IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

XINGMAI INNOVATION TECHNOLOGY (SUZHOU) CO., LTD.
D/B/A BEATBOT
Petitioner,

v.

AIPER GLOBAL PTE. LTD.
Patent Owner.

Case No. PGR2026-00012
U.S. Patent No. 12,221,196

DECLARATION OF NOAH COWAN

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IX.DECLARATION 372

Exhibit No.	Description
1001	U.S. Patent No. 12,221,196 to Liu et al. ("the '196 Patent")
1002	Prosecution file history for the '196 patent
1004	*Curriculum Vitae* of Dr. Noah Cowan
1005	U.S. Patent Application Publication No. 2025/0146315, published May 8, 2025 to Wang et al. ("Wang")
1006	Certified Translation of International Patent Application No. PCT/CN2024/076040 (published as WO 2024/169737), filed February 5, 2024 ("Wang '040")
1007	International Patent Application No. PCT/CN2024/076040 (published as WO 2024/169737), filed February 5, 2024 ("Wang '040")
1008	Chart of subject matter of Wang as supported by Wang '040
1009	U.S. Patent No. 11,946,282, issued April 2, 2024 to Zhang ("Zhang")
1010	Certified Translation of Chinese Patent No. CN117738506, published March 22, 2024 to Guo et al. ("Guo")
1011	Chinese Patent No. CN117738506 ("Guo")
1012	U.S. Patent No. 11,803,193, issued October 31, 2023 to Zhao et al. ("Zhao")
1013	International Patent Application No. PCT/US2007/063650 (published as WO 2007/106730), published September 20, 2007 ("Owen")
1014	U.S. Patent Application Publication No. 2003/0201218, published October 30, 2003 to Henkin et al. ("Henkin '218")
1015	U.S. Patent No. 5,985,156, issued November 16, 1999 to Henkin et al. ("Henkin '156")
1016	Certified Translation of Chinese Patent No. CN 117661894, published on March 8, 2024 ("Deng")
1017	Chinese Patent No. CN 117661894, published on March 8, 2024 ("Deng")

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Exhibit No.	Description
1018	Certified Translation of Chinese Patent No. CN 116166018, published on May 26, 2023 ("Liu")
1019	Chinese Patent No. CN 116166018, published on May 26, 2023 ("Liu")
1020	Publication J41 in the Curriculum Vitae of Dr. Noah Cowan
1021	Plot and Code of Simulation for Airbag Inflation
1022	Chapter 9: "Timers" of *Programmable Logic Controllers*, 6th Edition, W. Bolton, published in 2015
1023	U.S. Patent No. 11,124,982 to Korenfeld et al. ("Korenfeld")
1024	U.S. Patent No. 11,274,462 to Tryber et al. ("Tryber")

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I, Noah Cowan, declare as follows:

I. INTRODUCTION

1. I have been asked to submit this declaration on behalf of Xingmai Innovation Technology (Suzhou) Co., Ltd. d/b/a Beatbot ("**Petitioner**") in connection with a petition for post-grant review ("**PGR**") of U.S. Patent No. 12,221,196 (the **"'196 Patent**").[1] I have been informed that the petition is being submitted to the United States Patent and Trademark Office's ("**USPTO**") Patent Trial and Appeal Board (the "**Board**") by the Petitioner.

2. Specifically, I have been retained as a technical expert by the Petitioner to study and provide my opinions on the technology claimed in, and the patentability or unpatentability of all claims of the '196 Patent (the **"Challenged Claims**"). For purposes of this declaration, I was not asked to provide any opinions that are not expressed herein.

II. SUMMARY OF OPINIONS

3. This declaration is directed at the Challenged Claims of the '196 Patent and sets forth the opinions I have formed, the conclusions I have reached, and the bases for each.

4. In forming my opinions, counsel for Petitioner told me to assume that the effective filing date of the '196 Patent is **July 26, 2024**.

[1] I understand that the '196 Patent is Exhibit 1001 to this PGR.

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5. Based on my experience, knowledge of the art as of the effective filing date of the'196 Patent, analysis of prior art references, and understanding of the claim terms (in view of the specification that a person of ordinary skill in the art would have as of the effective filing date), it is my opinion that the Challenged Claims of the '196 Patent are indefinite and unpatentable as obvious over the prior-art references discussed below.

III. BACKGROUND AND QUALIFICATIONS

A. Background

6. I believe that I am well qualified to serve as a technical expert in this matter based on my educational and work experience. I received a Bachelor of Science degree in Electrical Engineering in 1995 from the Ohio State University. As an Electrical Engineering major, I received rigorous training on a mixture of curriculum components from both mechanical engineering and electrical engineering, including, for example, mathematics, physics, mechanical systems, control engineering, electronics, sensors, and software. I understand that my curriculum vitae (CV) is being filed in this proceeding as Exhibit 1004.

7. I earned my Master's and Ph.D. degrees in Electrical Engineering and Computer Science from the University of Michigan, Ann Arbor, in 1997 and 2001, respectively. My Ph.D. dissertation work focused on vision-based control of robotic navigation systems. My career in engineering and robotics spans over 25

years, during which I have been and remain active as both an academic and a scientist-engineer.

8. As an academic, I joined the University of California, Berkeley as a Postdoctoral Fellow from 2001 to 2003. I completed the postdoctoral fellowship jointly in Integrative Biology and Computer Science at the University of California, Berkeley. My postdoctoral work focused on the stability and control of locomotion in running animals and robots, investigating how insects utilize proximity sensors for navigation and control, and applying these concepts to robotic control systems.

9. I joined the faculty of Johns Hopkins University in 2003. I am currently a Tenured Full Professor in the Department of Mechanical Engineering. I served as the Deputy Director for the Johns Hopkins Robotics Program from 2013 to 2018. In this role, I co-developed and administered the university's undergraduate Robotics Minor program, as well as the university's Robotics Master's program. I have taught dozens of courses cumulatively to thousands of undergraduate and graduate students over the last 20 years in the areas of robot sensors, actuators, and control systems.

10. As a scientist-engineer, I have worked on many research and development (R&D) projects on technologies in the robotics field. For example, I have served as the director of my own independent research laboratory, the

Locomotion in Mechanical and Biological Systems (LIMBS) Laboratory, at Johns Hopkins University since 2003. My laboratory has garnered approximately $8 million in peer-reviewed funding to conduct original research in robotics and neuroscience. In my role as Director of the LIMBS Laboratory, I lead a team that designs sensor-based robotic control systems for a wide range of applications, including mobile robotics and medical robotics. My team also examines how animals, including humans, process sensory information and control their movements. A significant focus of my work and research has been designing proximity sensors for navigation and control, as well as developing new control systems for mobile systems. My work has also focused on understanding navigation algorithms, including how to store and update maps of local environments for a wide range of robotic systems. My team builds navigation and control algorithms, including integrated graphical user interfaces for mobile robotic platforms. These systems often utilize sensors to identify distinct environmental features, which are then displayed on a user interface. I regularly rely upon my experience in mechanical engineering, electrical engineering, computer science, biology, and neuroscience in my work in robotics and neuroscience.

11. I have a strong international reputation as a leading expert in robotic navigation and control. For example, I received a Presidential Early Career Award

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in Science and Engineering in 2010. This is the United States government's highest honor for scientists and engineers in the early stages of their independent research careers. This award recognized my work on sensing, control, and navigation in robots and animals. I also served as the chairman of the 2012 conference on Climbing and Walking Robots (CLAWAR). This prestigious international conference brings together the world's experts on designing climbing and walking robotic systems. I have been an invited speaker at several major robotics conferences, including the International Conference on Advanced Robotics (ICAR), Istanbul, Turkey, 2015, and the Dynamic Walking conference in 2012, 2015, and 2016, and an upcoming invited talk at the Journal of Experimental Biology 2026 International Symposium on Bio-Inspired Robotics in Comparative Biomechanics. These are prestigious international conferences that bring together leading experts in robotics. I have also been invited to give colloquia at top universities, including Yale University, the Massachusetts Institute of Technology, Harvard University, Cornell University, the Ohio State University, the University of Michigan, and the University of California, Berkeley, among others.

12. Moreover, my role at a research university like Johns Hopkins University also involves significant effort in conducting and publishing fundamental research in robotics. I have authored over 100 refereed papers, primarily focusing on the control of movement in robots and animals, including the

most prestigious interdisciplinary journals, such as *Nature*, *Proceedings of the National Academy of Sciences, Nature Neuroscience,* and *Nature Machine Intelligence*. These are the top journals in their fields and across fields. My CV includes a complete list of my published works and academic presentations.

13. A major line of research involves understanding underwater sensing, dynamics, and control for mobile autonomous systems. Specifically, my lab investigates sensing, hydrodynamics, navigation and control in the weakly electric glass knifefish, *Eigenmannia virescens* (*See* Fig. 1(A) below). We study these fish to "reverse engineer" their sophisticated sensing, neural processing, mechanical actuation, and control principles. One of the key aspects of our analysis has included the development of control algorithms for an underwater robot (*See* Fig. 1(B)). Using sophisticated hydrodynamic modeling (*See* Fig. 1(C)), along with biological and robotic experiments, we discovered new principles in actuation and control that were published in the *Proceedings of the National Academy of Science.* (*See* Exhibit 1020.)

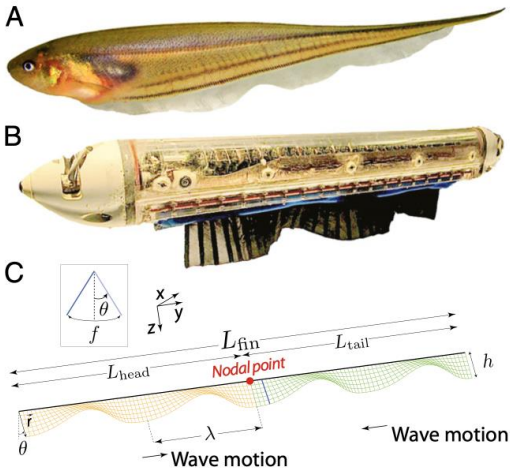


Fig. 1: Reproduced from Fig. 1 of Exhibit 1020: (A) the glass knifefish *E. virescens*; (B) biomimetic robotic; and (C) mathematical model.

14. My research and development projects have also generated significant intellectual property. I am a named inventor on three U.S. patents involving various aspects of robot mechanics and sensing, and a fourth is pending. I have been involved in the patent process, including discussing inventions with legal counsel to assist in drafting disclosures and claims, and consulting on technology to help counsel formulate responses to office actions. In 2016-2017, I was also retained as a technical expert to help determine the validity of a patent.

B. Compensation

15. I am being compensated for the services provided in this matter at $400 per hour. My compensation is not conditioned on the conclusions I reach as a result of my analysis or on the outcome of this matter, and in no way affects the substance of my statements in this declaration.

16. I do not have any financial interest in the Petitioner or real parties-in-interest, or any of their subsidiaries. I also do not have any financial interest in Patent Owner, Aiper Global Pte. Ltd. Further, I do not have any financial interest in the '196 Patent, and I have not had any contact with the named inventors of the '196 Patent: Xiaofeng Liu and Yongfei Hua.

IV. MATERIALS CONSIDERED

17. In forming my opinions, I read and considered the '196 Patent and its prosecution history, the exhibits listed in the Exhibit List filed with the PGR of the '196 Patent, as well as any other materials referenced herein.

V. LEGAL STANDARDS

18. In forming my opinions and considering the subject matter of the '196 Patent and its claims in light of the prior art, I am relying on certain legal principles that counsel in this case has explained to me. I understand that the claims define the invention. I also understand that an unpatentability analysis is a two-step process. First, the claims of the patent are construed to determine their meaning and scope. Second, once the claims have been construed, the content of the prior art is compared to the construed claims. I have been told the following legal principles apply to the analysis of patentability based on 35 U.S.C. §§ 102 and 103. I have also been told that, in a PGR proceeding, a patent claim may be deemed unpatentable if it is shown by a preponderance of the evidence that the claim was

indefinite, anticipated by a prior art patent or publication under § 102, and/or rendered obvious by one or more prior art patents or publications under § 103.

A. Level of Ordinary Skill

19. I understand a person of ordinary skill in the art is determined by looking at (1) the type of problems encountered in the art; (2) prior art solutions to those problems; (3) rapidity with which innovations are made; (4) sophistication of the technology; and (5) educational level of active workers in the field.

20. As described in more detail below, the '196 Patent relates to the design and control of an autonomous swimming pool robot that performs sinking and floating control through airbag inflation/deflation, combined with sensor-driven control logic for underwater navigation and cleaning. As described in the ***Field of the Invention*** and ***Background*** sections (pp. 11–12 of Exhibit 1001): the technology concerns underwater robotic systems capable of dynamically adjusting buoyancy for stable movement, wall detection, and energy-efficient operation. It involves embedded control systems, electromechanical actuation, and environmental sensing for autonomous cleaning tasks. The solutions combine mechanical, electrical, and software control disciplines. Relevant problems in the art include: maintaining robot stability and orientation underwater, rudimentary principles of buoyancy, optimizing air volume and pressure in buoyancy systems,

and implementing real-time feedback from multiple sensors (e.g., waterline detection, posture detection, distance measurement).

21. Prior to the '196 Patent's effective filing date, engineers in this field commonly worked on autonomous underwater vehicles (AUVs), robotic pool cleaners, and embedded mechatronic systems. Published patents and technical papers in the art describe comparable systems integrating: (1) air or pump-based buoyancy control mechanisms; (2) sensor fusion for localization and orientation (e.g., IMUs, depth sensors, and optical distance sensors); (3) microcontroller-based embedded control using PID feedback and state-machine algorithms; and (4) mechanical housings designed for water-tightness, corrosion resistance, and balance optimization. Innovation in the art was moderately rapid, driven by advances in microcontrollers, low-cost sensors, and battery technology between 2015 and 2024.

22. Based on the above considerations, it is my opinion that, as of July 26, 2024, a person of ordinary skill in the art ("**POSITA**") relating to the subject matter of the '196 Patent would have possessed at least a bachelor's degree in mechanical engineering, electrical engineering, mechatronics, robotics, computer engineering, or a closely related field; and at least three years of experience in the design, development, and control of mobile or underwater robotic systems, including work with buoyancy control systems, sensor integration, and embedded

firmware or control algorithms. Additional education, such as a Master's or Ph.D., can substitute for professional experience, and significant work experience can substitute for formal education. I meet this definition for a POSITA now and as of July 26, 2024.

23. I am also familiar with the knowledge of the POSITA as of the priority date of the '196 Patent (**July 26, 2024**). I can opine on how the POSITA would have understood the disclosure and claims of the '196 Patent, the disclosures of the prior art, the motivation and/or suggestion to combine the prior art, and what combinations would have been obvious to a POSITA.

B. Written Description

24. I understand that under 35 U.S.C. § 112(a), the specification of a patent must contain a written description of the invention that is sufficient to demonstrate that the inventor was in possession of the claimed invention as of the filing date. I understand that the written description requirement is separate from and in addition to the enablement requirement, and that it is intended to ensure that the patent applicant actually invented the subject matter claimed.

25. This requirement has two parts: (1) the specification must describe the invention, and (2) the originally-filed specification and claims must describe the manner and process of making and using the invention.

26. I have been informed and understand that to satisfy the written description requirement, the specification must clearly convey to a POSITA that the inventor had possession of the full scope of each claim, including all limitations, at the time of filing. This means that the specification must describe the claimed invention in sufficient detail such that a POSITA would recognize that the inventor had actually invented what is claimed.

27. I have further been informed and understand that it is irrelevant if the claimed subject matter is an obvious variant of the disclosed subject matter because a POSITA should not substitute their hindsight for the scope of disclosure of the application.

28. I further understand that a claim may lack written description support if it covers subject matter that is not adequately disclosed in the specification, or if the disclosure is overly generic and fails to support the full breadth of the claim. I understand that merely describing a general concept, function, or result—without sufficient structural, compositional, or methodological detail—may be insufficient to show possession of the claimed invention, particularly where the claim scope is broad or covers multiple possible embodiments.

29. I also understand that new claim limitations added during prosecution must find adequate written description support in the originally filed specification. If no such support exists, I understand that the resulting claim may be invalid for

lack of written description, even if the added limitation is technically enabled or understood in the field.

30. I understand that, in conducting a written description analysis:

- The written description analysis is based on an objective inquiry into the four corners of the specification.
- This inquiry into the specification is done from the perspective of one of ordinary skill in the art.
- The written description requirement does not require any particular form of disclosure, and support may be based on a combination of figures and disclosures throughout the specification.
- The specification need not recite the claimed invention in haec verba, *i.e.*, it need not use the same words, phrasings or presentation style as the claims.
- A description that merely renders the invention obvious does not satisfy the written description requirement.
- The level of detail required to satisfy the written description requirement depends on (i) the nature and scope of the claims and (ii) the complexity and predictability of the relevant technology.
- Factors to be taken under consideration include the existing knowledge in the particular field, the extent and content of the prior

art, the maturity of the science or technology, and the predictability of the aspect at issue.

C. Indefiniteness

31. I have been further informed by counsel that under 35 U.S.C. § 112(b), patent claims must clearly and distinctly identify what the inventor regards as the invention. A claim is considered indefinite if, when read in light of the specification and the knowledge of a POSITA, it does not inform, with reasonable certainty, what is covered by the claim. I understand that a patent claim is invalid if it is indefinite. I also understand that claim definiteness is measured from the viewpoint of a POSITA at the time the patent application (or priority application) was filed.

32. I am informed and understand that a claim can be found unpatentable due to the prior art (*i.e.*, anticipated or obvious) in certain circumstance even if the claim is indefinite. One example is where the outer bounds of a claim limitation are not reasonably certain, but the prior art disclosure falls within the scope of the limitation that is not subject to uncertainty.

D. Burden of Proof

33. I have been informed that the petitioner in an *inter partes* or *post grant* review bears the burden of establishing unpatentability by "a preponderance of the evidence." I have been further informed and understand that, to prove an

assertion by "a preponderance of the evidence," the party with the burden of proof must demonstrate that it is more likely than not that the assertion is true.

E. Claim Construction

34. I understand that the Board interprets claim terms in a PGR proceeding under the same claim construction standard that is used in a United States federal court. I understand that under this standard, the meaning of claim terms is considered from the viewpoint of a POSITA at the time of the alleged invention.

35. I have been informed that claim terms are generally given their ordinary and customary meaning as understood by a POSITA in light of the specification and the prosecution history pertaining to the patent. I understand, however, that claim terms are generally not limited by the embodiments described in the specification. I am further informed that a departure from this ordinary meaning is appropriate only in two circumstances: (1) when the patentee clearly sets forth a special definition and acts as its own lexicographer, or (2) when the patentee clearly and unmistakably disavows the full scope of the term either in the specification or during prosecution.

36. I understand that in addition to the claims, specification, and prosecution history, other evidence may be considered to ascertain the meaning of claim terms, including textbooks, encyclopedias, articles, and dictionaries. I have

been informed that this other evidence is often less significant and less reliable than the claims, specification, and prosecution history.

37. I am informed and understand that the doctrine of claim differentiation is a principle of claim interpretation that presumes different claims have different scope. In other words, the presence of a dependent claim that adds a particular limitation gives rise to a presumption that the corresponding independent claim is broader and does not include that limitation. I am informed that this doctrine is not a rigid rule, but rather a guide to claim construction that can be overcome where the specification or prosecution history clearly indicates a different intent. I am further informed that claim differentiation is most useful where a dependent claim adds a limitation that would otherwise be redundant if the independent claim already included that limitation. Thus, if claim 2 recites an additional feature that narrows claim 1, the independent claim is presumed not to contain that added feature.

38. I have also been informed that certain patent claim terms may be interpreted as "means-plus-function" claim terms under 35 U.S.C. §112(f). These types of terms and limitations should be interpreted to cover only the corresponding structure described in the specification, and equivalents thereof. I understand that a structure is considered structurally equivalent to the corresponding structure identified in the specification only if the differences

between them are insubstantial. For instance, if the structure performs the same function in substantially the same way to achieve substantially the same result. I further understand that a structural equivalent must have been available at the time of the issuance of the claim.

39. I have been further informed that if the claim language uses the phrase "means for," there is a presumption that 35 U.S.C. § 112(f) applies. However, this presumption may be overcome if the claim language itself recites enough structure to show how the function is performed. Conversely, even if the phrase "means for" is not used, 35 U.S.C. § 112(f) can still apply if the claim language fails to provide sufficient structure and is written only in functional terms.

40. Finally, I have been informed that when a claim does invoke 35 U.S.C. § 112(f), the scope of the claim is limited to (a) the specific function recited in the claim, and (b) the particular structure disclosed in the patent for carrying out that function (or, in the case of computer-implemented inventions, the specific algorithm). If the specification does not disclose an adequate structure or algorithm, then the claim is indefinite under 35 U.S.C. § 112(b).

F. Anticipation under 35 U.S.C. § 102

41. I understand that a patent claim is invalid as anticipated if a single piece of prior art teaches every element of the claims, viewed from the perspective of a POSITA.

42. I have also been told that an anticipatory reference does not have to recite word-for-word what is in the anticipated claim. Instead, anticipation can occur when a claimed limitation is "inherent" in the relevant reference. I have been told that if the prior art necessarily functions in accordance with, or includes, the claim limitations, it can anticipate even though the reference does not recite a limitation word-for-word.

G. Obviousness under 35 U.S.C. § 103

43. I understand that a patent claim is invalid as obvious if the claimed invention would have been obvious to a POSITA at the time the claimed invention was made. This means that even if all the elements of the claim cannot be found in a single prior art reference that would anticipate the claim, a POSITA who knew about all the relevant prior art would have come up with the claimed invention. I understand that in an obviousness determination, the POSITA is presumed to have knowledge of all material prior art. I understand that whether a claim is obvious is based upon the determination of several factual issues.

44. In considering obviousness, I understand that one must determine the scope and content of the prior art. I understand that one must determine what differences, if any, existed between the claimed invention and the prior art.

45. I understand that, in order to be considered as prior art to a patent being considered, a prior art reference must be reasonably related to the claimed

invention of that patent. A reference is reasonably related if it is in the same field as the claimed invention or is from another field to which a POSITA would look to solve a known problem.

46. I understand that a patent claim composed of several elements is not proved obvious merely by demonstrating that each of its elements was independently known in the prior art. In evaluating whether such a claim would have been obvious, one may consider whether a reason has been identified that would have prompted a POSITA to combine the elements or concepts from the prior art in the same way as in the claimed invention. There is no single way to define the line between true inventiveness on the one hand (which is patentable) and the application of common sense and ordinary skill to solve a problem on the other hand (which is not patentable). For example, market forces or other design incentives may be what produced a change, rather than true inventiveness.

47. I understand that one may consider whether (1) the change was merely the predictable result of using prior art elements according to their known functions, or whether it was the result of true inventiveness; (2) there is some teaching or suggestion in the prior art to make the modification or combination of elements claimed in the patent; (3) the innovation applies a known technique that had been used to improve a similar device or method in a similar way; (4) the claimed invention would have been obvious to try, meaning that the claimed

innovation was one of a relatively small number of possible approaches to the problem with a reasonable expectation of success by those skilled in the art; (5) the invention merely substituted one known element for another known element in order to obtain predictable results; (6) the invention merely applies a known technique to a known device, method, or product to yield predictable results, or (7) known work in the field may have prompted variations of use of the same inventions in the same or different fields due to market forces or design incentives that would have been predictable to a POSITA.

48. I understand that one must be careful not to determine obviousness using the benefit of hindsight; many true inventions might seem obvious after the fact. I understand that the determination should be based on the position of a POSITA at the time the claimed invention was made and should not consider what is known today or what is learned from the teaching of the patent.

H. Secondary Considerations of Non-Obviousness

49. I understand that certain secondary considerations may be considered in evaluating obviousness to prevent hindsight bias. These secondary considerations include the commercial success of products that practice the patent, the long-felt need for the patented technology, the failure of others to solve the problem addressed by the patent, initial skepticism by others in the industry,

industry recognition and praise of the patented products, and efforts by others to copy the patented technology.

50. I have been informed that these secondary considerations of non-obviousness must be balanced against the strength of the *prima facie* case of obviousness. Where the invention represents no more than the predictable use of prior art elements according to their established functions, secondary considerations are inadequate to establish non-obviousness.

51. I have also been informed that the patentee must establish a nexus between any secondary consideration factors and the claimed invention. Where a secondary consideration factor results from something other than what is both claimed and novel in the patent, there is no nexus to the merits of the claimed invention.

52. I have been informed that, for example, the nexus requirement as it applies to the evidence of commercial success requires that the patentee must show that the sales of a product that allegedly practices the claimed invention must be a direct result of the unique characteristics of the claimed invention, as opposed to other economic and commercial factors that are unrelated to the patented invention. I understand that this means if the commercial success is due to an element that existed in the prior art or an element that is not claimed by the patent, then no nexus exists.

53. I have been further informed that, for example, the nexus requirement as it applies to the long-felt need element must likewise be supported by evidence. Where the differences between the prior art and the claimed invention are minimal, it cannot be said that any long-felt need was met by the patented invention or that the patent solved any technological problems that were unaddressed by others.

54. I have been informed that evidence of industry praise must also show a nexus with the claimed invention, and that self-serving statements by the patentee regarding the merits of the claimed invention are generally not given weight.

VI. BACKGROUND AND TECHNOLOGY OF THE '196 PATENT

A. Overview of the '196 Patent

55. The '196 Patent, titled *"Controllable Sinking and Floating Swimming Pool Robot, and Sinking and Floating Control Method for a Swimming Pool Robot,"* issued on February 11, 2025, from U.S. Patent Application No. 18/822,334 (filed **September 2, 2024**) and claims priority to Chinese Patent Application No. 202411017697.3 (filed **July 26, 2024**).

56. The Challenged Claims are directed to a swimming pool cleaning robot equipped with a **sinking and floating control unit** that switches the robot between a sinking state (for submerged cleaning) and a floating state (for waterline or water surface cleaning).

