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(54) **LIQUID CIRCULATION SYSTEM AND LIQUID COOLING SYSTEM THEREWITH**

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(57) **ABSTRACT**

A pump equipped with an impeller having a plurality of vanes is installed through a packing at an opening section formed on a wall surface of one of components in a liquid circulation passage, such as a radiator so that the impeller of the pump section may be disposed herein. Inside the component, there is provided a partition plate formed with a hole at such a position as to face the center of the impeller. A port is provided between a wall surface having the opening section and the partition plate. By the rotation of the impeller, a liquid flow is produced toward the port from the inside of the compartment through the hole.

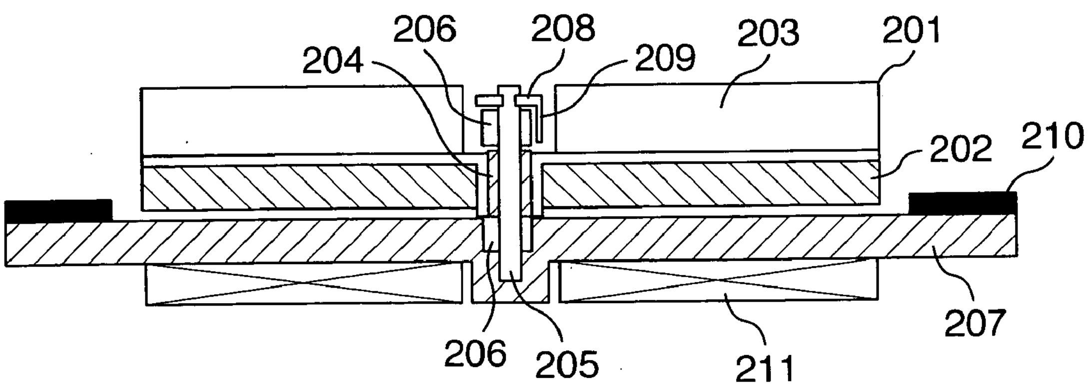


FIG.1

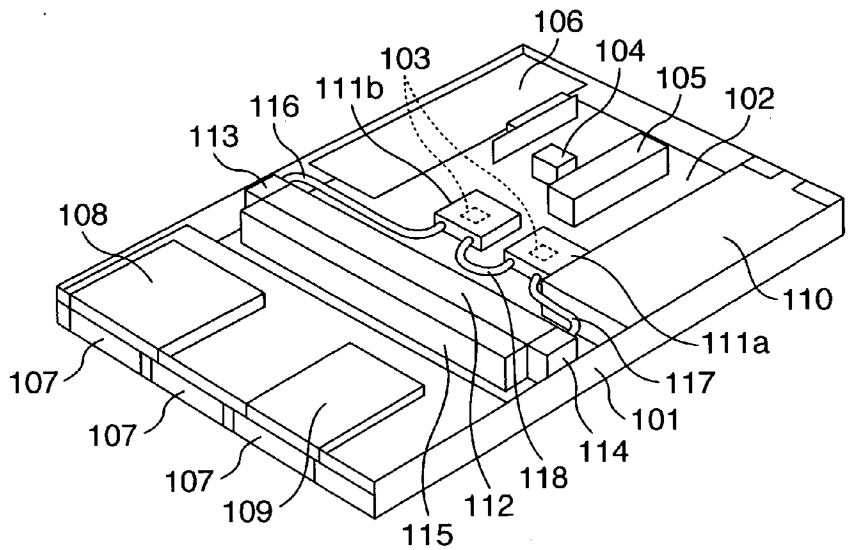

106
104
103
105
111b
116
102
113
108
110
111a
117
107
107
101
114
118
107
112
109
115

