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(54) Title: WAVE POWER PLANT

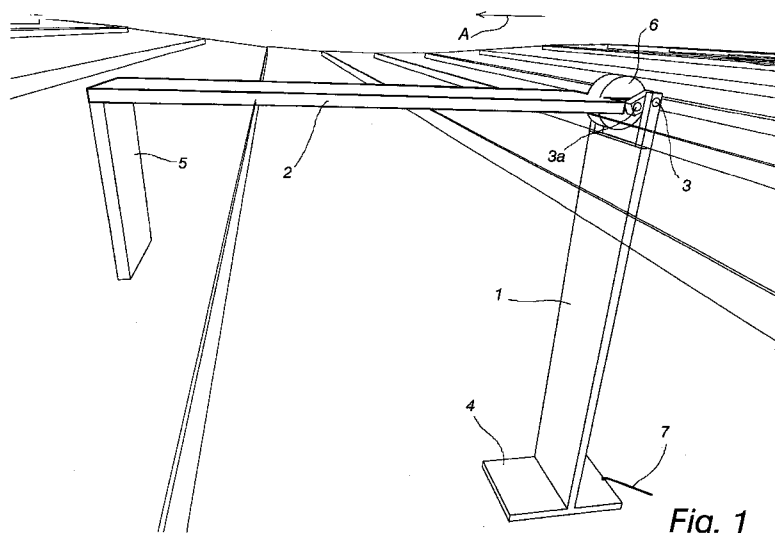


Fig. 1

(57) Abstract: The invention relates to a wave power plant, comprising two frame elements with a limited movement relative to each other. Frame elements (1, 2) are interconnected by a crankshaft (3). The first frame element (1) is vertical and has its bottom portion provided with a heavy horizontal flange (4) or some other form part, which opposes the up-and-down movement, and its top portion is flat and perpendicular to an incoming wave direction (A). The second frame element (2) is floating in a horizontal position and provided with a flange or fin (5) or some other form part, which is present at a distance from the crankshaft (3) and which is crosswise to the incoming direction (A) of waves. The crankshaft's (3) rotary motion is synchronic with a substantial wave period, whereby the power plant operates in a resonating manner.

Wave power plant

The invention relates to a wave power plant, comprising two frame elements with a limited movement relative to each other.

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In prior known wave power plants, it has been difficult or impossible to convert the movement of waves into continuous rotary motion with a high efficiency. This conversion is particularly hampered by the irregular motion and varying size of waves.

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An object of the invention is to provide a new type of wave power plant, wherein the pendular movement of waves can be converted with a high efficiency directly into continuous rotary motion.

15 This object is achieved by the invention essentially on the basis of the characterizing features presented in the appended claim 1. Preferred embodiments of the invention are presented in the dependent claims.

One exemplary embodiment of the invention will now be described more
20 closely with reference to the accompanying drawing, in which

Fig. 1 is a perspective side view, showing a wave power plant according to one preferred embodiment of the invention, and

25 Fig. 2 shows a crankshaft area of the same wave power plant in a larger scale.

The wave power plant of the invention is an apparatus, which utilizes ocean waves and converts the energy of waves into electrical energy or mechanical
30 energy. The wave power plant converts the movement of a wave directly into rotary motion.

The wave power plant consists of two frame elements 1, 2 and a crankshaft 3 interconnecting the two. From the crankshaft 3 is derived a power takeoff over a gear to a desired apparatus. The crankshaft 3 can also have a generator 6 mounted directly thereon.

5

The vertical underwater frame element 1 of the power plant has a depth which is approximately a half of the average wavelength in the area. The frame element 1 has its bottom portion provided with a heavy horizontal plate or flange 4 or some other form part, which opposes the up-and-down
10 movement. The number of plates or flanges 4 can be more than one and the shape thereof can be other than planar, e.g. the shape of a spherical cap, which has a different drag in opposite directions. If desired, it is also possible to employ a shape diverting the flow sideways for providing a lateral component force. A top portion of the frame element 1 is flat and perpendicular to
15 an incoming wave direction A. The frame element's 1 top portion has a function of following the horizontal movement of a wave. A total mass of the vertical frame 1, including that of the flange 4, is equal to a combined buoyancy of the vertical frame 1 and the flange 4.