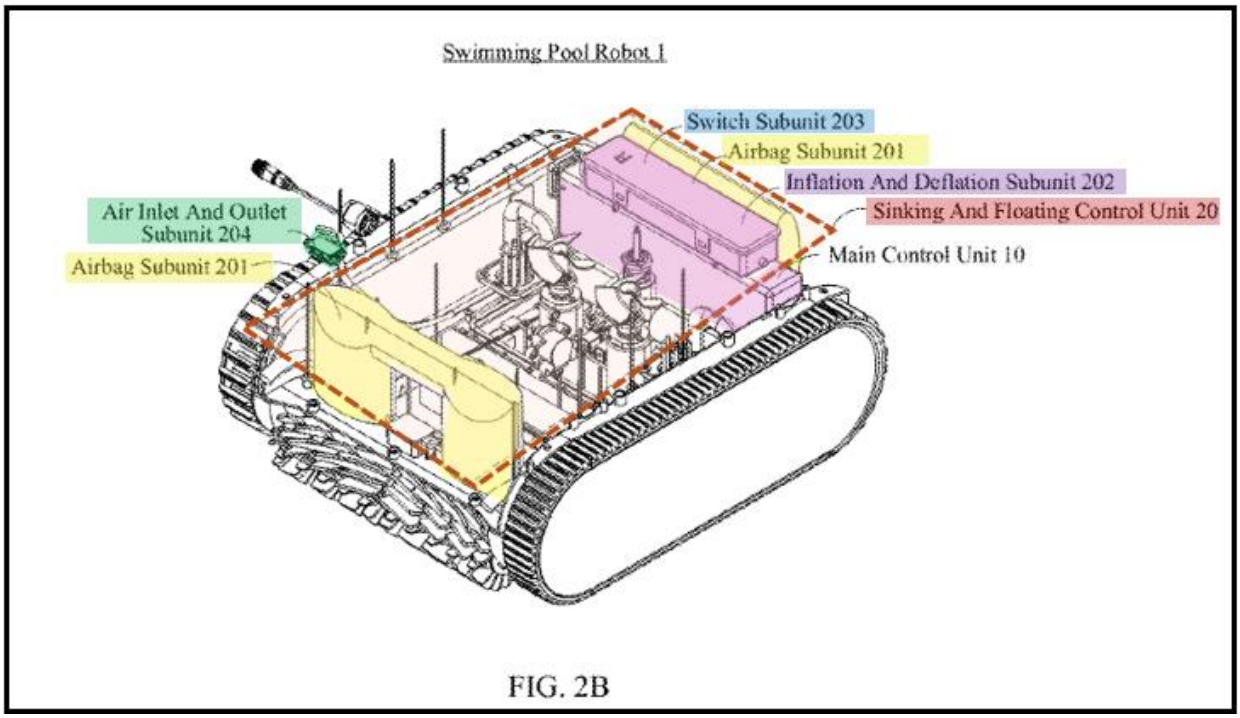


Fig. 2B of the '196 Patent (annotated)

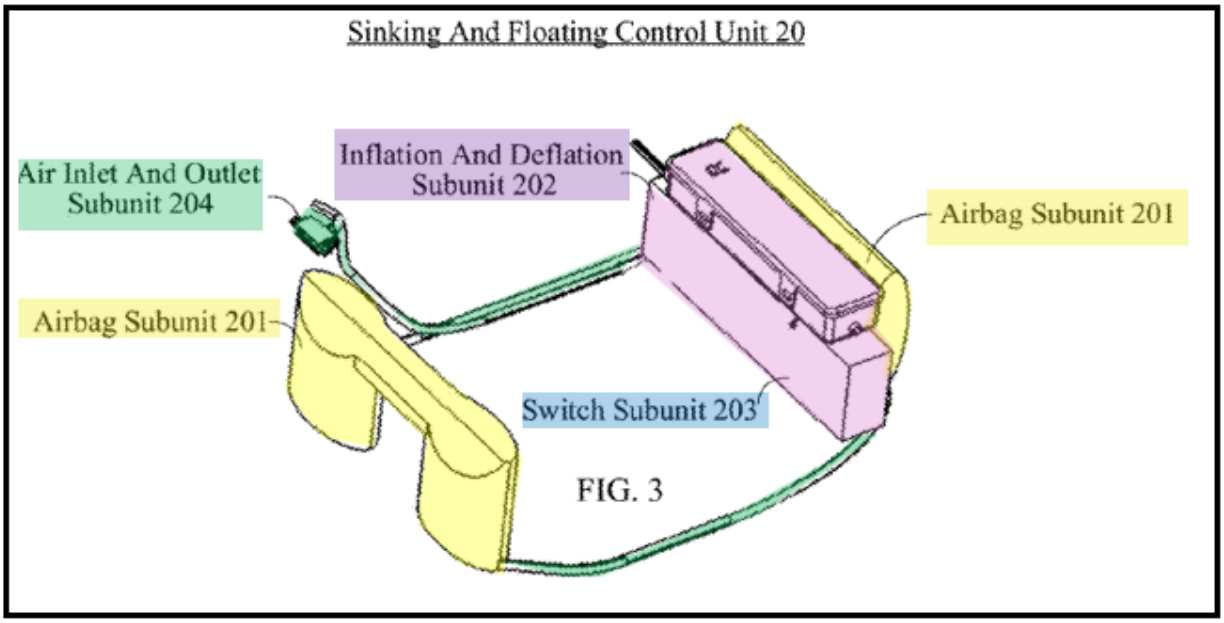


Fig. 3 of the '196 Patent

57. The sinking and floating control unit includes an inflation/deflation subunit (e.g., pumps), a switch subunit (e.g., valves), and an airbag subunit. These are connected to an inlet/outlet system that selectively inflates or deflates the

airbags to adjust buoyancy. Inflating the airbags increases buoyancy, causing the robot to float, while releasing air from the airbags decreases buoyancy, causing the robot to sink.

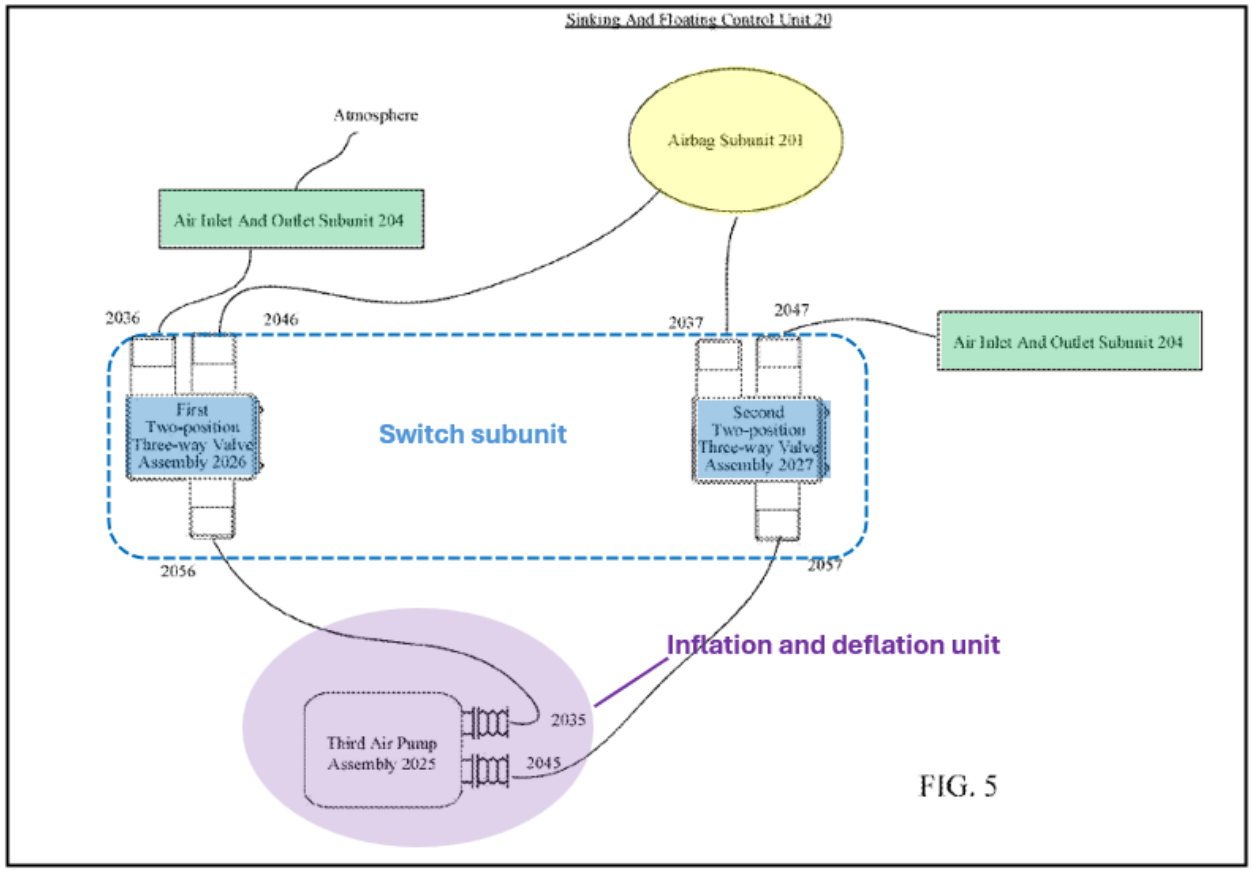


Fig. 5 of the '196 Patent (annotated)

58. The '196 Patent asserts that this configuration improves over prior art by inflating and deflating airbags with air drawn from above the waterline. This approach allegedly enables faster transitions between sinking and floating, compared to prior solutions that relied on altering the robot's mass through water absorption and drainage, and also simplifies the robot's internal structure. In addition, the "main control unit" is configured to stop the sinking and floating

control unit "***after the sinking and floating control unit enters the floating working state for a predetermined time***."[2] (Ex. 1001, Claim 1.) This time-based cutoff prevents continuous inflation, thereby **protecting the airbags from damage caused by overinflation**. (*See* Ex. 1001, 9:25-28, stating that "*In this case, inflation and deflation subunit **202** and switch subunit **203** are prevented from inflating the airbag subunit **201** for a long time, and airbag subunit **201** is protected from being damaged*.")

59. The '196 Patent also discloses sensor-based detection modules to guide buoyancy control. These include a waterline detection unit with (i) an outlet-water detection subunit that identifies when part of the robot emerges from the water, and (ii) a proximity waterline subunit that detects when the robot is within a preset distance from the surface. A posture detection unit (e.g., inertial sensor or IMU) is also disclosed to measure the robot's tilt and orientation. These sensor inputs enable the "main control unit" to determine when the robot is transitioning between different states (e.g., from wall climbing to the water surface) and to trigger appropriate sinking or floating operations.

B. Prosecution History of the '196 Patent

[2] Unless otherwise indicated, all the bolded portions of citations in this declaration are added for emphasis.

60. I am informed that the prosecution history of the '196 Patent may be relevant to how the claims of the '196 Patent and the prior art may be interpreted.

61. I have reviewed the prosecution history of the '196 Patent. The application leading to the '196 Patent was filed on September 2, 2024, and claims priority to Chinese Patent Application No. 202411017697.3 filed on July 26, 2024. On November 7, 2024, the USPTO Examiner rejected claim 11 under 35 U.S.C. § 112(b) as indefinite for lack of antecedent basis for "the switch subunit," "the inflation and deflation subunit," and "the airbag subunit." The Examiner also rejected claims 1, 3, 5, 10, and 16-19 under 35 U.S.C. § 103 as being unpatentable over U.S. Patent No. 11,124,982 ("*Korenfeld*"; Exhibit 1023) in view of U.S. Patent No. 11,274,462 ("*Tryber*"; Exhibit 1024). (Ex. 1002 at 121-123.)

62. **Korenfeld** discloses an autonomous pool cleaning robot equipped with a controller, sensors, and steering mechanisms configured to navigate along both vertical and non-vertical paths on pool sidewalls and at the waterline. The robot detects the waterline and reorients itself at a controlled yaw angle to travel horizontally along the surface while maintaining stability and minimizing steering corrections. The system uses sensor feedback—including orientation, yaw, and positional data—to actively control the robot's movement and compensate for deviations. Korenfeld's cleaning paths are designed to reduce the number of

directional changes compared to traditional vertical wall-cleaning paths, improving cleaning efficiency and coverage.

63. **Tryber** discloses an autonomous pool cleaning robot that controls buoyancy using an **active ballast system**. The robot includes a **piston-based ballast tank** divided into gas and fluid compartments, where movement of the piston—actuated by a compressed gas cylinder—adjusts the volume of water taken in or expelled to increase or decrease buoyancy. This allows the robot to submerge, hover, or surface as needed for cleaning. The Tryber pool robot further incorporates multiple **onboard sensors**, including acoustic, ultrasonic, optical, and pressure sensors, as well as gyroscopes and image sensors, to assist with navigation, depth control, and surface detection. Through this combination of mechanical buoyancy control and sensor-driven navigation, Tryber enables precise underwater maneuvering and automated cleaning of both submerged and surface regions of a pool.

64. Applicant responded to the Office Action by amending independent claims 1 and 16 to incorporate the limitation of "*wherein **the sinking and floating control unit is controlled to stop working** after the sinking and floating control unit enters the floating working state for a predetermined time*," which had appeared in allowable claim 14, "with minor expression adjustment for the sake of clarity." (Ex. 1002 at 128; 132.) Claim 14 recited "*wherein **the inflation and***

deflation subunit and the switch subunit are controlled to be closed *after the sinking and floating control unit enters the floating working state for a predetermined time*." Applicant also amended claim 11 to recite "*the sinking and floating control unit comprises an inflation and deflation subunit, a switch subunit and an airbag subunit connected to the inflation and deflation subunit*" to provide an antecedent basis for the terms "the switch subunit," "the inflation and deflation subunit," and "the airbag subunit." (Ex. 1002 at 131.)

65. On December 20, 2024, the Examiner issued a Notice of Allowance. (Ex. 1002 at 157-159.) The Examiner found that the prior art does not show or suggest "*the use of a robot and method which include* ***a sinking and floating control unit that is controlled to stop working after said unit enters a floating working state for a predetermined time***." (Ex. 1002 at 157.) Claims 15-20 were renumbered to become claims 14-19 of the '196 Patent.

66. The '196 Patent only cites two prior art references (Korenfeld and Tryber) identified by the Examiner; the applicant never submitted any prior art reference to the USPTO during the prosecution of '196 Patent.

C. Claims of the '196 Patent

67. I understand that the PGR Petition challenges all claims (claim 1-19) of the '196 Patent. I further understand that among those claims, claims 1 and 15 are independent claims.

D. Claim Interpretation

1. "Main Control Unit"

68. Claim 1 of the '196 Patent recites, in relevant part, "*a **main control unit** configured to control a working state of the sinking and floating control unit*," and further recites the "main control unit" as being capable of: (i) controlling the swimming pool robot; (ii) controlling the waterline detection unit; and (iii) controlling the sinking and floating control unit to enter a "floating working state" and then stopping after a predetermined time.

69. In my opinion, the claim language defines the "main control unit" solely by reference to its functions, not by reference to any specific structure. The term "control unit," and in particular the word "unit," does not connote a definite structure to a POSITA; instead, it serves merely as a placeholder for some unspecified mechanism or means that performs the recited control functions.

70. From a technical perspective, the claim text describes only what the "main control unit" does—namely, controlling other components of the swimming pool robot—but it provides no indication of how those functions are implemented in hardware or software. Because the limitation is expressed entirely in functional terms without reciting any structural features or algorithmic details, it is my opinion that the "main control unit" limitation invokes means-plus-function claiming under 35 U.S.C. § 112(f). Although the claim does not use the word "means," that omission creates only a rebuttable presumption that § 112(f) does not

apply. Here, in my view, that presumption is overcome because the term "main control unit" is drafted purely in functional language without any description of structure that performs the claimed control operations.

71. The express functions attributed to the "main control unit" in Claim 1 include (1) controlling the swimming pool robot to find a side wall or slope and enabling it to crawl along that surface; (2) controlling the waterline detection unit to determine the positional relationship between the robot and the waterline; (3) controlling the sinking and floating control unit to enter a "floating working state" based on detection results; and (4) controlling the sinking and floating control unit to stop working after operating in the floating state for a predetermined time. Under § 112(f), the specification must disclose the structure—or, for computer-implemented inventions, the algorithm—that corresponds to each of these functions.

72. In my review of the '196 Patent, the specification refers to the "main control unit" only at a high level, stating that it "controls" other units or sub-units. It does not describe the internal hardware configuration, circuitry, software modules, or algorithmic logic by which these control functions are actually performed. For example, with respect to the specific function of stopping the sinking and floating control unit after a predetermined time of operation, the specification does not disclose whether this timing control is achieved through a

software timer, a hardware counter, or any particular sequence of program instructions. The patent thus provides no concrete structural or algorithmic disclosure that a POSITA could use to understand how the claimed control behavior is realized.

73. To the extent the "main control unit" is intended to correspond to a generic processor, microcontroller, or computer system, I understand that the specification must disclose the programming logic or algorithm that enables the processor to perform the recited functions. In my opinion, merely referencing a generic processor or control device, without associated algorithmic detail, does not provide sufficient structure to satisfy § 112(f).

74. Accordingly, I conclude that the '196 Patent fails to disclose adequate structure corresponding to the recited functions of the "main control unit." A POSITA reading the patent would not have reasonable certainty as to what specific hardware, software, or programming constitutes this "main control unit." For that reason, it is my opinion that the "main control unit" limitation is indefinite because the specification does not identify a corresponding structure as required under § 112(f).

75. In the alternative, if the Board were to determine that § 112(f) does not apply, it is my opinion that the term "main control unit" should be construed to mean "**a processor, microcontroller, programmable logic controller, or**

equivalent control circuitry configured to perform the recited functions."

However, even under that alternative construction, the term remains purely functional and lacks any specific structural limitation beyond that generic description.

2. "Sinking and Floating Control Unit"

76. Claim 1 of the '196 Patent recites "*a* ***sinking and floating control unit*** *configured to control a swimming pool robot to float and sink*." Claim 1 further describes that the "main control unit" directs this "sinking and floating control unit" to enter a "floating working state", and to stop working after entering the "floating working state" for a predetermined time.

77. In my opinion, the phrase "control unit," particularly when paired with the functional language "sinking and floating," would be understood by a POSITA as a nonce term that does not, by itself, connote any definite structure. The claim describes only what the "sinking and floating control unit" does—namely, controlling the swimming pool robot to float and sink—but not what that unit is structurally. For that reason, the limitation is expressed purely in functional terms, without any recitation of the physical or algorithmic structure that performs the recited function.

78. Accordingly, it is my opinion that this limitation invokes means-plus-function treatment under 35 U.S.C. § 112(f). Although the claim does not employ

the word "means," that creates only a rebuttable presumption against § 112(f) application. In this instance, the presumption is overcome because the claim language provides no structural description and instead defines the element exclusively by its functional role.

79. While certain dependent claims identify subunits and components—such as air-pump assemblies and valves—that further refine or narrow aspects of the system, those narrower limitations do not alter whether independent Claim 1 is drafted in means-plus-function form. Rather, those dependent claims may assist in identifying what the specification discloses as corresponding structure for performing the recited function.

80. The function expressly recited for the "sinking and floating control unit" is to control the swimming pool robot to float and sink, which, in the context of Claim 1, includes entering a "floating working state" and stopping operation after remaining in that state for a predetermined time. The specification links this "sinking and floating control unit" to embodiments employing **air-based buoyancy control** implemented through pneumatic components. As described in the patent, those components include an inflation and deflation subunit (such as one or more air-pump assemblies), a switch subunit (such as one or more electromagnetic or two-position three-way valve assemblies), an airbag subunit connected to the pumps and valves, and an air-inlet and outlet subunit that provides

airflow to or from the atmosphere. (See, for example, Figures 4–5 and the corresponding description.)

81. In my opinion, these disclosures provide sufficient mechanical structure—comprising pumps, valves, airbags, and their interconnections—that a POSITA could readily recognize as performing the recited function of controlling the robot's buoyancy. Because this system operates through mechanical and pneumatic means rather than through computer-implemented algorithms, a POSITA would not require disclosure of any specific software logic to understand how the recited function is accomplished. The functional relationship among these components—pressurizing or venting the airbag to change the robot's buoyancy—is straightforward to one skilled in the art.

82. Accordingly, if § 112(f) applies, I construe "sinking and floating control unit" as follows:

- **Function**: To control a swimming pool robot to float and sink, including entering a floating working state and stopping operation after entering the floating working state for a predetermined time.
- **Structure**: The air-based buoyancy control assembly disclosed in the specification, including an inflation/deflation subunit (one or more air-pump assemblies), a switch subunit (one or more electromagnetic or two-position three-way valve assemblies), and, in certain

embodiments, an airbag subunit and air-inlet/outlet subunit connected and operated as shown in the figures, and equivalents thereof. (*See* Ex. 1001, Figs. 3-5 and description for such figures at 6:66-8:5.)

83. If, however, the Board determines that § 112(f) does not apply, it is my opinion that the term "sinking and floating control unit" should be construed according to its ordinary and customary meaning as understood by a POSITA at the time of the invention, in light of the claim language, specification, and prosecution history. I am informed that claim terms are generally given their ordinary meaning to a POSITA unless the patentee clearly acts as its own lexicographer or unmistakably disavows claim scope either in the specification or during prosecution.

84. Here, although the only embodiment described in the '196 Patent performs the sinking and floating function using an air-inflation and deflation system with valves and an airbag, there is no indication that the patentee expressly defined the term to have that limited meaning or disclaimed alternative implementations. To the contrary, the patent explicitly cautions that the described embodiments and their advantages are illustrative, not limiting, explaining that "the advantages, effects, and the like mentioned in the present disclosure are merely examples but not limitations," and that "the specific details disclosed above

are only for illustrative purposes and easy-to-understand functions rather than limitation." ('196 Patent at 14:26–36.)

85. Moreover, under the doctrine of claim differentiation, a POSITA would understand that the scope of "sinking and floating control unit" in independent Claim 1 must be broader than the specific air-inflation and deflation features added by dependent Claims 7 and 8. Because those dependent claims expressly narrow the limitation to include additional structural features, the independent claim is presumed not to be so limited.

86. For these reasons, if § 112(f) is found not to apply, I would interpret "sinking and floating control unit" in accordance with its plain and ordinary meaning to a POSITA—namely, "**a flotation subsystem that causes the robot to sink or float**."

3. **"Floating Working State"**

87. Claim 1 of the '196 Patent recites, in relevant part: "*controlling the sinking and floating control unit to enter a* ***floating working state*** *based on detection results to realize a floating of the swimming pool robot, wherein the sinking and floating control unit is controlled to stop working after the sinking and floating control unit enters the* ***floating working state*** *for a predetermined time*."

88. The '196 Patent appears to distinguish between two related but distinct concepts: the "floating working state" and the "floating state." The

"floating working state," as used in the claims, refers to a **mode or condition of the sinking and floating control unit**, namely, that sinking and floating control unit is in a mode so as to increase robot's overall buoyancy, while the "floating state" refers to the **physical condition of the robot itself**—namely, that the robot is buoyant and floating at or near the water surface. The specification explicitly describes the robot entering a "floating state" to clean a waterline area or a "sinking state" to clean a pool bottom or sidewall area. ('196 Patent, 6:22–30.)

89. Claims 7 and 8 further elaborate on the "floating working state" by indicating that, for the sinking and floating control unit to enter the floating working state, an "***inflation and deflation subunit is controlled to start sucking air***" and a "***switch subunit is controlled to open***." In my opinion, this language clarifies that the "floating working state" corresponds to a hardware actuation mode of the sinking and floating control unit—specifically, when the switch subunit is open and the inflation and deflation subunit is operating to draw air into the airbag subunit to increase buoyancy.

90. The specification is consistent with this interpretation, describing the "floating working state" as occurring when the inflation and deflation subunit and switch subunit are activated to inflate the airbag and raise the robot toward the water surface:

- *"According to another aspect of the present disclosure, there is provided a sinking and floating control method for a*

swimming pool robot, including: controlling a swimming pool robot to find a side wall or a slope based on operational requirement information of the swimming pool robot, and enabling the swimming pool robot to crawl along the side wall or the slope; detecting a positional relationship between the swimming pool robot and a waterline of a liquid surface of a swimming pool where the swimming pool robot is located; and controlling a sinking and floating control unit to enter a ***floating working state*** *based on detection results to* ***realize a floating*** *of the swimming pool robot. "* (Ex. 1001, 3:43-54.)

- *"In the* ***floating working state****, the first two-position three-way valve assembly 2026 and the third air pump assembly 2025 are in the power-on working state, and the second two-position three-way valve assembly 2027 is in the power-off state. The air above the water level line where the swimming pool robot 1 is located enters the third air pump assembly 2025 through the air inlet and outlet subunit 204 and the first two-position three-way valve assembly 2026, and is filled into the airbag subunit 201 through the third air pump assembly 2025."* (Ex. 1001, 8:6-15.)

- *"In the* ***floating working state****, the first air pump assembly 2021 and the second air pump assembly 2022 are in a power-on working state, and the first electromagnetic valve assembly 2023 and the second electromagnetic valve assembly 2024 are in a power-off state. The air above the water level where the swimming pool robot 1 is located enters the first air pump assembly 2021 through the air inlet and outlet subunit 204 and the first electromagnetic valve assembly 2023, and is filled into the airbag subunit 201 through the first air pump assembly 2021****."* (Ex. 1001, 7:36-45.)

