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PAPER A
ELECTRICITY / MECHANICS

This paper comprises:

*	Client's Letter	2009/A(E/M)/e/1-8
*	Client's Drawings	2009/A(E/M)/e/9-14

Client's Letter

Dear Mr. Nedland,

[001] My name is Pierre Aronnax. I am professor of marine biology and an enthusiastic hobby diver. I have invented a valve for a snorkel.

[002] All too often, a breathtaking coral reef seduces the snorkeller to dive deeper under water. When the free end of a conventional snorkel submerges, i.e. plunges completely below the water surface, its breathing tube fills with water. Upon resurfacing the snorkeller has then to blow the breathing tube free of water before drawing another breath through the snorkel. Different snorkel valves are on the market, which prevent water from entering the breathing tube. These snorkel valves automatically close the free end of the snorkel when the snorkel submerges.

[003] The most well-known of these snorkel valves is sold by Nemo Tubes Ltd. under the name "Nautilus". Fig. 1 shows a snorkel equipped with a Nautilus valve. Figs. 2A-2C show a Nautilus valve in use.

[004] Snorkel 1 has a J-shaped breathing tube 2 with a mouthpiece 3 at one end. At the other end of the breathing tube 2, a tube portion 5 of a mushroom-shaped snorkel valve 4 is releasably fixed. Alternatively, the tube portion 5 may be integrally formed with the breathing tube 2.

[005] The tube portion 5 opens into a hemispherical end piece 6. As can be seen from Figs. 1 and 2A, several openings 8 are provided in the flat surface 7 of the end piece 6. Through these openings 8 breathing air can flow towards the mouthpiece 3 via the end piece 6, the tube portion 5 and the breathing tube 2.

[006] A float 9 comprises a hollow ring-shaped body 10, which is made of plastic and surrounds the tube portion 5 such that the float can move up and down along the tube portion. Fig. 2A shows a stop 11 mounted on the tube portion 5 of the snorkel valve 4 for limiting the movement of the float 9 away from the end piece 6. A seal 12 is arranged in the top portion of the hollow ring-shaped body 10 facing the end piece 6.

[007] During snorkelling at the water surface, the snorkel valve 4 projects from the water as shown in Fig. 2A. The gravity force G acting on the float 9 keeps it at a rest position, in which the float rests on the stop 11. The free space between the end piece 6 and the float 9 ensures that breathing air can flow through the openings 8 into the tube portion 5, as indicated by the dashed arrow in Fig. 2A.

[008] Sometimes the snorkel valve submerges, as shown in Fig. 2B. According to Archimedes' Principle, a body submerged in water experiences a lifting force, called the buoyancy force. The buoyancy force corresponds to the weight of the water displaced by the submerged body. As the gravity force G acting on the hollow float 9 of the Nautilus valve is much smaller than the buoyancy force B acting on the float under water, the force R resulting from B and G promptly pushes the float upwards until it makes contact with the flat surface 7 of the end piece 6. In this position, shown in Fig. 2B, the seal 12 is pressed against the flat surface 7 so that the openings 8 are closed. No water can enter the tube portion 5.

[009] In general terms, the snorkel valve 4 comprises a valve member in the form of float 9 and valve orifices in the form of openings 8. The valve member is movable between an open position where the valve orifices are open and a closed position where the valve orifices are closed by the valve member.

[010] In my years of experience as an underwater explorer, I have noticed that the Nautilus valve only functions properly under water as long as it remains in the upright position shown in Fig. 2B. This requires the snorkeller not to turn his head too much. If the snorkeller does not keep the snorkel valve in the upright position under water, the snorkel valve may open, and water may enter.

[011] Such a situation is shown in Fig. 2C. Because the buoyancy force B acting on the float 9 is much greater than the gravity force G, the float moves away from the flat surface 7 of the end piece 6 in response to the force R resulting from B and G. As soon as the seal 12 loses contact with the flat surface 7, water can flow through the openings 8 into the end piece 6.

[012] Therefore, two years ago I developed a snorkel valve of the type shown in Figs. 3A-3D, which stays closed in any submerged position. Snorkel valves of this type were sold under the name "MagDiver".

[013] To make my MagDiver valve, I modified a Nautilus valve by placing permanent magnets 13 in the end piece 6 close to the openings 8. An annular sheet 14 made of a ferromagnetic metal was integrated in the float 9 around the seal 12.

