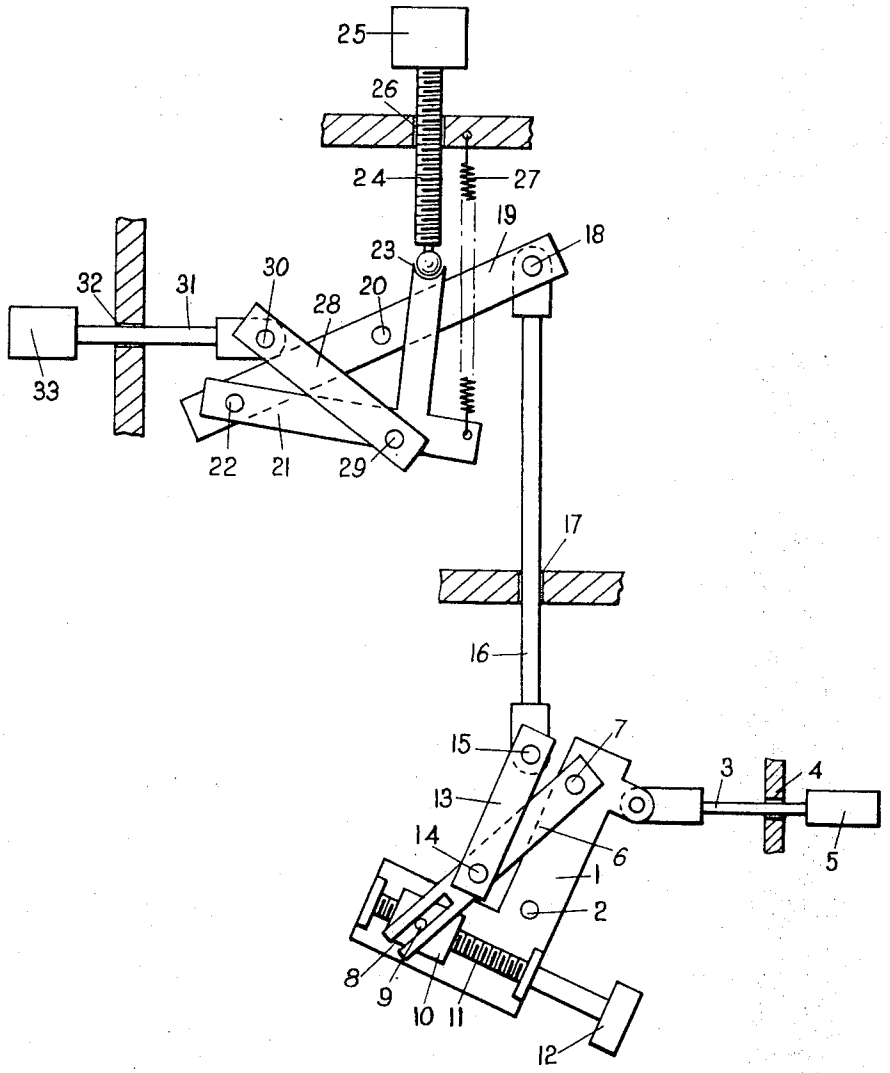
Oct. 6, 1970 R. S. WADDINGTON ET AL 3,531,875

HEEL REGULATING DEVICE FOR USE WITH SAILING SIMULATOR

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Fig. 1.



