(54) Title WAVE POWER PLANT

(57) Abstract A floating buoy (1) is connected to a reference buoy (10) below by a connecting pipe (20). A piston (32) of a pump (30) is attached to the pipe (20) and pumps water to a collection pipe (37) as buoy (1) moves relative to buoy (10). The pumped water is converted into electrical power by a turbine and a generator. The average distance between the buoys (1, 10) is maintained by controlling the specific gravity of the reference buoy (10). The wave power plant efficiently transforms wave energy from waves of different direction, wave length and height into electrical power. In a variant, the plant additionally desalinates sea water for irrigation or drinking water supply.
WAVE POWER PLANT

Wind power can be transformed to electric power by large propeller rotors connected to generators. The output of such generators depends on the local wind force which varies and can be zero at times. Energy from wind power is rather expensive due to high investment and maintenance costs. For adapting energy production to demand other power plants are required for the time the rotors stand still for lack of wind.

Wind, on the other hand, produces waves on ocean surfaces. The waves on the ocean surface are in fact a concentrated form of wind power collected over thousands of miles. Basically, this concentrated form of wind power should be converted to electrical power more efficiently than the local wind by a propeller.

The up and down movement of the sea surface can be used to produce energy. A wave power plant is known (see "NZZ Neue Zürcher Zeitung am Sonntag", Oct. 27, 2007) which relies on special geological conditions of the coast. A slanted wall and a bottom wall reach down into the water and are part of an upwardly closed chamber. The air in the upper part of that chamber is compressed and decompressed as waves approach the entrance opening between the walls. The air flow produced that way is transformed to electrical power by an air turbine connected to a generator. This system is restricted to locations with low tidal heights, can use only a narrow band width of wave length and directions, and is not very efficient and prone to storm damages.
A prototype named "wave dragon" was installed in Denmark in 2003. It collects incoming waves by reflectors to a slanted ramp into a storage basin above the sea surface, from where the water flows back to the sea via Kaplan turbines, which are connected to generators. This system floats on the sea surface and can be installed off coasts with large tidal heights. But again it is selective with respect to wave length and direction and is not storm safe. Part of the wave power is lost in foam and turbulence as the waves swash up the ramp.

There are also proposals with a chain of rafts using the relative tilting of adjacent rafts to produce power.

The problem to be solved by the present invention is to propose a wave power plant which can be installed along any coast, is storm-safe, has a high efficiency and can convert the energy of a large spectrum of wave length and wave directions. This problem is solved by the combination of features of claim 1.

The proposed wave power plant not only solves the above problem, but in addition it is cheap to manufacture and install. More important, it protects coasts from erosion. Costs for coastal protection can be substantially reduced so countries along ocean coasts should have an interest in subsidizing installation of the system. The proposed power plant produces electrical energy at lower costs than any known power plant, with no CO₂ emission. It could supply a substantial part of the electrical energy consumed worldwide.

An embodiment of the invention is described below with
reference to the drawings, in which

Fig. 1 shows a vertical section of a transforming unit,

Fig. 2 shows an example of use,

Fig. 3 shows an arrangement of several buoys of Fig. 1,

Fig. 4 shows a transforming unit anchored to the sea floor,

Fig. 5 shows a variant of Fig. 4,

Fig. 6 shows a simple variant of Fig. 5,

Fig. 7 shows a schematic top view of a further variant,

Fig. 8 a simpler version of Fig. 1, and

Fig. 9 a row of plants along a coast line.

Fig. 1 shows a floating buoy 1 which is preferably round and flat, e.g. 10 m in diameter and 1 m in height, about half immersed, which corresponds to a displacement of roughly 40 m$^3$. These dimensions would be ideal for wavelength of 10 m upwards. The axial cross section is preferably elliptical for maximizing strength and minimizing vulnerability. The buoy 1 consists of a shell 2 which is filled mostly with air 3 and some water 4 which communicates freely with the surrounding sea 5 through an opening 6 at the bottom.

The buoy 1 is connected to a reference buoy 10 of at least
equal mass by a connection pipe 20 or rope or a combination thereof. The pipe 20 is attached to buoy 1 e.g. by a ball joint 22 to allow tilting of the buoy 1 relative to pipe 20 and is spanned at its lower end by a weight 21, e.g. of concrete. The weight 21 is more than half the displacement of buoy 1. The pipe 20 is therefore hardly under compression stress. The weight helps to keep buoy 1 in average vertically above buoy 10.

