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(54) **WAVE ENERGY CONVERSION SYSTEM**

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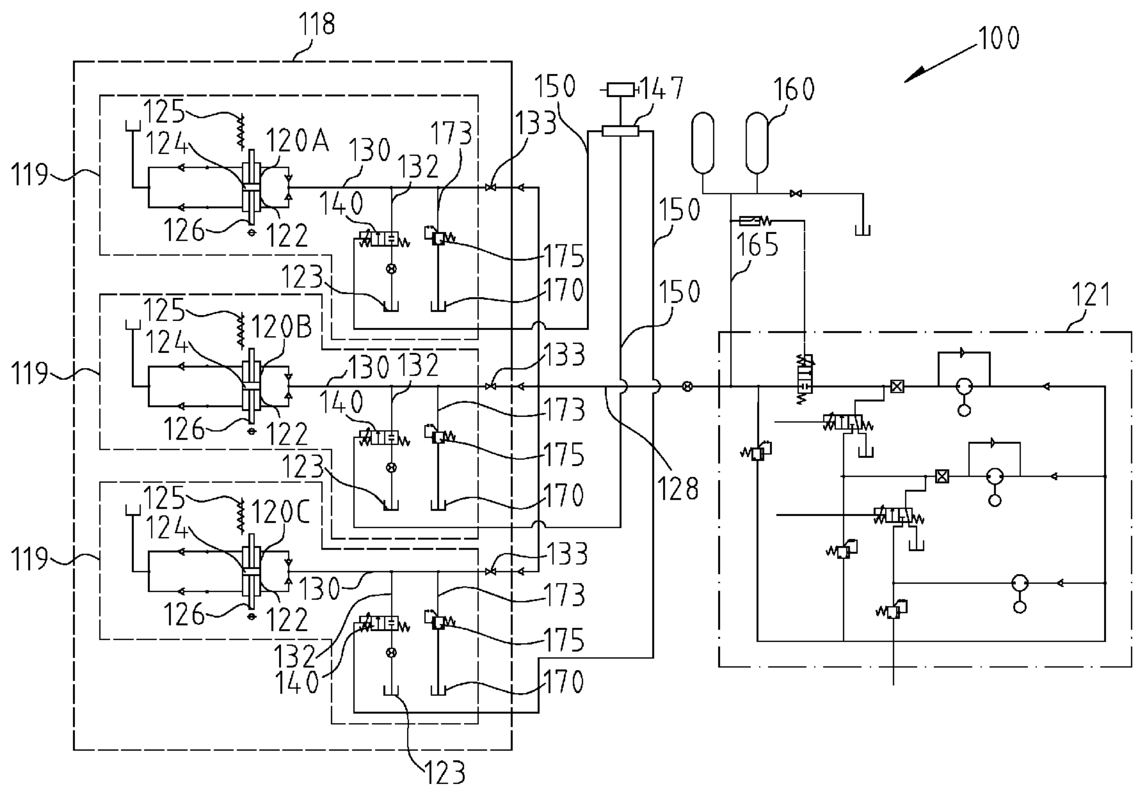
(57) **ABSTRACT**

A wave energy conversion system which includes a wave absorber that moves in response to passing waves. A power take off (PTO) is provided which comprises a plurality of individually selectable actuators. The wave absorber is operable coupled to the actuators for facilitating driving the actuators. Each actuator has an associated damping characteristic. A combination of the damping characteristics of each actuator defines a PTO damping characteristic. A controller is operable to determine a desired PTO damping characteristic in response to a sensed parameter of the wave absorber. The controller is further operable for selectively activating one or more actuators to provide the desired PTO damping characteristic in response to the sensed parameter.