- *"In addition, in response to the sinking and floating control unit 20 entering the* ***floating working state,*** *the outlet water detection subunit 301 and the posture detection unit 40 are closed, and after a predetermined time (for example, 40 seconds), the inflation and deflation subunit 202 and the switch subunit 203 are controlled to*

> *be closed. Alternatively, in one embodiment of the present disclosure, in response to that the outlet water detection subunit 301 does not detect that at least a part of the swimming pool robot 1 enters underwater again after the sinking and floating control unit 20 enters the* ***floating working state*** *for a predetermined time (for example, 40 seconds), the inflation and deflation subunit 202 and the switch subunit 203 are controlled to be closed."* (Ex. 1001, 13:42-54.)

91. Accordingly, it is my opinion that a POSITA would construe "floating working state" in accordance with its plain and ordinary meaning to refer to: "**a condition in which the sinking and floating subsystem is actively operating to cause the robot to float**."

4. "Waterline Detection Unit"

92. Claim 1 of the '196 Patent recites, in relevant part, "*a* ***waterline detection unit*** *configured to detect a positional relationship between the swimming pool robot and a waterline of a liquid surface of a swimming pool where the swimming pool robot is located*." In my opinion, the phrase "waterline detection unit" describes this component **solely in terms of its function**—detecting the positional relationship between the robot and the waterline—without identifying any **definite structure** for performing that function. The term "detection unit," and in particular the word "unit," is a **nonce term** that does not, by itself, convey a specific structure to a POSITA. It serves merely as a placeholder for some unspecified mechanism or means capable of performing the recited detection function. Because the claim recites what the "waterline detection unit" does but not

what it is structurally, the limitation is purely functional and, in my opinion, invokes means-plus-function claiming under 35 U.S.C. § 112(f).

93. Although the claim does not expressly use the word "means," I understand that this omission creates only a rebuttable presumption against § 112(f) applicability. That presumption may be overcome when, as here, the claim language defines an element entirely by its function and fails to provide any structural description. While certain dependent claims refer to subunits or components—such as an "outlet water detection subunit" or a "proximity waterline detection subunit"—those narrower limitations do not alter the analysis for independent Claim 1. Rather, they serve to identify potential corresponding structures disclosed in the specification that perform the recited detection function.

94. In my opinion, the function expressly recited for the "waterline detection unit" is "to detect a positional relationship between the swimming pool robot and the waterline of a liquid surface of a swimming pool." The specification consistently describes this unit as detecting whether the robot has reached, approached, or emerged from the waterline. (*See, e.g.*, '196 Patent, 6:6–10; 9:29–32; 10:32–34; 12:8–9; 12:22–26.) The patent links the "waterline detection unit" to embodiments that employ **sensor-based detection mechanisms**, specifying that the unit includes two subcomponents: (1) an "**outlet water detection subunit**" (such as a capacitive sensor or an ultrasonic ranging device) configured to detect

whether at least part of the robot has emerged from the water; and (2) a "**proximity waterline detection subunit**" (such as an ultrasonic ranging device) configured to detect whether the robot has crawled to within a predetermined distance of the waterline. (*Id.* at 8:29–44.)

95. In my opinion, this disclosure provides sufficient structural context—namely, specific physical sensors and their placement on the robot—that a POSITA could readily identify as performing the recited function of detecting the robot's positional relationship to the waterline. Because these are **conventional sensing components** operating on well-understood physical principles, no special algorithmic disclosure would be required to understand how the structure carries out the function. The relationship between these subunits and the control logic is straightforward and within the ordinary skill of a robotics engineer familiar with submerged sensing applications.

96. Accordingly, if § 112(f) applies, I construe the term "waterline detection unit" as follows:

- **Function:** To detect a positional relationship between the swimming pool robot and the waterline of a liquid surface of a swimming pool.
- **Structure:** The sensor-based arrangement disclosed in the specification, including, e.g., a capacitive or an ultrasonic sensor, and

equivalents thereof. (*See* Ex. 1001, Fig. 1 and corresponding description at 5:58-6:17; 8:24-47.)

97. Alternatively, if the Board determines that § 112(f) does not apply, it is my opinion that the term "waterline detection unit" should be construed according to its ordinary and customary meaning as understood by a POSITA at the time of the invention, in light of the claim language, specification, and prosecution history. Although the only embodiment disclosed in the '196 Patent implements this function using capacitive and ultrasonic sensors, I see no indication that the patentee clearly acted as its own lexicographer or disavowed other types of sensors that could achieve the same function. Indeed, the patent expressly disclaims any intention to limit its claims to the disclosed embodiments, stating that "the advantages, effects, and the like mentioned in the present disclosure are merely examples but not limitations," and that "the specific details disclosed above are only for illustrative purposes and easy-to-understand functions rather than limitation." (Ex. 1001, 14:26–36.)

98. In my opinion, a POSITA would understand this language to mean that the patentee did not intend to restrict the "waterline detection unit" to any particular sensor type or configuration. Therefore, if § 112(f) is found not to apply, I would construe the term "waterline detection unit" according to its plain and ordinary meaning as "**a sensor that detects the waterline of a swimming pool**."

5. "Posture Detection Unit"

99. Claim 2 of the '196 Patent recites, in relevant part, "*a* ***posture detection unit*** *configured to detect posture information of the swimming pool robot*." In my opinion, the claim language defines the "posture detection unit" only by the **function** it performs—detecting the posture of the swimming pool robot—without providing any description of the **structure** that carries out that function. The phrase "detection unit," and particularly the use of the word "unit," would be understood by a "POSITA" as a generic, nonce term that does not itself connote any definite structural meaning. It merely serves as a placeholder for some unspecified means or mechanism that performs the recited detection function.

100. Because the limitation is expressed entirely in functional terms without reciting any corresponding structure, it is my opinion that the "posture detection unit" limitation invokes means-plus-function treatment under 35 U.S.C. § 112(f). Although the claim does not employ the word "means," I understand that this omission creates only a rebuttable presumption against § 112(f) applicability, and that this presumption is overcome when, as here, the claim language describes a component purely by what it does rather than by what it is.

101. The express function recited for the "posture detection unit" is "to detect posture information of the swimming pool robot." (Ex. 1001, 9:29–30.) In the context of the specification, the posture detection unit provides detection

signals that indicate whether the robot's posture satisfies certain **predetermined conditions**, such as changing from a state parallel to the bottom surface of the pool to one parallel to a side wall, or vice versa. (Ex. 1001, 9:31–47.) When the posture detection unit detects a change in the robot's posture, the "main control unit" uses that signal to determine, for example, whether the robot is climbing a wall or has transitioned from a vertical to a horizontal orientation. (Ex. 1001, 12:10–17, 13:29–41.)

102. The specification further explains that the posture detection unit "is configured by, for example, an inertial sensor (IMU)," which detects the robot's posture information and provides corresponding signals to the "main control unit." (Ex. 1001, 9:29–32.) A POSITA would understand that an **inertial measurement unit (IMU)** is a well-known type of sensor used to determine an object's orientation and motion by measuring linear acceleration and angular velocity along multiple axes. Such components are common in mobile and underwater robotic systems and are readily available from commercial sources.

103. In my opinion, this disclosure provides sufficient **structural context** for a POSITA to understand how the claimed posture detection function is performed. Because the structure corresponds to a standard, well-understood sensor device operating on established physical principles, no special software algorithm is required to explain how it detects posture or orientation. The

functional relationship between the IMU's sensor outputs and the main control unit's control logic is conventional and would be fully understood by a POSITA.

104. Accordingly, if § 112(f) applies, I construe the term "posture detection unit" as follows:

- **Function:** To detect the posture of the swimming pool robot and output corresponding signals regarding whether the robot's posture satisfies a first predetermined condition.
- **Structure:** An inertial sensor (IMU) and equivalents thereof. (See Ex. 1001, Fig. 1 and corresponding description at 9:29-57; 12:5-21.)

105. Alternatively, if the Board determines that § 112(f) does not apply, it is my opinion that the term "posture detection unit" should be construed according to its ordinary and customary meaning as understood by a POSITA at the time of the invention, in light of the claim language, the specification, and the prosecution history. Although the only embodiment disclosed in the '196 Patent implements the posture detection function using an IMU, there is no evidence that the patentee expressly defined the term in a limiting way or disavowed the use of other types of sensors capable of achieving the same result. To the contrary, the specification expressly states that the disclosed embodiments are "merely examples but not limitations," and that the "specific details disclosed above are only for illustrative

purposes and easy-to-understand functions rather than limitation." (Ex. 1001, 14:26–36.)

106. A POSITA would understand these statements to mean that the patentee intended the "posture detection unit" to encompass a broader range of conventional sensor technologies capable of detecting inclination, acceleration, or orientation of a robot in a submerged environment, and not to be restricted solely to an IMU-based implementation. Moreover, a POSITA would recognize that IMUs and related sensors (e.g., gyroscopes or accelerometers) are standard components for posture detection in robotic systems, and that the described functionality—detecting orientation changes and transmitting corresponding signals—is fundamental to such devices.

107. For these reasons, if § 112(f) is found not to apply, I would construe the term "posture detection unit" in accordance with its plain and ordinary meaning as "**a sensor that detects the posture or orientation of a swimming pool robot**."

6. "Distance Measurement Unit"

108. Claim 4 of the '196 Patent recites, in relevant part, "*a **distance measurement unit** …, wherein the main control unit controls the swimming pool robot to find the nearest side wall or the nearest slope based on distance measurement results of the distance measurement unit …*." In my opinion, the claim language defines the "distance measurement unit" purely in terms of the

function it performs—measuring the distance—without providing any description of the **structure** that carries out that function. The phrase "measurement unit," and particularly the use of the word "unit," would be understood by a POSITA as a generic, nonce term that does not itself connote any definite structural meaning. It merely serves as a placeholder for some unspecified means or mechanism that performs the recited detection function.

109. Because the limitation is expressed entirely in functional terms without reciting any corresponding structure, it is my opinion that the "distance measurement unit" limitation invokes means-plus-function treatment under 35 U.S.C. § 112(f). Although the claim does not use the word "means," I understand that this omission creates only a rebuttable presumption against § 112(f) applicability, and that this presumption is overcome when, as here, the claim language describes a component purely by what it does rather than by what it is.

110. The express function recited for the "distance measurement unit" is to measure the distance. For example, the specification explains "[t]he distance measurement unit 50 **performs distance measurement** to control the swimming pool robot 1 to find the nearest side wall or slope," and that "the swimming pool robot 1 rotates once in situ to detect distances L1, L2, L3, and L4 among the swimming pool robot 1 and side walls of the swimming pool … so as to determine the nearest side wall Wr." (Ex. 1001, 11:31-41; Fig. 7.)

111. In my review of the '196 Patent, the specification refers to the "distance measurement unit" only at a high level, stating that it "**performs** distance measurement to **control** the swimming pool robot 1 to find the nearest side wall or slope …." (Ex. 1001, 9:58-66; 11:31-36.) It does not describe the internal hardware configuration, circuitry, software modules, or algorithmic logic by which the distance measurement or robot control functions are actually performed. For example, the specification appears to describe the "distance measurement unit" as capable of both **performing** distance measurement and **controlling** the robot to find the nearest side wall or slope. However, it is my opinion that this disclosure is inconsistent with both (1) a POSITA's common-sense understanding of the phrase "distance measurement unit" (which under plain language would be a unit or module for measuring distance, not a device or algorithm for controlling a robot) *and* (2) other language throughout the specification which states that the task of controlling the robot to the find nearest wall is performed not by the measurement unit, by rather by the "main control unit." For example, the '196 Patent states: "In addition, the controllable sinking and floating swimming pool robot according to one aspect of the present disclosure, further including a **distance measurement unit** or a map storage unit, wherein **the main control unit controls the swimming pool robot to find the nearest side wall** …" (Ex. 1001, 2:11-19; 10:5-11; 9:66-10:3). Irrespective of this ambiguity in the specification on the execution of the

task of controlling the robot to find the nearest wall, the specification does not disclose any corresponding structure or any particular sequence of program instructions that achieve these functions (much less even clarifying which unit performs said task). The patent thus provides no concrete structural or algorithmic disclosure that a POSITA could use to understand how the claimed measurement and control functions are realized.

112. If indeed the '196 Patent is to be interpreted to include the function of "controlling … to find the nearest side wall", and the "distance measurement unit" is intended to correspond to a generic processor, microcontroller, or computer system capable of executing control tasks, I understand that the specification must disclose the programming logic or algorithm that enables the processor to perform the recited functions. In my opinion, merely referencing a generic processor or control device, without associated algorithmic detail, does not provide sufficient structure to satisfy § 112(f).

113. Accordingly, I conclude that the '196 Patent fails to disclose adequate structure corresponding to the recited functions of the "distance measurement unit." A POSITA reading the patent would not have reasonable certainty as to what specific hardware, software, or programming constitutes this "distance measurement." For that reason, it is my opinion that the "distance measurement

unit" limitation is **indefinite** because the specification does not identify a corresponding structure as required under § 112(f).

114. In the alternative, if the Board were to determine that § 112(f) does not apply, it is my opinion that the term "distance measurement unit" should be construed to mean **"a device that measures a distance between the robot and a surrounding object."** However, even under that alternative construction, the term remains purely functional and lacks any specific structural limitation beyond that generic description.

7. "Map Storage Unit"

115. Claim 4 of the '196 Patent recites, in relevant part, "*a **map storage unit**, wherein the main control unit controls the swimming pool robot to find the nearest side wall or the nearest slope based on … map data in the map storage unit*." In my opinion, the term "map storage unit" provides a sufficiently definite structure because a POSITA would understand "storage" to refer to a memory device.

116. This understanding is further supported by the specification, which describes that "the map storage unit 60 is configured to store map data of the swimming pool," and that the "main control unit 10 controls the swimming pool robot [] to find the nearest side wall [] based on the map data in the map storage unit 60." (Ex. 1001, 11:48-52.)

117. In my opinion, while the '196 Patent does not specify the precise data-storage hardware, a POSITA would understand that the map storage unit could be implemented using standard memory device, such as flash memory, EEPROM, or other non-volatile data-storage components capable of retaining map data for navigation control. Accordingly, § 112(f) does not apply; it is my opinion that a POSITA would construe the term "map storage unit" according to its plain and ordinary meaning as **"a memory that stores map data of the swimming pool."**

8. "Outlet Water Detection Subunit"

118. As discussed above with respect to the "waterline detection unit," the '196 Patent explains that this unit includes two subunits—an outlet water detection subunit and a proximity waterline detection subunit—each performing a distinct sensing function to assist in detecting the robot's positional relationship to the waterline. The following paragraphs analyze the "outlet water detection subunit" individually, consistent with its recitation in Claim 5.

119. Claim 5 of the '196 Patent recites, in relevant part, "*the waterline detection unit comprises an* ***outlet water detection subunit*** *configured to detect whether at least a part of the swimming pool robot has come out of water*."

120. In my opinion, the claim language defines the "outlet water detection subunit" only in terms of **what it does**, not in terms of **what it is**. The claim recites the function—detecting whether at least part of the swimming pool robot has come

out of water—but does not describe any structural details of the "outlet water detection subunit" itself. The term "subunit" is a generic placeholder that does not connote any definite structure to a POSITA. Accordingly, this limitation is expressed in purely functional language and, in my opinion, invokes means-plus-function claiming under 35 U.S.C. § 112(f). Although the claim does not use the word "means," I understand that this creates only a rebuttable presumption against § 112(f) that may be overcome when, as here, the claim is drafted solely in functional terms.

121. The express function recited for the "outlet water detection subunit" is **to detect whether at least a part of the swimming pool robot has come out of water.** (Ex. 1001, 2:22-24; 2:36-38; 8:35-37; 12:28-30.) The specification describes this component as part of the waterline detection unit and explains that the outlet water detection subunit may be implemented using conventional sensors. Specifically, the patent states that the "*outlet water detection subunit … may be configured by, for example,* ***a capacitive sensor or an ultrasonic ranging device***." (Ex. 1001, 8:38-40.)

122. In my opinion, this disclosure provides sufficient structural context for performing the recited function. A POSITA would understand that capacitive sensors and ultrasonic ranging sensors are standard components capable of detecting the presence or absence of water around part of the robot's body.

Because these are well-known sensor types that operate on established physical principles, no special algorithm is required for a POSITA to understand how the disclosed structure accomplishes the detection function.

123. Accordingly, if 35 U.S.C. § 112(f) applies, I construe the term "outlet water detection subunit" as follows:

- **Function:** To detect whether at least a part of the swimming pool robot has come out of the water.
- **Structure:** A capacitive sensor or an ultrasonic ranging sensor, and equivalents thereof. (*See* Ex. 1001, Fig. 1 and corresponding description at 8:29-40.)

124. In the alternative, if the Board determines that § 112(f) does not apply, it is my opinion that the term "outlet water detection subunit" should be construed according to its ordinary and customary meaning, as understood by a POSITA at the time of the invention, in light of the claim language, the specification, and the prosecution history.

125. Although the only embodiment disclosed in the '196 Patent implements this function using capacitive or ultrasonic sensors, I see no evidence that the patentee acted as its own lexicographer or disavowed other sensing mechanisms capable of performing the same function. The specification expressly states that the disclosed embodiments are "merely examples but not limitations,"

and that "the specific details disclosed above are only for illustrative purposes and easy-to-understand functions rather than limitation." (Ex. 1001, 14:26-36.) A POSITA would therefore understand that the patentee did not limit the "outlet water detection subunit" to any particular sensor type, and that the term broadly encompasses conventional sensors capable of detecting whether a portion of the robot has exited the water.

126. Accordingly, if § 112(f) does not apply, I would construe the term "outlet water detection subunit" according to its plain and ordinary meaning as **"a sensor that detects water at the outlet of a swimming pool robot."**

9. "Proximity Waterline Detection Subunit"

127. As discussed above with respect to the "waterline detection unit," the '196 Patent explains that this unit includes two subunits: an outlet water detection subunit and a proximity waterline detection subunit, each performing a distinct sensing function to assist in detecting the robot's positional relationship to the waterline. The following paragraphs analyze the "proximity waterline detection subunit" individually, consistent with its recitation in Claim 6.

128. Claim 6 of the '196 Patent recites, in relevant part, "*the waterline detection unit comprises a* ***proximity waterline detection*** *subunit configured to detect whether the swimming pool robot has crawled to a distance less than or equal to a predetermined distance from the waterline*."

129. In my opinion, the claim language defines the "proximity waterline detection subunit" only in terms of **what it does**, not in terms of **what it is**. The claim recites the function—detecting whether the swimming pool robot has crawled to within a predetermined distance from the waterline—but does not describe any structural details of the subunit itself. The term "subunit" is a generic placeholder that does not connote a definite structure to a POSITA. Accordingly, the limitation is drafted in purely functional language and, in my opinion, invokes means-plus-function claiming under 35 U.S.C. § 112(f). Although the claim does not use the word "means," I understand that this creates only a rebuttable presumption against § 112(f) that may be overcome when, as here, the claim is expressed solely in terms of function.

130. The express function recited for the "proximity waterline detection subunit" is to detect the robot's proximity to the waterline of the swimming pool by detecting whether the swimming pool robot has crawled to a distance less than or equal to a predetermined distance from the waterline. (Ex. 1001, 2:25-31; 8:40-44.)

131. The specification describes this subunit as part of the waterline detection unit and provides examples of suitable structures for performing its function. Specifically, it states that "*the proximity waterline detection subunit …*

may be configured by, for example, ***an ultrasonic ranging device***." (Ex. 1001, 8:40-47.)

132. In my opinion, this disclosure provides sufficient structural context to a POSITA for performing the recited function. A POSITA would understand that an ultrasonic ranging device is a well-known type of distance sensor capable of measuring the gap between a sensor and a surface, including the water surface. Because this is a standard sensor technology that operates on established acoustic-reflection principles, no special algorithm or unique programming would be required for a POSITA to understand how the disclosed structure carries out the detection function.

133. Accordingly, if 35 U.S.C. § 112(f) applies, I construe the term "proximity waterline detection subunit" as follows:

- **Function**: To detect the robot's proximity to the waterline of the swimming pool by detecting whether the swimming pool robot has crawled to a distance less than or equal to a predetermined distance from the waterline.
- **Structure**: An ultrasonic ranging device and equivalents thereof. (*See* Ex. 1001, Fig. 1 and corresponding description at 8:29-47.)

134. In the alternative, if the Board determines that § 112(f) does not apply, it is my opinion that the term "proximity waterline detection subunit" should be

construed according to its ordinary and customary meaning, as understood by a POSITA at the time of the invention, in light of the claim language, the specification, and the prosecution history.

135. Although the only embodiment disclosed in the '196 Patent implements this function using an ultrasonic ranging sensor, I see no evidence that the patentee acted as its own lexicographer or clearly disavowed other distance-sensing mechanisms capable of performing the same function. The specification expressly states that the described embodiments are "merely examples but not limitations," and that "the specific details disclosed above are only for illustrative purposes and easy-to-understand functions rather than limitation." (Ex. 1001, 14:26-36.) A POSITA would therefore understand that the patentee did not limit the "proximity waterline detection subunit" to any particular sensor type, and that the term broadly encompasses conventional distance-measuring sensors capable of detecting whether the robot has approached the water surface.

136. In my opinion, the "proximity waterline detection subunit" works in conjunction with the "outlet water detection subunit" as part of the overall waterline detection unit disclosed in the '196 Patent. The proximity subunit detects when the robot nears the water surface, while the outlet subunit detects when the robot has partially emerged. A POSITA would understand that the combined operation of these subunits enables the waterline detection unit to perform its

overall function of detecting the robot's positional relationship to the waterline and controlling transitions between sinking state and floating state.

137. Accordingly, if § 112(f) does not apply, I would construe the term "proximity waterline detection subunit" according to its plain and ordinary meaning as **"a sensor that detects the robot's proximity to the waterline of the swimming pool."**

10. "Inflation and Deflation Subunit"

138. Claims 7 and 8 of the '196 Patent specify that the "sinking and floating control unit" comprises an "inflation and deflation subunit." Claim 7 recites, in relevant part, "*in response to the outlet water detection subunit detecting that at least a part of the swimming pool robot has come out of the water, the* ***inflation and deflation subunit*** *is controlled to start sucking air and the switch subunit is controlled to open, so that the sinking and floating control unit enters the floating working state.*" Claim 8 similarly recites, in relevant part, "*in response to the proximity waterline detection subunit detecting that the swimming pool robot has crawled to a distance less than or equal to a predetermined distance from the waterline, the* ***inflation and deflation subunit*** *is controlled to start sucking air, and in response to the outlet water detection subunit detecting that the robot has come out of the water, the switch subunit is controlled to open, so that the sinking and floating control unit enters the floating working state."*

139. In my opinion, a POSITA would understand that the term "inflation and deflation subunit" is defined only through its function or action rather than its structure. Accordingly, the recited limitations lack structural definition and, in my opinion, invoke means-plus-function treatment under 35 U.S.C. § 112(f). Although the claims do not use the word "means," this creates only a rebuttable presumption against § 112(f) that may be overcome when, as here, the claim language provides only outcome-based or operational descriptions.

140. Throughout the '196 Patent, the "inflation and deflation subunit" (e.g., one or more air pump assemblies) and the "switch subunit" (e.g., one or more electromagnetic valves or two-position three-way valve assemblies) are described as jointly controlling the air exchange that enables the robot to transition between submerged and floating states. The inflation and deflation subunit serves as the active component that draws in or discharges air from the airbags, thereby varying the buoyancy. (Ex. 1001, 8:48-64; 12:44-13:3) During the floating operation, when the proximity waterline detection subunit detects that the robot has approached the waterline, the main control unit first activates the inflation and deflation subunit to begin sucking air; after the outlet water detection subunit detects that at least a portion of the robot has emerged from the water, the main control unit then opens the switch subunit so that air can be drawn from the atmosphere into the airbags, increasing their volume and allowing the robot to enter the floating working state.

(*Id.)* These subunits are closed when the robot has entered a floating working state for a predetermined time. (Ex. 1001, 9:18-24.) The specification further explains that, during sinking, both subunits are opened to discharge air from the airbags, reducing the buoyancy until the robot submerges. (Ex. 1001, 6:52-59.)

141. In my opinion, these disclosures provide sufficient mechanical structure to a POSITA for performing the recited functions. Air-pump assemblies are standard pneumatic components that have well-understood configurations and modes of operation. Because these are purely mechanical devices, no software algorithm is required to understand how the disclosed structures accomplish the functions of inflation, deflation, and airflow control.

142. Accordingly, if 35 U.S.C. § 112(f) applies, I construe the term "inflation and deflation subunit" as follows:

- **Function**: To control inflation and deflation of the airbags.
- **Structure**: One or more air pumps and equivalents thereof. (*See* Ex. 1001, Figs. 1, 3-5 and corresponding description at 7:19-8:15.)

143. In the alternative, if the Board determines that § 112(f) does not apply, it is my opinion that the term "inflation and deflation subunit" should be construed according to their ordinary and customary meaning, as understood by a POSITA at the time of the invention, in light of the claim language, the specification, and the prosecution history.

144. I am informed that claim terms are generally given their ordinary and customary meaning as understood by a POSITA in view of the intrinsic record. I am further informed that a departure from this ordinary meaning is appropriate only in two circumstances: (1) when the patentee clearly sets forth a special definition and acts as its own lexicographer, or (2) when the patentee clearly and unmistakably disavows the full scope of the term either in the specification or during prosecution.

145. Here, although the only embodiment disclosed in the '196 Patent implements buoyancy control through an air-based pneumatic system using air-pump and valve assemblies, I see no evidence that the patentee acted as its own lexicographer or clearly disavowed other equivalent pneumatic or fluidic mechanisms capable of performing the same functions. The specification expressly states that the detailed embodiments are "merely examples but not limitations," and that "the specific details disclosed above are only for illustrative purposes and easy-to-understand functions rather than limitation." (Ex. 1001, 14:26-36.) A POSITA would therefore understand that the patentee did not intend to limit these subunits to the particular pump and valve structures described, but rather to encompass conventional pneumatic components capable of achieving inflation, deflation, and airflow control.