The buoy 10 has about the specific gravity of the surrounding sea 5 and consists of a shell 11 filled mostly with water 12 and some air 13. A preferred form of shell 11 would be a sphere, because that would resist least to tilting of the pipe 20 due to horizontal movement of the buoy 1 relative to buoy 10. The shell 11 has an opening 14 at the bottom. The buoy 10 is held in position by e.g. three anchors 15 with anchor chains 16 or ropes. It is free to move up and down with the tides and is located e.g. 20 m below buoy 1, i.e. at least twice the diameter of buoy 1.

A housing 31 of a water pump 30 is fixed to the buoy 10. The piston 32 of the pump 30 is fixed to the pipe 20. Inlet and outlet check valves 33 are connected to the upper and lower chambers 34, 35 of the pump 30. The pump outlet 36 is connected to a collection pipe 37 which collects pressure water from several of the described transforming units 49 aligned along a coast line.

In the example of Fig. 1 the pump 30 pumps sea water. Alternatively it could pump a different fluid to much higher pressure. In that case the inlet check valves 33 would be connected to a supply pipe 38 for that fluid, shown in
The diameters of the pump 30 and associated elements 31 to 37 could then be reduced considerably which might save costs.

An air supply pipe 40 supplies air to two three-position three-way valves 41,42. The valve 41 controls the amount of air 13 in buoy 10 such that the piston 32 is in average in the middle of housing 31. This can be achieved e.g. by a stroke sensor measuring the position of piston 32 in housing 31 or by proximity sensors 43,44 at the upper and lower end of the piston stroke in the housing 31. They should be approached by the piston 32 with about equal frequency or intensity respectively.

The valve 42 controls the amount of air 3 in buoy 1 such that under normal condition the buoy 1 is about half immersed, which can be controlled by a pressure sensor 45 at the upper end of the pipe 20. In stormy weather, when the piston 32 approaches its lower and upper stroke limits too frequently, the buoy 1 is flooded by releasing air 3 through valve 42 so that the buoy 1 sinks to a save level below the water surface. This save level can again be controlled by surveying the stroke of piston 32 and be maintained by the pressure sensor 45 via valve 42. The supply line 46 to the valves 41,42 is lead through the pipe 20 and the valves 41,42 are arranged inside the buoys 1,10 for protection. The controller 47 for controlling the valves 41,42 and which receives the signals from the sensors 43,44,45 could also be located inside the buoy 1 and receives its power supplied through pipe 20.

The transforming unit 49 shown in Fig. 1 could therefore work fully autonomously without any external control except
e.g. for a tsunami warning which should be transmitted to the controller 47 by a central controller 48 in time to lower the buoy 1 to a save level.

In case lowering of the floating buoy 1 in storms or for the passage of ships is not actually needed the transforming unit 49 can be simplified considerably. The three-way valve 41 and the proximity sensors 43, 44 can be replaced by two mechanically operated two-way valves 101, 102 (Fig. 8) replacing the sensors 43-44 and actuated by the piston 32 when it reaches its end positions. The top valve 101 feeds air to and the bottom valve 102 releases air from the reference buoy 10. In addition, the valve 42, the controller 47, the central controller 48, the water 4 inside the floating buoy 1, the pressure sensor 45 and the opening 6 may be deleted. The inside of the shell 2 may be filled with a honeycomb structure or with a hard, low density foam 103 with closed cells to improve strength.

As shown in Fig. 2 and 3 the pumped water of may be several thousands of the described transforming units 49 aligned off a coast line 50 is fed to the collection pipe 37 and to a riser tube 37" and then transformed to electrical power by a turbine 51 or hydro motor and a generator 52. Where the geography and geology allows it the collection pipe 37 could additionally feed a storage lake 53, e.g. 100 m above sea level. That would allow to store the pumped water e.g. at night and transform it to electrical power mainly at peak hours when prices are high by opening a valve 54.

A buoy 1 of 40 tons displacement moving up and down with the waves at an average speed of 0,2 m/sec has a power potential of roughly 80 kW. A thousand of those buoys 1 could
generate 80 MW and would need and protect a coastal length of 20 km. Most of that power potential can be transformed into electrical power because hydraulic pumps and turbines are very efficient.

