronic signal processing, the trim control can employ a relatively simple comparison network for actuating of the trim positioning motor or the like. For example, FIG. **8** illustrates a simple differential relay system.

In FIG. **8,** a control rheostat **96** and a trim indicator rheostat **97** have one end connected in common to the battery **98** and related movable taps connected to selectively energize a differential relay **99.** The control rheostat **96** is mounted for manual adjustment. The trim indicator rheostat **97** is coupled to the drive unit for example as shown in previously referred to U.S. Pat. No. 3,641,965. The rheostat taps provide corresponding power signals in accordance with a desired trim angle and the actual trim angle.

The differential relay **99** includes a first winding **100** connected in series with the rheostat **96** and energized accordingly. The winding **100** is electromagnetically coupled to one end of an armature **101** which is centrally pivoted at **102.** The armature **101** is, generally, a T-shaped member which is connected by a line to battery **98** and with the stem portion carrying suitable contacts including a first set of contacts **103** which are closed upon predetermined pivoting of the armature **101** toward the electromagnetic unit defined by winding **100.** An opposed winding **104** is similarly connected into circuit with the rheostat **97** and is coupled to the opposite end of the armature **101.** The electromagnetic force of the winding **104** tends to pivot the armature **101** in an opposite or counter-clockwise direction as viewed in FIG. **8.** Selected pivotal movement in this direction results in closing of an oppositely disposed set of contacts **106.** Thus, if the currents through the windings **100** and **104** are balanced or essentially balanced, the armature **101** is held in a central position with contacts **103** and **106** both open. Differential energization of windings **100** and **104** results in the closing of contacts **103** or **106** to provide corresponding energization of a pair of power relays **107** and **108.** The power relay **107** is connected to the one side of the contacts **103** and ground such that when the contacts **103** close, power is supplied to the power relay winding **107** to close a related set of contacts **107-1.** Similarly, power relay **108** is connected in circuit through the contacts **106** to control a related set of contacts **108-1.** The contacts **107-1** and **108-1** are connected respectively in series with the corresponding forward and reverse windings of a reversible motor **109,** for corresponding controlled energization thereof. The motor **109** is coupled to drive a pump **110** which in turn provides circulating fluid through an up-trim line **111** or a down-trim line **112** in accordance with the directional energization of the motor **109.** The down-trim line includes a surge valve **113.** In accordance with a further novel aspect of the present invention, a differential pressure switch **114** is provided in the energizing circuit of the motor **109** to momentarily remove the automatic trim control under "log jumping" conditions. The differential pressure switch **114** includes a pressure sensor **115** which is connected in parallel with the surge valve **113.** The pressure sensor **115** is coupled to control a normally closed switch **116** which is connected between ground **117** and the ground side of the motor **109.** If a back pressure is created on the drive unit resulting in a greater pressure on the down side line of the actuator in excess of the pump pressure at line **112** and thus a net back pressure, the switch **116** opens. This effectively opens the circuit for the control and permits the lower drive unit to move upwardly in a relatively unrestricted manner to clear an obstruction.

The operation of the embodiment shown in FIG. **8** is otherwise generally similar to that previously described. Thus, the current flow of the two windings of the differential relay **99** is in accordance with the resistance in the respective branches which in turn is proportional to the desired setting and the actual trim setting, with the current in the one coil or winding greater than in the other in an amount equal to the relay threshold leve, the corresponding contacts **103** or **106** close to provide corresponding energization of the appropriate power relay **107** or **108.** This, of course, establishes the desired operation of the trim pump **110** to readjust the trim angle until such time as the trim angle sensing rheostat **97** again equals the preset rheostat **96.** This then re-establishes the null condition with the trim unit at the desired position.

As in the previous systems, any disturbance or oil leakage may result in a corresponding change in the trim angle from the dial setting. This again operates the trim angle control to automatically reset the system.

Further, various safety features can, of course, be incorporated into the trim setting control of this invention. For example, an interlock relay may be interconnected to open when the ignition switch is turned off with a required manual reset switch. The interlock relay would remove the system until such time as the manual reset switch is positively actuated. A simple on-off switch could, of course, be provided with reliance on the operator to turn off the switch whenever the ignition system is turned off. For energency use, a direct override control could be provided at the trim pump to permit desired positioning if the automatic system malfunctions or the like.

In addition to the illustrated sensing devices, any other suitable sensors can be employed. For example, inductive and capacitive sensors can be readily applied within the broadest concept of the present invention as well as various photo devices such as photoresistive and photoemissive devices. Further, although the control setting dial is shown on the instrument panel of the boat, it may also be incorporated in the throttle control, the steering wheel hub or the steering column for convenient manipulation by the operator. It may also be desirable to have the control setting dial constructed to provide automatic indication of the setting position through the sense of touch by the operator such that he can maintain complete visual attention to the driving of the boat.