[014] The closer the float 9 is to the flat surface 7, the stronger the magnetic force F acting on the float is. During snorkelling at the water surface, due to the distance between the float 9 and the flat surface 7, the magnetic force F is smaller than the gravity force G acting on the float so that the snorkel valve remains open, as shown in Fig. 3A.

[015] Fig. 3B shows the situation where the snorkel is submerged and the snorkel valve is closed. When the float 9 is in the closed position the holding force F applied by the magnets 13 exceeds the force R resulting from the gravity force G and the buoyancy force B acting on the float. Therefore, the float 9 is held in the closed position, even when the snorkel valve is upside down as shown in Fig. 3C.

[016] However, shortly afterwards I realized that something had to be changed to overcome the main drawback of my MagDiver valve: since the holding force F applied by the magnets in the closed position of the float 9 is greater than the gravity force G acting on the float, the float remains in the closed position upon resurfacing, as can be seen in Fig. 3D. To reopen the snorkel valve, the snorkeller needs to pull the float 9 away from the end piece 6 by hand.

[017] To avoid this inconvenience, in a first step, my faithful assistant Conseil tackled the problem empirically by experimenting with different sets of permanent magnets. Alas, he soon realised that merely fine-tuning the holding force F applied by the magnets did not help a bit. Either the magnets were too strong and the snorkel valve did not open upon resurfacing - as is the case with the MagDiver valve -, or they were too weak and the snorkel valve opened under water, similarly to the Nautilus valve. No matter how much he increased or decreased the strength of the magnets, he never managed to make a snorkel valve which meets both conditions, i.e. which remains closed in any position under water and which automatically opens upon resurfacing. Nevertheless, Conseil published all the details of these snorkel valves and of his experiments in the popular diver's journal "Scubaduba" one year ago.

[018] Later, when I analysed the problem in detail myself, it struck me that in addition to the holding force F applied by the magnets, the gravity force G and buoyancy force B acting on the valve member would also have to be changed in such a way that the snorkel valve works as desired. To do that, the mass and the volume of the valve member can be adapted, e.g. by modifying its structure, material or dimensions.

[019] As a first example of my invention I have developed a snorkel valve as shown in Figs. 4A-4D. This snorkel valve 4 differs structurally from the MagDiver valve of Figs. 3A-3D in that the hollow ring-shaped body 10 of the valve member 9 is filled with rubber. Alternatively, the mass of the valve member can be adapted by filling the hollow ring-shaped body with a material other than rubber, or a suitable liquid, such as water. Instead, the valve member could also be a solid body made from a single material. The valve member could even be a hollow body made of a heavy material, such as stainless steel.

[020] When the snorkeller dives deeper and the snorkel valve 4 submerges as shown in Fig. 4B, the gravity force G acting on the valve member 9 nearly compensates the buoyancy force B acting on the valve member, so that only a weak force R results from B and G. As with the MagDiver valve, once the snorkel valve is closed, the valve member 9 is always held in the closed position by the holding force F applied by the magnets 13. The magnets 13 therefore act as holding means. This applies even when the snorkel valve is upside down as shown in Fig. 4C.

[021] From the force diagram of Fig. 4C it follows that the snorkel valve 4 stays closed if the holding force F applied by the magnets 13 exceeds the force R resulting from B and G, which respectively depend on the volume and mass of the valve member 9. This also applies if the structure of the valve member is such that the gravity force G acting on the valve member substantially differs from the buoyancy force B.

[022] In contrast to the MagDiver valve, at the moment when the snorkel valve 4 resurfaces, as shown in Fig. 4D, the gravity force G exceeds the holding force F acting on the valve member 9 in the closed position, so that the valve member moves to the open position, as indicated by dashed lines.

[023] I have noted that the snorkel valve sometimes fails to open upon resurfacing it is not in the upright position of Fig. 4D. However, the snorkel valve always opens in least one position, namely the upright position.

[024] In the following I will describe further examples of my invention, which also work according to the basic principles explained above.

[025] One of these examples is shown in Fig. 5. This snorkel valve 4 differs from the one shown in Figs. 4A-4D in that the holding means are springs rather than magnets.

[026] Springs 15 extend through some of the valve orifices 8 and are fixed at one end to the inner hemispherical surface 16 of the end piece 6 and at the other end to the valve member 9. Springs 15 are tension springs. This means that the springs 15 permanently "attempt" to pull the valve member 9 towards the flat surface 7 of the end piece 6 in order to close the valve orifices 8. As the springs 15 limit the downward movement of the valve member 9 when the snorkel valve is out of the water, there is no need for a stop in this example.