20 The vertical frame 1 is connected at its top end to the power plant's floating horizontal frame element 2 by means of a crankshaft 3 which is crosswise to the incoming direction of waves.

The horizontal frame element 2 has also a length which about a half or less
25 of the typical wavelength. Its end opposite to the crankshaft is provided with a vertical fin or flange 5, which is crosswise to the incoming wave direction A and extends from the frame element 2 downward over a substantial distance to below the water surface. Naturally, the number of fins or flanges 5 can be more than one and the shape thereof can be other than planar, e.g.
30 the shape of a spherical cap, which has a different drag in opposite directions. If desired, it is also possible to employ a shape diverting the flow sideways for providing a lateral component force. The fin or flange 5 pushes

the frame element 2 in a direction opposite to the vertical frame element 1, the wave at the fin or flange 5 being as a rule in the opposite phase with respect to the wave present at the vertical frame 1. By virtue of a buoyant force resulting from the alternating vertical motion of a wave, the horizontal
5 frame 2 has its crankshaft 3 side end moving up and down at an averagely quarter-cycle phase difference relative to the horizontal movement.

By virtue of this assembly, the crankshaft 3 develops vertical and horizontal reciprocating forces, which by virtue of their phase difference set the crank-
10 shaft in rotating motion. The rotating motion is synchronic according to a substantial wave. As a result, the wave power plant is resonant according to a substantial wave frequency, thus improving efficiency. The distance between the crankshaft 3 bearing lines is less than a half of the extent of wave movement, for example 20-60% thereof. Because the crankshaft, as a result
15 of its dimensions, does not allow a full scale movement, the crankshaft 3 shall develop a major rotating force.

In an alternative embodiment of the invention, the distance between the crankshaft 3 bearing lines can be in such a way permanent that the crank-
20 shaft 3 can be set at a desired stroke. The distance between crankshaft bearing lines may also adjust by a spring, either against a spring force or by means of a spring force. The necessary adjustment mechanisms and/or springs can be included in bracket members 3a present between the bearing lines. The crankshaft 3 can be implemented in many ways in a single- or
25 multi-piece component. What is essential is its ability to allow for the mutually adjacent ends of the frame elements 1, 2 to perform limited rotating motions which at the same time rotate the crankshaft 3.

The power plant is anchored securely to the seabed by means of a mooring
30 cable 7, which is coupled to the vertical frame's 1 bottom end and which also carries therewith an electrical cable leading to mainland. The apparatus is

floating and finds a proper orientation for itself with the assistance of a surface flow generated by wind and swell.

5 The flange or fin 5 of the horizontal frame element 2 can be heavier than the amount of water displaced thereby, but the buoyant force of the horizontal frame element 2 prevents it from sinking. The buoyant forces of the frame elements 1, 2 are preferably rated in such a way that in calm water the crankshaft 3 bearing lines settle at a substantially common level. The crankshaft can be located partly or completely above the water level during operation.
10 tion.

The power takeoff is implemented by means of an axle rotating on one of the crankshaft 3 bearing lines.

15 The flange or fin 5 of the horizontal frame element 2 can be adjustable in terms of its distance from the crankshaft 3. The flange 4 of the vertical frame element 1 can also be adjustable in terms of its distance from the crankshaft 3. As a result, the apparatus can be readily modified for optimal function in diverse wind and swell conditions.

20

The wave power plant includes preferably a computer-controlled RPM stabilizer for the crankshaft 3. A wide-range fluctuation of the crankshaft's 3 rotating speed in some swell conditions can be a problem. A large wave generates a rush which can be in a wrong phase with respect to the crankshaft's position and the next wave. The computer-controlled RPM stabilizer monitors
25 the crankshaft's rotating speed and allows for its variation within a set range, for example not more than 5%/cycle. If the rotating speed endeavors to increase faster than what has been set, the automatics shall increase the resistance of a generator. If the RPM endeavors to decrease faster than what has been set, the resistance of a generator 6 shall be reduced or the crankshaft's
30 3 rotating speed shall even be increased by feeding energy into the generator.

By virtue of the rotating speed stabilizing system, the rotation of the power plant's rotating parts is smoother and more continuous. Stoppages do not occur and thus the energy output is also increased.