FIG.2

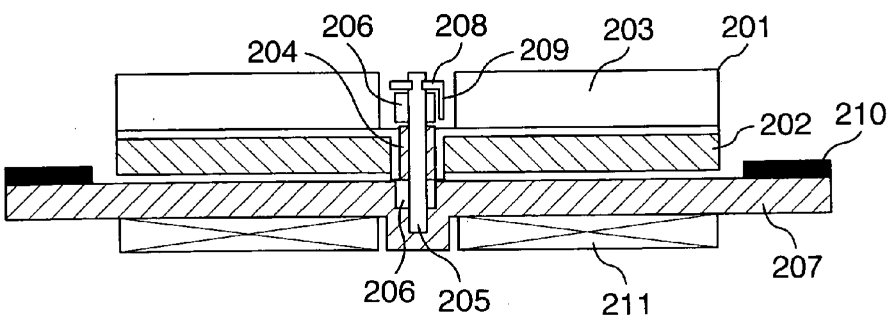

206
208
203
201
204
209
202
210
207
206
205
211

FIG.3

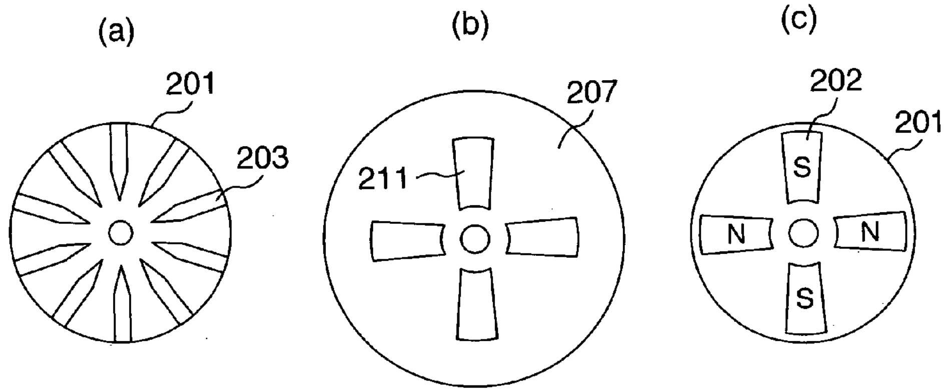

(a)
201
203
(b)
207
211
(c)
202
201
S
N
N
S

FIG.4

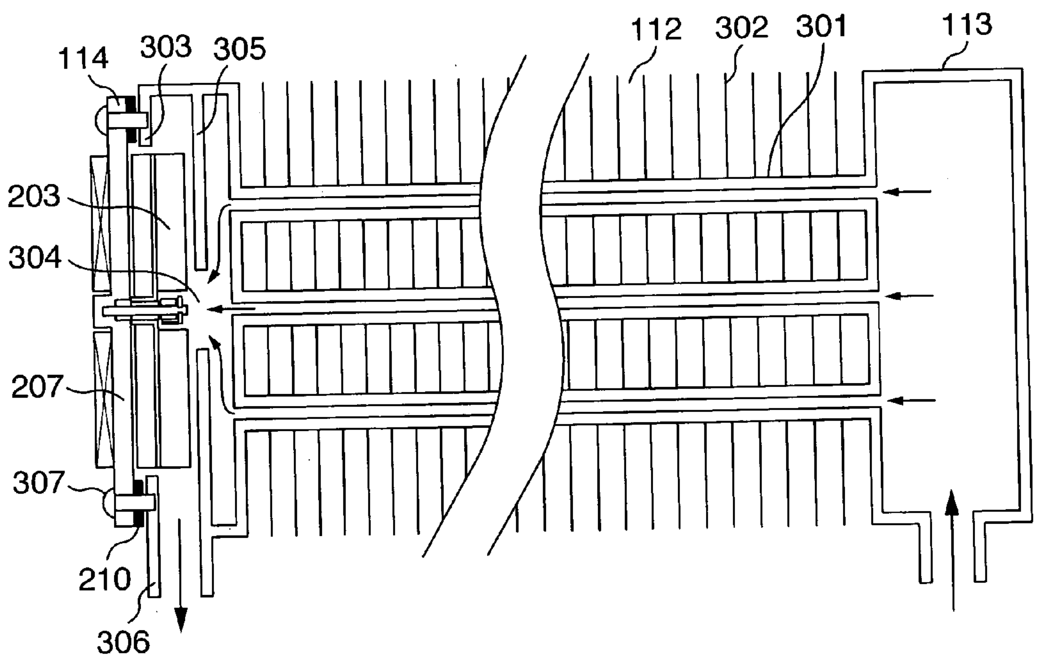

114
303
305
112
302
301
113
203
304
207
307
210
306

FIG.5

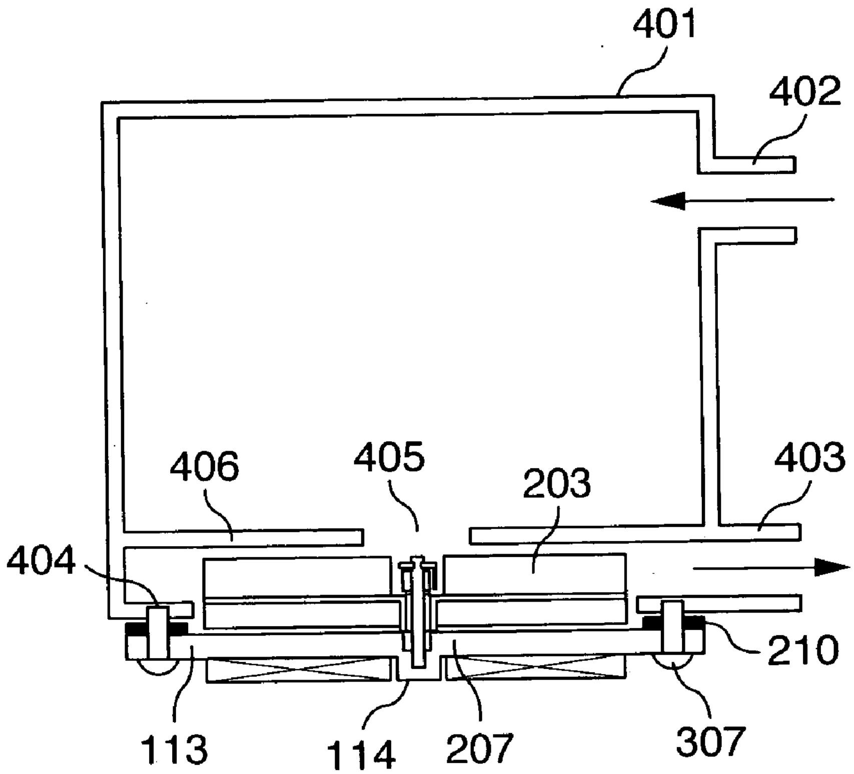


FIG.6

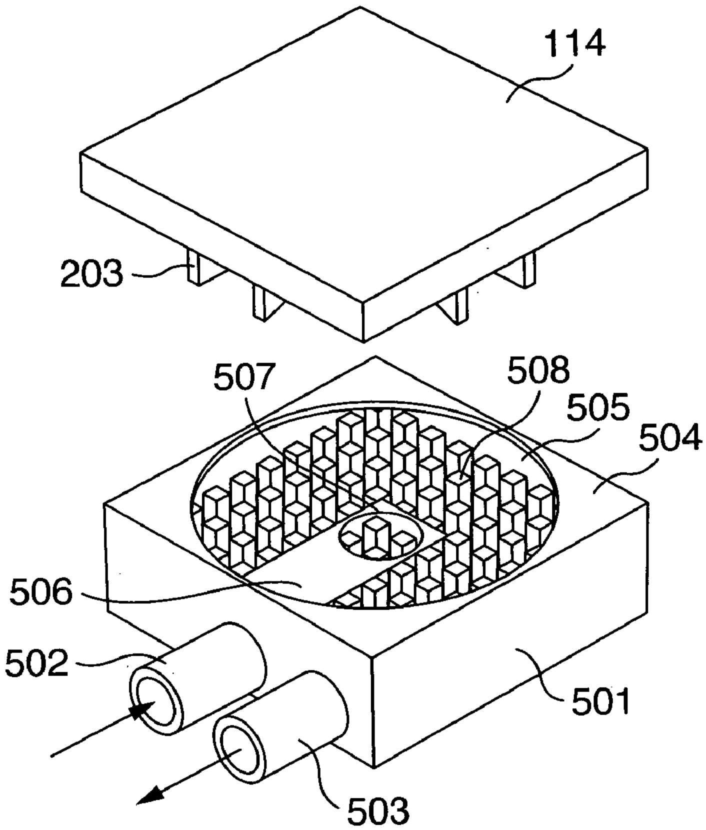
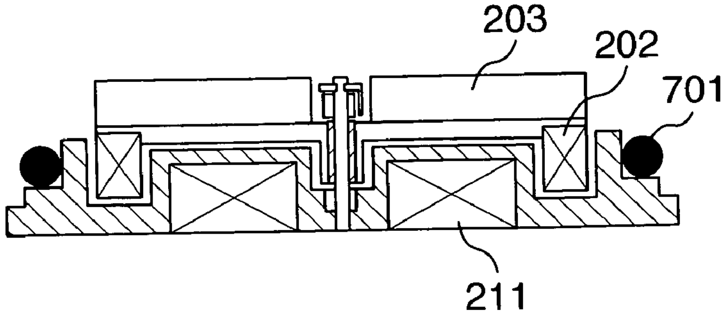



FIG.7



# LIQUID CIRCULATION SYSTEM AND LIQUID COOLING SYSTEM THEREWITH

## INCORPORATION BY REFERENCE

[0001] The present application claims priority from Japanese application JP2004-214574 filed on Jul. 22, 2004, the content of which is hereby incorporated by reference into this application.

## BACKGROUND OF THE INVENTION

[0002] The invention relates to a liquid circulation system for circulating liquid using a pump and a liquid cooling system therewith, and more particularly to a liquid circulation system equipped with a pump capable of being miniaturized and a mounting structure thereof, and a liquid cooling system therewith.

## PRIOR ART

[0003] The increasing speed of a device and an integrated circuit used in a personal computer, a server or the like, especially a CPU has been recently much-needed, which has been increasing heating value.

[0004] The present mainstream of cooling a CPU is a direct air-cooling system for spraying cooling air to a heat sink by fixing the heat sink on the CPU and mounting a fan on it. However, cooling by means of the direct air-cooling system restricts a space around the CPU due to high-density conversion of an apparatus, as well as the size of the heat sink, thus restricting cooling capacity and fan size. To obtain high air volume, this needs to rotate a small-sized fan at a high speed, which leads to increasing noise.

[0005] For utilization of a large-sized heat sink and a large-sized fan with high efficiency, attempts have been made to apply a heat transport system such as a liquid cooling system. However, the conventional liquid cooling system is constituted of a larger amount of parts than an air cooling system, which causes difficult miniaturization and needs reduction in the number of parts and size.

[0006] As a related art capable of miniaturizing the liquid cooling system, for example, an art disclosed in JP-A-2004-92610 is known. This related art relates to miniaturization of a pump and uses a small-sized impeller.