[027] As in Figs. 4B and 4C of the first example of my invention, when the snorkel valve 4 is submerged, the holding force applied by the springs 15 must exceed the force resulting from buoyancy force and gravity force in order to ensure that the snorkel valve remains closed in any position. When the snorkel valve resurfaces, the gravity force exceeds the holding force of the springs 15 acting on the valve member 9 in the closed position and stretches the springs. As a result, the valve member 9 automatically opens the valve orifices 8 and moves to the rest position shown in Fig. 5.

[028] Another example of my invention is shown in Figs. 6A-6C. This example is a development of the example of Fig. 5. In contrast thereto, a ring-shaped body 110 and hemispherical end piece 106 are made in one piece to form a valve member 109. In the mushroom-shaped snorkel valve 104 of this example, the entire valve member 109 including the hemispherical end piece 106 is therefore positioned around a tube portion 105 such that it can move up and down along the tube portion.

[029] Four axial channels 117 are foreseen between the ring-shaped body 110 and the tube portion 105 for the passage of breathing air. Two of these channels 117 can be seen in Fig. 6A. The other channels are shown in Fig. 6B, which represents a cross section of the snorkel valve along line A-A of Fig. 6A. The channels 117 are formed by axial recesses in the inner surface 118 of the ring-shaped body 110 facing the tube portion 105.

[030] An annular collar 111 projects from the end of the tube portion 105 into the hemispherical end piece 106. Valve orifice 108 is the passage in-between the collar 111 and the ring-shaped body 110 of the valve member 109. A seal 112 is arranged in the top portion of the ring-shaped body 110 facing the collar 111.

[031] A spring 115 is fixed at one end to the inner hemispherical surface 116 of the valve member 109 and at the other end to the tube portion 105. Unlike the example of Fig. 5, the spring 115 is a compression spring. This means that the spring 115 permanently "attempts" to push the inner hemispherical surface 116 of the valve member 109 away from the collar 111 and to move the ring-shaped body 110 of the valve member towards the collar, in order to close the valve orifice 108. The closed position of the valve member 109 is shown in Fig. 6C.

[032] When the snorkel valve is not submerged, as shown in Fig. 6A, the spring 1 compressed in response to the gravity force acting on the valve member 109. As a consequence, the ring-shaped body 110 is spaced from the collar 111 and breathing air can flow through the channels 117 and the valve orifice 108 into the tube portion 105, as indicated by the dashed arrow.

[033] Upon submerging, the compression spring 115 extends and presses the ring-shaped body 110 of the valve member 109 against the collar 111. The holding force applied by the spring 115 exceeds the force resulting from gravity force and buoyancy force acting on the valve member 109 and holds the valve member in the closed position shown in Fig. 6C.

[034] Upon resurfacing, the gravity force exceeds the holding force of the spring 115 acting on the valve member 109 in the closed position and pulls the valve member down along the tube portion 105. As a result, the spring 115 is compressed again and the valve member 109 moves to the open position shown in Fig. 6A.

[035] In order to ensure that the snorkel valve opens and closes as desired, the spring and the mass and volume of the valve member must be configured such that the above described force conditions are fulfilled.

[036] I hope that the above information will prove helpful in drafting a European patent application which covers all examples of my snorkel valve.