Various other designs can, of course, be incorporated in connection with each of the particular portions of the circuit and the like although that illustrated has been found to provide satisfactory operation. It may be desirable to employ a suitable stop means to prevent selection of the two uppermost positions while under power and thereby eliminate the possible danger of moving the drive unit (when running) upwardly out of the water. Other mechanical or electrical interlocks, not shown, can also be readily designed into the system to prevent such selection.

These and similar features can, of course, be readily provided for those skilled in the art and thus no further particular discussion or illustration thereof is given.

The present invention has been found to provide a relatively simple and reliable trim power control system and apparatus.

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.

I claim:

1. A marine drive trim setting apparatus for selectively, angularly positioning a pivotally mounted outboard drive unit upon a pivot supporting means including means for pivoting of the drive unit about a vertical axis for steering and a horizontal axis for trim setting, comprising

a power positioning trim setting means having an output coupling means for connection to the drive unit and pivoting the drive unit about a generally horizontal axis,

a trim position sensing means having a movable means for coupling to the drive unit and generating an electrical position signal having a characteristic related to the angular position of said drive unit with respect to the horizontal axis,

a signal generating means operable to produce a reference signal corresponding to the signal of said position sensing means,

a signal comparator means connected to said sensing means and said signal generating means and producing an output signal in accordance with the difference therebetween, and

energizing control means connected to said positioning means and including circuit controlling means connected to said comparator means and selectively responsive to the output signal to correspondingly drive said output coupling means and setting the trim position of the drive unit.

2. The marine drive trim setting apparatus of claim 1 including a dead band means connected to said comparator means to allow selected differences in said references and position signals.

3. The marine drive trim setting apparatus of claim 1 including fail-safe means connected to the comparator means to disable the control means in response to an abnormal input signal.

4. The marine drive trim setting apparatus of claim 3 wherein position sensing means includes variable resistor means and said fail-safe means includes a voltage sensitive switch means connected to said comparator means and to said resistor means and responsive to the open circuit conditions to said resistor means to operatively disable the control means.

5. The marine drive trim setting apparatus of claim 4 wherein said fail-safe means includes a solid state switch connected to disable said down-drive means, said voltage sensitive means connected to the switch to selectively enable the switch.

6. The marine drive trim setting apparatus of claim 1 for setting the trim angle of said drive unit, said drive unit being mounted on a pivot shaft in a gimbal ring member, said position sensing means including a permanent magnet connected to the shaft and rotating therewith, a Hall cell connected to said gimbal ring member and located in the field of the permanent magnet to generate a sine wave voltage with rotational movement of the shaft.

7. The marine drive trim control apparatus of claim 1 wherein said position sensing means is constructed to produce a signal varying in accordance with a sine wave in response to the angular movement of the drive unit.

8. The marine drive trim control apparatus of claim 7 wherein said position sensing means includes a variable resistor having a movable means as a movable contact and connected in a series circuit with a fixed resistor, a regulated voltage supply connected across said series circuit to create a sine wave voltage in response to the angular movement of the drive unit.

9. The marine drive trim control system of claim 7 wherein said position sensing means includes a Hall cell and a permanent magnet mounted for relative movement to generate a sine wave voltage signal in response to the angular movement of the drive unit.

10. The marine drive trim setting apparatus of claim 1 wherein position sensing means includes a magnetic unit establishing a flux field and a Hall cell unit mounted in said field, one of said units being connected to the pivot support means and the other of said units being connected to the drive unit, and an output means connected to said Hall cell unit.

11. The marine drive trim setting apparatus of claim 1 including a fail-safe circuit connected to said position sensing means and responsive to an abnormal electrical signal, and

means connecting the fail safe circuit to said energizing control means to selectively disable said controlling means to prevent operation of said output coupling means.

12. The marine drive trim setting apparatus of claim 1 wherein said position sensing means is a variable resistor having a movable contact means for coupling to the drive unit and producing a voltage signal related to the angular position of said drive unit,

said signal comparator means including amplifier means which is fully on or fully off for said output signal, and

a fail-safe circuit means connected to said comparator means and including circuit controlling means connected to said comparator means and selectively responsive to a selected abnormal voltage signal of the sensing means to correspondingly remove said output signal from said energizing control means.

13. The marine drive trim setting apparatus of claim 12 wherein said fail-safe circuit includes a voltage sensitive switch between the energizing contact means and a second input connected to the output of the position sensing means, a cutoff switch means having an input means connected to said voltage sensitive switch and an output means connected to short the output signal from energizing control means.