The coastal length required can be reduced by a zig-zag formation 61 of the buoys 1. As shown in Fig. 3 there could be arranged several rows 62,63 of buoys 1 with decreasing diameter towards the coast line 50, all feeding the same collection pipe 37. The outer, larger buoys collect energy from longer waves, whereas the smaller buoys 60 closer to the coast line 50 damp out and collect energy from shorter waves.

With three rows 62,63 of buoys 1,60 staggered e.g. 8 m, 4 m and 2 m most of the energy of incoming waves could be transformed to electrical energy, so that under normal condition the area 64 between the innermost row 63 and the coast line 50 would be calm. The energy harvested would be roughly 8 MW/km. This power output would be maintained in storms when the buoys 1,60 are submerged below the surface of the sea 5, but the area 64 will get rough. However, the waves are still damped out efficiently so storm damages are minimized. The power output collected along 100 km coastal length would correspond to the output of a large modern electric power plant.

A variant of the embodiment shown in Fig. 1 to 3 is shown in Fig. 4 where the reference buoy 10 is not free floating but anchored to the sea floor 65 by an anchor block 66 via an anchor pipe '67 which may be a continuation of the wall of the housing 31 of the pump 30. The length of the housing 31 is at least the sum of the maximum tidal height at the
place of installation and the maximum wave height the system should manage. The anchor pipe 67 is connected to the anchor block 66 by a ball joint 68 or a cross link. In this case the reference buoy 10 does not serve as a counter mass for the up and down movement of the floating buoy 1, but only to keep the system upright. It is filled mostly with air. It would only be flooded by valve 41 in case the floating buoy 1 should be lowered to a lower level than the stroke of the piston 32 allows.

In Fig. 4 the proximity sensors 43, 44 are eliminated compared to Fig. 1. Flooding the floating buoy 1 in storms could be commanded by the central controller 48 which surveys average wave height anyway for controlling the pressure in the collection pipe 37.

The connection pipe 20 is larger in diameter because the pulling weight 21 is lacking and the pipe 20 is more loaded on compression stress. It should not buckle when the floating buoy 1 is lifted fully above the surface 69 of the sea.

In order to maintain the average distance between adjacent buoys 1 they may be interconnected by ropes 70 which are loaded half way in between adjacent buoys 1 by weights 71. When the surface 69 is flat the ropes 70 slant downward at about 45°. This way collisions between adjacent buoys can be avoided. Because the weight 21 is lacking the buoy 1 contains more water 4 than in the variant of Fig. 1.

In the variant of Fig. 4 the floating buoys 1 have the tendency of moving sideways instead of pushing the piston 32 down when the sea level 69 drops towards a wave through. To
avoid that is one of the reasons for the ropes 70 and weights 71 in Fig. 4 and for the weight 21 in Fig. 1. Fig. 5 shows another variant with which the above problem can be avoided: it combines the weight 21 of Fig. 1 which largely avoids compression stress on the connection pipe 20 with the simplicity of the variant of Fig. 4. The weight 21 would be preferably an iron lump because of the much higher specific weight compared to concrete when submerged in water. The anchor pipe 67 between the housing 31 of the pump 30 and the ball joint 68 is larger in diameter than the weight 21 and has large openings 76 at least at the upper and lower end.

Fig. 6 shows an even simpler variant where the housing 31 of the pump 30 is directly connected to the ball joint 68 and the weight 21 is attached to the connection pipe 20 above the pump 30. The distance between the underside of the weight 21 and the piston 32 is not much more than the piston maximum stroke to minimize sideways motion of the buoy 1 when it moves down.

In the variants of Fig. 4 to 6 it would be advantageous to arrange the rows 62, 63 of buoys 1, 60 along lines of constant depth under normal sea level 69 which can be seen on accurate navigation maps because they are important for shipping.

When there is no wind (no wind waves) and the sea looks calm, there are actually still the waves of longer length (swell) e.g. from 10 m upwards which originate from far away storms. The large buoys 1 are sensitive to these wave lengths whereas the smaller buoys 60 contribute less. When the sea looks calm, the plant described still produces a
substantial amount of electrical energy. The present invention can trap energy from storms that had happened thousand of miles away, which wind power plants cannot.