146. Accordingly, if the Board determines that 35 U.S.C. § 112(f) does not apply, it is my opinion that a POSITA would construe the term "inflation and deflation subunit" according to its plain and ordinary meaning as "**a component or assembly configured to supply or remove air to adjust the buoyancy of a swimming pool robot**."

11. "Switch Subunit"

147. Claims 7 and 8 of the '196 Patent specify that the "sinking and floating control unit" comprises a "switch subunit". Claim 7 recites, in relevant part, "*in response to the outlet water detection subunit detecting that at least a part of the swimming pool robot has come out of the water, the inflation and deflation subunit is controlled to start sucking air and the* ***switch subunit*** *is controlled to open, so that the sinking and floating control unit enters the floating working state.*" Claim 8 similarly recites, in relevant part, "*in response to the proximity waterline detection subunit detecting that the swimming pool robot has crawled to a distance less than or equal to a predetermined distance from the waterline, the inflation and deflation subunit is controlled to start sucking air, and in response to the outlet water detection subunit detecting that the robot has come out of the water, the* ***switch subunit*** *is controlled to open, so that the sinking and floating control unit enters the floating working state."*

148. In my opinion, a POSITA would understand the term "switch subunit" to refer to a definite and recognizable structure. The word "switch" is commonly used in the field of electrical, mechanical, and pneumatic systems to denote an electromechanical device that turns something on/off or that closes/opens something. The addition of the term "subunit" simply indicates that the switch is a component of a larger buoyancy-control assembly and does not alter the established structural meaning of "switch." A POSITA would thus understand that the "switch subunit," even with the modifier "subunit," retains the same structural connotation as a conventional electromechanical switch used in pneumatic or underwater systems.

149. The specification is consistent with this understanding. The '196 Patent describes the switch subunit as an electromagnetic valve assembly that opens or closes the air pipes connected to the air bag; thereby enabling inflation and deflation of the air bags. (Ex. 1001, Figs. 3-5; 7:9-8:23.) In the floating working state, the valve is opened and air is drawn into the airbags to increase their volume and buoyant force, allowing the robot to rise and float; once floating state is achieved for the robot, the valve is closed; in the sinking working state, air is expelled from the airbags, reducing their volume and buoyant force, allowing the robot to sink. (Ex. 1001, 6:40-59.)

150. Accordingly, it is my opinion that a POSITA would construe the term "switch subunit" according to its plain and ordinary meaning as "**a device that opens or closes.**"

12. "Airbag Subunit"

151. Claim 9 of the '196 Patent recites, in relevant part, "*the sinking and floating control unit further comprises an* ***airbag subunit*** *connected to the inflation and deflation subunit, wherein the* ***airbag subunit*** *is connected to or disconnected from outside atmosphere through the inflation and deflation subunit and the switch subunit*."

152. In my opinion, a POSITA would understand the term "airbag subunit" to refer to a definite and recognizable structure. The word "airbag" is commonly used in the field of mechanical and pneumatic systems to denote an inflatable, sealed chamber made of flexible material that expands or contracts with air intake or discharge. A POSITA would readily recognize that such a structure changes its internal volume in response to the amount of air contained within it, thereby varying the buoyant force acting on the swimming pool robot. The addition of the term "subunit" simply indicates that the airbag is a component of a larger buoyancy-control assembly and does not alter the established structural meaning of "airbag." A POSITA would thus understand that the "airbag subunit," even with the

modifier "subunit," retains the same structural connotation as a conventional airbag used in pneumatic or underwater systems.

153. The specification is consistent with this understanding. The '196 Patent describes the airbag subunit as a sealed inflatable chamber connected to the inflation and deflation subunit and the switch subunit, together forming a closed pneumatic circuit used to regulate buoyancy. (Ex. 1001, Figs. 2B, 3; 6:36-40; 6:43-59.) In the floating working state, air is drawn into the airbags to increase their volume and buoyant force, allowing the robot to rise and float; in the sinking working state, air is expelled from the airbags, reducing their volume and buoyant force, allowing the robot to sink. (Ex. 1001, 6:40-59.)

154. A POSITA would understand from these disclosures that the airbag subunit provides the main structure for generating and maintaining buoyancy in the robot. The airbag operates as a sealed, expandable volume that interacts with the surrounding water to produce an upward force proportional to the displaced fluid. The specification further shows that the airbag subunit is connected through tubing to the inflation and deflation subunit and the switch subunit, which controls the intake and exhaust of air to dynamically adjust buoyancy. These components collectively form the pneumatic buoyancy-control system that allows the robot to float or sink as required.

155. Accordingly, it is my opinion that a POSITA would construe the term "airbag subunit" according to its plain and ordinary meaning as "**an airbag (i.e., an inflatable structure that changes its volume in response to air intake or discharge).**"

13. "Air Inlet and Outlet Subunit"

156. Claim 9 of the '196 Patent recites, in relevant part, "*the sinking and floating control unit further comprises an* ***air inlet and outlet subunit****, wherein the switch subunit is connected to the outside atmosphere through the air inlet and outlet subunit*."

157. In my opinion, a POSITA would understand that the term "air inlet and outlet subunit" refers to a definite structural component that provides the interface through which air enters or leaves the pneumatic buoyancy-control system. The words "air inlet and outlet" connote a physical passage, port, or channel for gas exchange, and would not be interpreted as a purely functional label. A POSITA would therefore understand that the air inlet and outlet subunit forms part of the air path connecting the robot's internal air circuit to the external atmosphere.

158. The specification is consistent with this understanding. It describes the air inlet and outlet subunit as a structural element connected to the switch subunit and forming part of the air passageway that links the internal air circuit to the

outside atmosphere. In the floating working state, the inflation and deflation subunit is turned on to suck air from outside, and the switch subunit is opened so that air above the water level enters the airbag subunit *through the air inlet and outlet subunit, the switch subunit, and the inflation and deflation subunit.* (Ex. 1001, Figs 2B, 3; 6:43-48.) Conversely, in the sinking working state, the inflation and deflation subunit is turned on to extract air from the airbags, and the switch subunit is opened so that the air in the airbags is discharged *through the inflation and deflation subunit, the switch subunit, and the air inlet and outlet subunit.* (Ex. 1001, 6:52-59.) These descriptions show that the air inlet and outlet subunit provides the physical opening or conduit through which air exchange occurs between the internal pneumatic system and the external environment.

159. A POSITA would therefore understand that the air inlet and outlet subunit serves as a fixed structural interface enabling controlled airflow to and from the airbag subunit. It does not perform the active pumping or switching functions of the inflation and deflation subunit or the switch subunit, but rather provides the port or passage that allows gas transfer when those other subunits are activated. Because this component is defined by well-known structural characteristics and its function as an air exchange interface is straightforward, no specialized algorithm or control logic is required to understand how it operates.

160. Accordingly, it is my opinion that a POSITA would construe the term "air inlet and outlet subunit" according to its plain and ordinary meaning as "**a port or conduit that allows air to enter or exit the swimming pool robot.**"

14. "Sinking Working State"

161. Claim 10 of the '196 Patent recites, in relevant part, "*the main control unit is further capable of controlling the sinking and floating control unit to enter a* ***sinking working state*** *based on the operational requirement information of the swimming pool robot to realize a sinking of the swimming pool robot*."

162. I understand that a patent claim is indefinite if, when read in light of the specification and prosecution history, it fails to inform, with reasonable certainty, those skilled in the art about the scope of the invention.

163. The '196 Patent appears to distinguish between a *"**sinking working state**"* and a *"**sinking state**."* In my opinion, the "sinking working state" refers to a condition or mode of the "sinking and floating control unit." In contrast, the "sinking state" refers to the physical condition of the robot itself (i.e., that the robot is descending or operating below the water surface). (*See, e.g.*, Ex. 1001, 6:22-30 ("*[The operational requirement information] instruct[s] the swimming pool robot 1 to switch to a* ***floating state*** *to clean a waterline area … or to switch to a* ***sinking state to clean a pool bottom or sidewall area***.").)

164. Claim 11 further elaborates on the "sinking working state" by specifying that "*controlling the sinking and floating control unit to enter the sinking working state* ***comprises controlling the switch subunit to open and controlling the inflation and deflation subunit to discharge air in the airbag subunit***" [sic]—i.e., discharge air from the airbag subunit to reduce buoyancy. In my opinion, this limitation clarifies that the "sinking working state" corresponds to a hardware actuation mode of the sinking and floating control unit — specifically, when the switch subunit is open and the inflation/deflation subunit is operating to discharge air from the airbag to reduce buoyancy.

165. The specification is consistent with this interpretation, describing the "sinking working state" as occurring when the switch subunit opens and the inflation and deflation subunit begins to extract air, thereby deflating the airbag and decreasing buoyancy:

- "***In the sinking working state,*** *the inflation and deflation subunit 202 is* ***turned on to extract air*** *from the airbag subunit 201, and the switch subunit 203 is* ***turned on*** *... so that the volume of the airbag subunit 201 becomes smaller and the buoyancy of the swimming pool robot 1 is reduced to sink.*" (Ex. 1001, 6:52-59.)
- Embodiment example with 2 pumps (passive deflation): "***In the sinking working state****, the first air pump assembly 2021 and the second air pump assembly 2022 are in the* ***power-off state****, the first electromagnetic valve assembly 2023 and the second electromagnetic valve assembly 2024 are in the* ***power-on working state****. The air in the airbag subunit 201 enters the second air pump assembly 2023* [sic; should be

2022] *and is discharged through the second air pump assembly 2023, the second electromagnetic valve assembly 2024 and the air inlet and outlet subunit 204*." (Ex. 1001, 7:46-54.)

- Embodiment example with 3 pumps (active deflation): "***In the sinking working state**, the first two-position three-way valve assembly 2026 is in the **power-off state**, the second two-position three-way valve assembly 2027 and the third air pump assembly 2025 are in the **power-on working state**, and the air in the airbag subunit 201 enters the third air pump assembly 2025 and is discharged through the third air pump assembly 2025, the first two-position three-way valve assembly 2026 and the air inlet and outlet subunit 204*." (Ex. 1001, 8:16-23.)

166. Although these passages and Claim 11 support the hardware-mode interpretation, the specification also links the sinking working state to the robot's physical movement, stating that "*[i]n the sinking working state, the inflation and deflation subunit [] is turned on… so that the volume of the airbag subunit [] becomes smaller and the buoyancy of the swimming pool robot 1 is reduced to sink*." (Ex. 1001, 6:52-59.) In my opinion, a POSITA would recognize that the robot's physical descent is the *result* of the control unit's operation rather than part of the definition of the state itself. Thus, any reference to the robot's "sinking state" would not create uncertainty about the meaning of "sinking working state."

167. Accordingly, it is my opinion that a POSITA would construe "sinking working state" according to its plain and ordinary meaning as: "**a condition in**

which the floating and sinking subsystem is actively operating to cause the robot to sink."

15. "Water Pump Unit"

168. Claim 14 of the '196 Patent recites, in relevant part, *"**a water pump unit** configured to pump liquid in the swimming pool where the swimming pool robot is located and discharge the liquid to drive the swimming pool robot."* The claim further recites that *"a power of the **water pump unit** is changed after the sinking and floating control unit enters the floating working state or after the swimming pool robot climbs the side wall or the slope."*

169. In my opinion, a POSITA would understand the term "water pump unit" to refer to a definite and well-known mechanical structure. The word "pump" is a common term in the mechanical and fluid-handling arts that denotes a device for moving or circulating liquid by mechanical action, such as via impellers, diaphragms, or pistons. A POSITA would recognize that a "water pump unit" refers to the physical assembly containing one or more water pumps, motors, and related housings that generate water flow to propel, drive, or assist in the movement of the swimming pool robot. The addition of the word "unit" merely indicates that the pump assembly forms part of the overall robot system and does not alter the structural meaning of "water pump."

170. The specification supports this understanding. The '196 Patent describes that, when the sinking and floating control unit enters the floating working state, "a power of the water pump unit 70 is changed" in response to the working state of the robot, for example, "when at least a part of the swimming pool robot 1 is out of the water, a running power of the water pump unit 70 is reduced, thereby reducing an adsorption force between the swimming pool robot 1 and the side wall or slope, and facilitating the swimming pool robot 1 to gradually enter a floating state." (Ex. 1001, 10:17-29) These demonstrate that the water pump unit provides the hydraulic drive and suction forces used for propulsion, wall-climbing, and cleaning operations, and that its power output is dynamically adjusted in coordination with the buoyancy control system.

171. A POSITA would therefore understand that the water pump unit is a conventional mechanical assembly incorporating one or more pumps that generate water flow through the robot's internal ducts or jets to provide thrust, suction, or adhesion. Its operation is based on well-established hydraulic principles, and the specification makes clear that it is structurally realized as a motor-driven water pump. Because the term "pump" itself conveys a specific and recognized structure, a POSITA would not regard "water pump unit" as a purely functional expression, and no special algorithm or programming is required to understand how the disclosed structure performs the claimed pumping and driving functions.

172. Accordingly, it is my opinion that a POSITA would construe the term "water pump unit" according to its plain and ordinary meaning as "**a pump that displaces water.**"

VII. STATE OF THE ART

173. I understand that the '196 Patent claims priority to Chinese Application No. 202411017697.3 filed on July 26, 2024. This section provides an overview of the state of the art in autonomous pool cleaning robots as of July 26, 2024.

174. In my opinion, all the prior art products and references I describe below (including Wang, Zhang, Zhao, Guo, Owen, Henkin, Deng, and Liu) are analogous art because they are all controllable sinking and floating swimming pool robots and/or trying to solve the same problem as the '196 Patent. They are also reasonably pertinent to the problem with which the inventor was involved, namely, controlling the buoyancy system of the pool robot to enable transitions between submerged and water surface operations. The significant overlap in features between these prior art products and references and the '196 Patent provides further evidence that they are analogous art and highly relevant for a POSITA.

175. The prior art discloses autonomous swimming pool cleaning robots equipped with buoyancy control subsystems that enable the robot to actively

transition between sinking and floating states. These systems typically include buoyancy units with one or more cavities or airbags, operated by multiple pumps and valves configured either to exchange air with the atmosphere or to circulate gas internally. By selectively inflating or deflating the airbags, the robot adjusts its buoyancy to submerge for cleaning the pool bottom and sidewalls or to float for cleaning along the waterline and surface. *See e.g.,* Ex. 1005, ¶¶ [0067], [0109] - [0111], [0120]; Ex. 1009, 4:24-27, 4:57-62; Ex. 1010, ¶¶ [0042] - [0051]; Ex. 1014, ¶¶ [0007], [0040] - [0041], [0046] - [0050]; Ex. 1015, 4:31-43, 16:31-48, Fig. 27.

176. The prior art further discloses that such pool cleaning robots may utilize mapping and sensor-based feedback systems to guide and control their pool cleaning operation. For example, ultrasonic sensors may be used to measure distances to nearby pool walls and identify the nearest wall for climbing, inertial measurement units (IMUs) to monitor posture, orientation, and tilt, and pressure sensors to detect hydrostatic pressure or internal air-bag pressure conditions. These sensors collectively enable the robot to trigger or adjust buoyancy control operations—such as detecting when the robot has partially emerged from the water, determining its depth relative to the waterline, and identifying when it has achieved a floating posture. *See e.g.,* Ex. 1009, 7:35-39, 8:13-31; Ex. 1012, 1:38-42, 4:9-17, 6:16-32;

177. Additionally, the prior art discloses controllers programmed to operate buoyancy units in response to specific events, such as the expiration of a predetermined time interval, to prevent over-inflation of airbags or other buoyancy components. Ex. 1013, 3:19-28, 4:7-10, 4:20-26. The cleaning modes of these robots are coordinated with their buoyancy states, allowing the robots to initiate or modify cleaning operations either in response to user commands, according to scheduled time intervals, or based on environmental sensor detections. *See e.g.,* Ex. 1009, 16:42-17:13; Ex. 1014, ¶¶ [0040] - [0041]; Ex. 1015, 2: 31-40, 4:29-40.

178. In my opinion, at the time of the alleged invention of the ’196 Patent, a POSITA would have been well aware of autonomous swimming pool cleaning robots incorporating buoyancy control systems that used air pumps, valves, and airbags or cavity structures to adjust between floating and sinking states. A POSITA would also have understood that such systems commonly employed controllers configured to process input from various sensors—including capacitive, pressure, gyroscopic, inertial measurement (IMU), and ultrasonic sensors—to determine parameters such as the robot’s depth, orientation, and proximity to the waterline. Moreover, it would have been obvious to a POSITA to utilize these sensors for multiple, related purposes, such as detecting when the robot approaches or emerges from the water surface or when it reaches a stable floating posture. Likewise, a POSITA would have recognized it as obvious to control the operation

of pumps and valves for a predetermined time interval or until specific posture or depth conditions are satisfied; operating a pump for a fixed duration of time would provide reliable and predictable result in inflating a buoyancy system to exceed a buoyancy threshold necessary to transition to a floating state. A POSITA would also recognize that such a fixed interval would also prevent damage to buoyancy components from over-inflation or prolonged operation.

A. U.S. Patent Application Publication No. 2025/0146315 ("Wang")

179. Wang was filed on Jan. 18, 2025, and claims priority as a continuation-in-part of prior International Patent Application No. PCT/CN2024/076040 ("**Wang '040**"; published as WO 2024/169737), filed with the World Intellectual Property Organization on February 5, 2024, and entitled "*A CLEANING DEVICE*." The Examiner never cited, and the Applicant never distinguished, Wang or Wang '040 during the prosecution of the '196 Patent.

180. I have reviewed Wang '040. Wang '040 fully discloses the subject matter contained in Wang, and its disclosure fully supports the corresponding technical content of Wang relied upon in this PGR. Accordingly, in my opinion, Wang is entitled to claim the priority date of Wang '040. *See* Ex. 1008.

181. Wang discloses a swimming pool cleaning robot that "*can be flexibly switched between a position* ***on a liquid surface*** *30 and a position* ***under the liquid***

surface *30, so that the cleaning device 10 can comprehensively clean the target region 40.*" (Ex. 1005, ¶ [0064]; Ex. 1006, p.6:66-67.)

182. Wang explains that conventional pool cleaners lack the ability to autonomously manage buoyancy, requiring manual retrieval or external assistance to surface, which reduces both efficiency and user convenience. To overcome this limitation, Wang describes a sinking and floating control unit that includes a mode-switching member 510 and a buoyancy cavity 5111 with pump 5112. This pump inflates or deflates the cavity to raise or submerge the robot, providing controllable buoyancy. (Ex. 1005, ¶ [0067]; ¶¶ [0109]-[0111]; Ex. 1006, p.7:18-28; p.11:60-p.12:26.) Wang also discloses a waterline detection unit comprising two sensors: a first sensor for real-time depth measurement, and a second sensor that determines whether the air inlet 5113 is exposed to air, thereby identifying the robot's relationship to the waterline. (Ex. 1005, ¶¶ [0113]–[0115]; Ex. 1006, p.12:39-64.)

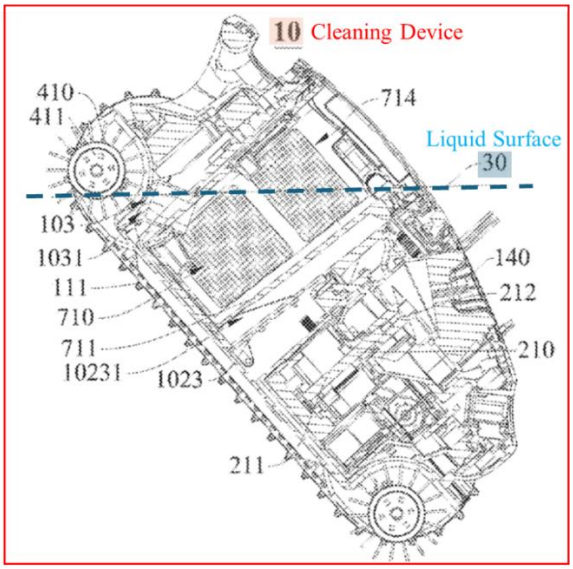


FIG. 3 of Wang (annotated)

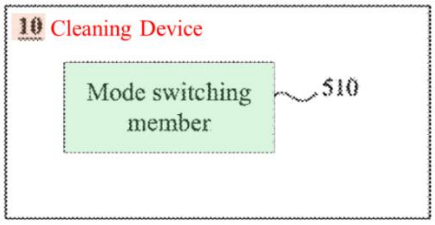


FIG. 4 of Wang (annotated)

183. In operation, Wang teaches that the main control unit activates pump 5112 when preset conditions are satisfied, inflating the buoyancy cavity to raise the robot to the surface. After a preset condition is met, the system reduces buoyancy to re-submerge the robot. (Ex. 1005, ¶ [0114]; ¶ [0120]; Ex. 1006, p.12:46-61; p.13:25-36.) In addition, Wang explains that the main water pump 210 generates suction to enable wall climbing, and that this suction power is reduced or stopped when the robot disengages from a wall or floats at the surface. (Ex. 1005, ¶¶ [0144]–[0145]; Ex. 1006, p.12:46-64.)

184. Taken together, Wang teaches a pool cleaning robot that integrates multiple aspects of buoyancy and propulsion management. Specifically, Wang discloses: (1) a sinking and floating control unit incorporating inflation, deflation, and mode-switching elements; (2) waterline detection through depth and air-

exposure sensors; (3) a main control unit that governs transitions, timing, and posture stability; and (4) coordination of propulsion with buoyancy operations to support both underwater and surface cleaning.

B. U.S. Patent No. 11,946,282 ("Zhang")

185. Zhang was filed on July 17, 2023, and claims priority as a continuation of International Application No. PCT/CN2023/091116, filed on Apr. 27, 2023. The Examiner never cited, and the Applicant never distinguished, Zhang during the prosecution of the '196 Patent.

186. Zhang discloses a pool cleaning robot equipped with a sinking and floating control unit, referred to as the "mode switching member," which is designed to "achieve a position switching of the moving device 100 **above the liquid surface** and **below the liquid surface**," thereby providing controllable sinking and floating functionality. (Ex. 1009, 4:24–27; Abstract.) As described, "when the moving device 100 is below the liquid surface 200, all of the moving device 100 is submerged below the liquid surface 200, and when the moving device 100 is above the liquid surface, at least a portion of the moving device 100 is above the liquid surface." (Ex. 1009, 4:31–35.)

187. Zhang explains that this sinking and floating control is achieved through buoyancy. Specifically, the mode switching member includes a **buoyancy force adjustment assembly** that "may be configured to adjust the magnitude of

the buoyancy force to which the moving device 100 is subjected in the vertical direction." (Ex. 1009, 4:57–62.) The buoyancy force adjustment assembly "may include a buoyancy cavity 1111 and a buoyancy force adjustment member." (Ex. 1009, 5:1–3.)

188. Zhang further teaches that a processor monitors the robot's position in real time. A "first sensor… [is] configured to determine the position of the moving device 100 in real time… includ[ing] a vertical position (or depth) of the moving device 100 in the liquid." (Ex. 1009, 7:35–39.) In addition, a "second sensor… [is] configured to detect in real time whether the air inlet of the buoyancy cavity 1111 is positioned in air." (Ex. 1009, 8:13–16.) This allows the processor to detect when part of the robot has risen above the waterline. When the processor determines, through either the first or second sensor, that a preset condition is satisfied—such as at least part of the robot being above the water surface, as shown in FIG. 4A—it may "increase the volume of the gas in the buoyancy cavity 1111 to achieve the switching of the moving device 100 from below the liquid surface to above the liquid surface." (Ex. 1009, 8:28–31.) This operation places the robot into a floating working state, as depicted in FIG. 4B.