[0007] As another related art, for example, an art disclosed in JP-A-2003-343492 is known. This related art, a centrifugal pump being slimmed, constitutes a pump from a slim impeller and a small-sized port.

[0008] As a further related art, an art disclosed in JP-A-2004-47921, which miniaturizes a liquid cooling system by integrating a pump with a cooling jacket, is used.

## SUMMARY OF THE INVENTION

[0009] The foregoing related art disclosed in JP-A-2004-92610 has a problem that a small-sized impeller cannot increase a flow rate because efficiency is lower than that of a large-sized impeller. In the foregoing related art disclosed in JP-A-2003-343492, its centrifugal pump has a characteristic that its open flow rate is higher and static pressure is lower than that of one of other systems, for example, a piston pump. The related art using a small-diameter port has a problem that the flow rate of coolant becomes lower, especially in using coolant with high viscosity. Moreover, the art disclosed in JP-A-2004-47921 has a problem that the shape of a pump case must be specialized in accordance with the shape of an object to be cooled because part of a pump casing becomes a heat receiving surface, which leads to lost general versatility of a pump itself and difficult cost reduction by mass-production effect.

[0010] Any of the respective related arts relates to a liquid cooling system using a centrifugal pump. One of fundamental problems of the centrifugal pumps is that a liquid flow stops when air is mixed into an internal pump. The liquid flow stop is more apt to occur due to air mixing as the space of the internal pump is smaller.

[0011] A conventional liquid cooling system aimed at free maintenance has a problem of the permeability of coolant from a pump surface, namely, that coolant is lost while passing through a material constituting a pump case. This problem can be solved by using metal for a pump casing. However, if an impeller must be driven by magnetic force, metal cannot be, in practice, used for the case and polymer material is unavoidably used. A portion which is hardly associated with the magnetic force can use metal, which causes a problem that a cost increase occurs.

[0012] Accordingly, it is an object of the present invention to provide a liquid circulation system for circulating liquid using a pump and a liquid cooling system therewith, capable of solving the foregoing problems of conventional arts and the foregoing problem a centrifugal pump has, reducing the number of parts, and being miniaturized.