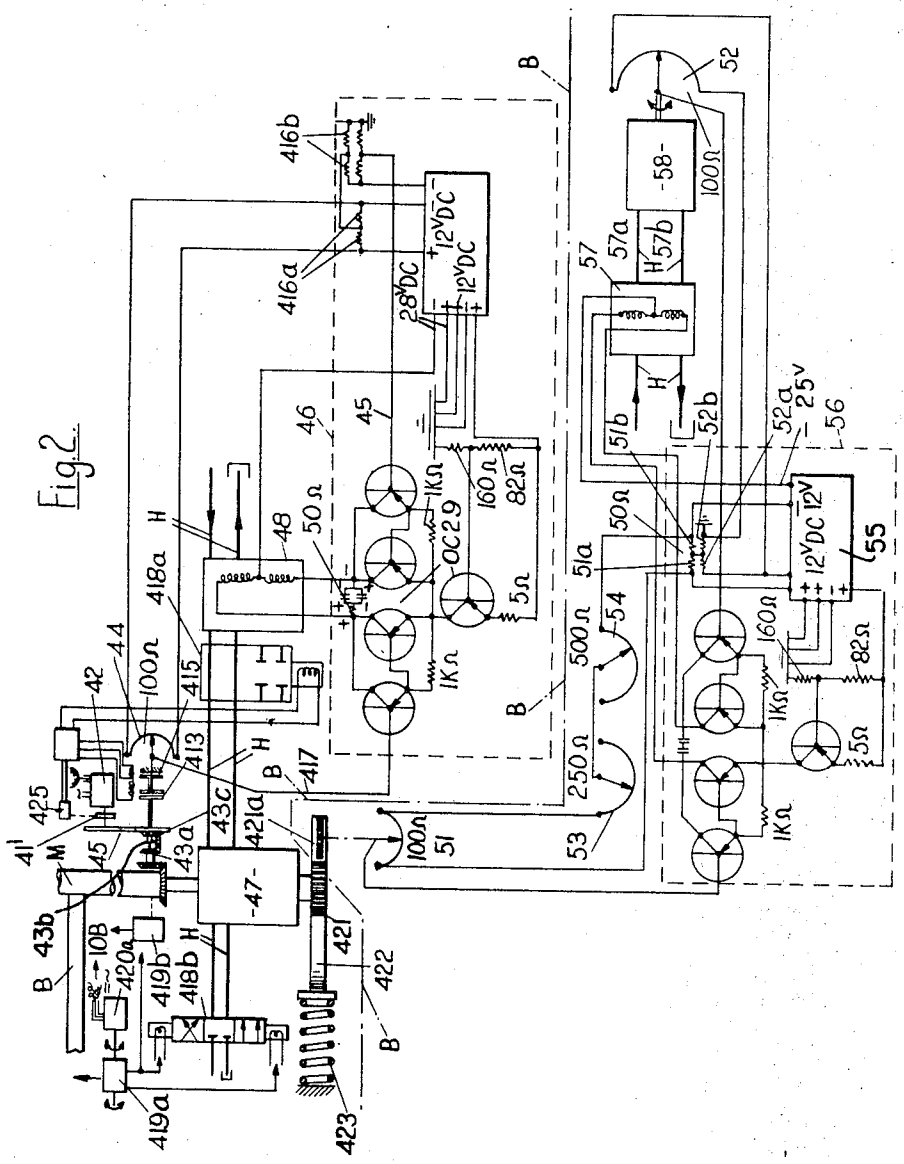
Inventors
ROGER STRANGE WADDINGTON
BRUCE DUVAL
By Jacobs & Jacobs
Attorney

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HEEL REGULATING DEVICE FOR USE WITH SAILING SIMULATOR

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Fig. 2.



Inventors
ROGER STRANGE WADDINGTON
BRUCE DUVAL
By Jacobs & Jacobs
Attorney

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HEEL REGULATING DEVICE FOR USE WITH SAILING SIMULATOR

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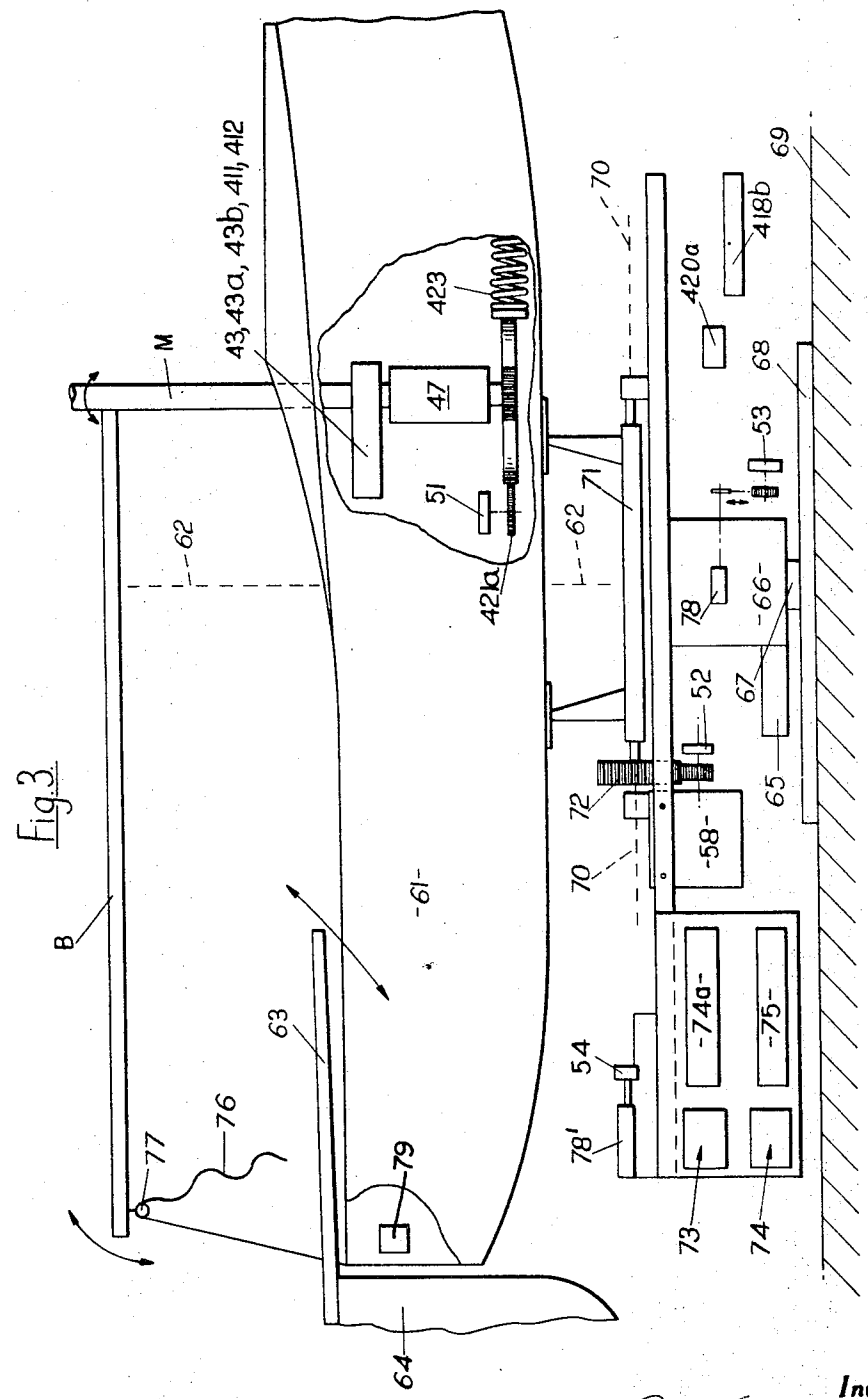


