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(54) **Title**: PLANT FOR ELECTRICITY GENERATION AND/OR DESALINATION BY WATER CURRENT TURBINES

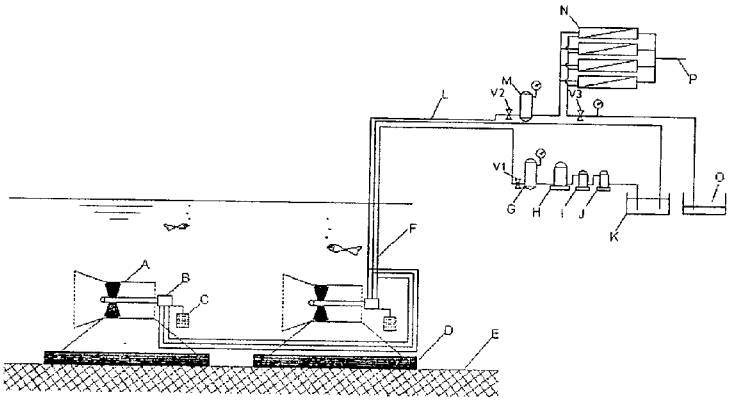

Figure 1

(57) **Abstract**: The proposed invention describes a plant for electricity production and/or water desalination, by using submerged turbines and other equipments. In the desalination operation, the plant does not use electricity. The plant can operate at rivers or at oceans. Both in the rivers and in the oceans, the plant can operate with the turbines fixed in the ground or in a floating-anchored structure. In rivers, the equipment of electricity generation and/or desalination are installed in one of the borders. In the ocean, these equipment are installed above the water level, in a platform fixed at the seabed, in cases of oceans with up to 50 meters deep. For oceans with more than 50 meters deep, these equipment are installed in a semi-submersible platform that is anchored to the seabed. In both of these configurations, the turbines can be fixed in other floating structure, that is also anchored to the seabed. In all the installation purposes of the plant, the turbines are interconnected to the equipment of electricity and/or desalination, through a rigid or flexible pipe. The plant can be installed for three different purposes: 1 - Electricity generation. 2 - Water desalination 3 - Electricity generation and desalination.

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PLANT FOR ELECTRICITY GENERATION AND/OR DESALINATION BY WATER CURRENT TURBINES

TECHNICAL FIELD

The present invention is related to a plant which is composed by submerged turbines of hydrokinetic type. The plant can be used for electricity generation and/or water desalination by reverse osmosis, by the energy from marine currents, tidal currents and river currents. In the desalination operations, the plant does not use electricity. The plant can be commutative operating both for desalination and for electricity generation. It is basically composed by three main systems: submerged turbines of pumping, external high pressure system, group of electricity generation and/or desalination system. Each submerged turbine is constituted of a hydraulic pump and a set of directional valves. The external system (of high pressure and which stays outside of the water) consists of hyperbaric chamber and hydro pneumatic accumulator. The electricity generation group is composed by a turbine, an electric generator and a module of control. The plant can have several interconnected turbines supported at the bottom of rivers or oceans. The efficiency maintenance of the turbines, which operate in different speeds, is done by adjusting the angle of the turbines blades whose mechanism is driven by dedicated software. The turbines have automatic devices for operating in any current direction. The power of the plant or the flow of desalinated water may be enhanced by increasing the number of interconnected turbines.

TECHNICAL BACKGROUND

There are many technical processes for water desalination. Among them, the most known are: distillation, reverse osmosis and electrical dialysis. In general, all of these processes demand high consumption of electrical energy.

Although there are already some patent registers about the water desalination using sea waves as power source, the development of the

technology for desalination of water by reverse osmosis, using either river or ocean currents as energy source, is still in the beginning. So far it has not been found patent applications with the same technical characteristics presented in this invention.

SUMMARY OF INVENTION

The present invention is related to a plant which operates on rivers or oceans with submerged turbines of hydrokinetic type. The working principle of this system allows the generation of electricity and/or the desalination of sea water, brackish water and wastewater treatment from industrial or domestic sources. The operation of the plant is based on the submerged turbines that can be supported either on the river bed or on the seabed. The installed position of the turbine on the water is optimized in order to reach higher current speeds without affecting the navigation. On river or ocean regions with large depths, where there is no conflict with the navigation, other alternative is to keep the turbines hung, fixed at the bottom of a floating structure anchored at the ocean floor or at the floor/border when the installation occurs on rivers. The equipments used for electricity generation and/or desalination do not keep in water. They are installed at the dry margin, when it concerns about rivers or on a bottom-fixed platform, when it concerns about oceans.