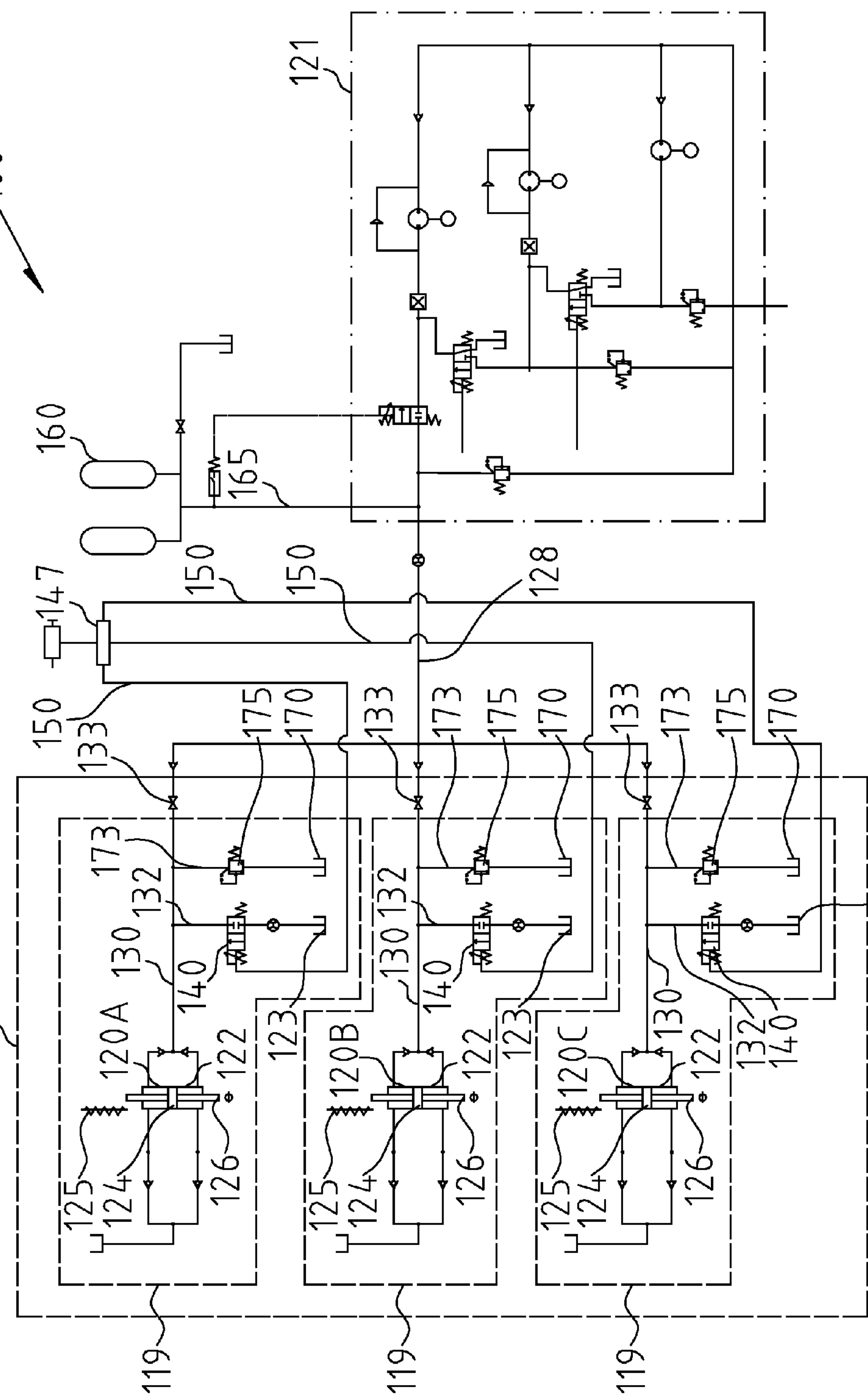

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Fig. 1

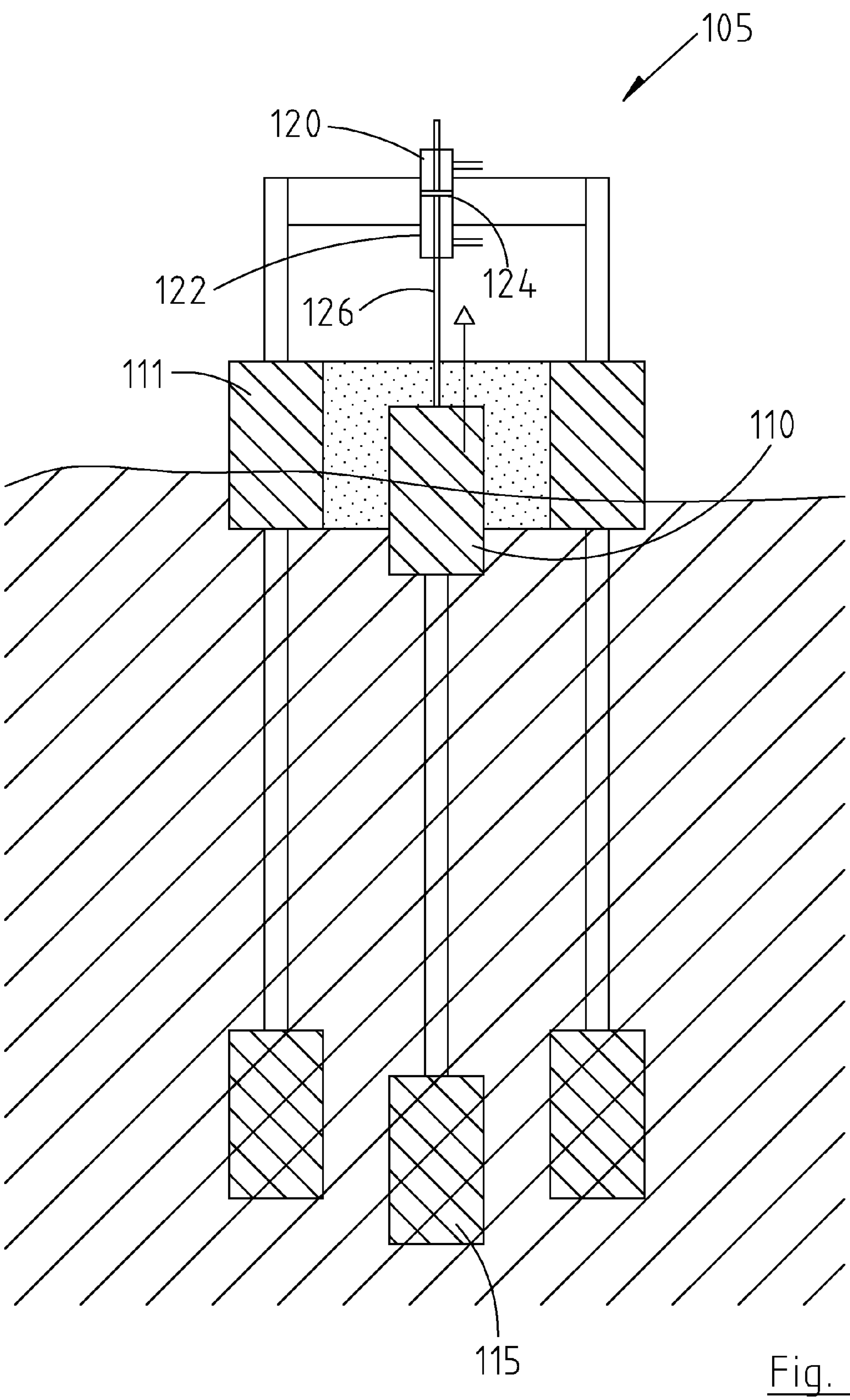
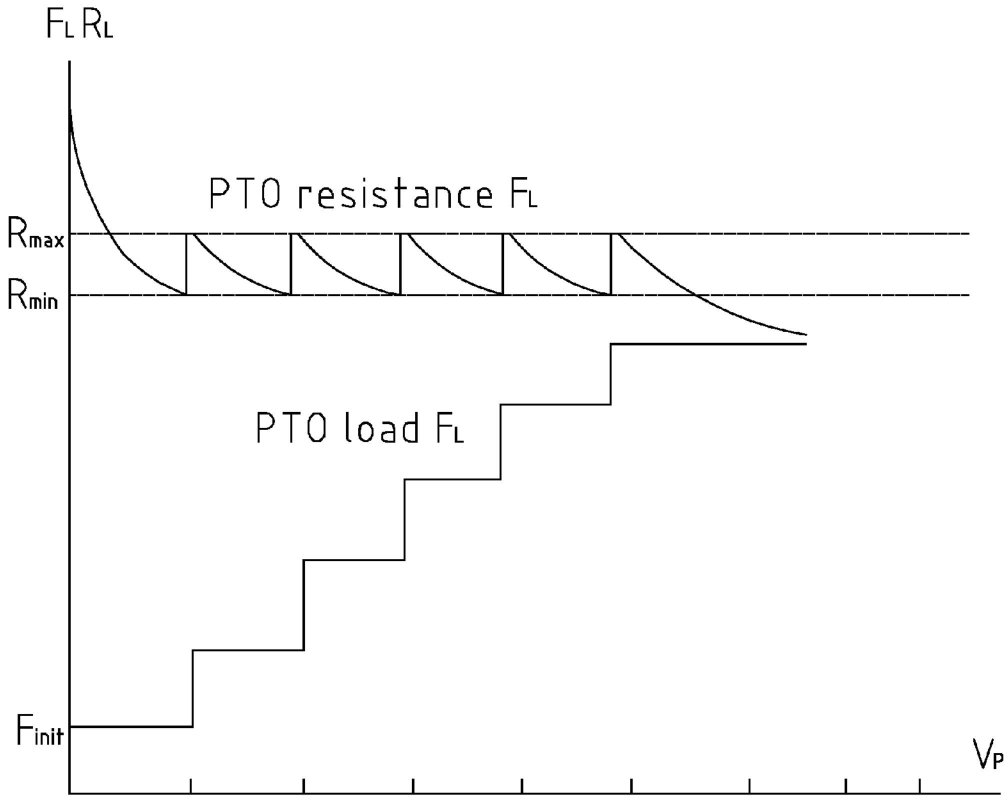
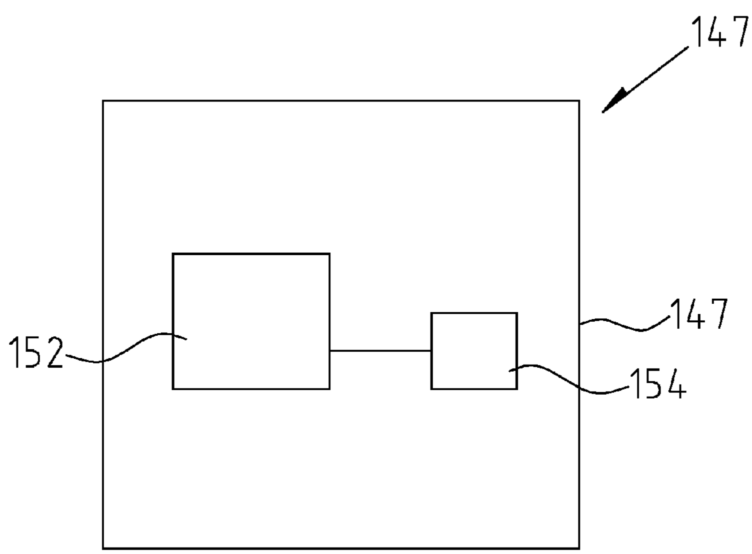



Fig. 2



$F_L$ $R_L$
PTO resistance $F_L$
$R_{max}$
$R_{min}$
PTO load $F_L$
$F_{init}$
$V_P$


Fig. 3



147
152
147
154


Fig. 4

# WAVE ENERGY CONVERSION SYSTEM

## FIELD OF THE INVENTION

**[0001]** The present invention relates to a wave energy conversion system. In particular the present invention relates to a wave energy conversion system which includes a control means for determining a desired damping in response to a sensed parameter of a wave absorber. The control means is operable for selectively activating one or more actuators to achieve the desired damping.