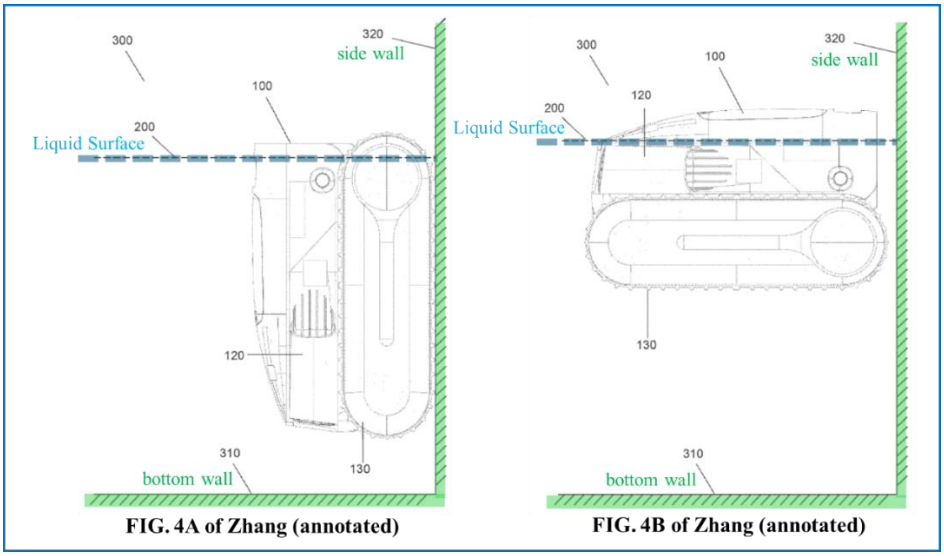
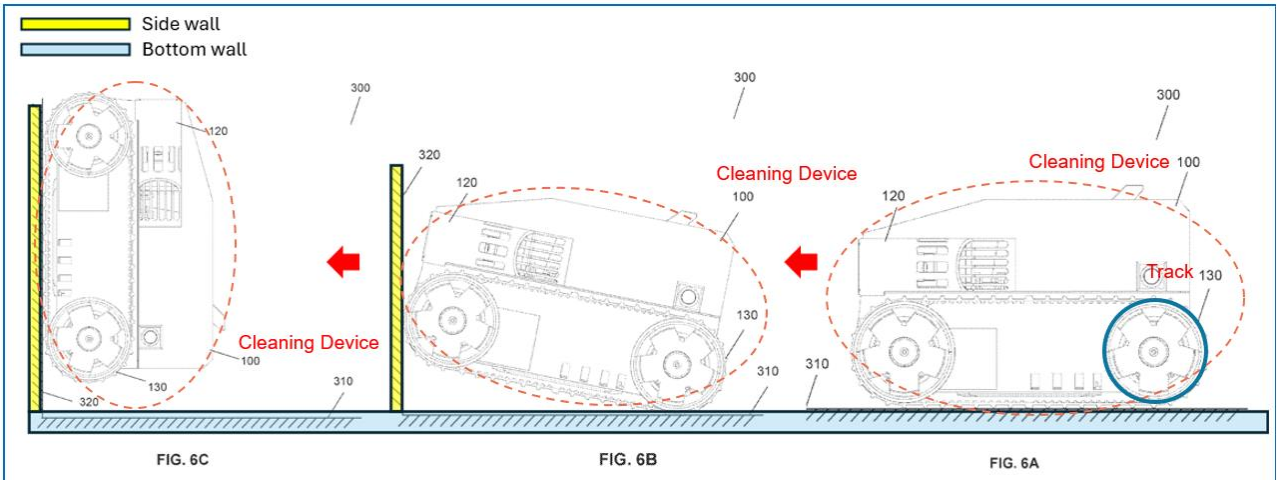


FIG. 4A of Zhang (annotated) FIG. 4B of Zhang (annotated)

189. Zhang also discloses that the processor can control the pool cleaning robot to locate a side wall or slope and crawl along it. The processor first obtains a "target task" for cleaning a pool through user input, scheduled tasks, or analysis of environmental data such as images of pool walls. (Ex. 1009, 16:54–17:13; FIG. 10, step 1005.) It then determines an "adjustment parameter" that includes route information for moving the robot from its current location to the area where the target task is to be performed. (Ex. 1009, 17:28–31; FIG. 10, step 1020.) Based on this adjustment parameter, the processor directs the robot to move and perform cleaning operations, which may include opening the dust box and activating roller brushes to complete the assigned task. (Ex. 1009, 17:42–55.) Zhang further teaches that "the moving device 100 may move against the side wall 320 of the target region 300" (Ex. 1009, 7:14–17), and that "the track 130 also drives the moving device 100 on the side wall 320… when the moving device 100 is pressed against

the side wall 320" (Ex. 1009, 11:47–49). Moreover, "the main water pump 140… may drive the moving device 100 to press against the side wall 320," with tracks, propellers, and pumps providing the necessary upward and downward forces to enable vertical crawling along the wall. (Ex. 1009, 13:23–33.)



Figs. 6A-6C of Zhang (annotated)

190. Finally, Zhang explains that the "target task" may also include underwater cleaning operations, such as cleaning the pool body, the pool bottom, and individual walls. (Ex. 1009, 16:42–53.) In this case, when the processor determines that an underwater cleaning task is required, it controls the buoyancy force adjustment member to discharge gas from the buoyancy cavity, "thereby reducing the volume of the gas in the buoyancy cavity 1111 to reduce the buoyancy force to allow the moving device 100 to be switched from above the liquid surface to below the liquid surface." (Ex. 1009, 8:37–49.)

C. Chinese Patent No. CN117738506 ("Guo")

191. Guo was published on March 22, 2024, from Chinese Patent Application No. 202410095060.X, filed on January 23, 2024. The Examiner did not rely on Guo, and the Applicant never addressed it, during the prosecution of the '196 Patent.

192. Guo discloses a swimming pool cleaning robot incorporating a buoyancy control system that enables autonomous floating and sinking. (Ex. 1010, Abstract.) The technology addresses the limitations of conventional pool cleaners, which either lack controlled buoyancy or rely on bulky gas storage tanks. (Ex. 1010, ¶ [0003].) Guo provides a compact solution by integrating inflatable airbags and a gas-exchange mechanism within the drive compartment. This design improves maneuverability, reduces cost, and allows the robot to clean the pool bottom, sidewalls, and water surface. (Ex. 1010, ¶ [0002]; [0019].)

193. Guo teaches that the robot includes a housing, a **buoyancy assembly**, and a drive assembly. (Ex. 1010, ¶ [0008].) The buoyancy assembly features one or more inflatable airbags connected by air tubes to an inflation-and-deflation assembly. (Ex. 1010, ¶ [0033].) This assembly, located inside a sealed drive cabin, contains pumps and valves that selectively transfer gas between the drive cabin and the airbags. (Ex. 1010, ¶¶ [0009]; [0034].) When gas is drawn from the drive cabin into the airbags, the robot becomes more buoyant and floats. Conversely, when gas

is expelled from the airbags back into the cabin, the robot loses buoyancy and submerges. (Ex. 1010, ¶¶ [0019]; [0034].)

194. Guo further describes multiple configurations of the inflation-and-deflation assembly to regulate gas exchange. In one configuration, two separate sets of pumps and valves are used: one set to draw gas from the drive cabin into the airbags for floating, and another to return gas for sinking, providing precise buoyancy control. (Ex. 1010, ¶¶ [0042]–[0043].) In another, a pump is paired with a one-way valve, allowing gas to flow into the airbags through the pump and back through the valve for a simpler, reliable design. (Ex. 1010, ¶¶ [0045]–[0046].) A third embodiment employs a reversible pump, such as a peristaltic pump, gear pump, or Roots blower, which inflates the airbags when rotated forward and deflates them in reverse. An optional **solenoid valve** can open during operation and close when idle to enhance sealing and stabilize airflow. (Ex. 1010, ¶¶ [0048]–[0050].)

195. Taken together, Guo demonstrates that, prior to later buoyancy-based pool cleaning robotic designs, it was already known to regulate buoyancy in robotic cleaners by using pumps and valves to transfer gas between sealed drive cabins and inflatable airbags. These teachings establish a state-of-the-art buoyancy control approach in which the drive cabin itself serves as the gas source for the airbags, integrating propulsion and flotation functions into a compact structure.

This integration provides practical improvements in stability, maneuverability, and overall efficiency of robotic pool cleaners. (Ex. 1010, ¶¶ [0019], [0034], [0056].)

196. By comparing Figs. 3 and 4 of the '196 Patent with Figs. 4 and 5 of Guo, it is evident that both references disclose substantially similar buoyancy-control structures. In the '196 Patent, Fig. 3 illustrates a sinking and floating control unit including an **airbag subunit (201)** connected with an **air inlet/outlet subunit (204)**, an **inflation/deflation subunit (202)**, and a **switch subunit (203)**, arranged to inflate or deflate the airbag for regulating buoyancy. Fig. 4 further details the pneumatic connections among these components, showing the **airbag subunit (201)** connected to the **air inlet/outlet subunit (204)**, **two-position three-way valves**, and an **air pump assembly**, such that air can be selectively drawn from or vented to the atmosphere through the pump and valve network to expand or collapse the airbag and thereby control sinking and floating.

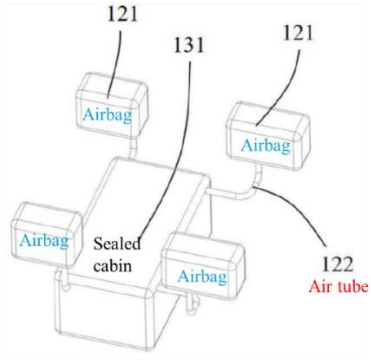


FIG. 4 of Guo (annotated)

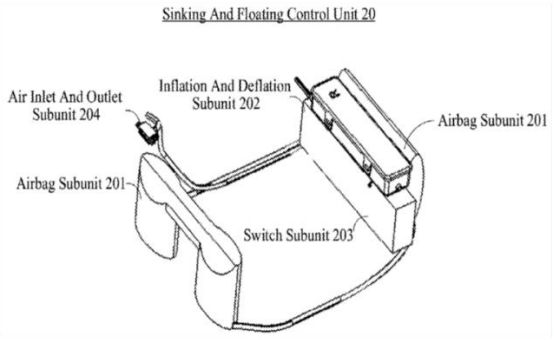


FIG. 3 of the '196 Patent (annotated)

197. Similarly, Guo's Figs. 4 and 5 disclose a **floating and diving assembly (120)** in which multiple **airbags (121)** are connected via **air tubes (123)** to **inflation/deflation device (122)** housed inside the **driving cabin (131)**. The inflation/deflation device (122) is configured to selectively transfer gas between the airbags (121) and the driving cabin (131) to regulate buoyancy and thereby control the robot's sinking and floating. As described in Guo, the inflation/deflation device (122) may take several forms: a) a first air pump, a first air valve, a second air pump, and a second air valve (embodiment 1); b) a pump and an one-way valve (embodiment 2); or c) a power mechanism which may be a peristaltic pump, a gear pump, or a Roots blower (embodiment 3). (Ex. 1010, ¶¶ [0041]-[0049].)

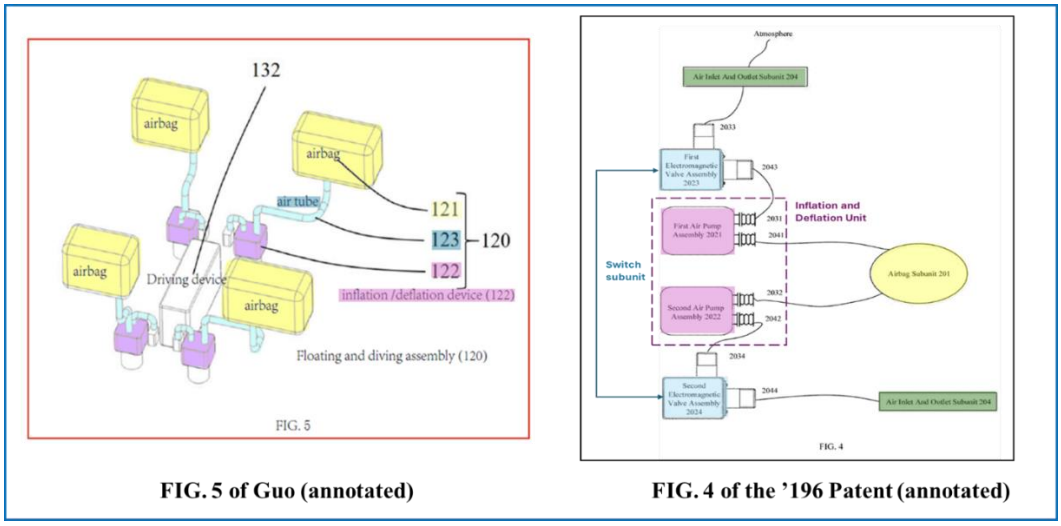


FIG. 5 of Guo (annotated) **FIG. 4 of the '196 Patent (annotated)**

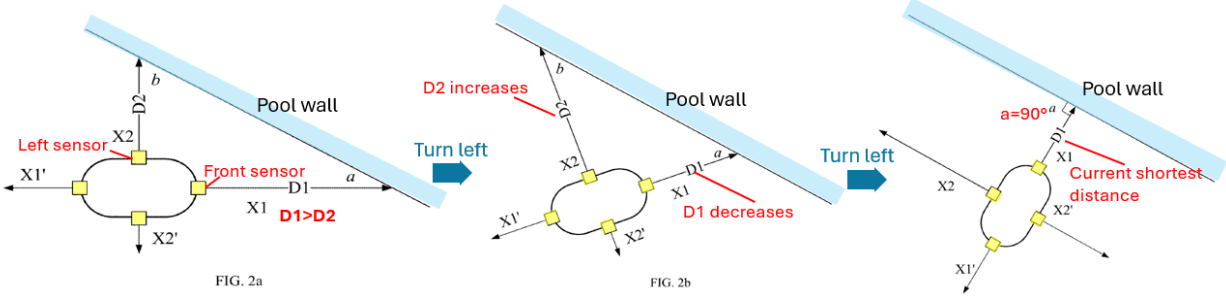
D. U.S. Patent No. 11,803,193 ("Zhao")

198. Zhao was filed on January 3, 2023, and issued on October 31, 2023. It claims priority to Chinese patent application CN 202210659313.2, filed on June

13, 2022. The Examiner did not rely on Zhao, and the Applicant never addressed it during the prosecution of the ’196 Patent.

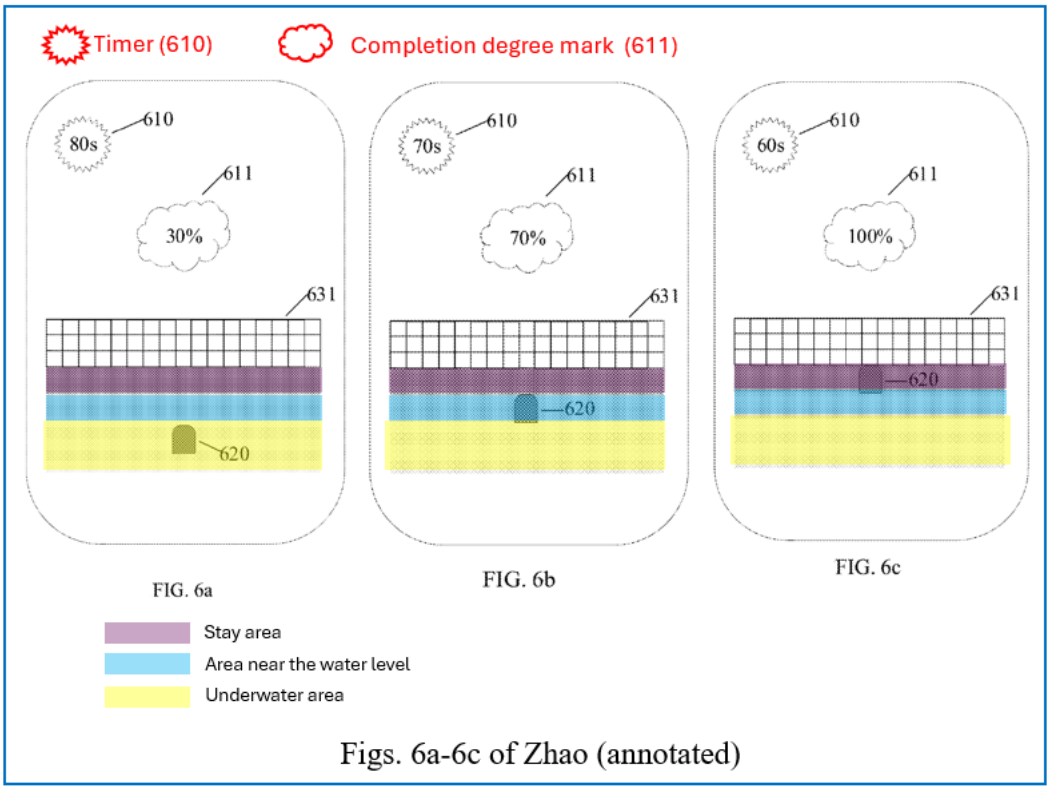
199. Zhao describes methods and systems for automatically docking a swimming pool cleaning robot at or near the waterline. (Ex. 1012, Abstract; Fig. 1.) The disclosed technology addresses the challenge of enabling a robot to autonomously locate a pool wall, align itself, and surface for docking or retrieval, thereby improving both user convenience and operational reliability of robotic pool cleaners. (Ex. 1012, 1:38–42; 2:63–65; 5:3–49; 7:60–8:5.)

200. To achieve this, Zhao teaches that the robot is equipped with multiple ultrasonic sensors positioned on its front, rear, left, and right sides. (Ex. 1012, 4:12-13.) These sensors measure respective distances to nearby pool walls, identified as D1, D1’, D2, and D2’. (Ex. 1012, 4:49-51.) When a docking instruction is received, the robot compares these distance measurements to determine the closest wall. (Ex. 1012, 1:38-42; 4:6-17; 4:33-40; 4:62-65; 5:3-49; Figs. 2a–2d.) If the nearest wall is not directly ahead, the robot adjusts its orientation by varying motor speeds until its forward direction aligns with the selected wall. (Ex. 1012, 5:34-49.) Once aligned, the robot advances until it reaches or collides with the wall (Ex. 1012, 6:55-57.)



Figs. 2a-2c of Zhao (annotated)

201. After contacting the wall, Zhao discloses that the robot initiates a climbing maneuver to ascend vertically until it reaches the waterline. (Ex. 1012, 6:16–21.) This maneuver is supported by a gyroscope that monitors inclination, a counter that tracks motion, and control logic that maintains balance when the robot is at or near the surface. (Ex. 1012, 4:18–25; 6:21–32.) The system is designed to ensure stability even when part of the robot is exposed above the waterline. (Ex. 1012, 8:1–5.) Zhao also describes optional enhancements, including a docking locator mounted on the pool wall to aid in precise alignment (Ex. 1012, 7:56–59), and a **user interface** for displaying docking progress (Ex. 1012, 8:11–15), such as indicators of proximity to the waterline or completion of the docking sequence (Ex. 1012, 8:15–42; Figs. 6a–6c).



Figs. 6a-6c of Zhao (annotated)

202. Taken together, Zhao establishes that, prior to the filing of the '196 patent, it was already known in the art to enable a robotic pool cleaner to: (1) autonomously detect and navigate toward the nearest wall, (2) climb vertically up the wall to the waterline, and (3) maintain stable positioning at or near the water surface for docking or retrieval. Zhao's teachings demonstrate state-of-the-art techniques in robotic navigation, wall climbing, and surfacing maneuvers for pool cleaning robots.

E. International Patent Application Publication No. WO 2007/106730 ("Owen")

203. International Patent Application No. PCT/US2007 /063650 (published as WO 2007/106730) was filed with the World Intellectual Property Organization

on March 9, 2007. The Examiner did not rely on Owen, and the Applicant never addressed it, during the prosecution of the '196 Patent.

204. Owen discloses pumps for inflatable support systems that include an **automatic shutoff timing mechanism**. (Ex. 1013, 1:30-32.) The disclosed technology addresses the need for a pump that can inflate an object, such as an air mattress, **for a preset period and then stop automatically**, thereby avoiding over-inflation or motor damage when the user is not present. (Ex. 1013, 1:19-23; 1:33-2:15.)

205. To accomplish this, Owen teaches that the pump incorporates a timer circuit, which is implemented on a circuit board or integrated chip, that allows the motor to run **for a specified time** (e.g., about 60 seconds) and then **automatically shuts off** the pump when that time elapses. (Ex. 1013, 3:19-28.) Owen explains that the timer may be programmed for slightly longer durations (e.g., 70 seconds) to ensure full inflation and that different time settings may be used for different inflation levels or bladder sizes. (Ex. 1013, 3:29-4:6.)

206. Owen further describes optional safeguards such as a pressure sensor that signals the motor to de-energize once a threshold pressure is reached, or a combination of timer and pressure sensor that provides a **failsafe automatic shutoff** in either mode. (Ex. 1013, 4:11-26.) These embodiments confirm that

inflation is controlled to occur for a fixed period or until the cutoff condition is met, after which the pump ceases operation without user input.

207. Taken together, Owen establishes that, prior to the '196 Patent, it was already known to provide a pump system in which inflation automatically stops after a predetermined period, i.e., a time-based or pressure-based shutoff, to ensure consistent inflation and prevent over-inflation of an inflatable object (e.g., airbag).

F. U.S. Patent Application Publication No. 2003/0201218 ("Henkin '218")

208. Henkin '218 was filed on April 26, 2002, published on Oct. 30, 2003, and claims priority as a continuation of application no. PCT/US00/31156, filed on Nov. 14, 2000. Henkin '218 specifically incorporates U.S. Patent No. 5,985,156 ("**Henkin '156**") by reference in its entirety. The Examiner did not rely on Henkin '218, and the Applicant never addressed it, during the prosecution of the '196 Patent.

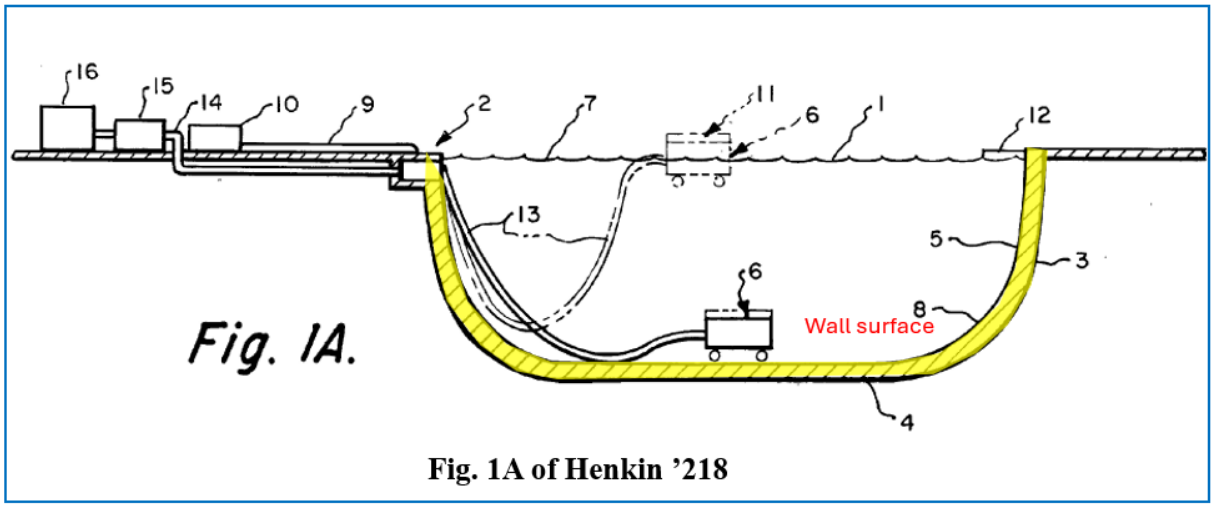


Fig. 1A of Henkin '218

209. Henkin ’218 discloses an automatic pool cleaning system “employing a unitary body configured to move through a pool to collect debris from adjacent to the pool containment wall surface and/or the pool water surface.” (Ex. 1014, Abstract.) In particular, Henkin ’218 teaches the use of a level control subsystem that “selectively modify[ies] the buoyancy of the body, e.g., by filling or exhausting onboard air bags or expanding and compressing onboard air utilizing an electrically powered pump.” (Ex. 1014, ¶ [0007].) Consistent with this teaching, Henkin ’218 discloses a closed chamber 30 that houses an air bag 32, a pump/motor 46, and a multi-port level valve 44 (with a default valve 70), all of which are connected to an air source 36. The air source may be either an onboard compressed air reservoir or a conduit connected to atmosphere above the water surface. (Ex. 1014, ¶¶ [0046]–[0048]; [0050].)

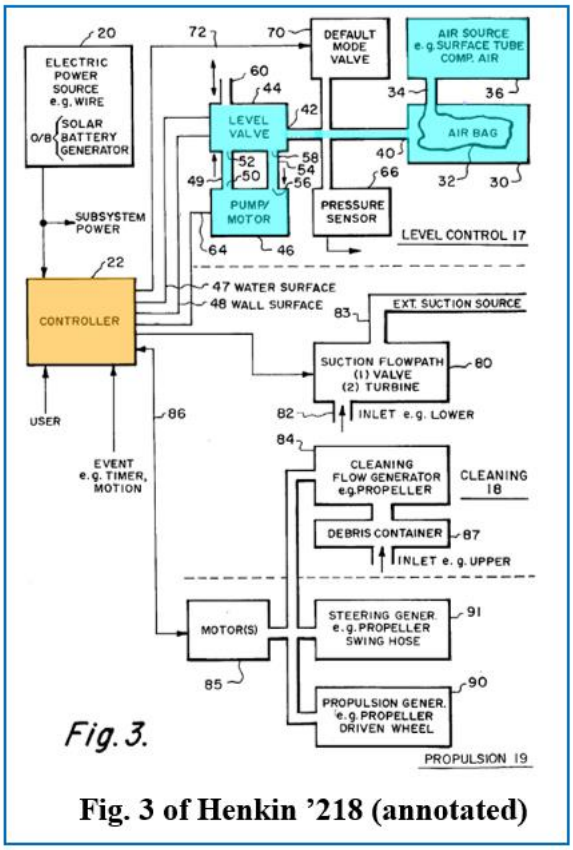


Fig. 3 of Henkin '218 (annotated)

210. As illustrated in FIG. 3 of Henkin '218, the level valve 44 selectively routes the pump's suction and pressure ports to chamber port 40. In a surface-cleaning mode, water is extracted from chamber 30 and the air bag 32 expands, thereby increasing buoyancy. Conversely, in a wall-cleaning mode, water is driven into chamber 30 to collapse the air bag and expel air, reducing buoyancy and allowing the robot to submerge. (Ex. 1014, ¶¶ [0046]–[0050].)

211. Henkin '218 further explains that the controller 22 governs these operations by defining "water surface" and "wall surface" modes. In response to user inputs or timed events, the controller commands valve positions and energizes

the pump to inflate or deflate the air bag, thus modifying buoyancy as needed. (Ex. 1014, ¶ [0044].)

212. Henkin ’218 discloses that a pressure sensor 66 is placed on the line between valve port 42 and chamber port 40. (Ex. 1014, Fig. 3.) The output of this sensor serves as an event input to the controller. Henkin explains that “[t]he output of the pressure sensor 66 comprises one of the event inputs to controller 22 to cause it to de-energize pump/motor 46 when the pressure is out of limits.” (Ex. 1014, ¶ [0050].) Henkin ’218 describes an automatic pool-cleaning system whose operating subsystems are **explicitly governed by timed events and interval expirations**. For example: “The level of the body 6 in the water pool 1, i.e., proximate to the water surface or proximate to the wall surface, can be controlled by a level control subsystem capable of selectively defining either a water surface mode or a wall surface mode. The mode defined by the subsystem can be selected via a user control, e.g., a manual switch or valve, or via an event sensor responsive to an event **such as the expiration of a time interval**.” (Ex. 1014, ¶ [0040]). Henkin ’218 also discloses switching between wall and surface modes triggered by a timer: “… the water surface and wall surface modes are alternately defined, typically controlled by a user input or by a timed event.” (Ex. 1014, ¶ [0044]).