The reason to install the equipments out of the water, in a dry place, facilitates the operation and maintenance of the system. In the desalination, the used process is the reverse osmosis one. The necessary energy for obtaining the required high pressure in the process (900 psi) is provided by the action of marine currents, tidal currents and river currents. Thus, the desalination of water occurs without electricity, witch reduces significantly the potable water costs. The potable water can be used for domestic usage, industrial processes and irrigation of agricultural lands. An additional advantage is that the irrigation can be done in distances of hundreds

of kilometers, since the system can provide hydraulic energy higher than that required by the desalination process.

The plant is composed of three main systems: submerged turbines for pumping, external system of high pressure, group of electricity generation and/or desalination unit. The plant can operate in a commutative way: generating electricity in a certain period of time and desalinating water in another period.

DESCRIPTION OF DIFFERENT OPERATING POSSIBILITIES OF THE PLANT:

The plant can be installed for operation in three different purposes or different scenarios:

1- First purpose: Electricity generation.

2- Second purpose: Desalination of sea water, brackish water of rivers, or wastewater from industrial or domestic sources.

3- Third purpose: Electricity generation and desalination.

In the first scenario, the plant operates in closed circuit. Each pump installed at each turbine craft is connected to two principal ducts. One of them is for feeding the pumps and the other for the discharge the water in high pressure. The utilized fluid can be water or any other. The suction duct feed the turbines with the fluid contained in a reservoir. This reservoir together with a hydropneumatic accumulator, a hyperbaric chamber and a generator group are located in the land in the river border. If the plant is installed in the ocean, these equipments are mounted above sea level at a floating platform anchored to the bottom or on a fixed platform in the seabed.

The mechanical energy, from the currents that drive the turbines, pressurizes the fluid in the hydropneumatic accumulator. The pressurized fluid is ejected through a controllable valve to move the turbine, or a hydraulic motor, coupled to an electric generator to produce electricity. The hyperbaric chamber is linked to the hydropneumatic accumulator, both containing nitrogen or carbon gas. This system acts to storage energy which contributes to the pressure

stabilization. In case of inversion of the current direction, a directional valve automatically reverses the direction of flow in the hydraulic circuit and keeps regularized the electricity generation.

In the second scenario, the plant operates in open circuit to desalinate salty water. The pump inputs of the several turbines are connected to the main suction duct which conducts the water to be desalinated. The water to be desalinated must be captured from distant regions of the margin, in order to minimize the presence of contaminants such as oils, greases and kerosene. At the turbines, pumps pressurize water and send it to a filter system. The system is composed of three filters of different levels of porosity arranged in line within the desalination unit, which is installed in the land. By passing the filters, the water is deposited in a reservoir. From this reservoir, the water feeds the turbine pumps in other circuit and the pressure is now elevated up to 900 psi (61 bar) in order to get the desalination process in normal flows. The water at this pressure is conducted to the desalination cartridges, which contain the membranes of the reverse osmosis. After passing by these membranes the water is desalinated and conducted to a second reservoir. The brine, with high degree of salinity, is driven to a distant region of the margin and of the intake. This place should have a stream for dissipation of salinity, to minimize the risks to the river or marine environment.

In the third scenario, the plant is commutative. The installation is applied to operate in two purposes: electricity generation and desalination of water. Each way of operation must occur in different moments. This plant woks in open circuit and the water used for any of the two purposes is captured in the same manner described in the second scenario (desalination). A switch valve is responsible for directing the water to one or other purpose. During the operation on the first scenario, i.e., electricity generation, the water is returned to the river or sea near the plant, without any mixture or addition of pollutants.

The external system that operates in high pressure is installed in the land and consists of hyperbaric chamber and hydro pneumatic accumulator. The generating group is composed of the turbine, electric generator and plant module control. The plant can have several interconnected turbines supported at the bottom of the river or seabed, at a deep suitable for the current power exploitation without the prejudice of navigation and integrity of the turbines. The efficiency maintenance of the turbines, which operate in different speeds, is done by adjusting the angle of the turbines blades whose mechanism is driven by dedicated software. The turbines have automatic directional devices for operating in any current direction. The power of the plant or the flow of desalinated water may be selected by choosing the number of interconnected turbines.