## BACKGROUND

**[0002]** Wave energy converters are known in the art. Examples of such arrangements include those described in our earlier patents EP1439306, EP1295031 and EP1036274. Such arrangements are usefully deployed in a maritime environment and generate energy from wave motion.

**[0003]** To provide such generation it is known for such converters to employ power take off systems. Typically such systems comprise a hydraulic circuit which is driven by the wave energy which in turn drives a power generator to generate electricity. The hydraulic circuit is controlled such that it remains at a constant pressure so that the electrical power generated by the generator is of a stable frequency. By generating power at a stable frequency permits the power to be readily used in a power grid without the need for complex power electronics. The main disadvantage of constant pressure power take off systems of the type known heretofore is that wave energy absorption is not maximised.

**[0004]** There is therefore a need for a system which optimises wave energy absorption.

## SUMMARY

**[0005]** These and other problems are addressed by providing a power take off system which includes a control means for determining a desired damping in response to a sensed parameter of a wave absorber. The control means is operable for selectively activating one or more actuators to achieve the desired damping.

**[0006]** Accordingly, a first embodiment of the invention provides a wave energy conversion system as detailed in claim **1**. Advantageous embodiments are provided in the dependent claims.

**[0007]** These and other features will be better understood with reference to the followings Figures which are provided to assist in an understanding of the teaching of the invention.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0008]** The present invention will now be described with reference to the accompanying drawings in which:

**[0009]** FIG. **1** is a diagrammatic view of a wave energy conversion system in accordance with the present invention.

**[0010]** FIG. **2** is a detail of the wave energy conversion system of FIG. **1**.

**[0011]** FIG. **3** is a graph illustrating the relationship between the damping force of the system of FIG. **1** and the velocity of a wave absorber.

**[0012]** FIG. **4** is a block diagram of a detail of the system of FIG. **1**.

## DETAILED DESCRIPTION OF THE DRAWINGS

**[0013]** The invention will now be described with reference to an exemplary system which is provided to assist in an understanding of the teaching of the invention.

**[0014]** Referring to FIG. **1** there is illustrated a wave energy conversion system **100** which includes a power take off (PTO). The PTO comprises a plurality of actuators to convert wave energy to electricity or some other form of energy. In this exemplary arrangement the actuators are hydraulic pumps, and in the example of FIG. **1** three hydraulic pumps **120** are provided. The pumps **120** are driven by a wave absorber **115**, and in turn, drive an energy converter, namely, a power converter **121**. The hydraulic pumps **120** may be selectively operated so as to achieve a varying of an operating characteristic of the PTO to a response of a wave absorber **115** to wave action thereon. In this exemplary arrangement, the operating characteristic is a measure of the damping provided by the actuators, and the response of the wave absorber to wave action thereon is provided as a sensed characteristic. The sensed characteristic may be provided as an indication of any one of a number of variable parameters associated with the response of the wave absorber to the wave action. In this exemplary arrangement the sensed characteristic is provided as a measure of the velocity of the wave absorber **115**. The damping force of the PTO may be varied such that there is a relationship between the damping force of the system **100** and the velocity of the wave absorber **115**. This relationship between the damping force and velocity may be any desired relationship that facilitates wave absorption, and in the exemplary arrangement is substantially linear. Thus, the output of the system **100** is maintained within a predefined operating range, thereby providing a substantially linear output. It will therefore be appreciated that the damping provided by the hydraulic pumps **120** is maintained proportional to the velocity of the wave absorber **115**. By providing the power take off (PTO) as a system comprising a plurality of individually selectable actuators with the wave absorber being operably coupled to the actuators for facilitating driving the actuators and each actuator having an associated damping characteristic it will be appreciated that a combination of the damping characteristics of each actuator defines a PTO damping characteristic.

**[0015]** The hydraulic pumps **120** are driven by at least one wave absorbing system **105** for facilitating the conversion of wave energy to, in this exemplary arrangement, electrical energy. Wave energy absorbing systems are known in the art, an example of which is shown in our earlier patent EP 1295031 and replicated in FIG. **2** of the instant application. This exemplary wave energy absorbing system or apparatus **105** comprises a first and second device. The two devices are arranged relative to one another such that the first device may be considered an inner device **110** surrounded by an annular outer device **111**. Each of the two devices comprises a surface float and/or at least one submerged wave absorber **115** below the surface of the body of liquid. Linkages are provided between the at least two devices. By configuring each of the two devices to oscillate at different frequencies relative to one another in response to passing waves, relative movement between the at least two devices may be used to generate an energy transfer which may be harnessed by the linkages between the at least two devices **110**, **111**. The linkages may be coupled to the hydraulic pumps **120** that harnesses the energy generated by the wave absorbing system **105** and converts the wave energy into hydraulic energy. The hydraulic energy from the pumps **120** drives the power converter **121** to generate electricity.