[0013] To achieve the aforementioned object, a liquid circulation system of the present invention, circulating liquid with a pump equipped with an impeller having a plurality of vanes, is structured as follows: the pump is installed through a liquid sealing mechanism on an opening section formed in a wall for a component in a liquid circulation passage so that the impeller in the pump may be disposed inside the component, a partition plate formed with a hole at such a position as to face the center of the impeller, a port is formed between a wall surface having the opening section and the partition plate, thereby generating a liquid flow in the direction of the port through the hole from the inside of the component by the rotation of the impeller.

[0014] In the foregoing structure, the pump equipped with the impeller comprises a shaft inserting through the center of the rotating shaft of the impeller, a wall for vertically supporting the shaft, permanent magnets mounted on the impeller, and electromagnets, which are respectively fitted on a surface on the opposite side to the impeller, sandwiching the wall to drive the rotation of the impeller.

[0015] The aforementioned object can be achieved by using the foregoing liquid circulating system in addition to a liquid cooling system having a component for performing heat exchange, a component for holding coolant, and a component which is brought into contact with a heat generating member and cools the heat generating member.

[0016] Accordingly, the present invention can miniaturize a liquid circulation system and minimize pressure drop loss in piping.

[0017] Other objects, features and advantages of the invention will become apparent from the following description of the embodiments of the invention taken in conjunction with the accompanying drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

[0018] **FIG. 1** is a perspective view illustrating an example of a configuration of an electronic device to which a liquid cooling system is applied according to an embodiment of the present invention;

[0019] **FIG. 2** is a sectional view illustrating a configuration of a pump section used according to one embodiment of the present invention;

[0020] **FIG. 3** is an explanatory view illustrating shapes of an impeller and vanes constituting a pump section, arrangement of electromagnets, and arrangement of permanent magnets;

[0021] **FIG. 4** is a sectional view illustrating a configuration of a liquid cooling system according to a first embodiment of the present invention;

[0022] **FIG. 5** is a sectional view illustrating a configuration of a liquid cooling system according to a second embodiment;

[0023] **FIG. 6** is a sectional view illustrating a configuration of a liquid cooling system according to a third embodiment; and

[0024] **FIG. 7** is a sectional view illustrating another configuration of a pump section used according to an embodiment of the present invention.

[0025] Reference will now be made in detail to embodiments of the present invention, examples of which are illustrated in the accompanying drawings. However, this does not limit the present invention.

## PREFERRED EMBODIMENTS OF THE INVENTION

### First Embodiment

[0026] **FIG. 1** is a perspective view illustrating an example of a configuration of an electronic device to which a liquid cooling system is applied according to an embodiment of the present invention, where a reference symbol **101** is a casing, a reference symbol **102** is a mother board, a reference symbol **103** is a CPU, a reference symbol **104** is a chip set, a reference symbol **105** is a memory, a reference symbol **106** is a PCI board, a reference symbol **107** is a HDD, a reference symbol **108** is a CD-ROM, a reference symbol **109** is FDD, a reference symbol **110** is a power supply unit, reference symbols **111***a*, **111***b* are jackets, a reference symbol **112** is a radiator, a reference symbol **113** is a tank section, a reference symbol **114** is a pump section, a reference symbol **115** is a fan, and reference symbols **116** to **118** are tubes. The electronic device illustrated in **FIG. 1** is an approx. 44.4 high slim server, that is, a 1U server as an example.

[0027] The server as the electronic device illustrated in **FIG. 1** is constituted by mounting the CPU **103**, the chip set **104**, the memory **105**, and the PCI board **106** on the mother board **102** provided inside the casing **101**. As an external storage, the HDD **107**, the CD-ROM **108**, and the FDD **109** are mounted ahead, and the power supply unit **110** is mounted on the rear side of the casing **101**.

[0028] The liquid cooling system provided on the server is constituted of the radiator **112** fitted with the fan **115**, the tank section **113** provided at its one end, the pump section **114** provided at the other end, jackets **111***a*, **111***b* mounted on the two CPUs **103**, the tube **118** for making a connection between the jackets, the tube **116** for connecting the jacket **111***b* with the tank section **113**, the tube **117** for connecting the jacket **111***a* with the pump section **114**, and coolant circulating inside the tube **117**. As the coolant, it is sufficient to use a mixture of ethylene glycol or propylene glycol and water. A mixture prepared by mixing ethylene glycol or propylene glycol with water at the rate of approx. 30% to water may be used.

[0029] The jackets **111***a* and **111***b* of the liquid cooling system are respectively mounted on the CPUs **103** and absorb heat from the CPUs **103**. Specifically, the jackets **111***a*, **111***b* are formed out of metal with high heat transfer such as copper or aluminum. Contact surfaces between the jackets **111***a*, **111***b* and the CPU **103** are crimped with thermal compound, silicon rubber with high heat transfer or the like sandwiched therebetween so that the heat generated by the CPU **103** may be transferred to the jacket with high efficiency. The coolant passes through the inside of each of the jackets **111***a*, **111***b*, and heat from the CPU **103** is transferred to the coolant and carried to the radiator **112**.

[0030] The radiator **112** for cooling coolant is provided with the tank section **113** for storing coolant and the pump section **114** for generating a liquid flow. The configuration of the radiator **112** having the pump section **114** is described below. The radiator **112** is attached with the fan **115**, and wind is sent to the radiator **112**.

[0031] As described earlier, piping of the liquid cooling system is formed out of the tubes **116** to **118**. The tube **116** connects the jacket **111***b* with the tank section **113**, the tube **117** connects the pump section **114** with the jacket **111***a*, and the tube **118** connects the jacket **111***a* with the jacket **111***b*.