The present invention is related to a plant for electricity generation by the action of marine currents, tidal currents and river currents. The plant is composed by three main systems: submerged turbines of pumping, external high pressure system, group of electricity generation and/or desalination unit. The turbines are placed in the seabed or riverbed in a suitable height and have devices that allow their orientation to be altered according to the current direction, for maintenance of the highest efficiency. The turbines also operate with reverse flow of the stream, common in the river mouths. The efficiency maintenance of the turbines, operating in different current speeds, is done by adjusting the angle of the turbines blades, whose mechanism is driven by dedicated software. Each turbine has its axis connected to a hydraulic pump for conversion of mechanical energy into hydraulic energy.

In the plant for electricity generation, the turbines capture clean water (or other fluid) from a reservoir of low pressure located in the margins of the rivers or in a platform, if the installation is in the sea. The water is pressurized by the pumps to the hydro pneumatic accumulator. This accumulator releases the fluid at high pressure to move the turbine (or hydraulic

motor) coupled with an electric generator to produce electricity. After leaving the generating system, the fluid returns to the reservoir of low pressure, which characterizes a closed circuit operation. The conduction of the fluid between the immersed turbines and the external system of electricity generation is done by rigid and flexible pipe of low and high pressures.

The systems of high pressure and of electricity generation are installed in the border of the river or above the sea level and they can be fixed or floating. These systems consist of hyperbaric chamber, hydro pneumatic accumulator and generating group. The generating group is composed of the turbine, the electric generator and the plant module control. The plant can have several interconnected turbines supported at the bottom of the river or seabed.

The turbines are designed to move the pumps in a wide range of pressures that can reach up to 3000 psi (204 bar).

DESCRIPTION OF THE OPERATING MANNERS, PLANT AND EQUIPMENTS

The plant operates through the action of river or sea currents, which moves the blades of hydraulic submerged turbines supported and anchored in the floor. These turbines have hydraulic pumps connected to the principal axis. The pumps capture water from the river or sea, sends it to a hydro pneumatic accumulator and elevate its pressure to the suitable level for desalination or electricity generation. The accumulator is linked to the hyperbaric chamber, which acts as an energy storage system, responsible for the pressure stabilization. The pumped water at high pressure is released from the hydro pneumatic accumulator through a flow control valve to move a turbine or a hydraulic motor. The rotation of the turbine axis (or motor axis) is transmitted to an electric generator, for conversion of mechanical energy into electricity. The flow controlled valve releases the jet, through an electronic control system that maintains constant the turbine speed.

In desalination operation, a switch valve redirects the water at high pressure for disconnecting the generating group connecting the desalination system.

OPERATIONAL PROCESS FOR ELECTRICITY GENERATION

The power of the plant in kilowatts units (at the water jet output) is proportional to the product of the flow (m^3/s) and the pressure (m.w.c.) which are supplied during the plant operation by the hydro pneumatic accumulator. In a conventional hydroelectric plant, this pressure is supplied by the water level difference, called "head" (potential energy). The plant in the present invention as mentioned in the first scenario, for electricity generation, operates in closed circuit by pumping freshwater from a reservoir (which is located on the land, when it concerns about rivers or on a platform, when it concerns about oceans) to the hydro pneumatic accumulator. The water input flow in the accumulator that is pumped from the turbines, should be equal or bigger than the water output flow used to move the turbine (or hydraulic motor). This water volume supplied to the accumulator from the pumping modules maintains the system pressure constant through a pressure regulator valve. A valve controls the water output flow and regulates the speed of the generating group according with the electric load, in order to keep the electrical frequency within technical required values.

OPERATIONAL PROCESS FOR DESALINATION BY REVERSE OSMOSIS

The extracted power from river or ocean currents is given by the following formula $P = (\eta\rho Av^3)/2$, where P is the extracted power, ρ is the water density, A is the area in the internal diameter of the turbine, v is the current speed and η is the efficiency of conversion.