**[0016]** While the wave absorbing system of EP 1295031 is described as employing a power take off system—an example of which is described in FIG. 7 of EP 1295031, the specific implementation described utilises hydraulic pumps, the damping force of which is not controlled to the response of the wave absorber to wave action thereon. The present inventors have realised that in order to maximise wave absorption it is possible to control the damping of the pumps to the response of a wave absorber to wave action thereon. In this exemplary embodiment, the response of the wave absorber to wave action thereon is provided as a sensed characteristic representative of the velocity of the wave absorber. In this way the actual response will be better suited to the conditions prevalent. It will be appreciated by those skilled in the art that the velocity of the wave absorber **115** varies depending on the ocean conditions where the wave absorbing system **105** is moored. The operating characteristic of the system **100** may be dynamically varied during operation as the velocity of the wave absorber **115** changes due to changing ocean conditions. The damping provided by the hydraulic pumps **120** may be varied during a unitary wave period thereby ensuring that the output response changes rapidly and does not have to wait for the next wave period to begin before taking effect. A wave period is the time taken for two consecutive wave troughs to pass a given point. A typical wave pattern will have crests formed by a volume of water between consecutive troughs. A control unit **147** or controller is provided and is operable to vary the damping at different instances during the wave period. Alternatively, the operating characteristic of the system **100** may be tuned by estimating/approximating the velocity of the wave absorber resulting from the prevalent ocean conditions.

**[0017]** The system **100** of FIG. **1** of the instant application is specifically configured to maximise wave energy absorption. The hydraulic pumps **120** are controlled by a control means, namely, a control unit **147** so that the damping force provided by the pumps **120** may be varied in response to changes in velocity of the wave absorber **115**. In this way, the wave energy conversion system **100** provides a substantially constant output irrespective of the velocity of the wave absorber **115**.

**[0018]** In one exemplary arrangement each hydraulic pump **120** provides a predetermined constant damping force. The constant damping force provided by each hydraulic pump **120** can be chosen to be different to that of the other pumps, or indeed selected ones can have the same and others different. The mechanism for varying the operating characteristic may be for example the selective use of pumps having different dimensions. As there are a plurality of pumps it is possible, in accordance with the teaching of the invention to selectively activate individual ones of the pumps to optimise the response characteristic of the system to the operating conditions of the wave energy absorber **115**.

**[0019]** One preferred arrangement is effected by the control unit **147** activating a combination of pumps **120** in a predetermined sequence such that the damping force provided by the pumps is matched to the velocity of the wave absorber **115**. As the velocity of the wave absorber **115** increases the control unit **147** dynamically activates a certain combination of pumps **120** so that the damping force of the system **100** also increases. Similarly, as the velocity of the wave absorber **115** decreases the control unit **147** dynamically activates a certain combination of pumps **120** so that the damping force decreases. In this exemplary arrangement, three pumps **120** are provided each providing a different damping force when activated. As three pumps **120** are provided the pumps **120** may be activated in seven combinations, which in turn provide seven different combinations of damping forces from which the control unit **147** can select from. While it will be appreciated that this is a specific example and the teaching should not be restricted to such an exemplary arrangement for the purposes of understanding the number of combinations that are possible it will be seen the seven combinations of damping forces are provided by the following combinations of pumps:

**[0020]** 1. Pump **120**A,
**[0021]** 2. Pump **120**B,
**[0022]** 3. Pump **120**A+Pump **120**B,
**[0023]** 4. Pump **120**C,
**[0024]** 5. Pump **120**A+Pump **120**B+Pump **120**C,
**[0025]** 6. Pump **120**A+Pump **120**C, and
**[0026]** 7. Pump **120**B+Pump **120**C.

**[0027]** In this exemplary arrangement, the control unit **147** actives the pumps **120** so that the system **100** has a constant load resistance such that:

$$R=F/V_p$$

**[0028]** Where:
**[0029]** R is the load resistance,
**[0030]** F is the damping force provided by the active pumps **120**, and
**[0031]** $V_p$ is the velocity of the wave absorber **115**.

**[0032]** Referring now to the graph of FIG. **3**, which shows the damping force F provided by the pumps **120** versus the velocity $V_p$ of the wave absorber **115**.