In order to gain the optimum of the wave energy it would be advantageous to adapt the system such that the stroke of the piston 32 is used as much as possible. This is possible by adapting the pressure in the collection pipe 37 to the prevailing average wave height by arranging several storage lakes 53 (Fig. 2) on different levels and opening only the connection to the lake of appropriate level and by controlling the flow rate through the turbine 51, e.g. in the manner of a Kaplan turbine. When the pressure in the collection pipe 37 is lowered the buoy 1 follows the wave surface better because it is less braked by the piston 32. Therefore, the system cannot only efficiently use a broad spectrum of wave length and direction but also a broad range of wave heights.

Optimization of the pressure in the collection pipe 37 may be achieved by switching that pressure between a chosen constant pressure $p_i$ and a 5% lower pressure $p_2$ in periods of e.g. two hours. In case the mean power output of the associated generator 52 is higher at the pressure $p_2$ than at $p_i$ then the pressure in the collection pipe 37 is switched between $p_2$ and a 5% lower $p_3$. If, on the other hand, the power output is higher at $p_i$ than at $p_2$ the periodic change of pressure is between $p_i$ and a 5% higher $p_4$. If the mean power output at the pressure $p_2$ is about the same as at $p_i$ the system keeps on switching between these two values. This way the hysteresis of the pumps 30 automatically adapts to the average wave height. Of course, the hysteresis should not exceed e.g. 80% of the height of the float-
ing buoy 1. Therefore, the pressure in the collection pipe 37 has an upper limit.

The floating buoy is flat, i.e. its diameter is at least five times its height, for the following reason: a) The vertical movement of the piston 32 and the floating buoy 1 have a hysteresis. The force on the piston 32 divided by its area has to exceed the pressure in the collection pipe 37 before the piston 32 moves in the housing 31. This threshold (in both directions) should be as small as possible in order to utilize wave energy as much as possible.

This calls for a flat buoy 1. b) A flat buoy 1 is less sensitive to horizontal movement of the water due to waves or currents, c) Wind resistance is minimized.

Lowering the floating buoys 1 in storms might be commanded pneumatically by changing the supply pressure in the air supply pipe 40 in a similar way as air brakes on railroad cars are controlled. There the engineer controls all the brakes of all cars of the train by slightly changing the pressure in the line supplying all brake cylinders of the train. Transformed to the present case this means that the valve 42 is a pneumatically actuated valve, the pressure sensor 45 has a pneumatic signal output and the controller 47 is a pneumatic controller. The supply line 46 also supplies the controller 47 and the sensor 45 plus an air supply container inside the floating buoy 1 (as on railroad cars). If, e.g., the air supply pressure is lowered from regular 10 bar to 9 bar this would be a command signal to lower the floating buoy 1 by 10m. The controller 47 would then shift the valve 42 to release air 3 until the sensor 45 signals an increase of static pressure by 1 bar.
This would simplify the system considerably. No electric or electronic connection is needed between the transforming units 49 and the shore. A network of air supply pipes 40 could be spanned along the ropes 70 over a network of dozens of transforming units 49 and be connected to a respective subcontroller on shore via a connecting pipe 20 of a single one of those units 49. The signal to the subcontroller for lowering the supply pressure in the air supply pipe 40 could be derived from the local mean wind force.

On stretches on the coastline 50 where long waves with heights above 2m are frequent the system can be expanded later on without interrupting the system already operating. A further double-row of transforming units 49 with even larger floating buoys 1 of e.g. 15m diameter and 1.5m height may be installed further off the coastline 50. The pumped water will feed a separate collection pipe 37 and drive a separate turbine 51 with a separate generator 52. The pressure in this pipe 37 will be optimized separately. A substantial increase in electrical power output and coastal protection can be realized that way without intervening in the system already operating.

Maintenance costs of the system are low because any flora or fauna that populates the shells 2, 11 and the weight 21 do not deteriorate its efficiency. They have the specific gravity of the surrounding water. Unlike ship hulls the shells 2, 11 do not need regular cleaning. A zinc coating for protection against corrosion is sufficient. No painting or paint renewal is required.

The transforming unit 49 allows ships to pass at specified and signaled passage routes or, if required, anywhere be-
cause the central controller 48 can in fact command any
buoy 1 under its control to descend to a commanded level
when a ship approaches and raise to operational level, when
it has passed. This can happen fully automatically con-
trolled by radar.