Fig. 3

Inventors
ROGER STRANGE WADDINGTON
BRUCE DUVAL
By Jacobs & Jacobs
Attorney

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3,531,875

HEEL REGULATING DEVICE FOR USE WITH SAILING SIMULATOR

Rogor Strange Waddington and Bruce Duval, Lausanne, Switzerland, assignors to T.P.I. Limited, Nassau, Bahamas, a company of the Bahamas

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Int. Cl. G09b 9/06
U.S. Cl. 35—11 11 Claims

ABSTRACT OF THE DISCLOSURE

With a sailing simulator for teaching a pupil the art of sailing on dry land by instructing him in a stationary hull mounted for rotational movement in response to a tiller and mounted for heeling motion by an actuator to simulate the heeling action of the supposed wind, it is necessary to provide arrangements whereby the heeling actuator is activated to a degree depending upon the strength of the supposed wind and in direction thereof relative to the instantaneous bearing of the craft. This has been achieved by having a skilled operator to activate the actuator in accordance with his experience. In accordance with this invention there is provided a computor device having transducers responsive to supposed wind direction, supposed wind strength and the position of the boom of the simulator relative to the hull. Two of the transducers are linked to provide an output dependent upon the effect of two of the parameters and a third transducer is arranged to modify said output, which modified output is applied to the heeling actuator.

The present invention relates to training devices and is especially concerned with sailing simulators by which a pupil may learn the art of sailing on dry land. Such simulators have a hull and a boom, the latter of which is usually controlled by a rope known as the main sheet held by the pupil, as well as mechanism which causes the hull to rotate in response to movements of a helm, e.g. a tiller, by the pupil.

With such sailing simulators, it is essential that the angle of heel of the hull (i.e., the structure in which the pupil is seated) should respond realistically to the pupil's actions as in actual sailing. The angle of heel depends upon the speed of the supposed wind, the direction of the supposed wind relative to the hull or to the boom and the angle of the boom relative to the hull. The direction relative to the hull is, of course, related to the direction relative to the boom in a simple manner which depends upon the angle of the boom relative to the hull. In order to avoid having an instructor constantly present to set the angle of heel to correspond with the conditions, it is advantageous to provide a computor responsive to the three conditions and operable to give an output signal corresponding with the required angle of heel so that the heeling action can be performed by a suitable mechanism such as a servo system.

As will be appreciated the angle of heel should be zero when the supposed wind is astern and the boom let fully out to make a right angle with the fore-aft axis of the hull. Under conditions representing reaching or sailing close hauled there should be an angle of heel which is appropriate to the conditions for an actual sailing vessel under way. For given conditions in actual sailing the angle of heel naturally depends upon the design of the vessel and it is to be assumed hereinafter when reference is made to the angle of heel that the angle is an appropriate one for the general kind of vessels, e.g. racing dinghies, that the pupil will eventually handle on water.