**[0033]** The control unit **147** activates the pumps **120** such that there is a substantially linear relationship between the damping force F of the pumps **120** and the velocity $V_p$ of the wave absorber **115**. The inventors of the present application have realised that by maintaining a substantially predetermined relationship between F and $V_p$, in this case, a linear relationship, it is possible to significantly enhance the quantity of wave energy which may be absorbed by the system **100**, and therefore the efficiency of the overall system. For example, if the velocity $V_p$ is within a first range, the control unit **147** may activate pump **120**A such that the system **100** has a corresponding first damping force. If the velocity $V_p$ is within a second range, the control unit **147** may activate pump **120**B such that the system **100** has a corresponding second damping force. If the velocity $V_p$ is within a third range, the control unit **147** may activate pumps **120**A and **1208** such that the system **100** has a corresponding third damping force. If the velocity $V_p$ is within a fourth range, the control unit **147** may activate pumps **120**C such that the system **100** has a corresponding fourth damping force. If the velocity $V_p$ is within a fifth range, the control unit **147** may activate pumps **120**A, **120**B and **120**C such that the system **100** has a corresponding fifth damping force. If the velocity $V_p$ is within a sixth range, the control unit **147** may activate pumps **120**A and **120**C such that the system **100** has a corresponding sixth damping force. If the velocity $V_p$ is within a seventh range, the control unit **147** may activate pumps **120**B and **120**C such that the system **100** has a corresponding seventh damping force.

Thus, it will be appreciated by those skilled in the art that the control unit **147** may be configurable to dynamically activate and/or deactivate predetermined pumps **120** at different instances during a single wave period so that there is a substantially linear relationship between F and $V_p$. In other words, the controller or control unit **147** is configured to dynamically activate various combinations of pumps during the time period for two consecutive wave troughs to pass a given point. The control unit thereby achieves a tuning of the response of the PTO throughout the passage of individual waves. In this way the response of the device is not restricted to a single response characteristic for a single wave. A single wave may require a modification of the damping forces at multiple iterations during the passage of that single wave. It will be appreciated by those skilled in the art that as the pumps **120** are selectively activated and/or deactivated it is possible to vary the operating characteristic of the system **100** to the sensed characteristic. At least one of the pumps **120** may be activated and another one of the pumps **120** deactivated simultaneously. Alternatively, at least two pumps **120** may be activated simultaneously, and at least two pumps **120** deactivated simultaneously. The pumps **120** may be operated in a sequence.

**[0034]** In this exemplary arrangement, the system **100** comprises a network **118** of hydraulic pumping circuits **119** which are driven by wave energy for pumping fluid from reservoirs **123** to the power generator **121**. The pumped fluid drives the power generator **121** to generate electrical energy. Each pumping circuit **119** has an associated damping force. The pumping circuits **119** are selectively activated and/or deactivated for actively varying the damping force of the PTO system **100** to be dynamically matched with the velocity of the wave absorber **115** of the wave absorbing system **105**.

**[0035]** Each pumping circuit **119** comprises a hydraulic pump **120** with corresponding wave absorbing rams **124** axially moveable in cylinders **122** and operably coupled to the wave absorbing system **105** by a coupling shaft **126**. As the submerged wave absorbing body **115** oscillates due to wave energy it provides a driving force to the rams **124** via the coupling shaft **126**, which in turn forces the rams **124** to oscillate. Position sensors **125** sense the movement of the rams **124**. The control unit **147** is in communication with the position sensors **125** for calculating the velocity of the rams **124**, which in turn calculates the velocity of the wave absorber **115**. Depending on the velocity of the wave absorber **115** certain pumps **120** are activated so that there is a substantially linear relationship between the damping force of the system **100** and the velocity of the wave absorber **115**. The oscillating rams **124** pump fluid from the reservoirs **123** to the power generator **121**. The pumping circuits **119** are in fluid communication with the power generator **121** via a primary hydraulic circuit **128**. Each pumping circuit **119** comprises a main line **130** extending between the pump **120** and the primary circuit **128** and coupled thereto by a coupling valve **133**. A supply line **132** extends between each reservoir **123** and corresponding main line **130** which ensures that the reservoirs **123** are in fluid communication with the pumps **120**. A flow control means, in this case, a bidirectional pneumatic valve **140** is located in each supply line **132** intermediate the main lines **130** and the reservoirs **123**, and are selectively controlled for activating and/or deactivating the corresponding pumps **120**. It will be appreciated by those skilled in the art that the activated pumps **120** contribute to the damping force of the overall system **100**. Deactivated pumps **120** do not contribute to the damping force of the overall system **100**.

**[0036]** The damping force of each pumping circuit **119** is set by the dimensions of the pumps **120**. In this exemplary arrangement three pumping circuits **119** are provided and each pumping circuit **119** has a different damping force as the pumps **120** have different dimensions. The transverse cross sectional area of the rams **124** and the corresponding cylinders **122** progressively increase from the first pump **120**A to the third pump **120**C. While the preferred arrangement includes three pumping circuits **119** it will be appreciated by those skilled in the art that any desired number of pumping circuits **119** may be provided. It is not intended to limit the invention to this described arrangement. It will be appreciated by those skilled in the art that the pumping circuits herein described are exemplary of the type of circuitry that may be employed to match the response of the PTO to the climatic conditions of the wave absorbing system.