[0032] The order of a coolant flow according to this embodiment is as follows: pump section **114**→jacket **111***a*→jacket **111***b*→tank section **113**→radiator **112**→pump section **114** (again). By passing the coolant cooled by the radiator **112** through the pump section **114** in this way, the pump section **114** can be prevented from being overheated.

[0033] **FIG. 2** is a sectional view illustrating a configuration of a pump section **114** in **FIG. 1**, **FIG. 3** is an explanatory view illustrating shapes of an impeller and vanes constituting a pump section **114**, arrangement of electromagnets, and arrangement of permanent magnets, and **FIG. 4** is a sectional view illustrating a configuration of a liquid cooling system according to an embodiment. The liquid cooling system illustrated in **FIG. 4** is constituted by installing the pump section **114** on the radiator **112**. FIGS. **2** to **4**, a reference symbol **201** is an impeller, a reference symbol **202** is a permanent magnet, a reference symbol **203** is a vane, a reference symbol **204** is a bearing, a reference symbol **205** is a shaft, a reference symbol **206** is a washer, a reference symbol **207** is a bottom wall, a reference symbol **208** is a stopper, a reference symbol **209** is a bent section, a reference symbol **210** is a packing, a reference symbol **211** is an electromagnet, a reference symbol **301** is a passage, a reference symbol **302** is a fin, a reference symbol **303** is a wall surface, a reference symbol **304** is a hole, a reference symbol **305** is a partition plate, a reference symbol **306** is a port and a reference symbol **307** is a screw, and other symbols are the same as in **FIG. 1**.

[**0034**] The pump section **114** is constituted as a centrifugal pump formed integrally with a motor and, as illustrated in **FIG. 2**, the pump section **114** consists of the impeller **201** having the permanent magnets **202** and the vane **203**, the bottom wall **207** for supporting the impeller **201**, and the electromagnets **211** mounted on the bottom wall **207**. The impeller **201** includes a plurality of permanent magnets **202** as illustrated in **FIG. 3** (*a*) and **FIG. 3** (*c*), and the plurality of vanes **203**. The bearing **204** is in the center of the impeller **201**, and the shaft **205** penetrates through the bearing **204**. The shaft **205** which penetrates through the inside of the bearing **204** is formed with the two washers **206** at the top and bottom thereof. The bottom washer **206** has a notched shape and is embedded to be fixed in the bottom wall **207**. On the other hand, the top washer **206** is constituted so as not to be rotated by the bent section **209** of the stopper **208**.

[**0035**] The bearing **204**, the shaft **205**, and the washer **206** may be formed out of a material with excellent wear resistance, such as ceramic. The bearing **204** is set so as to be brought into contact with the top and bottom washers **206**, therefore contact surfaces thereof rub with each other while the impeller **201** is rotating, however, these parts have excellent wear resistance, thus exhibiting long service life.

[**0036**] On the bottom wall **207** supporting the shaft, the packing **210** is provided at a surface on the same side as the surface on which the impeller **201** is installed, and electromagnets **211** are provided at the opposite surface. A motor for driving the rotation of the impeller **201** is formed out of the electromagnets **211** provided on the bottom plate **207** and the permanents magnets **202** provided on the impeller **201**. The electromagnets **211** provided on the bottom plate **207**, as illustrated in **FIG. 3** (*b*), is constituted of a plurality of coils producing a magnetic force in such a direction as to vertically penetrate through the bottom wall **207**, and the permanents magnets **202** provided on the impeller **201** similarly, as shown in **FIG. 3** (*c*), is a plurality of permanents magnets for generating magnetic forces in a direction perpendicular to the bottom wall **207**, where the adjacent magnets are arranged so as to have reversed polarity each other.

[**0037**] The motor for rotating the impeller **201** is constituted of the permanent magnets **202** facing through the bottom plate **207** and the electromagnets **211**, therefore the bottom plate **207** requires use of a member made of a material capable of penetrating a magnetic force, and it may be formed out of hard plastic or the like.

[**0038**] The pump section **114** does not have a port or a casing for ensuring water tightness, which a conventional pump uses. The pump section **114**, being not used solely with only a structure illustrated in **FIG. 2**, can exhibit a function serving as a pump only by being installed other radiator, tank or the like. Referring now to **FIG. 4**, there is described an example of a configuration in which the pump section **114** illustrated in **FIG. 2** is installed on the radiator **112**. An arrow indicated in **FIG. 4** shows a flow of coolant.

[**0039**] The radiator **112** is constituted of piping forming a plurality of passages **301** and a great number of fins **302** mounted thereon. On the left and right thereof, the tank section **113** and the pump section **114** are installed, and each of them is connected with the passages **301**. The plurality of passages **301** are parallel, and the fins **302** are thermally jointed to the passages **301**, so that the heat of the coolant running through the passages **301** is transmitted to the fins **302**. The passages **301** and the fins **302** are formed so that the wind from the fan **115** may hit, where the heat of the coolant is cooled. The radiator section **112** is formed out of copper or aluminum with high thermal conductivity.

[**0040**] The tank section **113** stores a fixed amount of coolant to ensure long-term reliability of the liquid cooling system. The liquid cooling system includes some portions using a member causing water permeation such as a polymer member, from which water permeation occurs, thus gradually reducing liquid amount. The tank section generally requires to maintain a sufficient amount of liquid for endurance against long-term use, however, this embodiment requires a smaller amount of polymer material usage, thus causing reduction in water permeation amount. Therefore, a smaller-size tank than a conventional one may be used.