The hydraulic energy is converted by the submerged turbine into mechanical energy. This mechanical energy moves a hydraulic pump of two different stages. The pump is attached at the turbine shaft. On the first stage, the pump captures salty water and raises its pressure up to 45 psi (3 bar). This

is the filtering pressure. The pressurized water is carried out by the duct until the desalination unit for the initial filtering operation. This desalination unit is located at the river border or above the sea level, if the installation is in the sea. After the filtering process, the water returns to the turbine, on a second stage, for elevating its pressure up to 900 psi (61 bar). This is the desalination pressure. The water at high pressure is again carried out by the duct until the desalination unit. At the desalination unit approximately half of the water volume, at high pressure, passes by the cartridges of reverse osmosis becoming potable water with quality for human consumption. The volume of non-desalinated water is the brine or concentrate. This brine is also discarded through pumping process on a third stage for dissipation in distant currents.

DESCRIPTION OF FIGURES

Figure 1 presents the simplified scheme of the set of equipments that compose a desalination plant without use of electricity. The set is composed basically of two distinct units: the conventional module of desalination with membrane by reverse osmosis and the module of pumping through turbines that consists in the conversed energy from currents into pumps movement. In the scheme, the letter A represents the turbine supported at the riverbed or seabed. Letter B is the pump responsible for elevating the water pressure. Letter C represents the filter in the suction line mounted with a water retention valve at the suction input of the pump. Letter D represent the turbine's support. Letter E represents the riverbed or seabed. Letter F represents the pipe containing the interconnection lines between the turbines and the desalination unit. Letter G is the accumulator of low pressure. Letter H is the first filter with porosity of 75 micra. Letter I is the second filter with porosity of 25 micra. Letter J is the last filter with porosity of 5 micra.

Letter K represents the first water reservoir of the hydraulic circuit, and is used for the storage of the filtered water. Letter L represents the line of high pressure. V2 represents the input valve of the high-pressure accumulator.

Letter M is the high-pressure line hydro pneumatic accumulator of the hydraulic circuit. Letter N represents the set of membrane cartridges for the desalination by reverse osmosis. V3 represents the pressure regulator valve at the output of the desalinated water line. Letters O represents the desalted water reservoir and letter P represents the output line of the brine with high salinity concentration.

Figure 2 presents a scheme of a desalination plant mounted in the river. In this scheme, the turbines are fixed on a metal or concrete base anchored in the riverbed. The electricity generating and/or desalination equipments are installed on the borders of the river in the land. A rigid or flexible pipe line which is deposited in the riverbed interconnects the set of turbines to the equipments on the land.

In this scheme, letter A represents the riverbed. Letter B represents one of the installed turbines at the bottom of the river. Letter C represents the pipe that interconnects the set of turbines to the installations on the land. Letter D represents the soil on the land. Letter E represents the electricity generation and/or water desalination equipments, mounted at the river border.

Figure 3 represents the scheme of a plant installed also in the river, where the difference concerns about the way the turbines are fixed. In this scheme, the turbines are suspended at a floating structure in the river. This structure either can be anchored in the river boarders or in the river bed. In this scheme, letter A represents the floating structure in the river. Letter B represents one of the turbines hanged in a floating structure. Letter C represents the pipe that interconnects the set of turbines to the installations on the land. Letter D represents the soil of one of the river borders. Letter E represents the installations for electricity generation and/or water desalination. Letter F represents the water level of the river. Letter G represents the riverbed.

Figure 4 presents a scheme of a plant mounted in the sea, where the depth is up to 50 meters. In this plant, the bottoms of the turbines are fixed in the seabed. The height of the base will define the operational position of the turbines with respect to the speed of the current and the sea level. The equipments of the electricity generation and desalination processes are installed on a superior base of a platform fixed at the seabed. This platform is similar to those jacket type platforms used in drilling and oil extraction.

In this scheme, letter A represents the superior base of the platform where the equipments are installed. Letter B represents the equipments of the electricity generation and/or desalination processes. Letter C represents one of the turbines mounted at the seabed. Letter D represents the pipe that interconnects the set of turbines to the equipments installed on the platform.

Figure 5 presents a scheme of a plant mounted in the sea, where the depth is more than 50 meters. In this plant, the bottoms of the turbines are also fixed in the seabed. In the same manner, the base height will define the operation position of the turbines with respect to the current speed and the sea level. In this case, there should have a minimum draft necessary for navigation. The platform is similar to those semi-submersible platforms used in the oil activities.