**[0037]** The control unit **147** is operably coupled to the pneumatic valves **140** by electrical cables **150** for providing control signals to the pneumatic valves **140** which selectively activate and/or deactivate the pneumatic valves **140**, which in turn selectively activates and/or deactivates the corresponding pumps **120**. The control unit **147** comprises a microprocessor **152** and a memory chip **154** which stores a control algorithm. The microprocessor **152** calculates the velocity of the wave absorber **115** by communicating with the position sensors **125** and generates an optimised damping force which the system **100** needs to have in order to optimise wave absorption. Tables containing velocity data and corresponding damping force data may be preloaded to the memory chip **154** which can then be read by the microprocessor **152** for selecting the optimum damping force. The control unit **147** controls the pneumatic valves **140** based on the velocity of the wave absorber **115** so that the overall damping force of the system **100** is set at the optimised value. The control unit **147** may be operable to communicate with local and/or remote data systems for receiving data for populating the tables in the memory chip **154**. This data may then be used for estimating/approximating/determining the appropriate damping force of the system **100**. The data systems which supply data to the control unit **147** may include a weather system. The data received by the control unit **147** may be historical data representative of seasonal wave conditions. Additionally or alternatively, the data may be real-time data representative of real-time wave conditions. It will be appreciated by those skilled in the art that the data received may be any type of data which can be used for selecting an optimum damping force. The control unit **147** may be in wireless communication with the data systems.

**[0038]** A pressure accumulator **160** is operably coupled to the primary circuit **128** via an interconnecting circuit **165** for maintaining the pressure in the primary circuit **128** constant. It will be appreciated that wave energy varies significantly depending on the conditions in the ocean. In periods of large swells, the wave energy absorbing system **105** generates a large amount of kinetic energy which drives the pumps **120** at a high rate so that the fluid in the primary circuit **128** is under high pressure. In periods of relatively small swells, the kinetic energy generated by the wave energy absorbing system **105** is significantly less than periods of large swells resulting in less kinetic energy and as a consequence the pumps **120** are driven at a slower rate resulting in the fluid in the primary circuit **128** being under less pressure. The pressure accumulator **160**

regulates the pressure within the primary circuit **128** so that the pressure in the primary circuit **128** remains substantially constant. Overflow wells **170** are in fluid communication with each main line **130** via outlet lines **173** for receiving fluid from the primary circuit **128** when pressure in the primary circuit **128** exceeds a threshold level. A unidirectional valve **175** is provided in each outlet line **173** for controlling the flow of fluid to the overflow wells **170**.

**[0039]** In operation, the pumps **120** are operably coupled to the wave absorbing system **105**. The submerged wave absorber **115** of the wave energy absorbing system **105** is forced to oscillate by the wave energy, which in turn provides a driving force which drives the rams **124** to pump fluid to the power generator **121**. The pumped fluid to the power generator **121** drives the power generator **121** to generate electricity. The control unit **147** dynamically activates one of seven combinations of pumps **120** sequentially so that there is a substantially linear relationship between the damping force of the system **100** and the velocity of the wave absorber **115**. As the wave absorber of this specific example generates energy from relative motion of two devices in response to passing waves its movement effects a driving of the rams to move bi-directionally. In other words, the wave absorber **115** pushes the rams **124** of the pumps **120** in an upwardly direction when the wave absorber **115** moves towards the surface of the water, and pulls the rams **124** in a downwardly direction when the wave absorber **115** sinks to a lower depth. In certain instances, it may be desirable to increase the potential energy which the wave absorber **115** provides by urging the wave absorber **115** to a lower depth. The pumps **120** may be controlled by the control unit **147** to drive the wave absorber **115** downwardly. It will therefore be appreciated that while the wave absorber **115** drives the pumps **120** for the majority of the time, in certain instances the pumps **120** drive the wave absorber **115** to increase the potential energy of the wave absorber **115**. It will therefore be understood that the wave absorber **115** drives the pumps **120** for major portion of an operating cycle of the wave energy conversion system **100**, while the PTO drives the wave absorber **115** for a minor portion of the operating cycle.

**[0040]** It will be understood that what has been described herein is an exemplary embodiment of a wave energy conversion system. While the present invention has been described with reference to exemplary arrangements it will be understood that it is not intended to limit the teaching of the present invention to such arrangements as modifications can be made without departing from the spirit and scope of the present invention. For example, in the exemplary arrangement the predetermined relationship between F and $V_p$ has been described as being substantially linear. It will be appreciated by those skilled in the art that the relationship between F and $V_p$ may be non-linear. It will be understood that the invention is to be limited only insofar as is deemed necessary in the light of the appended claims.

**[0041]** The words comprises/comprising when used in this specification are to specify the presence of stated features, integers, steps or components but does not preclude the presence or addition of one or more other features, integers, steps, components or groups thereof.

**1**. A wave energy conversion system comprising:

a wave absorber being moveable in response to passing waves;

a power take off (PTO) comprising a plurality of individually selectable actuators, the wave absorber being operably coupled to the actuators for facilitating driving the actuators, each actuator having an associated damping characteristic, a combination of the damping characteristics of each actuator defining a PTO damping characteristic;

a controller operable to determine a desired PTO damping characteristic in response to a sensed parameter of the wave absorber, the controller being further operable for selectively activating one or more actuators to provide the desired PTO damping characteristic in response to the sensed parameter, wherein at least two actuators differ in dimensions.

**2**. A system as claimed in claim **1**, wherein the wave absorber is operable to move the actuators bi-directionally.

**3**. A system as claimed in claim **2**, wherein the wave absorber is operable for pushing and/or pulling the actuators.