The connection between the central controller 48 and the
individual controllers 47 could be by radio waves, laser,
sonar or a cable through pipe 20. Malfunction of the system
under control of the central controller 48 can easily be
detected and localized by comparing the irranergence depth of
adjacent buoys 1.

The system is fully storm- and tsunami proof. The wave en-
ergy is collected along a substantial coast length and
transformed to electric energy at a convenient place with a
single turbine 51 and electric generator 52 (3 phase). This
is not only much cheaper than known systems but also more
efficient. Redundancy of the system is very high because if
one of the buoys 1 should fail the power output would be
reduced by less than 1 o/oo.

Of course, fishers could not fish, particularly not with
drag nets along the ocean floor, under the rows 62, 63 of
buoys 1, 60 and perhaps 50 m on either side. Fishers
would, on first thought, oppose installation of the system.
Taxes paid to the communities along the coast where the
system is installed would be justified and could easily be
paid from the sale of electric power. On the other hand a
band of e.g. 200 m width where no fishing, particularly no
drag net fishing is allowed or even possible and stretching
along a large part of the coast line 50 would be extremely
helpful in maintaining diversity of ocean species and rais-
ing young fish in a protected area. It would be worth much more to ecology than isolated protected spots. Since fish population increases where the system is installed fishers might, on second thought, even promote its installation.

The power plant according to the invention is in fact a well protected artificial coral riff which protects the ocean coasts and efficiently harvests the renewable energy of the ocean waves.

As shown in Fig. 9 a large number of the wave power plants 104 as described above, each one driving its generator 52, will be aligned next to one another along the ocean coast line 50 of a continent, e.g. the west coast of Africa. Since there are large stretches of that coast line 50 with low or no demand for electrical energy the generators 52 of all the power plants 104 are interconnected by a high voltage, high current electrical power line 105 running substantially along and close to the coast line 50 from generator 52 to generator 52. If large AC-power networks 106 further inland exist, branch lines 107 of the power line 105 might supply them. Since very high power is transmitted over long distances it might be advantageous to transmit DC-current to avoid induction losses. In that case the generators 52 would be DC-generators and a DC-AC converter 108 (indicated in dashed lines) would be required between the power line 105 or the branch lines 107 and the existing local AC-networks 106. A surplus of wave power harvested by the wave power plants 104 might be exported or converted to a different form of energy, e.g. by producing aluminum from bauxite. This might be interesting for Australia from where at present bauxite is shipped to Iceland because electrical energy is cheaper there.
Instead of the pump 30 a linear electric generator (not shown) could be provided which transforms the relative motion between the buoys 1 and 10 directly into electrical power.

Fig. 7 shows a further variant in which a desalination plant 80 is arranged in the line 85 between the collection pipe 37 and the turbine 51. The desalination plant 80 may comprise a reverse osmosis plant 81 with a pretreatment unit 82 which is required to prevent biofouling, scaling or plugging of the semi permeable membrane of the reverse osmosis plant. Reverse osmosis requires pressures of 60-100 bar with associated pretreatment unit 82. The pistons 32 of the pumps 30 (see Fig. 1) have to be dimensioned accordingly. Both reverse osmosis plants 81 and pretreatment unit 82 are known in the art so they need not be described in detail here. Instead of the pretreatment unit 82 a nanofilter may be installed which would require lower pressures. Such nanofilters are also known in the art. The desalination plant 80 has a fresh water outlet 83 and a salt water outlet 84 which is connected to the turbine 51. The sum of the flow of the two outlets 83,84 is about the flow rate in the line 85 from the collection pipe 37 to the desalination plant 80.

Several pressure reducing valves 88 which each feed a cross pipe 89 are connected to a distribution pipe 87. A number of feed pipes 90 extend from the cross pipes 89. Both sides of the feed pipes are equipped with miniature pipes (not shown) onto which small rubber tubes 91 are plugged. The tubes 91 have a calibrated output end so that a certain number of drops exit per hour. A commercially available system squeezes each rubber tube 91 individually such that
the moisture in the soil remains constant around the dripping end of the rubber tube 91. The irrigation grid 92 thus formed could be covered with soil of a few centimeters or sand for easier cultivation. No vehicles could be allowed to drive over the grids 92. The grids should be interrupted by roads for cultivation.