14. The marine drive trim setting apparatus of claim 13 wherein said fail-safe circuit includes time delay means to allow momentary abnormal voltage signals from said position sensing means.

15. The marine drive setting apparatus of claim 1 wherein

said position sensing means and said signal generating means are variable resistor elements,

said circuit controlling means including first and second circuits to correspondingly drive said output coupling means, and

said signal comparator means is a differential relay connected in circuit through said resistor elements in parallel branch circuits and selectively establishing either of said first and second circuits in accordance with the relative resistance of said resistor elements.

16. The marine drive setting apparatus of claim 15 wherein said differential relay includes a first and a second winding connected in parallel branch circuits, an armature means pivotally mounted between said first and second windings and positioned in accordance with the relative level of energization of said windings, and

a lift switch actuated in response to selected pivotal movement of the armature in a first direction, and

a lower switch actuated in response to selected pivotal movement of the armature in a second opposite direction.

17. The marine drive setting apparatus of claim 1 wherein said positioning means include a hydraulic drive including an up-trim line and a down-trim line, a surge valve in the down-trim line, a differential pressure switch means connected across said surge valve and having a switch connected to selectively disable the positioning means in response to a positive lifting force on the coupling means.

18. The marine drive setting apparatus of claim 1 for setting the trim angle of said drive unit including a manual control switch means connected in the energizing control means to selectively remove the control when the drive unit is turned off.

19. A marine drive control system for selectively, angularly positioning a pivotally mounted drive unit about a pivot support means comprising an angle sensing means having a magnetic unit coupled to a Hall cell unit, mounting means for attaching one of said units to the pivot support means and the other of said units to the pivot support means, and an output means connected to said Hall cell unit.

20. A marine trim setting control apparatus for the selective angular orientation of a pivotally outboard mounted drive unit for a watercraft, said drive unit having a horizontal pivot axis means for trim setting, comprising a sine wave signal generator coupled to the drive unit to provide position sensed signals, a regulated direct current power supply, an angle selection means connected to said power supply means and including an adjustable resistance means to provide a plurality of D.C. reference signals, an operational amplifier comparator having a first input means connected to the sine wave signal generator and a second input means connected to the adjustable resistance means and establishing signals at a pair of output means related to the relative magnitude of sensed signal and the reference signal, dead band means connected to said input means to allow a selected error voltage at the input means without an output signal at either of said output means, feedback means connected between the output and input of the comparator to establish a full on or full off output at the respective first and second output means of the comparator, a pair of rapid acting electronic switching means having an input bias means connected to a corresponding one of the comparator output means, and each of said switching means including a timing circuit creating an operative rapid turn-off of the switching means and an operative delayed turn-on of the switching means to eliminate outputs related to momentary disturbances of the outboard drive unit.

21. The trim setting control apparatus of claim 20 having a hydraulic power system including a reversible electric motor-pump unit, and an input power connection connected to said motor-pump unit and said switching means for reversibly driving said motor-pump unit.

22. The trim setting control apparatus of claim 20 wherein said sine wave signal generator includes a Hall cell unit mounted to the pivot axis means in fixed relation to said drive unit and generally coaxial of the pivot axis means with the magnetic input radially oriented, said regulated power supply means connected to said Hall cell, an annular permanent magnet means encircling said Hall cell unit and secured to the pivot axis means to rotate therewith about the horizontal axis of movement, and said magnetic means being diametrically polarized and thereby establishing an operative flux field which varies as a sine wave with the angular orientation of the magnet means to establish a corresponding sensed signal of voltage.

23. The marine trim setting control apparatus of claim 20 wherein said operational amplifier comparator includes at least four input means including a first pair of corresponding input means connected to the sine wave signal generator and a second pair of corresponding input means connected to the adjustable resistance means for establishing said signals at a pair of

output means related to the relative magnitude of sensed signal and the reference signal, said dead band means including resistors connected to said second pair of input means to allow a selected error voltage at the input means without an output signal.

24. The marine trim setting control apparatus of claim **20** wherein said feedback means includes a first paralleled resistive-capacitive feedback network connected between the output of the comparator and the input means and includes a second paralleled resistive-capacitive feedback network connected between the output of the comparator and the input means, said resistive portion of said network being selected to establish said full on or full off output at the respective first and second output means of the comparator, said capacitive portion of each of said networks limiting the frequency response to prevent positive feedback conditions.

25. The marine trim setting control apparatus of claim **20** wherein said comparator includes a pair of operational amplifiers oppositely connected to respond to the inputs, said dead band means each including a pair of input bias resistor means connected to the opposite one of the comparator input means, said resistor means permitting a selected input voltage difference to the corresponding amplifier before producing a signal to complete the circuit to the comparator for the delayed turn on of the switching means.