In accordance with the present invention there is provided a computor device for computing the angle of heeling of the hull of a sailing simulator having a hull and a boom appropriate to the position of the boom, the speed of the supposed wind and the direction of the supposed wind relative to the simulator, which device comprises three transducers respectively operable to generate a signal representative of the speed of the supposed wind, a signal representative of the direction of the supposed wind relative to the simulator (preferably relative to the boom rather than the hull) and a signal represenative of the position of the boom of the simulator, two of said transducers being linked together to provide a combined output which is variable by the signals from either of said two transducers independently of the signal provided by the other and the third transducer being arranged to provide a heel output signal which is modified by said combined output, the magnitudes and senses of the signals being such that the modified heel output signal has a magnitude and sense appropriate for a sailing craft.

Preferably, the said two of the transducers are operable to generate signals representative of the direction of the supposed wind and the speed of the supposed wind respectively.

It is to be noted that the output of the device, viz the modified heel output signal, is necessarily altered when the signal from any one of the transducers changes. The device is therefore to be contrasted with a device where a signal merely changes the ratio between the effect of two signals without necessarily producing an output. An example of a device of the latter type is a rotary plate whose angular position represents the supposed wind speed which drives a parallel and coaxial rotary plate via a radially movable ball gripped between the two plates, the radial position of the ball representing the angle of the boom to the wind and rotation of the said parallel and coaxial rotary plate being the output from the device. A change of boom angle to the wind would merely move the ball radially to change the potential output from the device and an actual output would be obtained only when rotation of the first rotary plate occurred to represent a change of wind speed. A change of wind direction unaccompanied by a change of wind speed would produce no change of heel angle even though a change of wind speed would produce a change in the absence of a change of wind direction. The result would be quite useless.

Advantageously a device according to the present invention is provided with a heeling position senser for generating a signal representative of the angle of heel of the hull and comparator means for generating an error signal from the heeling position senser signal and the modified heel output signal.

The device can be provided in any one of various different forms for example mechanical, electronic or fluid-logic forms. Hereinafter mechanical and electronic forms will be described but it is to be understood that the invention is not to be regarded as limited thereto.

A heeling position senser as referred to hereinbefore can be one input of a differential gear the other input of which is connected with a heeling actuator and the output of which provides the error signal.

One of the said two transducers may be linked to an adjustable throw crank, one of them being arranged to rotate the crank and the other of them being arranged to adjust the throw thereof, the combined output being represented by the movement of a member connected with the arm of the crank. The third transducer may be arranged to adjust the throw of a second adjustable throw crank which is rotatable by the said movement of the said member, and an output member is connected with the arm of the second crank.

The cranks, or one of the cranks, may be of complex construction to facilitate adjustment and manufacture provided that the fundamental features of a crank are retained. For example the first crank may be provided in the form of a body adapted to be rotated by an actuator serving as one of the pair of transducers, a first link pivoted on said body and adapted to be rotated by a further actuator serving as the second of the pair of transducers, and has a second link pivoted on the first link and connected to a sliding rod, the sliding of said rod providing the combined output; whether or not this arrangement is adopted the second crank may be provided in the form of a first link adapted for rotation in accordance with the combined output, a second link pivoted on the first link and adapted for rotation by an actuator serving as the third transducer and a third link pivoted on the second link, a sliding rod connected to the third link providing the modified output. The sliding rod may be connected to an output transmitter for transmitting a heeling signal to the hull.

Alternatively instead of providing a mechanical arrangement based on cranks or otherwise constructed, the device may have an electrical circuit for producing the combined output and modifying the heel output signal by the combined output. The said two of the transducers are, in a preferred construction, rheostats connected together in series; one of the rheostats is preferably constructed to break the circuit when set to its maximum position, said rheostat being employed as the transducer for the speed of the supposed wind.

The third transducer may be a potentiometer. For example the said two of the transducers are rheostats connected together in series and the third transducer is a potentiometer series connected with the rheostats so that the current therethrough depends upon the setting of the rheostats, the output taken from the wiper of the potentiometer being the modified heel output.

In a most preferred arrangement having an electrical computor circuit, the computor device is connected to a reversible heeling actuator for the hull, the device has an amplifier for the modified heel output, and the electrical circuit is provided with a transducer operable to provide a signal corresponding with the heel angle of the hull and an amplifier for this signal, the two amplifiers being arranged to operate the heeling actuator in opposite heeling directions and to terminate heeling motion of the hull of the device when the required angle of heel is reached.

The following description in which reference is made to the accompanying drawings is given in order to illustrate the invention.