- 5 Alternatively or additionally, it is also possible to employ a flywheel as an RPM stabilizer. A massive, fast-rotating flywheel linked to the crankshaft by way of an increasing gear can be used as a stabilizer for RPM fluctuations the same way as the above-mentioned computer-controlled RPM stabilizer. The generator 6 can be connected to the flywheel, which can be present in the
- 10 same housing along with the generator 6. The increasing gear can be continuously variable and the adjustment of gear ratio can be handled by automatics so as to achieve a sufficient RPM equalization for the crankshaft 3.

- It is also preferred that the crankshaft's 3 phase angle in relation to a swell-
- 15 generated movement of the frame elements be also optimized by means of computer control. The computer-controlled phase angle optimizer is a system, which monitors the crankshaft's phase angle with respect to movements, accelerations and forces between the frame elements and which strives to maintain the phase angle averagely at an optimum. From the
- 20 standpoint of energy yield, the most desirable condition would be reached if the ends of the frame elements in the vicinity of the axle lines should tend to move in a direction substantially perpendicular to a plane extending through the axle lines. In this condition, the crankshaft's 3 torque moment is at its maximum. The computer-controlled phase angle optimizer may also receive
- 25 advance information about an incoming wave from a wave height or acceleration measuring buoy/sensor placed at a specified distance in front of the apparatus in the incoming direction of a wave.

- All of the described functions are related to the crankshaft's 3 rotation generated by the movements of frame elements, such that said functions either
- 30 promote the wave-generated movement of frame elements or independently convert the movement of waves into the movement of frame elements, the

latter being in turn useful for rotating the crankshaft 3. Accordingly, various combinations of the presented functions are plausible or all of the functions can be utilized in a single floating power plant. The described functions enable providing a stably mobile and high-yield power plant.

5

The power plant can be provided with a desired performance by selecting a breadth appropriate therefor. The length, depth and the crankshaft's 3 measurements for the apparatus are determined by typical wave dimensions in a particular region. Naturally, a plurality of power plants can be arranged in parallel and in succession.

10

Claims

1. A wave power plant, comprising two frame elements with a limited movement relative to each other, **characterized** in that the frame elements (1,
5 2) are interconnected by a crankshaft (3), that the first frame element (1) is vertical and has its bottom portion provided with a heavy horizontal flange (4) or some other form part, which opposes the up-and-down movement, and its top portion is flat and perpendicular to an incoming wave direction (A), and that the second frame element (2) is floating in a horizontal position
10 and provided with a flange or fin (5) or some other form part, which is present at a distance from the crankshaft (3) and which is crosswise to the incoming direction (A) of waves.
2. A wave power plant as set forth in claim 1, **characterized** in that the distance between the bearing lines of the crankshaft (3) is adjustable or adjusts
15 against a spring force or by means of a spring force.
3. A wave power plant as set forth in claim 1 or 2, **characterized** in that the distance of the crankshaft (3) from the flange or fin (5) of the horizontal
20 frame element (2) is about a half of the typical wavelength.
4. A wave power plant as set forth in any of claims 1-3, **characterized** in that the distance of the crankshaft (3) from the flange (4) of the vertical frame element (1) is about a half or less than a half of the length of a typical
25 wave.
5. A wave power plant as set forth in any of claims 1-4, **characterized** in that the vertical frame element (1) and the flange (4) associated therewith have a total buoyant force which is substantially equal to the combined mass
30 thereof.

6. A wave power plant as set forth in any of claims 1-5, **characterized** in that the flange or fin (5) of the horizontal frame element (2) is heavier than the amount of water displaced thereby, but the buoyant force of the horizontal frame element (2) prevents it from sinking.