213. Henkin ’218’s system block diagram reinforces this disclosure by showing the controller linked to an “EVENT e.g. TIMER,” “PRESSURE

SENSOR," and "DEFAULT MODE VALVE" between the "AIR SOURCE e.g. SURFACE TUBE COMP. AIR" and the "AIR BAG" (Ex. 1014, Fig. 3), confirming that the device uses **timers and condition sensors to control actuation duration** and revert to a default safe state. A POSITA would recognize that these are standard design primitives for pump-based control loops—i.e., energize the motor for a preset interval or until a pressure threshold is detected, then automatically shut off.

214. Henkin '156, an earlier patent in the same family, complements these teachings by also supplying explicit time-based control, whereby operating modes are switched in response to "the expiration of a time interval." (Ex. 1015, 2:32–35.) As Henkin '156 explains

> *"The operating modes of the level control subsystem are preferably switched automatically in response to the occurrence of an event, such as the (1) expiration of a time interval, (2) the cycling of the external pump, or (3) a state change of the propulsion subsystem. The operating states of the propulsion subsystem are preferably switched automatically in response to the occurrence of an event such as the expiration of a time interval and/or the interruption of body motion."* (Ex. 1015, 2:31-39).

215. Henkin ’156 identifies “TIMING ASSEMBLY 171” (Ex. 1015, Fig. 8), “TIMING ASSEMBLY 271” (Ex. 1015, Fig. 15), and “TIMING ASSEMBLY 371” (Ex. 1015, Fig. 20), each controlling the duration of water-jet or pump operation. These assemblies ensure that propulsion and surface-cleaning cycles end after the predetermined time, protecting the motor and coordinating successive modes. For example, Henkin ’156 describes operating the robot in the water surface mode for a one-hour interval, followed by switching to the wall surface mode for a two-hour interval. (Ex. 1015, 2:32–40; 4:40–44.)

216. Together, Henkin ’218’s timed-event control and Henkin ’156’s adjustable timing assemblies show that preset-interval pump shutoff and automatic switching based on the “expiration of a time interval” were well-established, expressly taught features in pool-cleaning robots years before the ’196 patent’s priority date.

G. Chinese Patent No. CN 117661894 (“Deng”)

217. Deng was published on March 8, 2024, from Chinese Patent Application No. 202311660827.0, filed on December 6, 2023. The Examiner did not rely on Deng, and the Applicant never addressed it, during the prosecution of the ’196 Patent.

218. Deng discloses a method, system, and medium for cleaning swimming pool walls. (Ex. 1016, Abstract.) The technology addresses the limitations of

conventional pool cleaners that cannot continuously climb and clean along pool walls or that suffer from repeated and incomplete cleaning. (Ex. 1016, ¶ [0003].) Deng introduces a structured control method that enables the robot to autonomously detect the pool wall, adjust suction power, calibrate attitude, and switch between wall sections, thereby improving coverage and cleaning efficiency. (Ex. 1016, ¶¶ [0005]–[0008].)

219. Deng teaches that the robot uses an ultrasonic sensor to measure the distance from the pool wall and determine when to initiate wall climbing. (Ex. 1016, ¶¶ [0043]–[0047].) When the detected distance is less than or equal to a preset threshold (e.g., 400 mm), the controller reduces pump power and starts wall climbing. (Ex. 1016, ¶¶ [0050]–[0051].) As the robot approaches and contacts the wall, gyroscope and accelerometer are used to detect the change in orientation from horizontal to vertical. The pump power is then restored to maintain wall adhesion, and the robot continues to climb upward until reaching the waterline. (Ex. 1016, ¶¶ [0052]–[0054].)

220. Upon reaching the water surface, the robot performs a timed delay before reversing and descending along the wall to the pool bottom. The system further employs the gyroscope and accelerometer to identify when the robot has returned to a horizontal attitude, at which point it initiates backward movement and turns at a preset angle to begin cleaning a new region. (Ex. 1016, ¶¶ [0054]–

[0064].) The method ensures continuous alternation between wall and bottom cleaning without human intervention.

221. Deng further describes logic for switching between adjacent walls and handling curved pool surfaces. When the side distance is below a preset value (e.g., 300 mm), the robot rotates a defined angle (such as 90°) to transition to the neighboring wall; if the distance is greater, it reverses slightly and rotates in the opposite direction before resuming climbing. (Ex. 1016, ¶¶ [0067]–[0070].) For curved or non-vertical surfaces, the controller adaptively adjusts the climbing inclination based on sensor feedback to maintain stable adhesion. (Ex. 1016, ¶¶ [0072]–[0073].)

222. Taken together, Deng demonstrates that, prior to later developments in multi-surface autonomous pool cleaners, it was already known to use distance sensors and IMU-based attitude control to regulate pump power, detect wall contact, and execute automated wall-to-floor transitions. These teachings establish a well-structured control framework for wall-climbing cleaning robots, integrating distance sensing, orientation calibration, and wall-switching logic to achieve efficient, continuous, and stable cleaning operation. (Ex. 1016, ¶¶ [0042]–[0075].)

H. Chinese Patent No. CN 116166018 ("Liu")

223. Liu was published on May 26, 2023, from Chinese Patent Application No. 202310147645.7, filed on February 21, 2023. The Examiner did not rely on

Liu, and the Applicant never addressed it, during the prosecution of the '196 Patent.

224. Liu discloses a control method and device for a swimming pool cleaning robot that enhances path planning and cleaning coverage. (Ex. 1018, Abstract.) The technology addresses the deficiencies of conventional underwater cleaners, which lack intelligent path control and cannot perform coordinated bottom and wall cleaning. (Ex. 1018, ¶ [0003].) Liu provides a dual-mode control solution—comprising a bow-shaped cleaning mode and a wall-climbing cleaning mode—that allows the robot to automatically calibrate its attitude, detect obstacles, and switch between horizontal and vertical cleaning surfaces. (Ex. 1018, ¶¶ [0005]–[0008].) This design improves cleaning comprehensiveness, operational stability, and overall efficiency.

225. Liu teaches that the robot performs attitude calibration through an inertial measurement unit (IMU) and ultrasonic ranging sensors to establish a reference orientation before cleaning. (Ex. 1018, ¶ [0047].) In the bow-shaped cleaning mode, the robot moves to a preset distance from the pool wall, rotates by a preset angle, and reverses until its rear side is parallel to the wall. The IMU angle or ultrasonic ranging parameter is initialized at this point, and cleaning begins along a bow-shaped path. The robot detects obstacles and performs directional

changes—such as 90° or 180° rotations—to ensure full-area coverage. (Ex. 1018, ¶¶ [0046]–[0047].)

226. In the wall-climbing cleaning mode, the robot moves toward the pool wall until an ultrasonic sensor detects a threshold distance (e.g., 300 mm), at which point the pump power is reduced to a set ratio of its maximum value. The robot begins climbing the wall, and when the IMU angle exceeds a predetermined value or the distance sensor reads below a threshold, it is determined that the robot has reached the wall. The pump power is then restored to full power to enhance suction and stability. When the robot approaches the water surface, it delays for approximately two seconds before reversing to descend. (Ex. 1018, ¶¶ [0048]–[0049].)

227. Liu further discloses logic for detecting pool corners and switching between walls. When the side distance is less than 300 mm, the robot rotates by a preset angle (e.g., 65°) to transition to the adjacent wall; if the distance is greater than or equal to 300 mm, it reverses slightly and rotates in the opposite direction before resuming wall cleaning. (Ex. 1018, ¶ [0050].) The control device includes separate modules for bow-shaped cleaning and wall-climbing cleaning, each containing submodules for obstacle detection, angle calibration, water surface detection, and wall-climbing switching. (Ex. 1018, ¶¶ [0055]–[0068].)

228. Taken together, Liu demonstrates that, prior to later autonomous pool-cleaning robot developments, it was already known to use IMU and ultrasonic sensors to perform dynamic attitude calibration, obstacle detection, and mode switching between bottom and wall cleaning. These teachings establish a state-of-the-art control architecture integrating motion planning and sensor-based decision logic, which achieves improved stability, precision, and cleaning completeness in swimming pool robots. (Ex. 1018, ¶¶ [0047]–[0051], [0063]–[0068].)

VIII. ANALYSIS

229. Based on my personal experience at the relevant time and my review of the prior art, it is my opinion that: (1) Claims 1-7, 9-11, and 13-19 would have been obvious to a POSITA as of the effective filing date of the '196 Patent based on a combination of *Wang* in view of *Zhao* and *Owen*; (2) Claims 8 and 12 would have been obvious to a POSITA as of the effective filing date of the '196 Patent based on a combination of *Wang* in view of *Zhao, Owen,* and *Guo*, (3) Claims 1-6, 10, and 14-17 would have been obvious to a POSITA as of the effective filing date of the '196 Patent based on a combination of *Zhang* in view of *Zhao* and *Owen*; (4) Claims 7-9, 11-13, and 18-19 would have been obvious to a POSITA as of the effective filing date of the '196 Patent based on a combination of *Zhang* in view of *Zhao, Owen,* and *Guo*; (5) Claims 1-8, 10-13, and 15-19 would have been obvious to a POSITA as of the effective filing date of the '196 Patent based on a

combination of *Guo* in view of *Zhao* and *Owen*; (6) Claims 1-14 are indefinite due to the term "main control unit" as I explained above; and (7) Claim 4 is indefinite due to the phase "distance measurement unit" as I explained above.

A. Ground 1: *Wang*, in view of *Zhao* and *Owen*, Renders Claims 1-7, 9-11, and 13-19 Obvious

1. Independent Claim 1

a. Element [1pre]: "A controllable sinking and floating swimming pool robot, comprising:"

230. **Wang** discloses a controllable sinking and floating swimming pool robot, and more particularly **Wang** discloses a controllable robotic pool cleaning device that can switch between operating below the swimming pool water surface and on the pool water surface. *See, e.g.,* Wang at [0064]: "The cleaning device 10 of the present disclosure can be **flexibly switched between a position on a liquid surface 30 and a position under the liquid surface 30**, so that the cleaning device 10 can comprehensively clean the target region 40." *See also* **Wang '040 at p.6:63-65**.

b. Element [1a]: "a sinking and floating control unit configured to control a swimming pool robot to float and sink;"

231. **Wang** discloses a sinking and floating control unit configured to control a swimming pool robot to float and sink. For example, **Wang discloses a mode-switching member (including a buoyancy adjustment assembly, which in turn includes a buoyancy cavity and a buoyancy adjustment part)** that

controls the robotic cleaning device between cleaning on the pool water surface and cleaning beneath the pool water surface. *See, e.g.,* **Wang at [0067]**: "With reference to FIG. 1 to FIG. 3, the cleaning device body 101 includes a mode switching member 510. **The mode switching member 510 is configured for the cleaning device 10 to be switched between the position on the liquid surface 30 and the position under the liquid surface 30.**" *See also* **Wang '040 at p.7:20-22 and FIG. 4**.

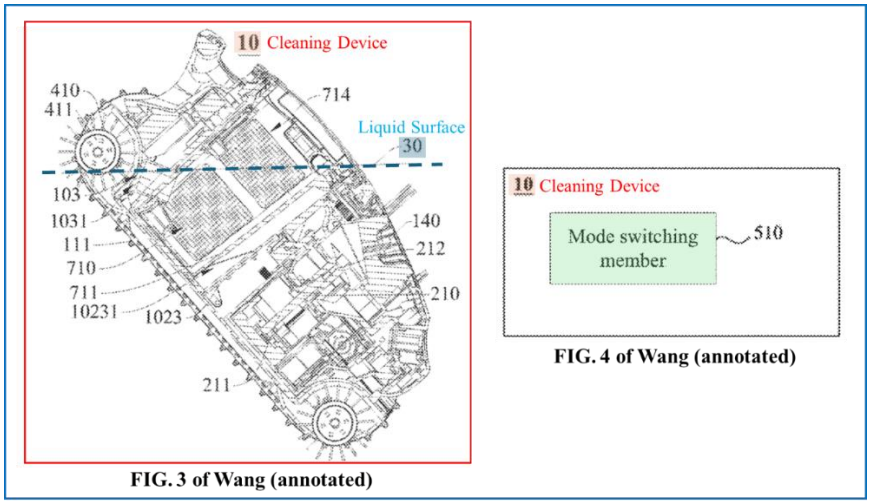


FIG. 3 of Wang (annotated)

FIG. 4 of Wang (annotated)

232. Additionally, **Wang** describes a manner of operation of the buoyancy adjustment assembly 511. *See, e.g.,* **Wang at [0098]**: "In some embodiments, the action force received by the cleaning device 10 in the vertical direction may include a buoyancy force applied to the cleaning device 10 in the vertical direction. When the action force includes the buoyancy force applied to the cleaning device 10 in the vertical direction, **the mode switching member 510 may include a buoyancy adjustment assembly 511. The buoyancy adjustment assembly 511 is**

configured to adjust a magnitude of the buoyancy force applied to the cleaning device 10 in the vertical direction." *See also* **Wang '040 at p.10:76-p.11:4**.

233. The buoyancy adjustment part operates by modifying an amount of liquid and/or gas within a buoyancy cavity 5111. *See, e.g.*, **Wang at [0099]**: "In some embodiments, **the buoyancy adjustment assembly 511 may include a buoyancy cavity 5111 and a buoyancy adjustment part**. The buoyancy cavity 5111 is configured to accommodate **liquid and/or gas**." *See also* **Wang '040 at p.11:5-6**.

234. **Wang** further describes control of the buoyancy of the device based on whether an air inlet is exposed to air. *See, e.g.*, **Wang at [0117]**: "In some embodiments, when the cleaning device 10 needs to be **switched from the position under the liquid surface 30 to the position on the liquid surface 30**, the processor 52 may obtain the detection result of whether the air inlet 5113 of the buoyancy cavity 5111 is exposed to the air. When the detection result indicates that the air inlet 5113 is exposed to the air, the **buoyancy adjustment part is controlled to increase the volume of the gas in the buoyancy cavity 5111 to switch the cleaning device 10 from the position under the liquid surface 30 to the position on the liquid surface 30**." *See also* **Wang '040 at p.13:3-7**.

235. **Wang** also teaches that the position of the cleaning device can be controlled using changes to a volume of gas in the buoyancy cavity 5111. *See, e.g.*, **Wang at [0118]**: "When the cleaning device 10 needs to be switched **from the position on the liquid surface 30 to the position under the liquid surface 30**, the **processor 52 may control the buoyancy adjustment part to reduce the volume of the gas in the buoyancy cavity 5111**." *See also* **Wang '040 at p.13:10-11**.

236. FIGS. 7 and 8 further illustrate the device of **Wang** in operation, showing relative positioning between the device and the side wall 402 and the bottom wall 401.

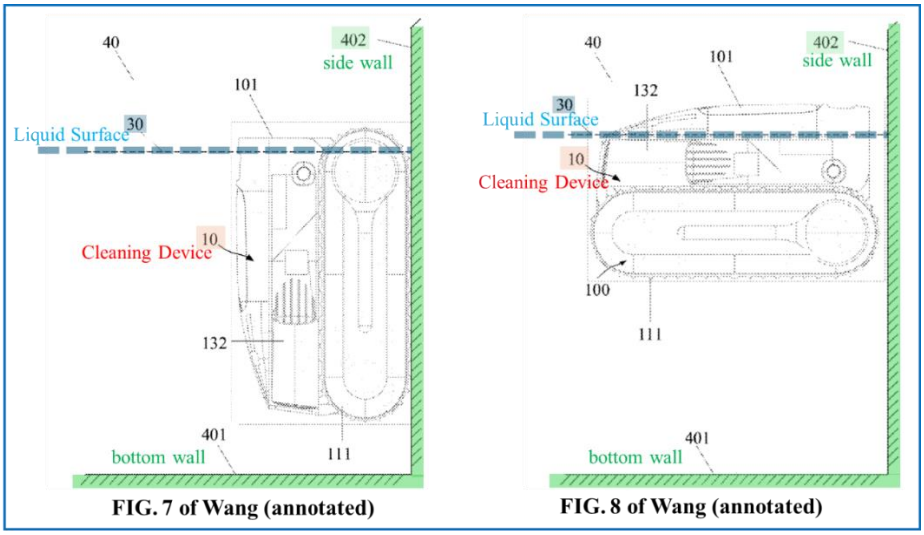


FIG. 7 of Wang (annotated) FIG. 8 of Wang (annotated)

c. Element [1b]: "a waterline detection unit configured to detect a positional relationship between the swimming pool robot and a waterline of a liquid surface of a swimming pool where the swimming pool robot is located; and"

237. **Wang** discloses a waterline-detection unit configured to detect a positional relationship between the swimming pool robot and a waterline of a

liquid surface of a swimming pool. For example, **Wang** discloses a waterline-detection unit where a first sensor continuously detects the robot's vertical position (depth) relative to the waterline, and a second sensor continuously detects whether the buoyancy-cavity air inlet is above the waterline. Each sensor is configured to detect the robot's positional relationship to the waterline. *See, e.g.,* **Wang at [0113]**: "In some embodiments, the cleaning device 10 may include a first sensor (not shown in the figure). **The first sensor may be configured to determine a position of the cleaning device 10 in real time. The position may be a vertical position (or referred to as a depth) of the cleaning device 10 in the liquid.** For example, the first sensor may be disposed at a central position of the cleaning device 10, and the position may be a depth of the central position of the cleaning device 10 in the liquid." *See also* **Wang '040 at p.12:39-41.**

238. **Wang** further describes the processor as receiving position information in real time from the first sensor and adjusting buoyancy in response to a sensed condition that the position is higher than a preset height. *See, e.g.,* **Wang at [0114]**: "When the cleaning device 10 needs to be switched from the position under the liquid surface 30 to the position on the liquid surface 30, **the processor 52 may obtain the position of the cleaning device 10 in real time from the first sensor**. When **the position of the cleaning device 10** meets a preset condition, the processor 52 may control the buoyancy adjustment part to increase the volume of

the gas in the buoyancy cavity 5111. **The preset condition may be that the position of the cleaning device 10 is higher than a preset height**. When a depth of the liquid in the target region 40 is fixed, the processor 52 may determine whether the position of the cleaning device 10 meets the preset condition to determine whether the air inlet 5113 of the cleaning device 10 is above the liquid surface 30. **When the position of the cleaning device 10 shown in FIG. 7 meets the preset condition, the processor 52 may determine that the air inlet 5113 of the cleaning device 10 is above the liquid surface 30**, the processor 52 may control the buoyancy cavity pump 5112 to drain the liquid from the buoyancy cavity 5111, and air may enter the buoyancy cavity 5111 through the air inlet 5113, to increase the volume of the gas in the buoyancy cavity 5111 and increase the buoyancy force applied to the cleaning device 10." *See also* **Wang '040 at p.12:49-59.**

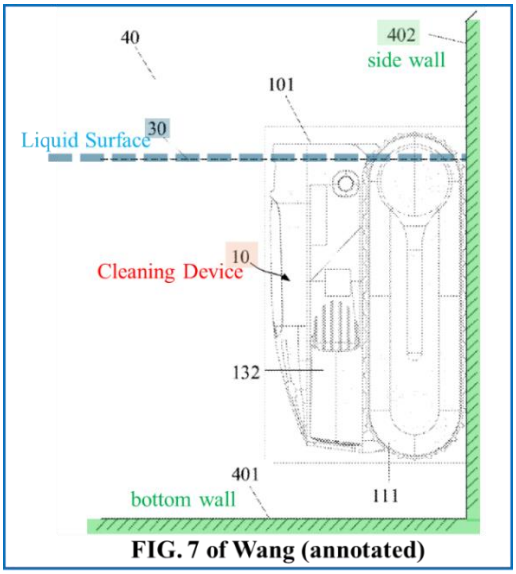


FIG. 7 of Wang (annotated)

239. Furthermore, **Wang** teaches that the cleaning device may use an additional sensor to detect whether the air inlet of the device is exposed to air. *See, e.g.,* **Wang at [0115]**: "In some embodiments, the cleaning device 10 may further include a second sensor (not shown in the figure). **The second sensor may be configured to detect in real time whether the air inlet 5113 of the buoyancy cavity 5111 is exposed to the air.** For example, the second sensor may be an ultrasonic sensor." *See also* **Wang '040 at p.12:62-64**.

d. Element [1c]: "a main control unit configured to control a working state of the sinking and floating control unit,"

240. **Wang** discloses a main control unit configured to control a working state of the sinking and floating control unit. For example, **Wang** discloses a **processor** (a microcontroller, embedded processor, or ASIC) that controls the buoyancy adjustment part of the mode switching member to increase the volume of the gas in the buoyancy cavity to make the cleaning robot enter a floating state. *See, e.g.,* **Wang at [0114]**: "In some embodiments, the cleaning device 10 may further include a processor 52 (not shown in the figure). **The processor 52 may be a micro-controller, an embedded processor 52, an application-specific integrated circuit (ASIC), or the like. The processor 52** may obtain various pieces of data information of the cleaning device 10 and analyze the obtained data information **to control various components of the cleaning device 10.** When the

cleaning device 10 needs to be switched from the position under the liquid surface 30 to the position on the liquid surface 30, the processor 52 may obtain the position of the cleaning device 10 in real time from the first sensor. **When the position of the cleaning device 10 meets a preset condition, the processor 52 may control the buoyancy adjustment part to increase the volume of the gas in the buoyancy cavity 5111.** The preset condition may be that the position of the cleaning device 10 is higher than a preset height. When a depth of the liquid in the target region 40 is fixed, the processor 52 may determine whether the position of the cleaning device 10 meets the preset condition to determine whether the air inlet 5113 of the cleaning device 10 is above the liquid surface 30. When the position of the cleaning device 10 shown in FIG. 7 meets the preset condition, the processor 52 may determine that the air inlet 5113 of the cleaning device 10 is above the liquid surface 30, **the processor 52 may control the buoyancy cavity pump 5112 to drain the liquid from the buoyancy cavity 5111**, and air may enter the buoyancy cavity 5111 through the air inlet 5113, to increase the volume of the gas in the buoyancy cavity 5111 and increase the buoyancy force applied to the cleaning device 10. When the buoyancy force applied to the cleaning device 10 in the vertical direction is greater than gravity of the cleaning device 10, the cleaning device 10 shown in FIG. 7 is switched to the cleaning device 10 shown in FIG. 8."

See also **Wang '040 at p.12:46-61.**

241. Specifically, **Wang's processor 52** functions as the main control unit that obtains data from sensors, determines when the cleaning device meets preset conditions, and controls the buoyancy adjustment part of the mode switching member (the sinking and floating control unit) by operating the buoyancy cavity pump 5112 and air inlet 5113 to adjust gas volume within the buoyancy cavity 5111. Through these operations, the processor controls the transition of the pool cleaning robot between submerged and floating states. *See, e.g.,* **Wang at [0117]**: "In some embodiments, when the cleaning device 10 needs to be switched from the position under the liquid surface 30 to the position on the liquid surface 30, **the processor 52 may obtain the detection result** of whether the air inlet 5113 of the buoyancy cavity 5111 is exposed to the air. When the detection result indicates that the air inlet 5113 is exposed to the air, the **buoyancy adjustment part is controlled to increase the volume of the gas in the buoyancy cavity 5111 to switch the cleaning device 10 from the position under the liquid surface 30 to the position on the liquid surface 30**." *See also* **Wang'040 at p.13:3-7**.

242. **Wang** explicitly describes both increasing the volume of gas in the buoyancy cavity 5111 and reducing the volume of gas in the buoyancy cavity. *See, e.g.,* **Wang at [0118]**: "When the cleaning device 10 needs to be switched from the position on the liquid surface 30 to the position under the liquid surface 30, the

processor 52 may control the buoyancy adjustment part to reduce the volume of the gas in the buoyancy cavity 5111." *See also* **Wang '040 at p.13:10-11**.

243. It is my opinion that increasing the volume of the gas in the buoyancy cavity would increase the buoyancy of the cleaning device, thereby causing it to rise (float) towards the surface, while decreasing the volume of the gas in the buoyancy cavity would decrease the buoyancy of the cleaning device, thereby causing it to settle (sink) towards the bottom wall.

e. Element [1d]: "wherein the main control unit is capable of controlling the swimming pool robot to find a side wall or a slope based on operational requirement information of the swimming pool robot and enabling the swimming pool robot to crawl along the side wall or the slope;"

244. **Wang**, alone or in view of **Zhao**, discloses that the main control unit is capable of controlling the swimming pool robot to find a side wall or a slope based on operational requirement information of the swimming pool robot and enabling the swimming pool robot to crawl along the side wall or the slope.

245. **Wang** discloses that the pool cleaning robot is capable of cleaning the pool based on operational requirement information, including user-input cleaning tasks. *See, e.g.,* **Wang at [0182]**: "Step 1010: Obtain a **target task** of cleaning a target swimming pool." *See also* **Wang '040 at p.19:21.**

246. **Wang** further discloses that the target task may include cleaning a **bottom or a wall of the swimming pool**. *See, e.g.,* **Wang at [0183]**: "The target

swimming pool may be a to-be-cleaned swimming pool. The target task may be a task of cleaning the target swimming pool. **The target task may include** water surface cleaning and/or **underwater cleaning.** The water surface cleaning may mean cleaning a water surface of the target swimming pool. The **underwater cleaning may mean cleaning an underwater part of the target swimming pool** (such as water in the swimming pool and **a wall of the swimming pool**). In some embodiments, the target task may further include a specific to-be-cleaned part. For example, **the underwater cleaning may further include, but is not limited to, cleaning the water, cleaning the bottom of the pool, cleaning each wall of the pool,** and the like." *See also* **Wang '040 at p.19:22-27.**

247. **Wang** teaches that the target task may be user-selected, or pre-scheduled. *See, e.g.,* **Wang at [0184]**: "The control member may obtain the target task in various manners. For example, **the control member may obtain the target task input by a user**. For another example, the control member may be configured to perform the target task periodically, such as perform water surface cleaning once every three days and perform underwater cleaning once every two days." *See also* **Wang '040 at p.19:28-30.**

248. **Wang** also discloses that, after obtaining the target task (e.g., pool wall cleaning task), the processor determines a **route** and **movement parameters necessary to complete that task**.