In the drawings:

FIG. 1 shows in plan a computor of the mechanical type,

FIG. 2 shows an electrical circuit the lower part of which is a computor of the electrical type and the upper part of which is an electrically operated boom actuating device, and

FIG. 3 shows diagrammatically a sailing simulator incorporating the circuit of FIG. 2.

Referring now to FIG. 1 an L-shaped plate **1** is pivotally mounted at **2** on the computor framework (not shown) and has an operating rod **3** which slides in the computor framework at **4** connected to it and to an actuator **5**.

A link **6** is pivotally mounted at one end at **7** on the plate **1** and is formed at the other end with a slot **8**. A pin **9** engages the slot **8** and is carried on a nut **10** which slides on the plate **1** and embraces a screwed spindle **11** which spindle is mounted on the plate **1** so as to be capable of rotation by an actuator **12**, the nut **10** being prevented from turning by plate **1**.

A further link **13** is pivotally mounted at one end at **14** on the link so that the distance between pivots **14** and **7** is equal to the distance between pivots **2** and **7**.

The other end of link **13** is pivotally connected at **15** to a rod **16** so that the distance between pivots **14** and **15** is equal to the distance between pivots **7** and **14**. The rod **16** is mounted in a guide **17** in the computor framework so as to be capable of axial movement and so that the axis of rod **16** produced passes through the axis of pivot **2** produced.

The rod **16** is pivotally connected at **18** to one end of a link **19** which link **19** is pivoted near its center on the computer framework at **20**. A link **21** is pivotally mounted on the other end of link **19** at **22** and has connected to it at the end opposite to pivot **22** a cupped rod **23** in which engages a ball on the end of a screwed spindle **24** which rod is adapted for rotation by an actuator **25** in a tapped hole in the computor framework at **26**. A tension spring **27** attached to the link **21** and to the computor framework is adapted to keep the cupped rod **23** in close engagement with the ball on the end of the rod **24**.

A further link **28** is pivotally mounted at one end at **29** on the link **21** so that the distance between pivots **22** and **29** is equal to the distance between pivots **22** and **20**. The other end of the link **28** is pivotally connected at **30** to a rod **31** so that the distance between pivots **30** and **29** is equal to the distance between pivots **22** and **29**. The rod **31** is mounted in a guide **32** in the computor framework so as to be capable of axial movement and so that the axis of rod **31** produced passes through the axis of pivot **20** produced. The rod **31** is connected at its other end to a transmitter **33**.

The actuator **5** moves the plate **1** about the pivot **2** so that the angle between the line joining pivots **2** and **7** and the axis of the rod **16** produced is equal to the angle through which the helmsman has pulled the boom from the position it would assume if it could respond freely to the wind. The actuator **5** may be controlled from a boom-angle transmitter of any convenient design.

The actuator **12** rotates the screwed spindle **11** by a function of wind speed such rotation displacing the pivot **14** from being immediately over the pivot **2** by an amount dependent on the wind speed.

It will be seen that if both the plate **1** is displaced so that the line between pivots **2** and **7** is not on the axis of the rod **16** produced, and the pivot **14** is displaced from being immediately over the pivot **2**, an axial movement will be imparted to rod **16**. This movement of rod **16** will be a function of wind speed and direction.

Any movement of rod **16** will rotate link **19** about its pivot **20**. Actuator **25**, when rotated for wind direction relative to the fore-and-aft axis of the hull, moves the link **21** so that the pivot **29** is displaced from being immediately over pivot **20**, and the angle between links **19** and **21** is dependent upon the angle between the direction of the wind and the fore-and-aft axis of the hull.

It will be seen that if both link **19** has been rotated about its pivot **20** so that the line joining pivots **20** and **22** produced is no longer coincident with the axis of the rod **31**, and the link **21** has been moved so that the pivot **29** is not immediately above pivot **20**, an axial movement will have been imparted to the rod **31**. This axial movement will operate the transmitter **33**.

It will be seen that the movement of transmitter **33** depends upon the angle fed by actuator **5**, the wind speed fed by actuator **12**, and the angle between the direction of the wind and the fore-and-aft axis of the hull fed by actuator **25**. The transmissions to and constructions of the actuators **5**, **12** and **25**, and the dimensions of the computor linkages are so arranged that the output from the transmitter **33** is a measure of the angle at which the hull should heel under the conditions fed to the computor.

The transmitter **33** is for example a bidirectional valve or switch mechanism for a hydraulic or electric circuit which controls the main hydraulic power supply for a reversible heeling hydraulic servo unit. Connected with

the heeling actuator is one input of a differential gear, the other input of which is connected with the hull of the trainer. The output of the differential represents an error signal and the hydraulic or electric circuit is so arranged that the heeling motion ceases when the correct heeling angle is reached and the error signal reduced to zero.