In this scheme, letter A represents the platform base where the equipments are installed. Letter B represents the equipments of the electricity generation and/or desalination processes. Letter C represents one of the turbines mounted at the seabed. Letter D represents the pipe that interconnects the set of turbines to the equipments installed on the platform. Letter E represents one of the cables for anchoring the platform at the seabed. Letter F represents the seabed.

Figure 6 presents a scheme of a plant mounted in the sea, where the depth is also more than 50 meters. In this plant, the turbines are fixed on a

floating structure at the sea. The operational position of the turbines is from 2 to 5 meters below sea level.

In this scheme, letter A represents the floating platform where the equipments are installed. Letter B represents the equipments of the electricity generation and/or desalination processes. Letter C represents the floating structure. Letter D represents one of the turbines hung at the floating structure. Letter E represents one of the cables for anchoring the floating structure at the seabed. Letter F represents one of the cables for anchoring the floating platform at the seabed. Letter G represents the pipe that interconnects the set of turbines to the equipments installed on the floating platform. Letter H represents the seabed.

ADVANTAGES OF THE PLANT FOR ELECTRICITY GENERATION AND/OR DESALINATION FROM CURRENTS

- Production of clean and renewable electrical energy without environmental impacts.
- Contribution to the local power transmission network, by adding other source of electrical energy.
- Electricity supply and/or desalinated water in islands or places distant from the shore, where the electrical transmission does not exist.
- The installation of the turbines is modular, requiring low rates of flow and high operation pressures, what means lower investment costs in the implementation and maintenance.
- The required final power determines the number of turbines to be installed.
- The plant can be installed for three different purposes:

First purpose: Electricity generation.

Second purpose: Desalination of sea water, brackish water of rivers, or wastewater from industrial or domestic sources.

Third purpose: Electricity generation and desalination.

The equipments listed in the present invention should not be considered as definitive. The quantity, types and arrangements of those equipments can be altered according to the characteristics of the place it will be installed.

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CLAIMS

1- PLANT FOR ELECTRICITY GENERATION AND/OR DESALINATION BY WATER CURRENT TURBINES, characterized by the use of submerged turbines of hydrokinetic type on rivers, where the electrical generation equipments are installed on the land in one of the river's border.

2- PLANT according to claim 1, characterized by using a hyperbaric chamber linked to a hydropmeumatic accumulator for electricity generation in rivers and installed on the land in one of the river's border.

3- PLANT according to claims 1 and 2, characterized by the use of equipments for rivers' water desalination installed on the land in one of the river's border.

4- PLANT according to claims 1 and 2, characterized by using equipment for desalination and electricity generation installed on the land in one of the river's border.

5- PLANT according to claim 1, characterized by operating with pressures up to 3000 psi.

6- PLANT according to claims 1, 2, 3 and 4 characterized by using a floating structure for fixing the turbines in rivers.

7- PLANT characterized by using submerged turbines of hydrokinetic type fixed at the seabed, with the electrical generation system installed on a platform fixed at the seabed.

8- PLANT characterized by using submerged turbines of hydrokinetic type that are fixed at a floating structure in the sea and with the equipments of electricity generation and desalination installed on a semi-submersible platform, that is also a floating structure in the sea.

9- PLANT according to claim 7, characterized by using desalination equipment installed on a fixed platform at the sea.

10- PLANT according to claims 7 and 8, characterized by using desalination and electricity generation equipments installed on a fixed platform at the sea.

11- PLANT according to claims 5, 7 and 8, characterized by using a hyperbaric chamber linked to a hydropmeumatic accumulator for electricity generation installed on a fixed platform at the sea.

12- PLANT according to claim 1, characterized by using a hydropmeumatic accumulator associated with the desalination equipments installed on a fixed platform at the sea.

13- PLANT characterized by using submerged turbines of hydrokinetic type in the sea with the electricity generation equipments installed on a floating platform at the sea.

14- PLANT according to claim 12, characterized by using the desalination equipments installed on a floating platform at the sea.

15- PLANT according to claims 12 and 13, characterized by using the desalination and electricity generation equipments installed on a floating platform at the sea.

16- PLANT according to claims 5, 12 and 13, characterized by using a hyperbaric chamber linked to a hydropmeumatic accumulator for electricity generation installed on a fixed platform at the sea.

17- PLANT according to claims 5, 12, 13 and 14, characterized by using a commutative valve in order to the system operates both for electricity generation and for desalination.