**4**. A system as claimed in claim **1**, wherein the PTO is operable to drive the wave absorber to a submerged depth to increase the potential energy of the wave absorber.

**5**. A system as claimed in claim **4**, wherein the wave absorber drives the actuators for a major portion of an operating cycle, and the PTO drives the wave absorber for a minor portion of the operating cycle.

**6**. A system as claimed in claim **1**, wherein the controller is configured to selectively activate a combination of actuators in response to a change in the sensed parameter.

**7**. A system as claimed in claim **6**, wherein the controller is configured to selectively activate two or more actuators in response to a change in the sensed parameter.

**8**. A system as claimed in claim **1**, wherein the controller is configured to selectively deactivate one or more actuators in response to a change in the sensed parameter.

**9**. A system as claimed in claim **1**, wherein the controller is configured to effect activation of at least one of the actuators and deactivation of another of the actuators simultaneously.

**10**. A system as claimed in claim **9**, wherein the controller is configured to provide for simultaneous activation of at least two actuators.

**11**. A system as claimed in claim **9**, wherein the controller is configured to provide for simultaneous deactivation of at least two actuators.

**12**. A system as claimed in claim **1**, wherein the sensed parameter comprises a velocity of the wave absorber.

**13**. A system as claimed in claim **1**, wherein the controller is configured to control the actuators to vary the PTO damping characteristic during a time period for two consecutive wave troughs to pass a given point.

**14**. A system as claimed in claim **12**, wherein the controller is operable for dynamically activating and/or deactivating predetermined actuators at different instances during a single wave period.

**15**. A system as claimed in claim **12**, wherein the controller is operable for dynamically activating various combinations of actuators at different instances during a time period for two consecutive wave troughs to pass a given point.

**16**. A system as claimed in claim **1**, wherein the controller is configured to operate the actuators in a sequence.

**17**. A system as claimed in claim **1**, wherein the controller controls the actuators for controlling a load resistance of the system.

**18**. A system as claimed in claim **17**, configured such that operably the damping force provided by the actuators is proportional to a velocity of the wave absorber.

**19**. A system as claimed in claim **17**, configured such that the load resistance may be varied during a unitary wave period.

**20**. A system as claimed in claim **1**, wherein the controller is configured to change which actuators are active during a unitary wave period.

**21**. A system as claimed in claim **1**, wherein at least some of the actuators are configured to provide different damping.

**22**. (canceled)

**23**. A system as claimed in claim **1**, wherein the wave absorber is operably provided below surface of the wave.

**24**. A system as claimed in claim **23** wherein the wave absorber is operably coupled to a surface float.

**25**. A system as claimed in claim **23**, wherein the actuators are provided intermediate the wave absorber and the surface float.

**26**. A system as claimed in claim **24**, wherein the wave absorber is suspended from the surface float.

**27**. A system as claimed in claim **23**, wherein the surface float is surrounded by an annular surface float.

**28**. A system as claimed in claim **27**, wherein the surface floats and the annular surface float are configured to oscillate at different frequencies relative to one another in response to the passing waves.

**29**. A system as claimed in claim **1**, wherein the wave absorber is submerged.

**30**. A system as claimed in claim **1**, wherein the actuators are provided as hydraulic pumps with associated rams.

**31**. A system as claimed in claim **30**, wherein the rams are operably coupled to the wave absorber.

**32**. A system as claimed in claim **30**, wherein the wave absorber is operable to push and/or pull the rams.

**33**. A system as claimed in claim **30**, wherein at least some of the rams differ in dimensions.

**34**. A system as claimed in claim **30**, wherein at least some of the rams have different cross sectional area.

**35**. A system as claimed in claim **30**, wherein the wave absorber drives the rams with mechanical energy.

**36**. A system as claimed in claim **35**, wherein the hydraulic pumps are operable to convert the mechanical energy provided by the wave absorber into hydraulic energy.

**37**. A system as claimed in claim **1**, wherein the controller is operable to communicate with data systems for receiving data.

**38**. A system as claimed in claim **36**, wherein the received data is used by the controller for determining the desired PTO damping characteristic.

**39**. A system as claimed in claim **37**, wherein the controller is communicable with a weather system for facilitating the transmission of data there between.

**40**. A system as claimed in claim **37**, wherein the data comprises historical data representative of seasonal wave conditions.

**41**. A system as claimed in claim **37**, wherein the data is real-time data representative of real-time wave conditions.

**42**. A system as claimed in claim **37**, wherein the controller is configured to be in wireless communication with the data systems.

**43**. (canceled)

**44**. A wave energy conversion system comprising:

a wave absorber being moveable in response to passing waves;

a power take off (PTO) comprising a plurality of individually selectable hydraulic pumps with associated rams, the wave absorber being operably for driving the hydraulic pumps, each hydraulic pump having an associated damping characteristic, a combination of the damping characteristics of each hydraulic pump defining a PTO damping characteristic.

a controller operable to determine a desired PTO damping characteristic in response to a sensed parameter of the wave absorber, the controller being further operable for selectively activating one or more hydraulic pumps to provide the desired PTO damping characteristic in response to the sensed parameter, wherein at least two rams differ in dimensions.

* * * * *