249. **Wang** describes determining an adjustment parameter for a moving mechanism. *See, e.g.,* **Wang at [0185]**: "Step **1020:** Determine an **adjustment parameter** of a moving mechanism based on the target task and a current position of the cleaning device 10." *See also* **Wang '040 at p.19:41-42.**

250. The adjustment parameter may include route information as well as a target task position. *See, e.g.,* **Wang at [0187]**: "The **adjustment parameter may include information of a route from the current position to a position**, in the target swimming pool, **at which the target task needs to be performed and route information required to complete the target task**." *See also* **Wang '040 at p.19:45-46.**

251. The route information takes into account the starting position for the task and the current position of the cleaning device. *See, e.g.,* **Wang at [0188]**: "The control member may determine, based on the target task, a starting position, in the target swimming pool, at which the target task needs to be performed; determine, **based on the starting position and the current position, the information of the route of the cleaning device 10 from the current position to the position**, in the target swimming pool, **at which the target task needs to be performed**; and determine, based on the target task for the target swimming pool, the **route information required to complete the target task**, to determine the

adjustment parameter of the moving mechanism." *See also* **Wang '040 at p.19:47-50.**

252. Position determination, destination determination, and route information determination constitute planning and directing the robot's movement based on operational task information.

253. Additionally, to the extent that Wang does not explicitly disclose this feature, the control logic disclosed by Wang inherently enables the processor (i.e., main control unit) to **plan and direct the robot's movement based on operational task information**, for example, to **travel from its current location to the sidewall or slope region when the assigned task is to clean those surfaces**.

254. Consistent with this, **Wang** describes multiple motion states corresponding to distinct cleaning modes: a **first motion state** for bottom cleaning, a **second motion state** for wall climbing, and a **third motion state** for surface cleaning. *See, e.g.,* **Wang at [0068]**: "With reference to FIG. 7, FIG. 8, FIG. 10, FIG. 11, and FIG. 12**,** a **first motion state** is defined as a state in which the cleaning device 10 moves on the bottom wall 401, or an angle between the bottom wall 401 and an overall direction of the cleaning device 10 is less than 90° and the cleaning device 10 is away from the liquid surface 30. As shown in FIG. 10, that the cleaning device 10 is away from the liquid surface 30 may be understood as that the cleaning device 10 cleans the bottom of the pool or performs an action

underwater. A **second motion state** is defined as a state in which the cleaning device 10 moves on the side wall 402, or the overall direction of the cleaning device 10 is substantially parallel to the side wall 402, as shown in FIG. 7 and FIG. 12. A **third motion state** is defined as a state in which the cleaning device 10 moves on the liquid surface 30, or the cleaning device 10 is at least partially exposed at the liquid surface 30, or the cleaning device 10 is entirely located under the liquid surface 30 and close to the liquid surface 30." *See also* **Wang '040 at p.7:29-38.**

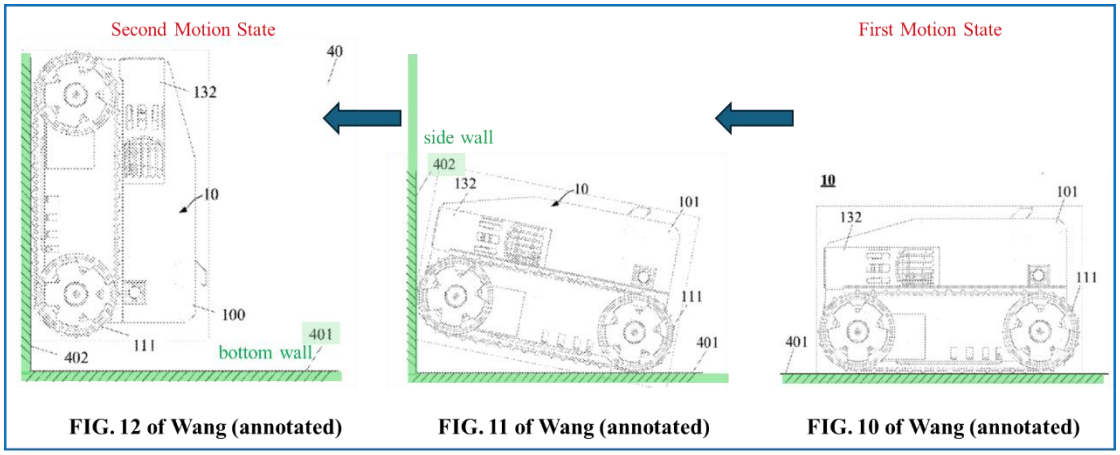


FIG. 12 of Wang (annotated) FIG. 11 of Wang (annotated) FIG. 10 of Wang (annotated)

255. **Wang** teaches control of the robot, including switching between first, second, and third motion states. Therefore, once the planned route brings the robot into contact with the pool wall, the control logic transitions the robot into a second motion state, enabling it to crawl upward along the wall or slope and perform the corresponding cleaning operation. *See, e.g.,* **Wang at [0070]**: "In some embodiments, the cleaning device 10 further has the second motion state. The **cleaning device can clean a pool wall or a waterline in the second motion state**.

Switching of the cleaning device 10 between the first motion state and the third motion state may include or exclude **switching of the second motion state**. In other words, the cleaning device may have the first motion state and the third motion state, or the cleaning device may have the first motion state, the second motion state, and the third motion state." *See also* **Wang '040 at p.7:46-49.**

256. **Wang** further provides detailed structural disclosure supporting this control process. *See, e.g.,* **Wang at [0138]**: "In some embodiments, the two first wheels 1121 are disposed at the front end of the bottom of the cleaning device body 101. The two second wheels 1122 are disposed at the rear end of the bottom of the cleaning device body 101. The first wheels 1121 and the second wheels 1122 can drive the cleaning device 10 to move in the horizontal direction. When the cleaning device 10 is located on the target bottom wall 401 of the target region 40, **the first wheels 1121 and the second wheels 1122 can operate to drive the cleaning device 10 to** move on the target bottom wall 401 and the target side wall 402 and **move from the target bottom wall 401 to the target side wall 402**." *See also* **Wang '040 at p.15:25-30.** *See, e.g.,* **Wang at [0139]**: "In some embodiments, the track 111 enables the cleaning device 10 to move from the target bottom wall 401 to the target side wall 402. As shown in FIG. 11, **when the track 111 moves to an intersection between the target bottom wall 401 and the target side wall 402**, a part of the track 111 moves on the target side wall 402, and the

other part of the track 111 moves on the target bottom wall 401. The part of the track 111 on the target side wall 402 can drive the cleaning device 10 to move upward until the cleaning device moves from the target bottom wall 401 to the target side wall 402. After the **cleaning device 10 moves from the target bottom wall 401 to the target side wall 402**, the cleaning device 10 may be driven by the track 111 to move on the target side wall 402." *See also* **Wang '040 at p.15:40-46.**

257. Accordingly, it is my opinion that **Wang** teaches both the **control-level behavior** (path planning and task-based actuation) and the **mechanical implementation** (drive wheels and track system) necessary for the robot to find and climb the pool wall or slope based on operational requirement information. Therefore, Wang discloses that the main control unit is capable of controlling the swimming pool robot to find a side wall or a slope based on operational requirement information of the swimming pool robot and enabling the swimming pool robot to crawl along the side wall or the slope.

258. To the extent that **Wang** is determined not to teach these features, **Zhao** teaches them.

259. **Zhao** discloses a robotic pool cleaner that includes a distance measurement unit, wherein the main control unit controls the swimming pool robot to find the nearest side wall based on distance measurement results. Specifically, Zhao discloses "when the pool cleaning robot **receives the docking instruction**,

the pool cleaning robot stops moving, **determines the closest pool wall** relative to the pool cleaning robot, and **moves towards the closest pool wall**." (**Zhao at 4:62-65; FIG. 1**.)

260. **Zhao** furthermore teaches that the robot body includes a set of ultrasonic sensors, and that based on docking instructions, the pool robot uses the ultrasonic sensors to measure distance to the pool walls and determine the closest pool wall relative to its position, enabling the robot to move toward that closest pool wall. *See, e.g.,* **Zhao at 4:62-5:2**: "At step S130, **when the pool cleaning robot receives the docking instruction**, the pool cleaning robot stops moving, **determines the closest pool wall relative to the pool cleaning 65 robot, and moves towards the closest pool wall**. FIG. 2a to FIG. 2d illustrate schematic diagrams of a process of the pool cleaning robot turning to dock upon receiving a docking instruction according to embodiments, but the scope of the present disclosure is not limited thereto." *See, e.g.,* **Zhao at 4:6-17**: "The sensor unit provided on the pool cleaning robot includes various types of sensors, such as collision sensors, distance sensors, counters, and gyroscopes. The distance sensors can include, for example, **ultrasonic distance sensors**, which can be configured to **measure a distance from an obstacle to the ultrasonic distance sensor**. The distance sensors can be provided on the front side, back side, right side and left side of the pool cleaning robot. The distance sensor can also be provided on the top

of the pool cleaning robot to measure distance by rotating, such that a distance from an obstacle near the pool cleaning robot to the distance sensor can be measured through the distance sensor."

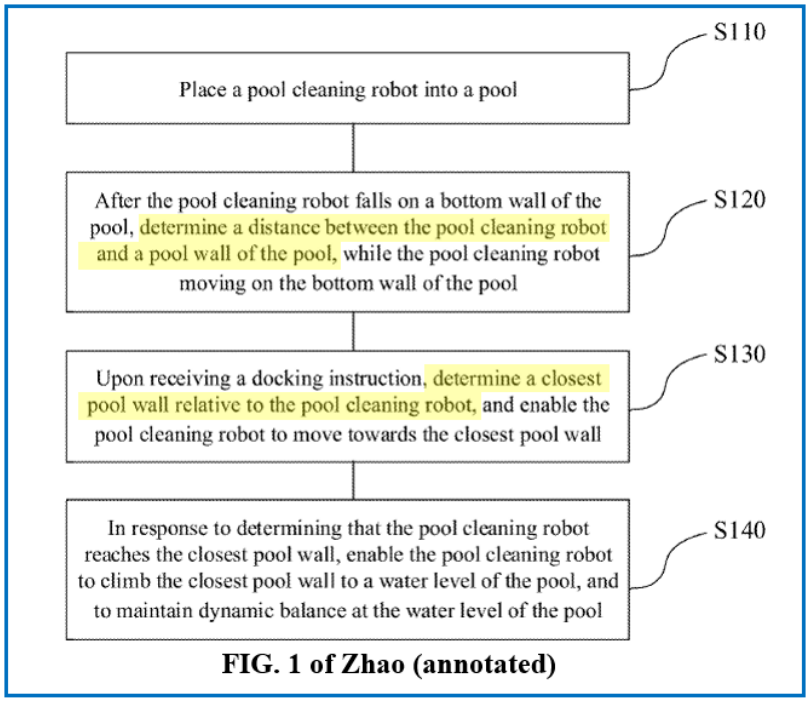


FIG. 1 of Zhao (annotated)

261. In my opinion, a POSITA would have had a clear and logical motivation to combine the teachings of **Zhao** and **Wang** to improve the robot's navigation and wall-cleaning capabilities. Both references address **autonomous pool cleaning robots** operating underwater and along pool walls, and both seek to enhance efficiency by enabling the robot to **locate, approach, and climb side walls** to perform wall/waterline cleaning or to achieve docking. **Zhao** teaches that the robot uses **distance sensors** (e.g., ultrasonic sensors) to detect nearby walls and determine the closest pool wall before initiating docking. *See*, *e.g.*, **Zhao at 4:62-65** ("the pool cleaning robot stops moving, determines the closest pool wall… and

moves towards the closest pool wall"). **Wang** complements this by describing a **control system and mechanical configuration** that allows the robot to **crawl along the wall once contact is established**, transitioning from bottom-wall cleaning to wall-climbing and waterline cleaning. *See, e.g.*, **Wang at [0068]-[0070]; [0138]-[0139]; Wang' 040 at p.7:29-51, p.15:25-62**.

262. Moreover, it is my opinion that a POSITA would have recognized that **Zhao's distance-based detection logic** and **Wang's wall-climbing control mechanism** are directly compatible and serve complementary purposes: **Zhao's** sensor system provides **real-time feedback to locate and orient toward the wall**, while **Wang's** motion-state control and tracked drive mechanism enable the robot to **engage and ascend the wall once contact is made**. Combining the two would yield a more complete, reliable control architecture, i.e., **Zhao** providing the sensing and approach algorithm, **Wang** providing the physical actuation and control logic for climbing.

263. Therefore, a POSITA implementing Zhao's control scheme would have found it **obvious and advantageous** to incorporate **Wang's** multi-state motion control (first, second, and third motion states) to provide a complete cycle of bottom, wall, and waterline cleaning. Conversely, a POSITA implementing Wang's robot would have found it **obvious to add Zhao's distance-sensing and**

wall-finding logic to automate the initiation of wall-climbing behavior. Both yield predictable and beneficial results—enhanced autonomy and cleaning efficiency.

f. Element [1e]: "controlling the waterline detection unit to detect the positional relationship between the swimming pool robot and the waterline of the liquid surface of the swimming pool where the swimming pool robot is located; and"

264. **Wang** discloses that the main control unit controls the waterline detection unit to detect the positional relationship between the swimming pool robot and the waterline of the liquid surface of the swimming pool where the swimming pool robot is located. *See, e.g.,* **Wang at [0114]**: "In some embodiments, the cleaning device 10 may further **include a processor 52** (not shown in the figure) .... When the cleaning device 10 needs to be switched from **the position under the liquid surface** 30 to the **position on the liquid surface** 30, the processor 52 may obtain the position of the cleaning device 10 in real time from the first sensor. When the position of the cleaning device 10 meets a preset condition, the processor 52 may control the buoyancy adjustment part to increase the volume of the gas in the buoyancy cavity 5111. The preset condition may be that the position of the cleaning device 10 is higher than a preset height. When a depth of the liquid in the target region 40 is fixed, the processor 52 may determine whether the position of the cleaning device 10 meets the preset condition to

determine whether the air inlet 5113 of the **cleaning device 10 is above the liquid surface 30."** *See also* **Wang '040 at p.12:46-55.**

265. Specifically, **Wang** describes that the processor 52 (i.e., the main control unit) obtains, in real time, position data of the cleaning device 10 from **a first sensor or a second sensor** (i.e., the waterline detection unit) when transitioning between submerged and water surface positions. The processor 52 uses this sensor data to determine whether the cleaning device 10 meets a preset condition—such as **being above a preset height or whether the air inlet 5113 is above the liquid surface**—and based on that determination, controls the buoyancy adjustment part accordingly. *Id.*

g. Element [1f]: "controlling the sinking and floating control unit to enter a floating working state based on detection results to realize a floating of the swimming pool robot,"

266. **Wang** discloses that the main control unit controls the sinking and floating control unit to enter a floating working state based on detection results to realize a floating of the swimming pool robot. First, **Wang** teaches that when the depth is shallower than the preset height, processor 52 starts pump 5112 to fill cavity 5111 with air, lifting inlet 5113 above the surface and enabling the cleaning device to float. *See, e.g.,* **Wang at [0114]**: "When the cleaning device 10 needs to be switched from the position under the liquid surface 30 to the position on the liquid surface 30, **t**he processor 52 may obtain the position of the cleaning device

10 in real time from the first sensor. **When the position of the cleaning device 10 meets a preset condition**, **the processor 52 may control the buoyancy adjustment part to increase the volume of the gas in the buoyancy cavity 5111**. The preset condition may be that the position of the cleaning device 10 is higher than a preset height. When a depth of the liquid in the target region 40 is fixed, **the processor 52 may determine whether the position of the cleaning device 10 meets the preset condition to determine whether the air inlet 5113 of the cleaning device 10 is above the liquid surface 30**. **When the position of the cleaning device 10 shown in FIG. 7 meets the preset condition**, the processor 52 may determine that the air inlet 5113 of the cleaning device 10 is above the liquid surface 30, **the processor 52 may control the buoyancy cavity pump 5112 to drain the liquid from the buoyancy cavity 5111, and air may enter the buoyancy cavity 5111 through the air inlet 5113, to increase the volume of the gas in the buoyancy cavity 5111 and increase the buoyancy force applied to the cleaning device 10.** When the buoyancy force applied to the cleaning device 10 in the vertical direction is greater than gravity of the cleaning device 10, the cleaning device 10 shown in FIG. 7 is switched to the cleaning device 10 shown in FIG. 8."

See also **Wang '040 at p.12:49-61.**

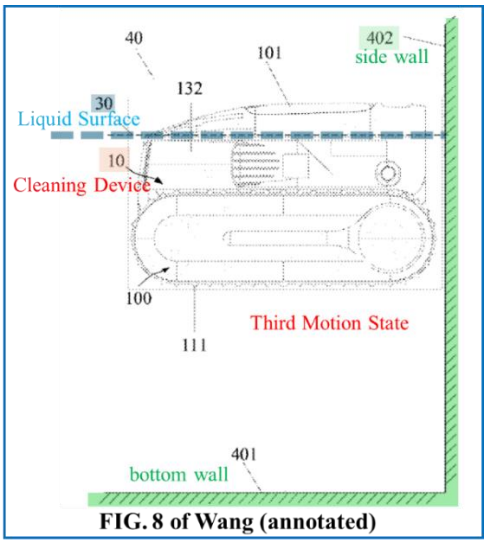


FIG. 8 of Wang (annotated)

267. Second, **Wang** discloses the specific pneumatic mechanism by which the robot's buoyancy is actively increased to enter the floating working state. **Wang** teaches that the buoyancy adjustment includes a **buoyancy cavity pump (5112)** and a **one-way valve** disposed at the **air inlet (5113)**. In the operating state, the pump drives air or gas into the buoyancy cavity 5111, thereby increasing the buoyancy of the robot and causing it to rise toward the water surface. A POSITA would understand that once the pump is energized, the one-way valve at the air inlet 5113 opens to admit air while blocking backflow, allowing the cavity to fill with gas and increasing buoyancy. *See, e.g.,* **Wang at [0109]:** "When the air inlet 5113 does not communicate with the gas, a one-way valve may be disposed at the air inlet 5113. **The one-way valve can prevent external water of the cleaning device body 101 from entering the buoyancy cavity 5111 through the air inlet 5113**... The buoyancy adjustment part may be any structure that can adjust the gas

and/or the liquid in the buoyancy cavity 5111. As shown in FIG. 6, **the buoyancy adjustment part may include a buoyancy cavity pump 5112**. The buoyancy cavity pump 5112 can drive the buoyancy cavity 5111 to drain the liquid therefrom. The buoyancy cavity pump 5112 may be, but is not limited to, **a pneumatic pump, a hydraulic pump, or an electric pump**. In **an operating state, the buoyancy cavity pump 5112 can adjust the liquid and/or the gas in the buoyancy cavity 5111**. In a non-operating state, the buoyancy cavity pump 5112 can prevent any external liquid and/or gas of the cleaning device 10 from entering the buoyancy cavity 5111, so that the buoyancy cavity 5111 is not affected by the external liquid and/or gas." *See also* **Wang '040 at p.11:68-76, p.12:1-5.**

268. **Wang** explicitly states that these adjustments of gas and/or liquid in the buoyancy cavity 511 modify a buoyancy force applied to the robot. *See, e.g.,* **Wang at [0120]:** "When the buoyancy cavity 5111 **adjusts the buoyancy force by using gas**, and the air inlet 5113 or an air outlet of the buoyancy cavity 5111 is located above the liquid surface, **the buoyancy cavity pump 5112 is started to adjust the volume of the gas in the buoyancy cavity 5111**." *See also* **Wang '040 at p.13:25-27.**

h. Element [1g]: "wherein the sinking and floating control unit is controlled to stop working after the sinking and floating control unit enters the floating working state for a predetermined time."

269. **Wang**, alone or in view of **Owen**, discloses a main control unit that controls the sinking and floating control unit to stop working after entering the floating working state for a predetermined time.

270. Specifically, **Wang** describes that when the cleaning device reaches the water surface and the air inlet 5113 is exposed to air, the processor 52 controls the buoyancy cavity pump 5112 to increase the gas volume within the buoyancy cavity 5111, thereby switching the device from the submerged to the floating state. **Wang** further explains that a **gas volume threshold** is established to maintain a balanced vertical force. A POSITA would understand that this gas volume threshold inherently requires the buoyancy cavity pump to stop working after a predetermined time to prevent overinflation or damage to the buoyancy cavity. *See, e.g.,* **Wang at [0117]**: "In some embodiments, when the cleaning device 10 needs to be **switched from the position under the liquid surface 30 to the position on the liquid surface 30**, the processor 52 may obtain the detection result of whether the air inlet 5113 of the buoyancy cavity 5111 is exposed to the air. When the detection result indicates that the air inlet 5113 is exposed to the air, **the buoyancy adjustment part is controlled to increase the volume of the gas in the buoyancy cavity 5111 to switch the cleaning device 10 from the position under the liquid surface 30 to the position on the liquid surface 30**." *See also* **Wang '040 at p.13:3-7**. *See, e.g.,* **Wang at [0122]**: "When the buoyancy cavity

5111 adjusts the buoyancy force by using gas, **the volume of the gas in the buoyancy cavity 5111 is set to be a gas volume threshold, so that a balanced force is applied to the cleaning device 10 in the vertical direction**. In this way, when the cleaning device 10 cleans the wall of the pool, the cleaning device 10 can be attached to the wall of the pool in the vertical direction and better clean the wall of the pool. When the cleaning device 10 is in the third motion state, there is a first volume of the gas in the buoyancy cavity 5111. When the cleaning device 10 is in the first motion state, there is a second volume of the gas in the buoyancy cavity 5111. The gas volume threshold is a value between the second gas volume and the first gas volume." *See also* **Wang '040 at p.13:47-52.** *See, e.g.,* **Wang at [0099]**: "The buoyancy cavity 5111 is configured to accommodate **liquid and/or gas**. The buoyancy cavity 5111 may be, but is not limited to, **an inflatable buoyancy cavity**, a liquid-containing buoyancy cavity, a partitioned buoyancy cavity, or the like. **A volume of the buoyancy cavity 5111 may be preset**. The buoyancy cavity 5111 **may be made of a flexible material** and/or a rigid material. The **flexible material** may include, but is not limited to, polyvinyl alcohol resin, polyethylene glycol terephthalate, rubber, and the like. The rigid material may include, but is not limited to, glass, ceramic, phenolic plastic, polyurethane plastic, epoxy plastic, unsaturated polyester plastic, and the like. For example, **the buoyancy cavity 5111 may be of a two-layer structure: an inner layer and an outer layer**. The inner

layer may be made of the flexible material and is configured to accommodate liquid and/or gas. The outer layer is a rigid protective housing and may be configured to provide protection and stability for the inner layer." *See also* **Wang '040 at p.11:5-13.**

271. A POSITA would understand that when an airbag is filled by a pump operating at a constant volumetric flow rate (Q), and while back-pressure remains low (i.e., the bag is still compliant and far below its geometric or pressure limit), the volume (V) of the airbag grows roughly linearly with time (t). This basic relationship is expressed as:

$$\mathbf{V \approx Q \times t}$$

272. As the airbag nears its maximum capacity, the internal pressure rises due to membrane tension and hydrostatic head. This increased back-pressure causes the pump's effective flow rate to decay toward zero, and consequently, the airbag's volume asymptotically approaches a limiting value rather than increasing indefinitely.

273. Given this relationship, a POSITA would readily appreciate that a **predetermined inflation time** can be selected to deliver a target gas volume that reliably exceeds the minimum buoyancy requirement (the "Gas Volume Threshold") while remaining safely below the airbag's structural or pressure limit. In practice, this predetermined time provides a robust operational margin—

ensuring consistent buoyancy performance while preventing overinflation or mechanical damage to the airbag.

274. This concept is illustrated by the simulation shown in Figure 1. (*See* below, Ex. 1021.) The simulation models airbag volume versus time for a pump delivering approximately 4.0 L/min of air into a compliant airbag. The **Gas Volume Threshold** (1.75 L; green dashed line) is reached at about t = 27.5 sec. The system continues inflating until the **Predetermined Time** of 40 seconds (magenta dashed line), reaching the **Predetermined Volume**, which remains below the asymptotic capacity (black dotted line).

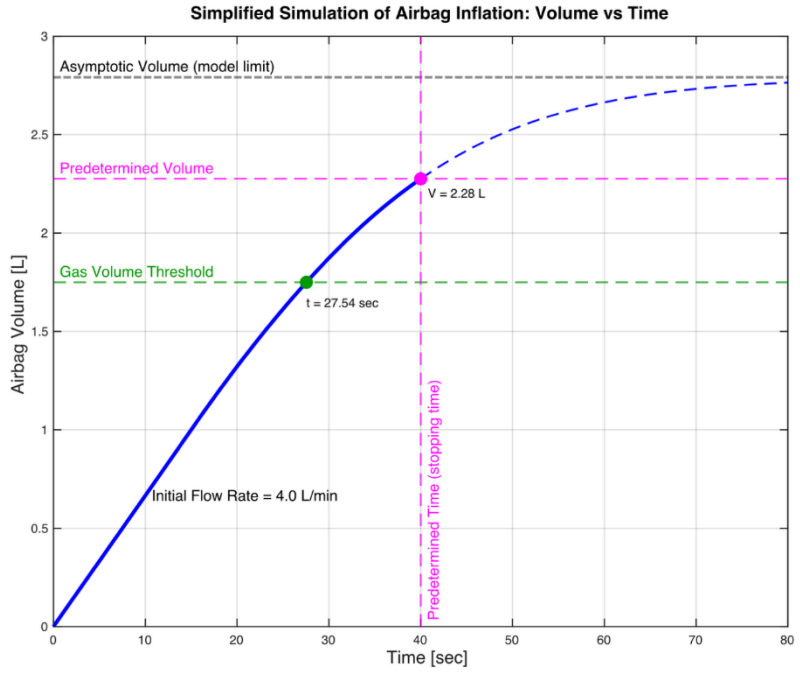


Fig. 1 of Exhibit 1021

275. This behavior reflects fundamental pneumatic system dynamics that a POSITA would find trivial to implement. The simulation merely visualizes these

well-understood relations; in practice, the precise parameters—such as the time duration, target volume, and pump flow rate—would be routinely selected based on design constraints like airbag geometry, material limits, desired buoyancy, and overall robot mass and cost.