Yours sincerely,

Prof. Pierre Aronnax

Client's Drawings

Nautilus

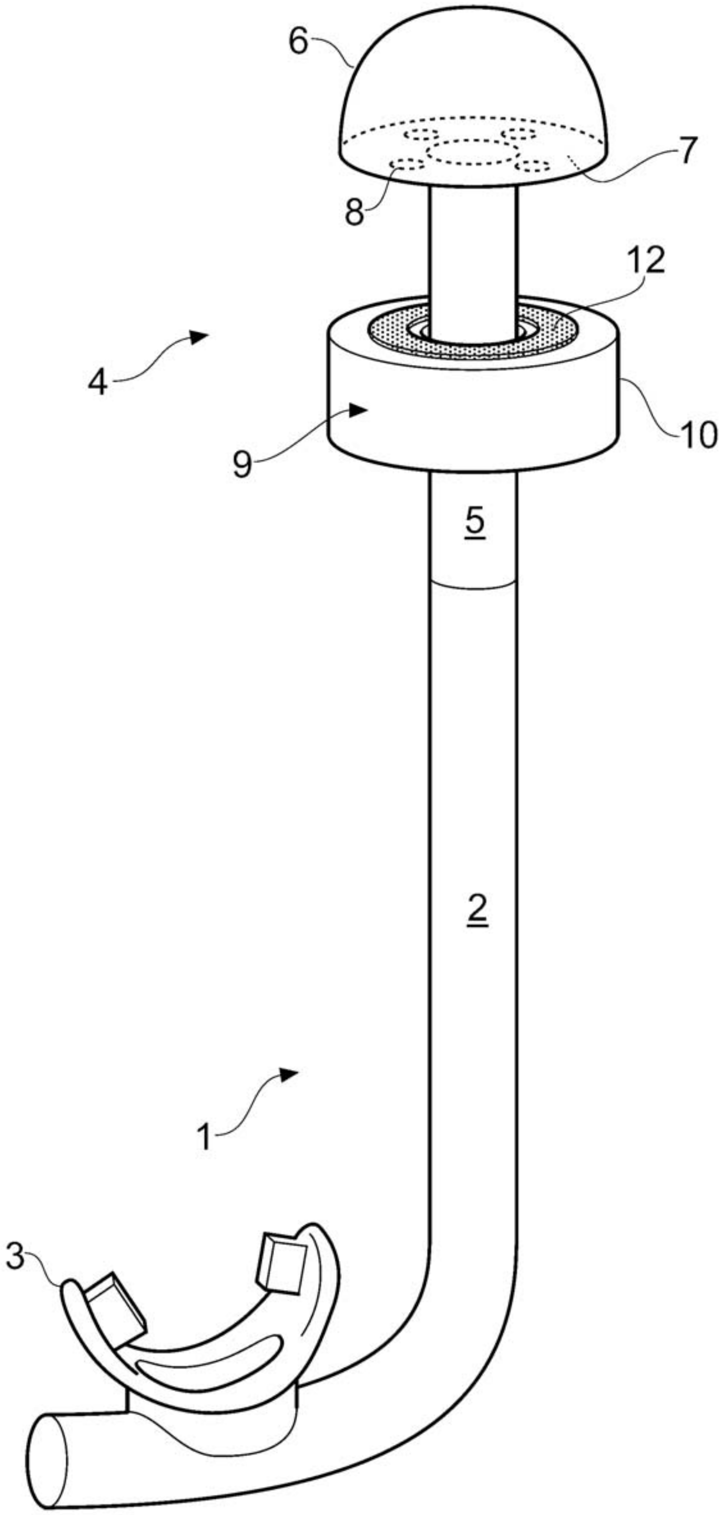

FIG. 1

Nautilus

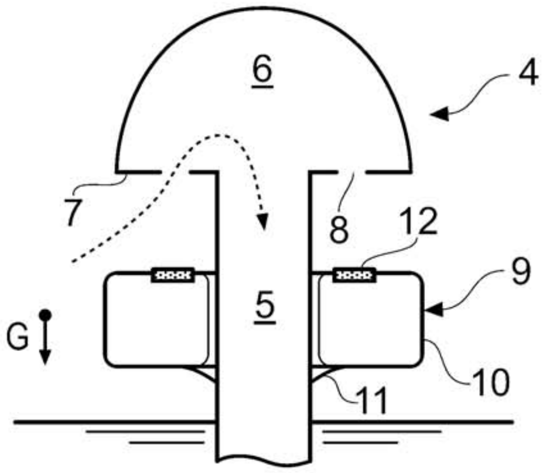

FIG. 2A

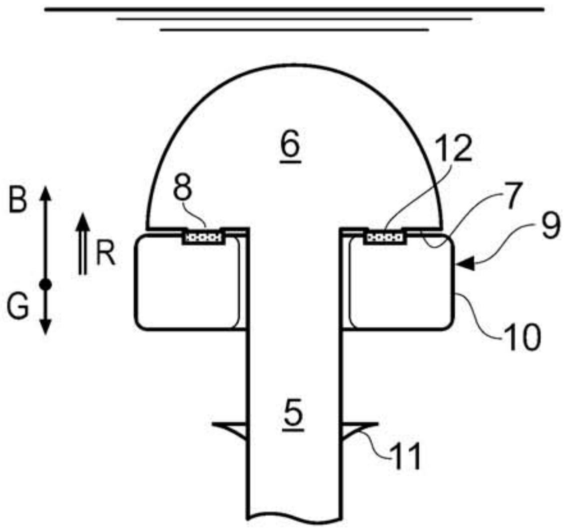

FIG. 2B