In the electrical arrangement shown in FIG. 2 the boom position part, i.e., the part above chain-dot line B, has a reversible hydraulic actuator **47** which rotates the mast M in either direction and so swings the boom B which is rigidly attached thereto. The angular position of the mast and boom are applied via bevel gearing to bevel pinion **43***a* forming part of a differential. A magslip receiver **42** driven by a star connection from a magslip transmitter **420** rotates the middle bevel pinion **43***b* of the differential. The output from the differential drives a 100-ohm potentiometer **44** via an electric clutch **413** and an electric brake **415**.

Magslip receiver **420**, is supplied with a signal representing the supposed direction of the wind and is fed, for example, from the output of a device for determining said direction as described in our copending application Ser. No. 639,77, filed May 18, 1967, now Pat. No. 3,457,783, issued July 29, 1969, said device driving magslip transmitter **420***a*.

Potentiometer **44** is fed from a 12 volts D.C. power supply bridged by two 50 ohm resistors **416***a* in series, the position at which they connect together being joined to another pair of 50-ohm resistors **416***b*. In parallel with the resistors **416***b* is a second pair of 50-ohm resistors the interconnection of which is joined to the input **45** of a D.C. amplifier system **46**. This arrangement of resistors ensures that when the potentiometer **44** is in its central position, the signal supplied to the other input to the amplifier via line **417** is identical with the reference input from the said second pair of 50-ohm resistors.

The amplifier system **46** is in the form of two similar amplifiers and the two outputs are applied to an electrically controlled hydraulic servo valve **48** which passes hydraulic fluid in one direction or the other, which depends upon the position of the wiper of potentiometer **44** relative to its mid point and so upon the degree and direction of imbalance of the amplifiers.

Connected across the outputs via a 50-ohm series resistance are two large electrolytic capacitors arranged in parallel with the negative pole of one connected with the positive pole of the other. This arrangement is superior to connecting the negative poles together and the positive poles together. The effect of the capacitors is to prevent unduly rapid movement of the boom.

Any imbalance results in the actuator **47**, operated from a hydraulic supply via the servo valve **48**, rotating the mast and boom until balance is restored by the differential **43***a*, **43***b*, **43***c* operating upon the potentiometer **44**.

When the boom reaches the limit of its travel (in practice the shrouds supporting the mast M) a microswitch **41'** releases the clutch **413** and applies the brake **415** and closes the solenoid valve **418***a* and via switch unit **419***b*, opens the valve **418***b* in a direction which holds the boom to port or starboard and movement of the boom ceases.

When the relative direction of the wind is such as to move the boom back to another position the microswitch **425** driven from the differential **43***a*, **43***b*, **43***c* by a cam closes the clutch **413** and releases the brake **415**, the valve **418***b* closes and **418***a* opens and allows the potentiometer **44** to signal the amplifier to cause the boom to follow in the reverse direction.

In order to simulate gybing, i.e., moving the boom suddenly from one side to the other (in for example 0.5 second) the valve **418***b* is operated by a switch unit **419***a*, controlled by the wind resolver system described in our copending application Ser. No. 639,377, filed May 18, 1967, which applies hydraulic pressure to the actuator **47**, sending the boom rapidly across the hull. When the boom reaches its extreme position switch unit **419***b* closes to maintain hydraulic pressure and prevent ready movement of the boom but stops the application of such a hydraulic feed as would tend to move the boom further. The actuator **47** is mounted on bearings (not shown) and its casing bears a pinion **421** which engages a pair of racks carried by powerful springs. Only one rack **422** and one spring **423** are shown in the drawing. This arrangement allows the pupil to move the boom, as against the force of the wind, by rotating the entire actuator body.

The symbol H used in FIG. 2 represents hydraulic lines. They do not require special explanation.

If the boom were unrestrained by the pupil, it would lie in the same direction as the wind and in actual sailing there would be no forward driving force (unless the boom were arrested by the shrouds). It is the hauling on the boom by the pupil which sets the boom at an angle to the wind and so produces the required forward driving force.

The pinion **421** on the actuator body drives a second rack and a pinion **421***a* which is employable for signalling the position of the boom to the potentiometer **51** of the computor part of the circuit shown below the chain-dot line B.