18- PLANT according to claim 1, characterized by operating with submerged turbines composed of hydraulic pumps and directional valves operating with pressures up to 3000 psi.

19- PLANT according to claim 1, characterized by having several interconnected turbines supported at the bottom of rivers or oceans.

20- PLANT, characterized by including a mechanism of angle adjustment of the turbines blades driven by a dedicated software.

21- PLANT, characterized by having directional valves for operation in the opposite direction of the currents in the rivers.

22- PLANT, characterized by having turbines with devices of direction and rotation for operation in any direction of the ocean currents.

23- PLANT, characterized by installation capacity and operations in the following manners: Electricity generation, water desalination and electricity generation with switching for desalination.

FIGURES

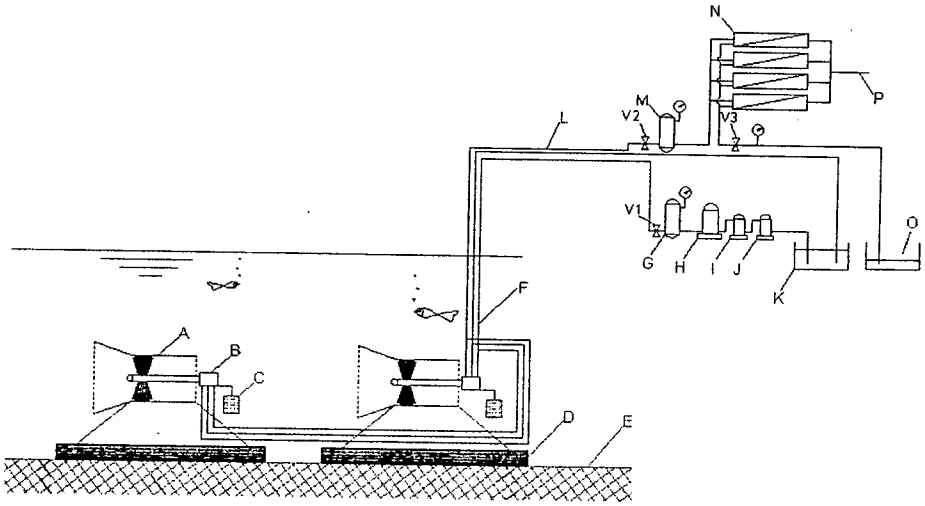

Figure 1

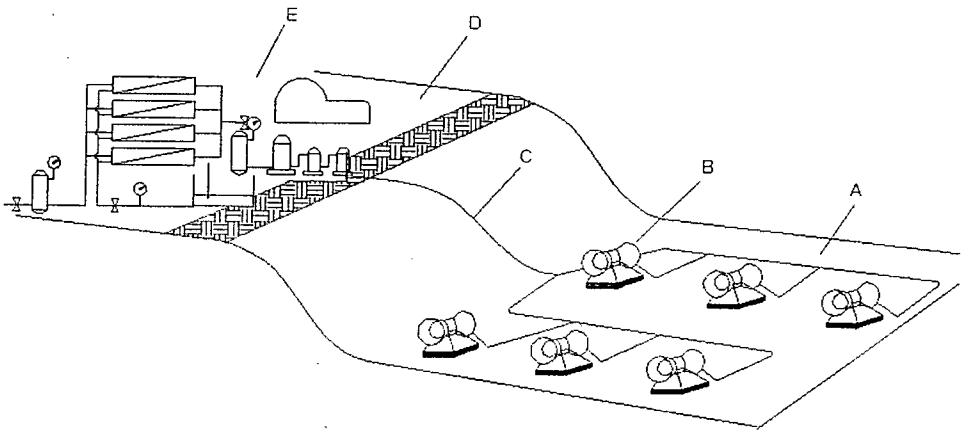

Figure 2

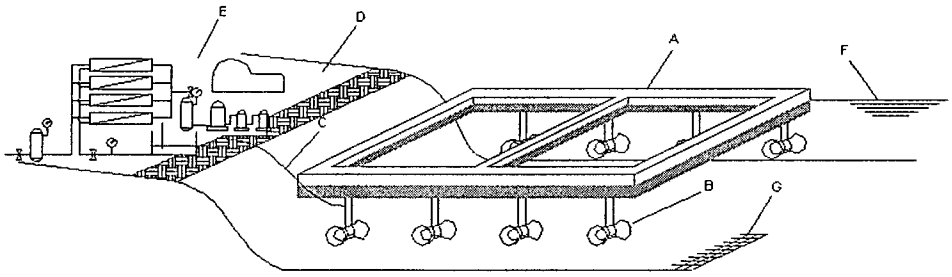

Figure 3

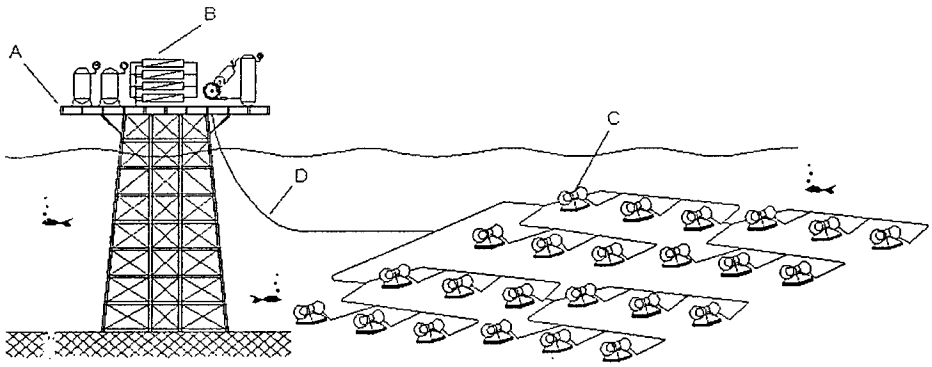

Figure 4

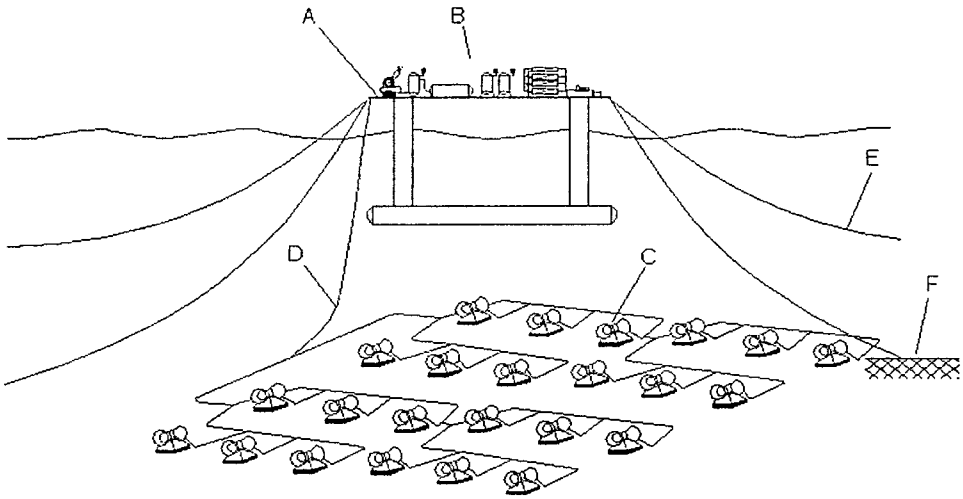

Figure 5

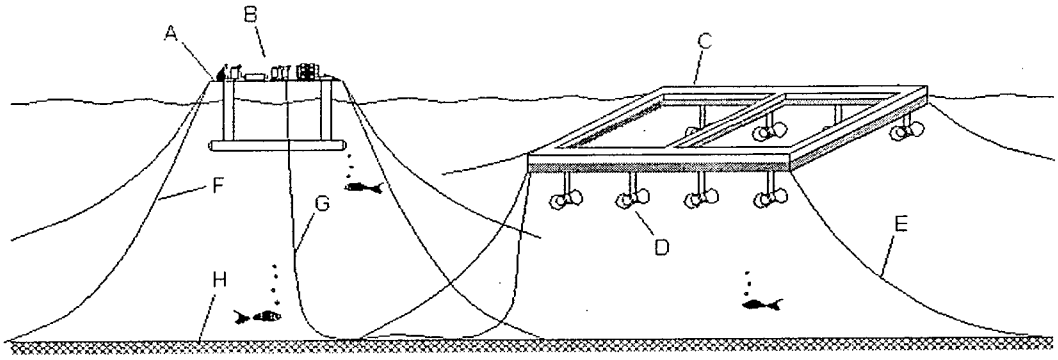

Figure 6