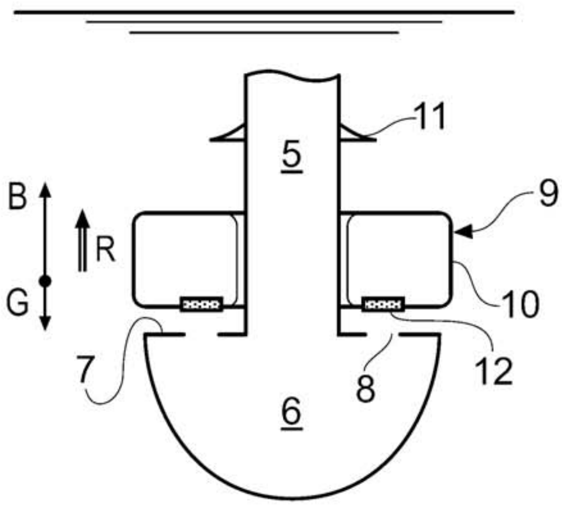

FIG. 2C

MagDiver

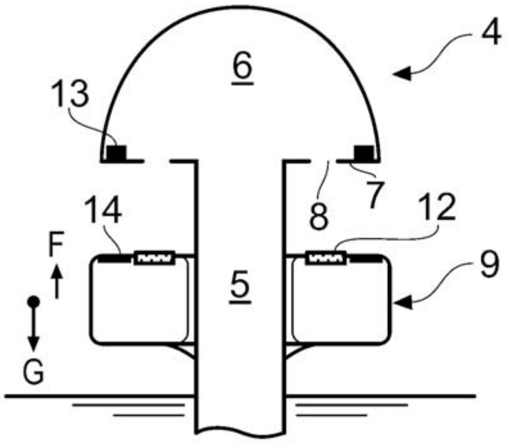

FIG. 3A

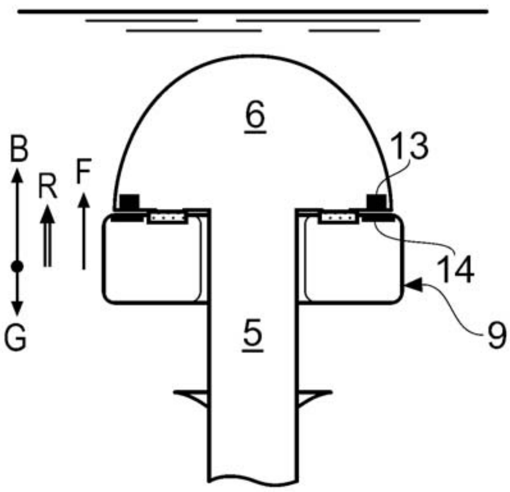

FIG. 3B

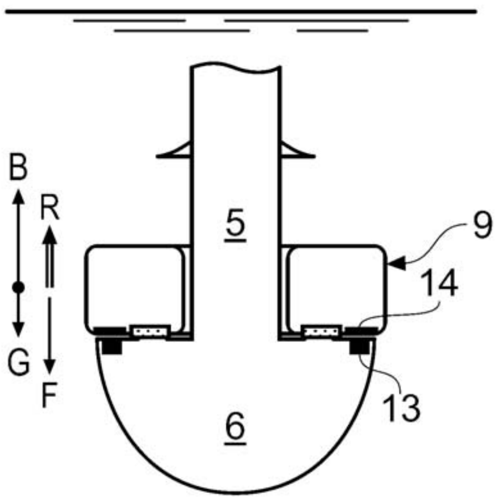

FIG. 3C