In the computor part of the circuit the angle of displacement of the boom from the position to which the wind would drive it naturally is sensed by the adjustment of a potentiometer **51** linked to the pinion **421***a* and the angle of heel is sensed similarly by a potentiometer **52**. Rheostats **53** and **54** are set to represent the wind direction relative to the fore-and-aft line of the hull and the wind speed. The rheostat **53** is preferably adjusted automatically to correspond with changes in the relative direction as the hull rotates about its vertical axis, e.g., by a device as described in our co-pending application Ser. No. 639,377, filed May 18, 1967, while rheostat **54** may be left set at a constant value or adjusted to simulate changes of wind speed (by an instructor or by a programmed mechanism if provided) such as occur under natural, including gusty conditions. Rheostat **54** is so constructed that in the extreme position which represents no wind the circuit is broken. The output from the potentiometer **51**, which is a signal representing the displacement of the boom relative to the position to which it would be driven naturally by the wind is fed to one input of a D.C. amplifier system **56** and the output from the potentiometer **52**, which represents the heel angle, is fed to a second input to the amplifier. A power pack **55** feeds the amplifier system and the two potentiometers.

The D.C. amplifier system is a transistorized circuit constituted by two identical amplifiers one of which has its input connected with potentiometer **51** and the other of which has its input connected with a potentiometer **52**. These inputs may diverge in either direction from the bias level depending upon whether the heeling is over to port or over to starboard and whether the boom is displaced to port or starboard. The outputs of the amplifiers can be identical or either can be greater than the other. The outputs are fed to an electro-hydraulic servo valve **57** having two windings one for each amplifier and two hydraulic outputs **57***a* and **57***b*. Which of these outputs is turned on depends upon which of the outputs of the amplifiers is the greater. The hydraulic output is fed to a hydraulic heeling actuator **58** which adjusts the angle of heel and thence the potentiometer **52**. The response of the device is thereby fed back to the amplifier system and the parameters of the circuit are so arranged that heeling stops when the appropriate angle is reached.

In order to prevent a violent heeling response, which in extreme cases would throw the pupil out of the hull two capacitors each of 2,000 μf., 25-volt electrolytic are

connected in series, the two positive sides being joined across the outputs from the amplifier and a 10,000 μf. capacitor is connected across the D.S. supply to potentiometer **51**.

The arrangement whereby the two electrolytic capactors are connected in opposite directions (positive to positive rather than positive to negative) is found to give greatly improved results though no explanation for this phenomenon is offered. The capacitors are not damaged as the voltage across them is trivial.

The appropriate angle of heel depends, besides on the position of the boom, on the wind direction and wind speed. These variables, by adjusting to voltage input to the boom position potentiometer **51** by means of the rheostats **53** and **54**, adjust the output from this potentiometer and therefore its input signal to the amplifier **56**, thus modifying the output from the amplifier and so affecting the heel angle applied to the hull.

If the supposed wind speed is zero, rheostat **54** is set at its maximum resistance, i.e., infinite. Similarly, the setting of rheostat **53** depends upon the wind direction and the output of the potentiometer **51** to the amplifier **56** therefore depends upon both these factors.

If a supposed significant wind is dead ahead the boom should align itself with the wind and if the wind is dead astern the boom should lie across the fore-aft line of the hull against the shrouds and in neither case should heeling be obtained. Potentiometer **51** gives a neutral output, i.e. an output corresponding with the bias current to its input to the amplifier system. If there is an angle of heel at the time the boom is allowed to go free the outputs to the servo valve **57** operate the heeling actuator **58** and potentiometer **52** to bring the angle to zero.

If the wind is on the beam or at another angle which should result in heeling and the boom is pulled by the mainsheet into a position where heeling and forward motion should be obtained, the potentiometer **51** produces an output signal which affects the input to the corresponding part of the amplifier system and changes the output thereof in one direction or the other. The output is applied to the heeling actuator **58** via to the servo valve **57** and fed back to the other input of the amplifier via potentiometer **52**. The heeling actuator adjusts the angle of heel to the appropriate extent to equalize the two signals from the amplifier when the correct angle of heel is reached.

The 50-ohm resistors **52***a* and **52***b* connected in series across potentiometer **52** and 50-ohm resistors **51***a* and **51***b* connected in series across the potentiometer **51** have their junction points connected directly together and thus maintained at the same potential. One side of the power supply to potentiometer **52** is grounded and the connection just mentioned prevents the power supply to rheostats **53** and **54** and potentiometer **51** floating and producing spurious results.

If desired, the transistorized amplifiers described hereinbefore may be replaced by vacuum tube or hybrid amplifiers or instead of providing rheostats, potentiometers and electronic amplifiers, their fluid equivalents (fluid-logic circuits) may be used. The fluid equivalents lead to little complication as hydraulic lines, from which the fluid may be derived, are present in any case.

It will be understood that a mechanical boom positioner device can be employed with an electronic or fluid-logic computor device or vice-versa if desired.