[**0041**] The side on which the pump section **114** of the radiator **112** is installed is constituted of the wall surface **303** with the hole, in which the pump section **114** is assembled. The vanes **203** of the pump section **114** are positioned on the inner side of the wall surface **303**. The pump section **114** is fixed on the wall surface **303** by a screw **307**. Between the wall surface **303** and the bottom wall **207** of the pump section **114**, the packing **210** exists, thus causing no liquid leakage. On the inside of the wall surface **303** with holes of the radiator **112**, there is provided a partition plate **305** with the hole **304** at a position approaching the impeller **201** of the pump section **114** installed on the wall surface **303** without contacting the impeller **201**. The hole **304** is formed so as to face the central portion of the impeller **201**. On the passage **301** side of the hole **304**, a room for guiding coolant collected from the plurality of passages **301** to the hole **304**. The port **306** is provided on the impeller side of the space partitioned by the partition plate **305**, that is, between the partition plate **305** and the wall surface **303**.

[**0042**] With the foregoing configuration, by driving the rotation of the impeller, the coolant passing through the passage **301** of the radiator **112** is sucked from the hole **304** formed on the partition plate **305** and flows out of the port **306**. The pump section **114** operates under a state assembled in the radiator **112** and can eliminate piping for connecting the pump section with the radiator, thus miniaturizing the liquid cooling system and further eliminating pressure loss due to piping. Specifically, a portion sucking liquid by negative pressure resulting from the rotation of the vanes **203** of the impeller **201** is the hole **304** on the partition plate **305**. The hole **304**, having no restrictions on its diameter, can be significantly enlarged, thus almost neglecting pressure loss.

[**0043**] In a conventional way, the pump section and the tank are structured so as to be connected with each other through piping. If large-diameter piping is used, a pump port itself is enlarged, thus upsizing the pump. If the pump needs downsizing, the port must be unavoidably reduced in diameter, thus causing lowering of flow rate due to pressure loss.

[**0044**] In a conventional way, water permeation occurs from the whole pump casing, while the pump section **114** according to this embodiment is half immersed in the metallic radiator **112**, therefore water permeation from the pump section **114** is limited to only a surface of the bottom wall **207**. The bottom wall **207** has a surface area not larger than the half of a conventional pump casing, thus achieving water permeation amount not larger than the half of a conventional one.

[**0045**] This embodiment can use the hole on the wall surface **303** installed with the pump section **114** as those for filling the liquid cooling system with liquid, and the pump section **114** as its lid. The hole on the wall surface **303** can facilitate filling with liquid because the hole is much larger in diameter than piping.

[**0046**] In this embodiment, a case where the tank section **113** is installed on the radiator **112** is described, however, the present invention may individually constitute the tank section **113** as the radiator **112** for connection with piping.

Second Embodiment

[**0047**] **FIG. 5** is a sectional view illustrating a configuration of a liquid cooling system according to a second embodiment. Referring now to **FIG. 5**, the liquid cooling system according to this embodiment is described below. The liquid cooling system illustrated in **FIG. 5** is constructed by installing a pump section on an independent tank section. In **FIG. 5**, a reference symbol **401** is a tank, reference symbols **402**, **403** are ports, a reference symbol **404** is a wall surface, a reference symbol **405** is a hole, and a reference symbol **406** is a partition plate. Other symbols are the same as in FIGS. **1** to **4**. An arrow indicated in **FIG. 5** shows a flow of coolant.

[**0048**] In **FIG. 5**, the tank **401** is made of metal, the bottom surface of the tank **401** has the holed wall surface **404** for mounting the pump section **114** thereon, where the pump section **114** is assembled. The vanes **203** of the pump section **114** are positioned inside the wall surface **404**. The pump section **114** is fixed on the wall surface **404** by the screw **307**. Between the wall surface **404** and the bottom wall **207** of the pump section **114**, the packing **210** is intervened, which prevents liquid from leaking. Inside the holed wall surface **404** of the tank **401**, the partition plate **406** with the hole **405** is provided at a such a close position as to come into no contact with the impeller **201** of the pump section **114** installed on the wall surface **404**. The hole **405** is formed so as to face the central portion of the impeller **201**, and is open directly to the coolant in the tank. On the impeller side of a space partitioned by the partition plate **406**, that is, between the partition plate **406** and the wall surface **404**, the outlet port **403** for coolant is formed and, on the top of the tank **401**, the inlet port **402** for coolant is formed.

[**0049**] With the foregoing configuration, when the rotation of the impeller **201** is driven, the coolant in the tank **401** is sucked from the hole **405** formed on the partition plate **406** and flows out of the outlet port **403**. The pump section **114** operates in such a state as to be assembled in the tank **401**, so that piping for connecting the pump section **114** with the tank **401** can be eliminated, thus achieving miniaturization of the liquid cooling system. Moreover, pressure loss due to piping can be also eliminated. Specifically, a portion which sucks liquid with negative pressure generated by the rotation of the vanes **203** of the impeller **201** is the hole **405** of the partition plate **406**. The diameter of the hole **406**, having no restrictions, can be set so as to be significantly large, thus setting pressure loss to a roughly negligible degree.

[**0050**] The coolant from the outlet port **403** flows in the order of the jacket and radiator and returns to the tank **401** from the inlet port **402**, which are not shown in **FIG. 5**.

[**0051**] In a conventional way, the pump section and the tank are structured so as to be connected with each other through piping. If large-diameter piping is used, a pump port itself is enlarged, thus upsizing the pump. If the pump needs downsizing, the port must be unavoidably reduced in diameter, thus causing lowering of flow rate due to pressure loss.

[**0052**] In the conventional way, water permeation occurs at the whole pump casing. On the other hand, the pump section **114** according to this embodiment, being half submerged in the metallic tank **401**, water permeation from the pump section **114** is restricted to only the surface of the bottom wall **207**. The bottom wall **207**, having a surface area not larger than a half as many as a conventional pump casing, can restrain water permeation to not larger than a half.