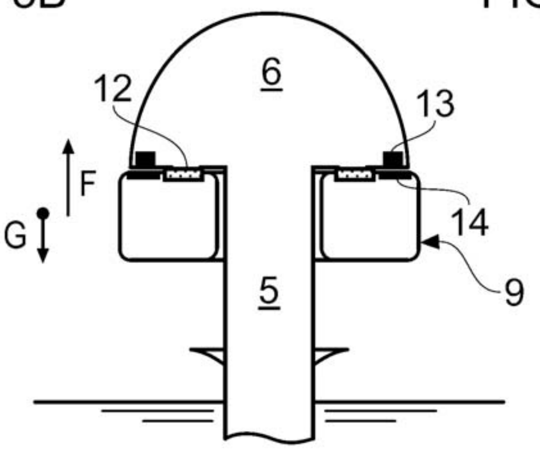

FIG. 3D

My Invention

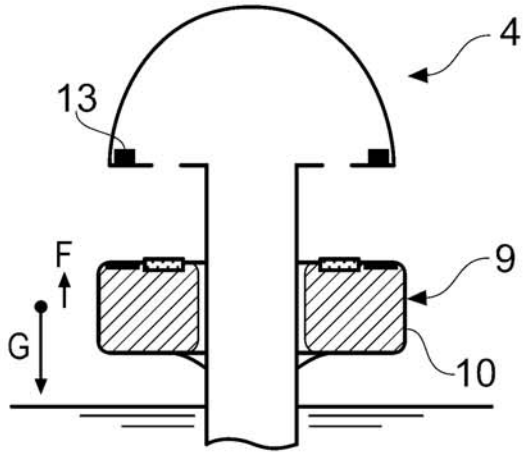

FIG. 4A

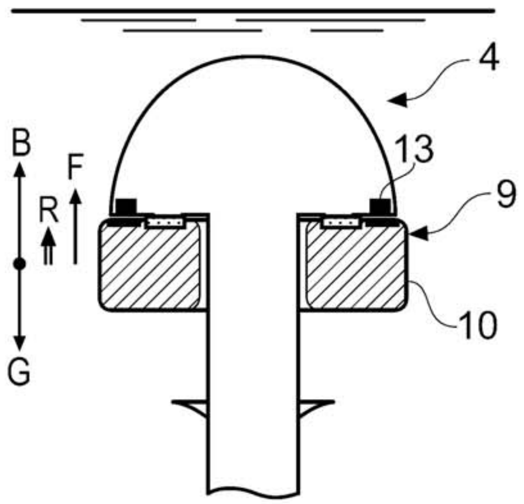

FIG. 4B

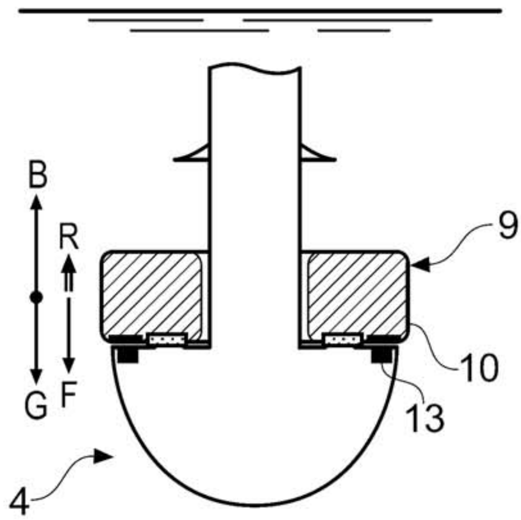

FIG. 4C

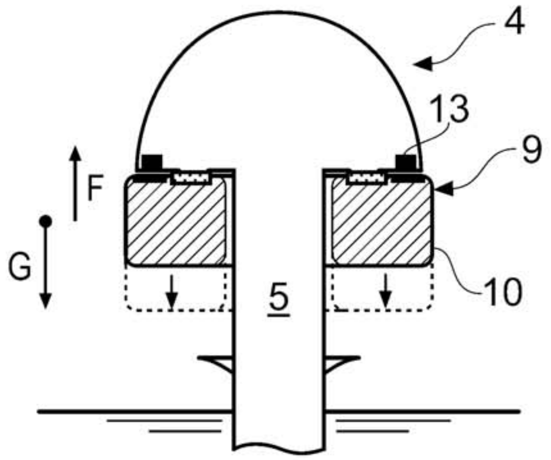