For adapting the fresh water supply to the irrigation needs (no irrigation when it's raining) or to the drinking water consumption (e.g. at night) a number of water towers (not shown) with storage containers will be mounted along the distribution pipe 87. When the valve 86 is shut because the storage containers are full the flow through line 85 bypasses the desalination plant 80 by turning a bypass valve 93 in a bypass 94 on. The pumps 30 of the transforming units 49 should remain working on nominal power for coastal protection, and it does not make sense to accept the pressure loss of the pretreatment unit 82 when no fresh water is required. When the valve 86 is shut the power output of the generator 52 is considerably higher because both the supply pressure and flow rate of the turbine 51 are higher. A check valve 95 is mounted in the outlet 84 of the desalination plant 80.

The evaporation losses are very low because the drop irrigation is directly fed to the roots of the plants. The surface of the soil and the plant leaves remain practically dry. Therefore the wave power plant according to the invention in this variant can irrigate a considerable area, besides producing electric energy.

In case of higher water demand for fresh water part of the output of the turbine 51 or the generator 52 could also be
used to drive a pump (not shown) in the line 85 to raise
the supply pressure of the desalination plant 80. The ratio
of fresh water to salt water output could thereby be in-
creased.

In the embodiments of Fig. 1-6 the outlet 51' of the tur-
bine 51 could be fed back to the inlet check valves of the
pumps 30 to reduce the pressure drop and maintenance of
inlet filters, e.g. by coupling the outlet 51' to the sup-
ply pipe 38 (Fig. 1). This is not possible in the variant
of Fig. 7 because of the higher salt concentration of the
water in its outlet 51' than in the sea water.

For round buoys 1, the ratio of diameter to an appropriate
height is 40:1 to 5:1. In same situations, buoys 1 having
other forms may be suitable. For such sort of corps, the
ratio of the average diagonal to the height is preferable
again 40:1 to 5:1. The upper limit mentioned above, is not
a limit based on the present invention, but rather a struc-
tural limit because of bending strength.
Claims

1. A wave power plant with a transforming unit (49) comprising:
   - a floating buoy (1) for floating on a water surface (69),
   - a reference (10,66) below the floating buoy (1), anchored to a sea floor (65),
   - a connection means (20) between the floating buoy (1) and the reference (10,66), and
   - a power transforming means (30) to transform the relative movement between the floating buoy (1) and the reference (10,66) into useful power.

2. The plant of claim 1, wherein the reference is a reference buoy (10) whose buoyancy or specific gravity is controlled by its average distance from the floating buoy (1).
3. The plant of claim 1, wherein the reference is an anchor block (66) anchored in the sea floor (65).

4. The plant of one of claims 1 to 3, wherein the specific gravity of the floating buoy (1) is controlled by average wave height, preferably by a central controller (48).

5. The plant of one of claims 1-4, wherein a weight (21) is attached to the connection means (20) close to or at its lower end.

6. The plant of one of claims 1 to 5, wherein the power transforming means comprises a linear electrical generator.

7. The plant of one of claims 1 to 6, comprising a plurality of transforming units (49) which are aligned along a coast line (50) and outlets (36) of the power transforming means (30) are connected together.

8. The plant of claim 7, wherein the power transforming means comprise a pump (30) in each transforming unit (49) with a pump outlet (36), the outlets (36) being connected to a collection pipe (37) which is connected to a hydro motor (51), preferably via a storage lake (53), which drives a generator (52).

9. The plant of claim 8, wherein a desalination plant (80) is arranged between the collection pipe (37) and the hydro motor (51), and wherein a bypass (94) with a bypass valve (93) is provided parallel to the desalination plant (80) between the collection pipe.
10. The plant of claim 8 or 9, wherein a pressure in the collection pipe (37) is controlled by average wave height.

11. The plant of one of claims 8 to 10, wherein a first row (62) of larger floating buoys (1) is arranged off the coast line (50) and at least one further row (63) of smaller floating buoys (60) is arranged closer to the coast line (50).
A. CLASSIFICATION OF SUBJECT MATTER

According to International Patent Classification (IPC) or to both national classification and IPC:

INV. F03B13/18

B. REGDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols):

F03B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched:

Electronic data base consulted during the international search (name of data base and, where practical, search terms used):

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Name and mailing address of the ISA:

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