[**0053**] The hole on the wall surface **404** of the tank **401** installed with the pump section **114** can be used as a hole for filling the liquid cooling system with liquid, and the pump section **114** can be used as a lid. The hole on the wall surface **404** is far larger in diameter than piping, which can facilitate filling with liquid.

[**0054**] Moreover, a centrifugal pump generally has a problem of a liquid flow being stopped at the time of air mixing, which requires to discharge air at air mixing, but the conventional liquid cooling system, having high pressure loss because of piping connection, requires additional means of discharging air in the pump.

[**0055**] However, this embodiment can facilitate discharge of air in a pump. In other words, in the embodiment of the present invention illustrated in **FIG. 5**, if air gathers in the pump **114**, that is, if air gathers around the vanes **203** of the impeller **201** surrounded by the partition plate **406** and the wall surface **404**, it is sufficient only to stop the operation of the pump section **114**, by which the air leaks upwards through the hole **405**. In this way, this embodiment can facilitate discharge of air in the pump.

[**0056**] Stopping of a liquid flow occurs if air gathers around the vanes **203** of the impeller **201** and liquid amount in the space reduces. With this embodiment, a volume surrounding the vanes **203** of the impeller **201**, that is, a space around the vanes **203** of the impeller **201** surrounded by the partition plate **406** inside the tank **401** is part of the tank **401**, however, the size of the tank is generally larger than that of the pump, and this volume, namely, liquid amount is more than that of a conventional pump, therefore, the effect of air mixing is relieved, thus making it difficult to generate stopping of a liquid flow.

Third Embodiment

[**0057**] **FIG. 6** is a sectional view illustrating a configuration of a liquid cooling system according to a third embodiment. Referring to the drawing, a liquid cooling system according to this embodiment is described. The liquid cooling system illustrated in **FIG. 6** is constituted by integrating the pump section with a radiator. In **FIG. 6**, a reference symbol **501** is a jacket, reference symbols **502**, **503** are ports, a reference symbol **504** is a wall surface, a reference symbol **505** is a hole, a reference symbol **506** is a duct, a reference symbol **507** is an opening section, and a reference symbol **508** is a heat sink. Other symbols are the same as in **FIGS. 1 and 2**. An arrow indicated in **FIG. 6** shows a flow of coolant.

**[0058]** In **FIG. 6**, the jacket **501** is formed out of metal with excellent thermal conductivity, such as copper or aluminum. Onto the bottom surface of the jacket **501**, a heat generating body to be cooled such as a CPU is jointed through thermal conductivity grease or the like. On the side of the jacket **501**, there are provided an inlet port **502** and an outlet port **503** for coolant. Moreover, a top surface **504** is formed with the hole **505**. In the hole **505** on the top surface **504**, the pump section **114** is assembled, and the vanes **203** of an impeller are put inside the jacket. Although not illustrated, like other embodiments, the pump section **114** is fixed by screwing, and a packing is provided between the top surface **504** and the pump section **114**, thus preventing liquid leakage from between the jacket **501** and the pump section **114**.

**[0059]** The duct **506** is provided inside the jacket **501**. The duct **506** is part of covered so as to include the pin-shaped heat sink **508** in a grid pattern. The duct **506** is connected with the inlet port **502** and is formed with the opening section **507**. The opening section **507** is formed so as to face the central portion of the vane **203** of the impeller **201**. That is, the duct **506** functions as piping from the inlet port **502** to the central portion of the vane **203** of the impeller **201**. Therefore, when the vanes **203** of the impeller **201** are rotated, its central portion is kept at a negative pressure, so that the inlet port **502** functions as a suction opening. The heat sink **508** provided inside the jacket **501** is formed integrally with a surface in contact with a heat generating body, namely, the bottom surface of the jacket **501** and constituted so that the heat of the heat generating body may be transmitted. Hence, the heat transmitted to the heat sink **508** is cooled by bringing it into contact with coolant.

**[0060]** With the foregoing configuration, the liquid cooling system formed integrally with the jacket according to this embodiment provides higher thermal conductivity than a conventional jacket. Detailed description is made about the liquid cooling system as follows:

**[0061]** The coolant from the port **502** is sucked into the vanes **203** of the impeller **201** from the opening section **507** through the duct **506**. Because the heat sink **508** exists in the duct **506** as well, cooling is performed to some degree at this point. The coolant passing through the vanes **203** of the impeller **201**, while being agitating by the rotation of the vanes **203** of the impeller **201**, is hurled against the heat sink **508** except a portion covered with the duct **506** and then flows out from the outlet port **503** toward the tank and the radiator not illustrated.

**[0062]** The thermal conductivity becomes higher as the flow rate of coolant is higher or coolant is more collision jet flow. In this embodiment, rotation of the vanes **203** of the impeller **201** produces a revolving liquid flow inside the jacket, so that a collision jet flow occurs, being hurled against the heat sink **508**. Therefore, a jacket constituting a cooling system illustrated in **FIG. 6** has a more rapid internal liquid flow than a conventional jacket through which coolant just passes and produces a collision jet flow, thus achieving high thermal conductivity and cooling performance.

**[0063]** In **FIG. 6**, the pump **114** operates under a state where the pump section **114** is assembled into the jacket **501**. Accordingly, piping for connecting the pump can be eliminated, thus miniaturizing the liquid cooling system.

**[0064]** In this embodiment, the shape of the heat sink **508** is like a pin-shaped fin in a grid pattern, however, the fin is not limited to this shape, but may be of any type if an area in a contact with coolant is wide.

**[0065]** **FIG. 7** is a sectional view illustrating another configuration of the pump section **114**. In **FIG. 7**, a reference symbol **701** is an O-ring, and other symbols are the same as in **FIG. 2**.