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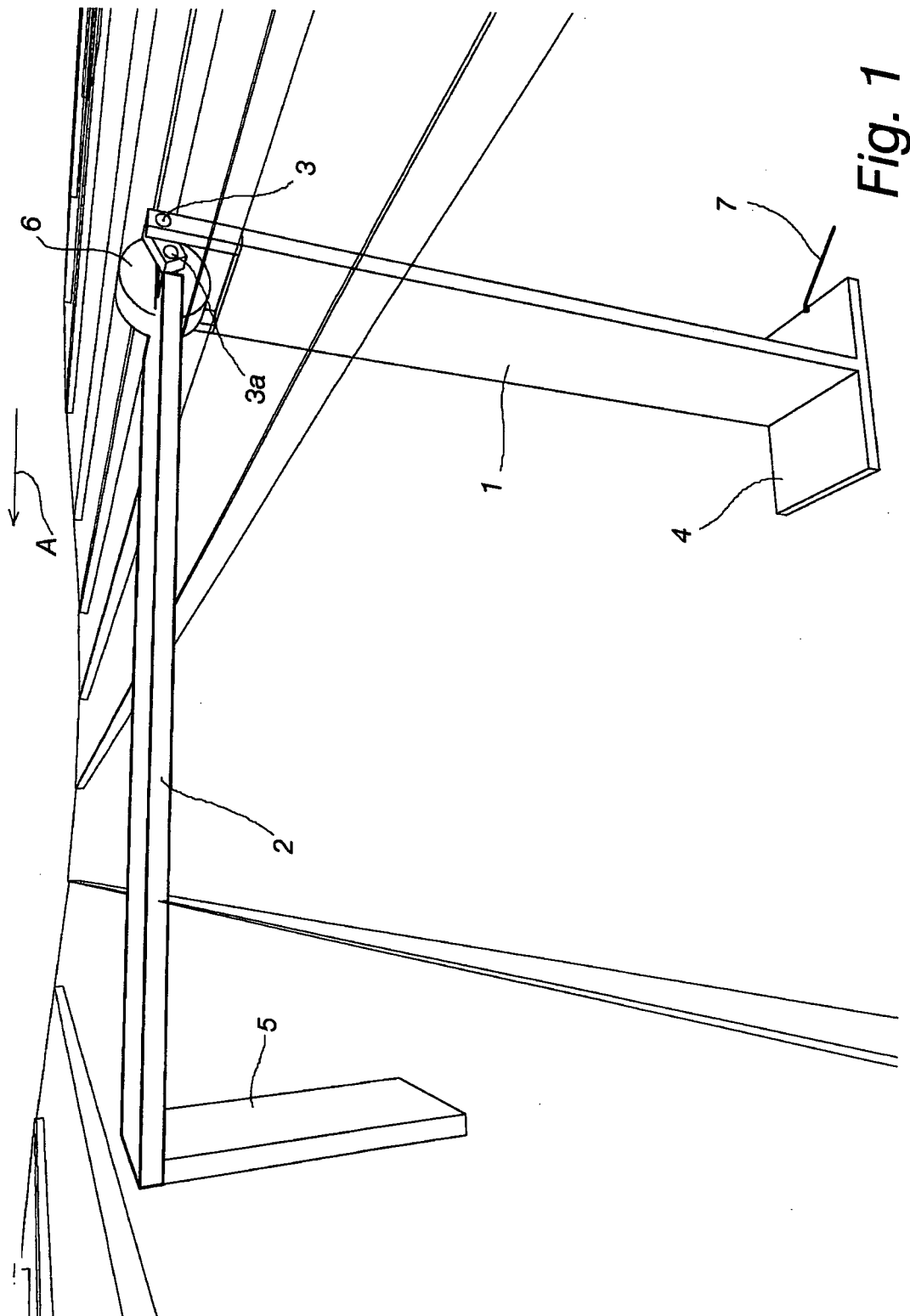
7. A wave power plant as set forth in any of claims 1-6, **characterized** in that the power takeoff is implemented by means of an axle rotating on one of the crankshaft (3) bearing lines.

10 8. A wave power plant as set forth in any of claims 1-7, **characterized** in that the flange or fin (5) of the horizontal frame element (2) is adjustable in terms of its distance from the crankshaft (3).

15 9. A wave power plant as set forth in any of claims 1-8, **characterized** in that the flange (4) of the vertical frame element (1) is adjustable in terms of its distance from the crankshaft (3).

20 10. A wave power plant as set forth in any of claims 1-9, **characterized** in that the crankshaft's (3) rotary motion is synchronic with a substantial wave period, whereby the power plant operates in a resonating manner.