26. The marine trim setting control apparatus of claim **20** including a fail-safe electronic switching circuit having an input connected to the signal generator and an output connected to the one output means and responsive to an abnormal signal voltage for locking of the drive unit in the set position and preventing removal of the corresponding output means from the corresponding electronic switching means.

27. A marine trim setting control system for the selective angular orientation of a pivotally outboard mounted drive unit for a watercraft, said drive unit having a horizontal pivot axis means, comprising a Hall cell unit mounted to the pivot axis means in fixed relation to said drive unit and generally coaxial of the pivot axis means with the magnetic input radially oriented, a regulated power supply means connected to said Hall cell, an annular permanent magnet means encircling said Hall cell unit and secured to the pivot axis means to rotate therewith about the horizontal axis of movement, said magnetic means being diametrically polarized and thereby establishing an operative flux field which varies as a sine wave with the angular orientation of the magnet means to establish a corresponding sensed signal of voltage, an angle selection means connected to said power supply means and including an adjustable resistance means, an operational amplifier comparator having at least four input means including a first pair of corresponding input means connected to the Hall cell and a second pair of corresponding input means connected to the adjustable resistance means and establishing signals at a pair of output means related to the relative magnitude of sensed signal and the reference signal, dead band resistance means connected to said second pair of input means to allow a selected error voltage at the input means without an output signal, a first paralleled resistive-capacitive feedback network connected between the output of the comparator and the one input of the first pair of input means, a second paralleled resistive-capacitive feedback network connected between the output of the comparator and one input means of the second pair of input means, said resistive portion of said network having selected to establish a full on or full off output at the respective first and second output means of the comparator, said capacitive portion of said network limiting the frequency response to prevent positive feedback conditions, a pair of output electronic switching means each including a Darlington transistor pair having an input bias means connected to a corresponding one of the comparator output means and responsive to a selected threshold voltage signal, each of said switching means including a capacitive feedback circuit having a rapid turn off of the switching means and a delayed turn on of the switching means to eliminate outputs related to momentary disturbances of the outboard drive unit, a hydraulic power system including an electric motor-pump unit and said switching means for reversibly driving said motor-pump unit.

28. A marine trim setting control system for the selective angular orientation of a pivotally outboard mounted drive unit for a watercraft, said drive unit having a horizontal pivot axis means, comprising a linear resistor mounted to the pivot axis means in fixed relation to said drive unit and generally coaxial of the pivot means, a reference resistor in series circuit with said linear resistor, a regulated power supply means connected across said series circuit, a wiper rotatably mounted in engagement with the resistor and secured to the pivot axis means to rotate therewith about the horizontal axis of movement, said wiper establishing a signal varying as a sine wave with the angular orientation of the drive unit to establish a corresponding sensed signal of voltage, an angle selection means connected to said power supply means and including an adjustable resistance means, an operational amplifier comparator having at least four input means including a first pair of corresponding input means connected to the adjustable resistance means and establishing signals at a pair of output means related to the relative magnitude of sensed signal and the reference signal, dead band resistance means connected to said second pair of input means to allow a selected error voltage at the input means without an output signal, a first paralleled resistive-capacitive feedback network connected between the output of the comparator and the one input of the first pair of input means, a second paralleled resistive-capacitive feedback network connected between the output of the comparator and one input means of the second pair of input means, said resistive portion of said network having selected to establish a full on or full off output at the respective first and second output means of the comparator, said capacitive portion of said network limiting the frequency response to prevent positive feedback conditions, a pair of output electronic switching means each including a Darlington transistor pair having an input bias means connected to a corresponding one of the comparator output means, each of said switching means including a capacitive feedback circuit having a rapid turn off of the switching means and a delayed turn on of the switching means to eliminate outputs related to momentary disturbances of the outboard drive unit, a hydraulic power system including an electric motor-pump unit, an input power connection connected to said motor-pump unit and said switching means for reversibly driving said motor-pump unit.

29. A marine means for angularly positioning in a pivotally mounted outboard drive unit having a pivot support means comprising a power positioning means having an output coupling means for connection to the drive unit for pivoting of such drive unit, angular position sensing means having a movable means for coupling to the drive unit and generating an electrical position signal having a characteristic related to the angular position of said drive unit, said position sensing means generating a sine wave signal, a sine wave signal generating means operable to produce a corresponding reference sine wave signal corresponding to the signal of said position means, a signal comparator means connected to said sensing means and said signal generating means and producing an output signal in accordance with the difference therebetween, an energizing control means connected to said positioning means and including circuit controlling means connected to said comparator means and selectively responsive to the output signal to correspondingly drive said output coupling means and thereby reposition said drive unit.

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