**[0066]** The first to third embodiments describe that a packing is used to fill a clearance between a pump section and a component assembled with the pump section, however, as illustrated in **FIG. 7**, another way of sealing a clearance between a pump section and a component assembled with the pump section with an O-ring may be taken. A further another way, not illustrated herein, of a watertight structure by caulking may be used. Briefly speaking, it is sufficient to use a structure of filling a clearance between a pump section and a component assembled with the pump section.

**[0067]** A mounting structure of the permanent magnets **202** and the electromagnets **211** constituting the pump section **114** may be constituted, as illustrated in **FIG. 7**, by using the permanent magnets **202** of O-ring shape and embedding the electromagnets **211**. Moreover, a permanent magnet may be used for the whole impeller **201**. In short, it is sufficient to actualize a function of rotating the impeller **201**.

**[0068]** In the first to third embodiments, the features of a pump section producing a liquid flow is that the pump section consists of an impeller, a shaft, a wall vertically supporting the shaft, a wall for vertically supporting the shaft, and electromagnets positioned on a surface opposite to the impeller sandwiching the wall, and that the pump section can be constituted without need for using a port nor a casing ensuring watertightness found in a conventional pump. In addition to the foregoing features, a wall surface of a component in a liquid circulation passage has an opening section larger than the impeller size of the pump section, the pump section is assembled into the opening section, a liquid sealing structure is provided between a wall of the pump section and a wall surface of the component, and a partition plate is provided inside the component to convert the pressure generated by rotating the impeller into a liquid flow in a desired direction.

**[0069]** The pump section operates under a state assembled into a component in the liquid circulation passage, which eliminates piping for connecting a pump found in a conventional way, thus miniaturizing a liquid circulation system.

**[0070]** A partition plate as means of converting the pressure generated by rotation of the impeller into a liquid flow in a desired direction has a hole at a position corresponding to the central portion of the impeller. The hole is made to serve as a port of a suction opening of the impeller, and an outlet port is provided on the impeller side of a space partitioned by the partition plate.

**[0071]** Such a configuration can eliminate pressure loss generated between a pump section and a component of a liquid circulation system, thus increasing the flow rate of coolant. Moreover, a port formed on a partition plate of the component of the liquid circulation system is made to serve as a port for the pump section, thereby miniaturizing the liquid circulation system.

**[0072]** Furthermore, a shaft passing through the center of a rotating shaft of an impeller is equipped with a stopper, therefore even the absence of a casing around the impeller can prevent the impeller from coming off the shaft.

**[0073]** A liquid cooling system constituted by use of the liquid circulation system can perform heat transport with a liquid flow by means of the liquid circulation system. As components assembled with the pump section, a radiator, a jacket and tank are used, thus achieving miniaturization of the system and high cooling performance by flow rate increase.

**[0074]** It should be further understood by those skilled in the art that although the foregoing description has been made on embodiments of the invention, the invention is not limited thereto and various changes and modifications may be made without departing from the spirit of the invention and the scope of the appended claims.

**1**. A liquid circulation system which permits liquid to pass through a component thereof, comprising:

an impeller having a plurality of vanes;

a wall of the component on which the impeller is mounted and in which an opening section is formed so as to permit the vanes to be disposed;

a partition section having a hole at such a position as to face a rotating shaft of the impeller; and

a port formed by the wall and the partition section, wherein

the liquid passing through the component flows into the port through the hole by the rotation of the impeller.

**2**. The liquid circulation system according to claim 1, comprising:

a bottom wall for supporting the rotating shaft of the impeller; and

electromagnets mounted on the opposite side to the impeller on the bottom wall, wherein

the impeller is rotated by the electromagnets and permanent magnets included in the impeller.

**3**. The liquid circulation system according to claim 2, wherein the bottom wall includes a liquid sealing member on the same side as the impeller.

**4**. A liquid circulation system which permits liquid to pass through a component thereof, comprising:

an impeller having a plurality of vanes;

an inlet port for permitting liquid to flow into from the outside of the component; and

a duct connected with the inlet port and having a hole such at a position as to face the rotating shaft of the impeller, wherein

liquid flowing into from the inlet port flows into the inside of the component through a hole of the duct by the rotation of the impeller.

**5**. The liquid circulation system according to claim 4, comprising:

a bottom wall for supporting the rotating shaft of the impeller; and

electromagnets mounted on the opposite side to the impeller on the bottom wall, wherein

the impeller is rotated by the electromagnets and permanent magnets included in the impeller.

**6**. The liquid circulation system according to claim 5, wherein

the bottom wall includes a liquid sealing member on the same side as the impeller.

**7**. The liquid circulation system according to claim 4, wherein

the liquid passing through the component is a collision jet flow against the inside of the component.

**8**. A liquid cooling system for cooling a component with coolant, comprising:

the liquid circulation system according to claim 1, wherein

the component is the one that performs heat exchange.

**9**. A liquid cooling system for cooling a component with coolant, comprising:

the liquid circulation system according to claim 1, wherein

the component is the one that retains coolant.

**10**. A liquid cooling system for cooling a component with coolant, comprising:

the liquid circulation system according to claim 4, wherein

the component is the one that comes into contact with a heat generating member to cool the heat generating member.

**11**. The liquid circulation system according to claim 1, including:

a pump section having a bottom wall for supporting the rotating shaft of the impeller and electromagnets mounted on the opposite side to the vanes on the bottom wall, wherein

the pump section rotates the impeller by the electromagnets and the permanent magnets included in the impeller.

**12**. The liquid circulation system according to claim 4, including:

a pump section having a bottom wall for supporting the rotating shaft of the impeller and electromagnets mounted on the opposite side to the vanes on the bottom wall, wherein

the pump section rotates the impeller by the electromagnets and the permanent magnets included in the impeller.

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