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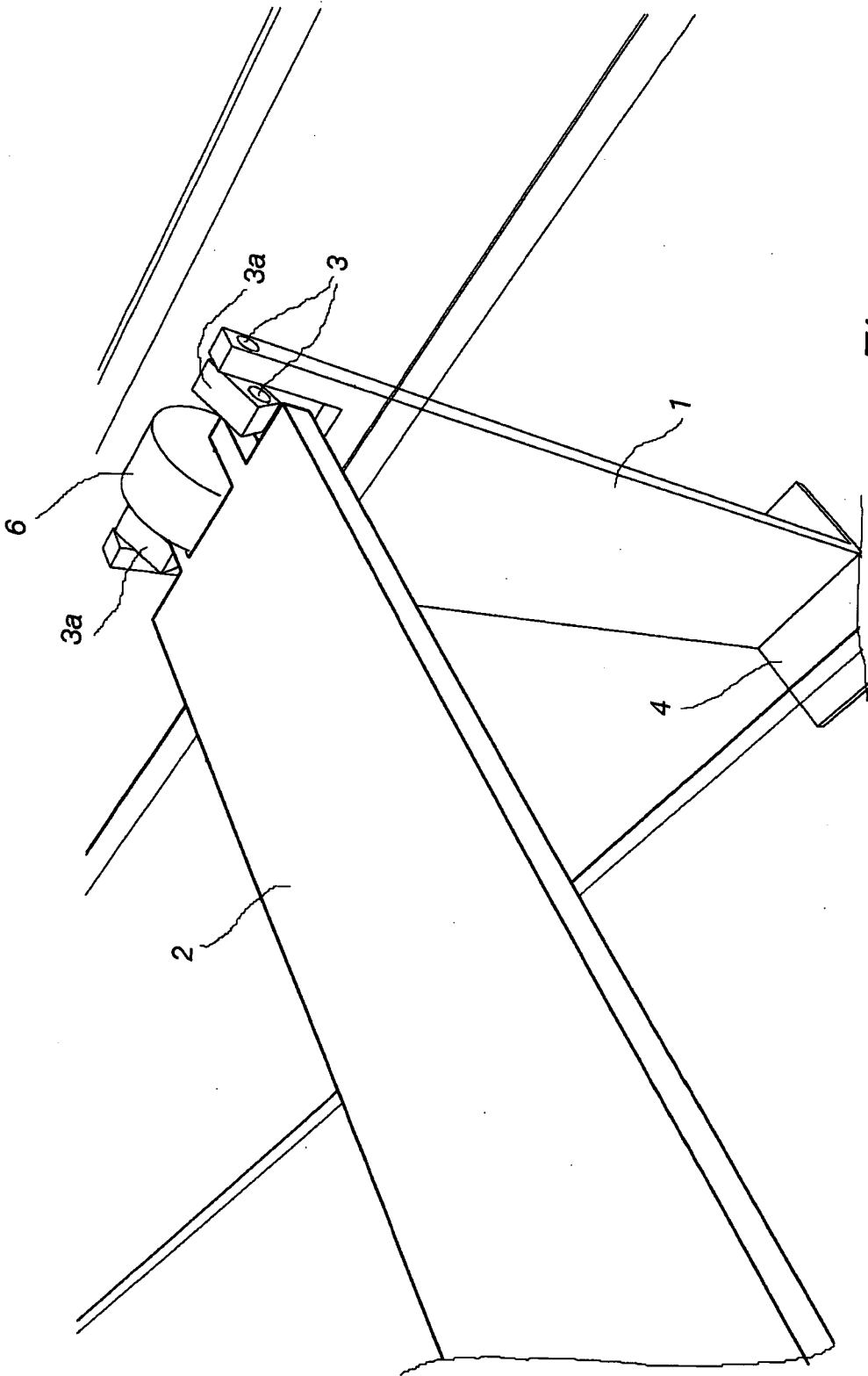


Fig. 2

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI2009/050777

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: F03B

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

FI, SE, NO, DK

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

EPO-INTERNAL, WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2008063086 A2 (IND RES LTD et al.) 29 May 2008 (29.05.2008) page 16, lines 28-30; page 19, lines 20-21; page 21, lines 4-18; page 33, lines 24-27; page 36, line 12 - page 39, line 11; figures 2b, 3b, 8a-8e	1-10

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

17 December 2009 (17.12.2009)

Date of mailing of the international search report

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INTERNATIONAL SEARCH REPORT

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CLASSIFICATION OF SUBJECT MATTER

Int.Cl.

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