FIG. 3 shows diagrammatically a sailing simulator having a hull **61** rotatable in the horizontal plane about an axis **62** by a tiller **63** connected with a rudder **64** through the medium of a turning motor **65** and a gear box **66** which rotates about a stout shaft **67** secured to a base **68** which rests on the floor **69** of a suitable building.

The hull is also rotatable for a heeling movement about an axis **70** of a shaft **71** driven by gearing **72**. The electronic heeling control of FIG. 2 is positioned at **73** and the electronic boom control of FIG. 2 is positioned at **74**. Power packs for these electronic controls are located at **74***a* and **75**.

Reference **76** shows a stern sheet which runs through pulley **77** on the boom.

Parts shown also in FIG. 3 are denoted by the same reference numerals or letters as are shown in FIG. 2. A wind resolver direction transducer is shown at **78** for feeding the direction of the supposed wind (which changes as the hull rotates about axis **62**) to the rheostat **53**. The unit **78** is a device for setting the wind speed, which may be a simple hand control or a programmed device for simulating gusty conditions.

79 is a potentiometer actuated by the tiller for controlling the motor **65**.

The parts below the hull **61** are enclosed by suitable panelling. Obviously, various layouts other than that shown may be employed if desired.

We claim:

1. A computor device for generating a heel output signal for regulating the angle of heeling of the hull of a sailing simulator having a hull and a boom and a heeling actuator for imparting heeling motion to said hull, said angle of heeling being appropriate to the position of the boom, to the speed of a supposed wind and to the direction of the supposed wind relative to the simulator, which device comprises three transducers respectively operable to generate a signal representative of the speed of the supposed wind, a signal representative of the direction of the supposed wind relative to the simulator and a signal representative to the position of the boom of the simulator, two of said transducers being linked together to provide a combined output which is variable by the signals from either of said two transducers independently of the signal provided by the other and the third transducer being arranged to provide a heel output signal which is modified by said combined output, the magnitudes and senses of the signals generated by the transducers being such that the modified heel output signal has a magnitude and sense appropriate for the instantaneous conditions of boom position, wind speed, and wind direction with respect to an actual sailing craft.

2. A device according to claim **1** in which the transducer operable to generate a signal representative of the direction of the supposed wind relative to the simulator is arranged to generate a signal representative of the direction of the supposed wind relative to the boom of the simulator.

3. A device according to claim **1** in which there is provided a heeling position senser for generating a heeling position senser signal representative of the heel angle of the hull and comparator means for generating an error signal from the heeling position senser signal and the modified heel output signal.

4. A device according to claim **1** in which the said two of said transducers are operable to generate signals representative of the direction of the supposed wind and the speed of the supposed wind respectively.

5. A device according to claim **1** in which there is provided a rotatable crank and, on the crank, a crank pin movable towards and away from the center of rotation of the crank to give the crank an adjustable throw, and an output member movable by the crank pin, one of the said two of the transducers being arranged to rotate the crank and the other being arranged to move the crank pin and thereby adjust the throw of the crank so that the combined output is represented by movement of the output member.

6. A device according to claim **5** in which there is provided a second rotatable crank arranged for rotation by the movement of the output member, and on the second rotatable crank a crank pin movable towards and away from the center of rotation of the second rotatable crank to give the second rotatable crank an adjustable throw, and a further output member movable by the crank pin of the second rotatable crank, the third trans-

ducer being arranged to adjust the throw of the second rotatable crank by movement of the crank pin thereof so that the modified heel output signal is represented by movement of the further output member.

7. A device according to claim 1 having an electrical circuit responsive to the signals of the said two transducers for producing the combined output and being further responsive to the signals of the third transducer for modifying the heel output signal by the combined output.

8. A device according to claim 7 in which the said two of the transducers are rheostats connected together in series.

9. A device according to claim 7 in which the said two of the transducers are rheostats connected together in series and one of the rheostats is constructed to break the circuit when set to its maximum position, said one of the rheostats being employed as the transducer for the speed of the supposed wind.

10. A device according to claim 7 in which the said two of the transducers are rheostats connected together in series and the third transducer is a potentiometer series connected with the rheostats so that the current therethrough depends upon the setting of the rheostats, the

output taken from the wiper of the potentiometer being the modified heel output.

11. A device according to claim 7 having a reversible heeling actuator for the hull connected thereto, an amplifier for the modified heel output, a fourth transducer operable to provide a signal corresponding with the heel angle of the hull and a second amplifier for this signal, the two amplifiers being connected to said heeling actuator and arranged to operate it in opposite heeling directions and to terminate heeling motion of the hull of the device when the required angle of heel is reached.

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WILLIAM H. GRIEB, Primary Examiner

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