FIG. 4D

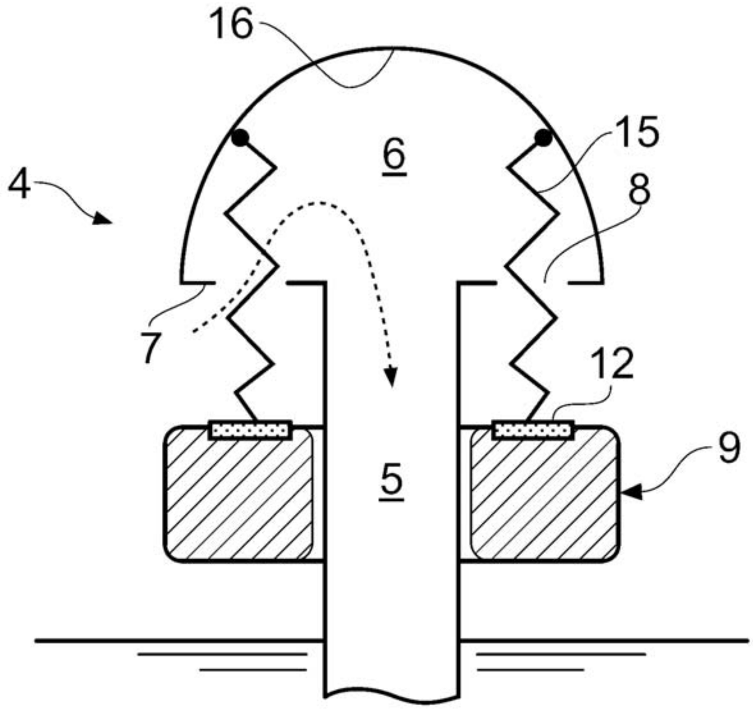

FIG. 5

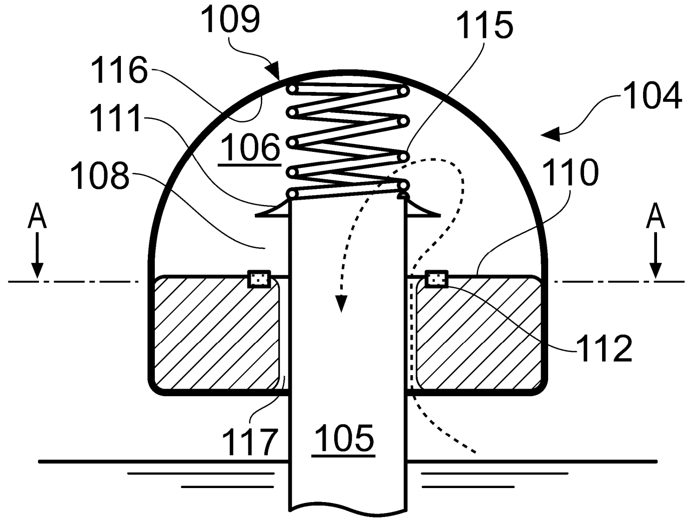

FIG. 6A

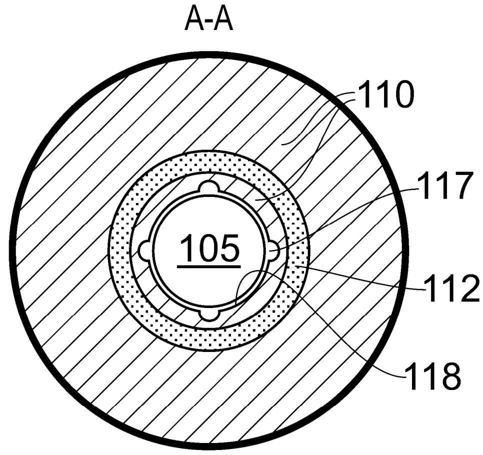

FIG. 6B

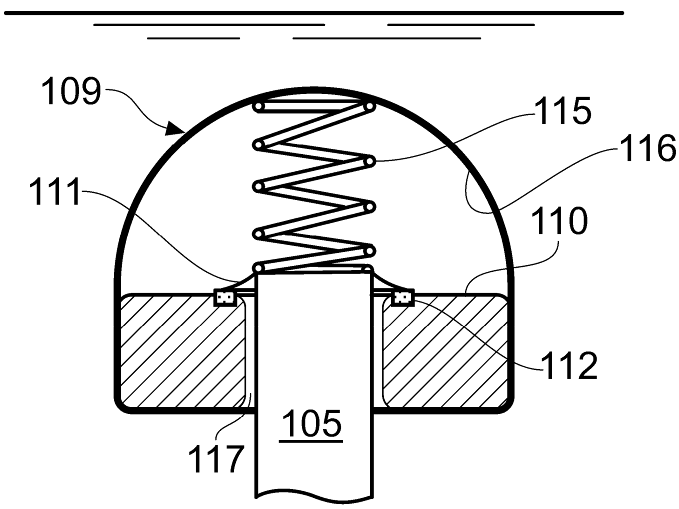

FIG. 6C