276. Accordingly, a POSITA reviewing Wang would understand that its disclosure of achieving a **gas volume threshold** inherently teaches the corresponding use of a **predetermined inflation interval**—chosen to reach the required buoyancy margin. A POSITA reviewing Wang would further understand that the **predetermined inflation interval** would avoid overfilling or damaging the gas cavity (i.e., airbag), or overheating or damaging the motor. This approach reflects an elementary control principle that naturally arises from the saturating Q–V relationship shown above.

277. A POSITA would have been thoroughly familiar with using **timers** and **timeouts** to control actuators such as pumps and motors. Standard industrial control systems, including programmable logic controllers ("**PLCs**"), have long incorporated built-in timer functions to **start, stop, or modulate motors and pumps for predetermined durations** based on preset intervals or program logic.

278. As discussed in Chapter 9: "Timers" of *Programmable Logic Controllers*, 6th Edition (Ex. 1022), timers are described as fundamental components of automation systems used because "**a motor or a pump might need**

to be controlled to operate for a particular interval of time." The chapter explains how **on-delay (TON), off-delay (TOF), and pulse (TP) timers** generate controlled-duration outputs that energize or de-energize motors, pumps, or valves after fixed time intervals. These timers rely on the PLC's internal clock and are programmed to execute self-terminating operations when a preset value is reached, providing a timeout feature that ensures reliable, repeatable, and safe device operation. Ladder-diagram examples illustrate common applications such as starting and stopping pumps and motors after defined intervals (e.g., Fig. 9.6 and Fig. 9.19), sequencing multiple motors, and maintaining output states for timed periods.

279. A POSITA would therefore have recognized that timer-controlled actuation was a foundational principle in automation, universally available across PLC and microcontroller platforms, and routinely applied to control devices operating under time or safety constraints.

280. Accordingly, given the routine use of timers in pump control, a POSITA would be motivated to implement this predictable control scheme using a **timer-based shutoff**, as explicitly taught by **Owen**. **Owen** discloses timer circuits, integrated chips, or timer switches configured to operate a pump for a set period of time to fill an inflatable bladder above a desired threshold and then automatically terminate inflation. The combination of **Wang's buoyancy-based gas threshold**

control and **Owen's timer-based shutoff** represents a straightforward and predictable implementation of the same fundamental principle: regulating airbag inflation for a predetermined time to achieve a consistent volume while avoiding overinflation. *See, e.g.,* **Owen at 3, 19-28**: "In one embodiment, a circuit board (not shown), or an integrated chip (not shown) that serves as a **timer** is mounted to such a circuit board, **is provided to control the pump**. The circuit board or chip is programmed to **allow the pump to run for a set period of time after it is activated**. For example, in one type of inflatable mattress 12, it may take 60 seconds to adequately inflate the mattress 12. In this case, **the circuit board is programmed to run the pump for at least 60 seconds before shutting it off**. The circuit board may also be programmed to **include a buffer to make sure that the inflatable mattress 12 is adequately inflated**. In the above example, the circuit board or chip could be programmed to operate the pump for 70 seconds to assure adequate inflation." The "buffer" Owen discusses is analogous to the operating margin I discussed above in the simplified buoyancy simulation. *See, e.g.,* **Owen at 4, 7-10**: "Alternatively, instead of the circuit board, a mechanism such as a timer switch (not shown) could be used to automatically shut off the pump. If such a timer switch is used, **the switch can be set to allow the pump to run for a set period of time once it is activated**, in the same fashion as the circuit board already described." *See, e.g.,* **Owen at 4, 20-26**: "In yet another embodiment, a

combination of a circuit board and/or **an integrated circuit (IC) chip may be used as a timing circuit along with a pressure sensor to provide the timing signal that indicates when terminate pumping**. The IC chip may include a controlled switch (not shown) in electrical communication with the pressure sensor, wherein the controlled switch is triggered by signals from the pressure sensor that include threshold pressures, which indicate when the pump is done pumping and should be automatically turned off."

281. **Wang** discloses a buoyancy-control system in which an air pump inflates a gas cavity or airbag to achieve a desired buoyant force. The system includes logic to terminate inflation once a gas-volume threshold associated with neutral buoyancy is reached. Although Wang identifies this volume threshold, it does not specify the control method used to halt the pump once that condition is met.

282. **Owen**, by contrast, explicitly teaches a control method for inflatable systems using a timer circuit or integrated chip to operate a pump for a predetermined time and then automatically shut it off. Owen describes a "mechanism for automatically shutting off the pump after inflation," (Owen, Technical Field) implemented either by a circuit board timer, a timer switch, or an integrated circuit configured to allow the pump to run for a set period of time

before automatically shutting off. This prevents over-inflation, motor burnout, or damage to the inflatable object.

283. Given the relationship between pump flow rate (Q), volume (V), and inflation time (t)—expressed simply as $V \approx Q \times t$ while back-pressure remains low—a POSITA would recognize that in an airbag system such as Wang's, the air volume inflating the buoyancy cavity increases roughly linearly with time until near capacity, at which point pressure rises and flow decays. Based on this well-known relation, a predetermined time interval can be set to deliver a consistent target gas volume sufficient for buoyancy while maintaining a safe margin below the overpressure limit.

284. This relationship is illustrated by the simulation shown above in Figure 1 (Ex. 1021), which demonstrates how the airbag volume crosses the gas volume threshold at approximately 27.5 seconds and continues inflation until a predetermined stop time of 40 seconds—achieving a robust margin that ensures buoyancy while avoiding overinflation. A POSITA would readily understand that this timing-based control can be implemented either through firmware, microcontroller software, or an external timer circuit such as that disclosed in Owen.

285. A POSITA would have been motivated to combine the teachings of **Wang** and **Owen** to achieve a predictable improvement in the control of air-pump-

based buoyancy systems. **Wang** identifies the operational goal—achieving a gas volume threshold sufficient for buoyancy—but does not specify a control mechanism for safely and consistently terminating inflation. **Owen** provides exactly that solution: a timer-based control circuit designed to run a pump for a fixed period and then automatically deactivate it.

286. Integrating **Owen's timer circuit** into **Wang's buoyancy architecture** would have been a routine substitution of one known control method for another to achieve the same function—automatically limiting inflation. This combination would have represented a predictable use of known elements to yield predictable results. The motivation to adopt a timer-based cutoff would have been reinforced by the practical engineering goals of reducing cost, simplifying control logic, and preventing overpressure or motor wear. Implementing a timer eliminates the need for continuous sensing feedback and can be executed using simple, reliable components already standard in the field.

287. A POSITA would have had a clear and reasonable expectation that integrating a predetermined-time pump shutoff into Wang's buoyancy-control system would function as intended. Timer-based motor and pump control circuits were well understood, universally available, and inherently reliable. The PLC literature, as one example control framework, explicitly teaches the use of timers to operate motors or pumps for a fixed duration, and the logic governing these

circuits is entirely deterministic: once triggered, the timer energizes the motor for the preset interval and then terminates operation automatically.

288. Adapting such control to a buoyancy pump would present no technical uncertainty. All key parameters—pump flow rate, airbag compliance, desired buoyancy volume—are measurable and stable, allowing straightforward determination of a safe and effective inflation time. The outcome would be entirely predictable: the pump would run long enough to achieve buoyancy but would stop before risking overinflation or damage to the airbag. Similar timeout controls have long been used in fluid systems, compressors, and pneumatic actuators to accomplish the same objective. Accordingly, a POSITA would have expected the combination of Wang and Owen to work reliably using standard timing components or microcontroller-based software timers, requiring only routine engineering adaptation.

289. It would have been obvious to a POSITA to incorporate a predetermined-time pump control into Wang's buoyancy system. **Wang** provides the structural system and operational objective (inflating an airbag to achieve buoyancy), while **Owen** provides the well-known control mechanism (a timer or timeout circuit for automatic pump shutoff). Combining these teachings merely applies a known control technique to a known inflation subsystem to achieve a predictable and desirable outcome—safe, consistent buoyancy without

overinflation. Because such time-based motor control was standard engineering practice and expressly taught for pumps in industrial automation, implementing this feature in Wang's system would have been a matter of routine optimization within the skill of the art.

290. I understand that under the analogous-art doctrine, a reference is prior art for an obviousness analysis if it is either (1) from the same field of endeavor, regardless of the problem addressed, or (2) reasonably pertinent to the particular problem the inventor was trying to solve. The determination turns on whether a POSITA would logically have looked to the reference in seeking to solve the problem identified in the '196 Patent.

291. Applying these standards, in my opinion, Owen is analogous art to both Wang and the '196 Patent, under both prongs.

292. Although Owen's disclosed product is an inflatable mattress or air-support system, it explicitly targets a broader technical field. "In one embodiment of the present disclosure, a pump for inflating an inflatable mattress or **other inflatable object** is provided. In the Figures provided, the pump is attached to a substantially fluid impermeable bladder 12, such as the inflatable mattress shown … **Other inflatable objects could also be used**." (*See, e.g.,* **Owen at 3, 1-5**). Critically, Owen's technical field centers on control of air pumps, air bladders, and automatic shutoff mechanisms—the same fundamental components and functions

found in buoyancy-control systems of pool-cleaning robots. Each of these systems (Owen, Wang, and the '196 Patent): (1) relies on an air pump or compressor to deliver a controlled quantity of gas; (2) uses a flexible air bladder or cavity to store that gas and change the state of the system (e.g., inflation or buoyancy); and (3) requires a control mechanism—here, a predetermined-time cutoff—to terminate inflation safely and prevent overpressure or damage.

293. The difference in environment for their respective embodiments (household bedding vs. aquatic robotics) is superficial when viewed through the lens of the simple, modular control problem: fill a bag to a desired volume. I understand that the Federal Circuit held that a toothbrush reference was analogous to a hairbrush reference because both were directed to handheld brush design, even though they served different end uses. Similarly, here, both Owen and Wang concern air-inflation control subsystems for an inflatable bag that use pumps, valves, timers, and pressure limits—technically indistinguishable in operation and structure.

294. A POSITA with expertise in automated pump or pneumatic control would therefore view Owen as directly relevant within the same mechanical and control-engineering field—namely, automated control of airbag or inflatable systems.

295. Even if the fields were considered distinct by end use, Owen is still reasonably pertinent to the problem faced by the inventors of Wang and the '196 Patent—namely, how to reliably control the inflation of an airbag or gas cavity to achieve a desired operational state (buoyancy) without overinflation or component damage.

296. **Owen** explicitly addresses this exact control problem in the context of an air pump and inflatable bladder: "[The pump] includes a timer that operates the pump after activation for a set period of time before automatically shutting off the pump." (*See, e.g.*, **Owen, Abstract**.)

297. A POSITA designing an autonomous underwater robot with air-filled buoyancy bladders faces the same underlying control challenge as the designer of Owen's mattress pump: determining how long to run the pump to introduce a sufficient volume of air, achieving the target inflation level safely and repeatably. Owen's timer-controlled shutoff directly solves this problem, regardless of the operating medium (air, water, or other environment).

298. Indeed, a POSITA working on Wang's buoyancy-control problem—achieving desired buoyancy using a pneumatic pump and airbag—would have logically turned to references in adjacent pneumatic-inflation technologies such as inflatable mattresses, airbags, and pneumatic bladders, where the same pump-control and safety concerns had already been solved and standardized.

299. I understand that a reference is reasonably pertinent if it "logically would have commended itself to an inventor's attention in considering his problem." **Owen** would have done exactly that: it offers an off-the-shelf, field-tested solution—timer-controlled inflation termination—to the precise problem Wang's designers face.

300. **Owen** and **Wang** use identical physical principles and control architectures:

Shared Feature	Owen	Wang
Pumped-air inflation	Electric pump inflates air bladder	Air pump inflates buoyancy airbag
Inflation target	Desired gas volume/firmness	Desired gas volume/buoyancy force
Safety constraint	Prevent overinflation, motor strain	Prevent overinflation, motor strain
Control variable	Time or pressure threshold	Volume or time threshold
Control solution	Timer or chip stops pump after preset interval	Gas volume threshold

301. A POSITA would further understand that from a control-system perspective, both **Owen** and **Wang** employ a very simple safety controller by time or volume proxy. The distinction lies only in the application domain, not the technology or control logic.

302. Thus, **Owen**'s teachings about using a timer to shut off a pump after a predetermined interval are directly transferable to **Wang**'s airbag system and to the '196 Patent's buoyancy-control unit.

2. Claim 2

a. Element [2a]: "The controllable sinking and floating swimming pool robot according to claim 1, further comprising a posture detection unit configured to detect a posture of the swimming pool robot,"

303. **Wang** discloses a posture detection unit configured to detect a posture of the swimming pool robot. For example, **Wang** discloses a posture detection unit comprising a gyroscope sensor configured to detect a rotation angle or attitude of the swimming pool cleaning robot. *See, e.g.*, **Wang at [0256]:** "In some embodiments, **the preset rotation angle** may be obtained by analyzing a received operation instruction by the cleaning device 10, and the second trigger sensor may be a **gyroscope sensor**. The gyroscope sensor may detect the **actual rotation angle of the cleaning device 10** after the cleaning device 10 receives the operation instruction and send the detected actual rotation angle to a central processing unit 52 of the cleaning device 10 to compare the detected actual rotation angle with the preset rotation angle. If a deviation exists between the detected actual rotation angle and the preset rotation angle and exceeds the preset deviation, the central processing unit 52 determines that the cleaning device 10 is currently trapped." *See also* **Wang '040 p.25:45-50.**

304. Furthermore, **Wang** provides a sensor disposed on the cleaning device 10 that cooperates with the processor to control the attitude of the cleaning device 10 to be stable during state switching. *See, e.g*., **Wang at [0120]:** "In addition, an **attitude sensor** disposed on the cleaning device 10 may **cooperate with a controller to control the attitude** of the cleaning device 10 **to be stable** during state switching." *See also* **Wang '040 at p.13:34-36.**

b. Element [2b]: "wherein the main control unit controls the waterline detection unit to start detecting the positional relationship in response to the posture meeting a first predetermined condition."

305. **Wang,** alone or in view of **Zhao**, discloses this limitation.

306. As described in the '196 Patent, a "first predetermined condition" could be "changing from a state parallel to the bottom surface of the swimming pool to a state parallel to the side wall of the swimming pool." ('196 Patent, at 9:37-40.)

307. **Wang** likewise discloses the use of sensors to detect whether a posture condition is satisfied and to initiate subsequent control actions. Specifically, **Wang** describes that the cleaning device includes a **gyroscope** and other sensors for determining its real-time posture and depth in the pool. The control system divides the robot's operation into multiple motion states, including a **first motion state** (bottom cleaning), a **second motion state** (wall climbing), and

a **third motion state** (surface cleaning). *See, e.g.*, **Wang at [0068]-[0070], [0138]-[0139]; Wang' 040 at p.7:29-51, p.15:25-62.**

308. **Wang**'s processor monitors the output of the gyroscope to detect when the robot has changed orientation from horizontal (parallel to the bottom) to vertical (parallel to the wall), and in response switches control to the wall-climbing mode, i.e., the second motion mode. *See. e.g.,* **Wang at [0068]** ("A **second motion state is defined** as a state in which the cleaning device **10** moves on the side wall **402,** or the **overall direction of the cleaning device 10 is substantially parallel to the side wall 402**."); *see also e.g.*, **Wang '040 at p.7:32-34**.

309. It is my opinion that a POSITA would therefore understand that the system's control logic uses posture feedback to identify when the robot transitions from bottom cleaning to wall climbing, i.e., when the "first predetermined condition" is met.

310. Once in wall-climbing mode (Wang's **second motion state**), **Wang** discloses that the first sensor (e.g., ultrasonic, pressure, etc.) begins sensing the positional relationship to the waterline. *See, e.g.,* **Wang at [0114]**: "When the cleaning device 10 needs to be switched from the position under the liquid surface 30 to the position on the liquid surface 30, the **processor 52 may obtain the position of the cleaning device 10 in real time from the first sensor** … The preset condition may be that the position of the cleaning device 10 is higher than a

preset height… When the position of the cleaning device 10 shown in FIG. 7 [*on the wall*] meets the preset condition [*according to the first sensor*], the processor 52 may determine that the air inlet 5113 of the cleaning device 10 is above the liquid surface 30… the cleaning device 10 shown in FIG. 7 is switched to the cleaning device 10 shown in FIG. 8."; *see also e.g.*, **Wang '040 at p.12:49-61**. That is, once the posture preset condition (**substantially parallel to the side wall**) is met via the gyroscope, thus confirming wall-climbing mode, **Wang**'s main control unit controls the waterline detection unit (the first sensor in Wang) to start detecting the positional relationship relative to the waterline.

311. While in the wall-climbing mode, **Wang** teaches that the robot continues ascending toward the water surface, and when the **air inlet (5113)** becomes exposed to air, the **buoyancy-cavity pump (5112)** is activated to adjust the gas volume in the cavity and complete the ascent to the surface. *See, e.g.,* **Wang at [0120]**: "When the buoyancy cavity 5111 adjusts the buoyancy force by using gas, and the air inlet 5113 or an air outlet of the buoyancy cavity 5111 is located above the liquid surface, the buoyancy cavity pump 5112 is started to adjust the volume of the gas in the buoyancy cavity 5111. In this case, **the cleaning device 10 may be from the first motion state to the second motion state until the air inlet 5113 is exposed at the water surface. Then, the attitude of the cleaning device 10 is adjusted to be in the third motion state.** In this way, the

cleaning device 10 is switched from the position under the liquid surface to the position on the liquid surface." *See also* **Wang '040 at p.13:25-30.**

312. Accordingly, **Wang** teaches that the system transitions from bottom cleaning to wall climbing (i.e., the first condition is met) and then begins sensing the position relative to the waterline using the first sensor. Upon detecting that the inlet has reached or emerged above the waterline, it begins air intake to achieve buoyancy for the surface-cleaning state. To support this transition, **Wang** further discloses that the control system uses **sensors** to monitor the robot's position relative to the water surface during ascent. This includes a **first sensor** for determining real-time depth (vertical position) and a **second sensor** for detecting whether the air inlet of the buoyancy cavity is in air. *See, e.g.*, **Wang at [0113]-[0115]**; **Wang '040 at p.12:39-65.**

313. It is my opinion therefore that a POSITA would understand from Wang that these waterline-related detections occur **after** the posture change has been detected and the robot has entered the wall-climbing state, serving as feedback for the control unit to initiate buoyancy adjustment and transition into the surface-cleaning (third) state.

314. In sum, a POSITA would understand that **Wang** discloses a sequential control process consistent with the '196 Patent's claimed logic: (1) the gyroscope detects that the robot has changed from a horizontal bottom-cleaning posture to a

vertical wall-climbing posture (first predetermined condition); (2) the main control unit responds by switching to wall-climbing control and monitoring ascent toward the waterline; and (3) upon detecting that the air inlet is exposed to air, the buoyancy pump is activated to adjust air volume and complete the transition to the floating state.

315. Furthermore, **Zhao** discloses a similar type of posture-based trigger. For example, the robot of Zhao can determine whether it is on the bottom wall or side wall of the pool (i.e., whether it has transitioned into a wall climbing mode) according to the data of the gyroscope (i.e., posture detection unit). *See, e.g.,* **Zhao at 7:1-7**: "Before cleaning, a 3D map of the pool has been transmitted to the pool cleaning robot. **According to the data of the gyroscope of the pool cleaning robot, the pool cleaning robot can determine its own position**, for example, the pool cleaning robot can determine that the pool cleaning robot is located on the bottom wall of the pool, or **on the pool wall of the pool**."

316. Once the robot determines that it has transitioned from the horizontal bottom surface to a vertical pool wall, i.e., when the posture meets the first predetermined condition, **Zhao** teaches that it begins its **docking and climbing sequence**, which necessarily requires detecting its positional relationship relative to the waterline. This control logic is further illustrated in FIG. 3 of Zhao.

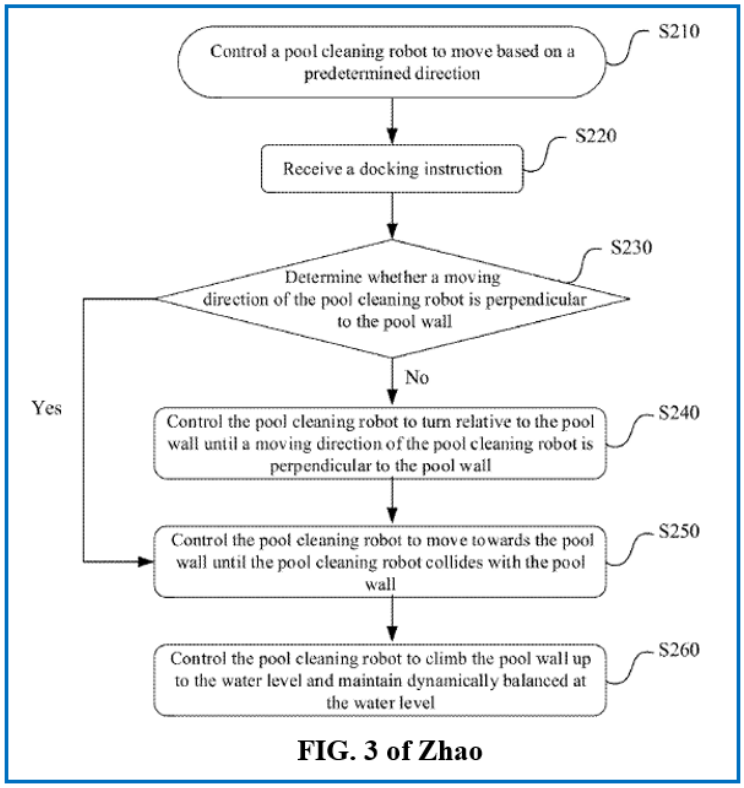


FIG. 3 of Zhao

317. **Zhao** describes, in relation to FIG. 3, that the transition to climbing is triggered by encountering the sidewall. *See, e.g.,* **Zhao at 6:42-60**: "As shown in FIG. **3**, embodiments of the present disclosure provide another method of a pool cleaning robot automatically docking, the method includes steps S**210** to S**260**. At S**210**, the pool cleaning robot is controlled to move based on a predetermined direction. At S**220**, a docking instruction is received. At S**230**, **whether the moving direction of the pool cleaning robot is perpendicular to the pool wall is determined**; if yes, proceed to S**250**; if not, proceed to S**240**. At S**240**, the pool cleaning robot is controlled to turn relative to the pool wall until a moving direction of the pool cleaning robot is perpendicular to the pool wall. At S**250**, **the pool cleaning robot is controlled to move towards the pool wall until the pool**

cleaning robot collides with the pool wall. At S260, the pool cleaning robot is controlled to climb the pool wall up to the water level and maintain dynamically balanced at the water level."

318. **Zhao** further explains that during the climb, the gyroscope and counter are used to record an angle and a rising height (i.e., the positional relationship). *See, e.g.,* **Zhao at 8:11-23**: "FIG. 6a to FIG. 6d are schematic diagrams of an interface of a control device coupled with a pool cleaning robot, showing a visual interface of the pool cleaning robot automatically climbing to a water level, according to embodiments of the present disclosure. After the pool cleaning robot 620 receives a docking instruction, the pool cleaning robot 620 docks and climbs up the pool wall 631. **A gyroscope and a counter built-in the pool cleaning robot 620 can record an angle and a rising height of the pool cleaning robot**. In FIG. 6a to FIG. 6d, the pool wall 631 is gridded, the dark gray area is a stay area for a water level, the medium gray area is an area near the water level, and the light gray area is an underwater area."

319. **Zhao** also describes tracking the distance to the water level and completion degree as the robot ascends through the underwater, near-water, and stay-at-water-level regions. *See, e.g.,* **Zhao at 8:24-42**: "**A completion degree mark 611 represents the docking completion degree calculated according to the moving speed of the pool cleaning robot 620 and a distance between the**

pool cleaning robot and the water level. Timer 610 represents a remaining time for the docking instruction. For example, in FIG. 6a , the pool cleaning robot 620 is in the underwater area, the timer 610 shows that the remaining time for the docking instruction is 80s, and the docking completion degree is 30%; in FIG. 6b , the pool cleaning robot 620 enters the area near the water level, and the remaining time for the docking instruction is 70s, and the docking completion degree is 70%; in FIG. 6c , the pool cleaning robot 620 enters the stay area for the water level, and the remaining time for the docking instruction is 60s, the docking completion degree is 100%; in FIG. 6d , the pool cleaning robot 620 waits in the stay area for a timeout and retreats to the underwater, the remaining time for the docking command is 0s, and the docking completion degree is 100%."

320. Accordingly, it is my opinion that a POSITA would understand that **Zhao** teaches controlling the waterline detection unit to start detecting the positional relationship in response to the posture meeting a first predetermined condition, where the posture triggers the beginning of the waterline-detection and climbing sequence.

321. Alternately, when considered together, **Wang** and **Zhao** provide a clear and complementary disclosure of the claimed control logic. **Zhao** teaches the **triggering condition**—the use of a gyroscope to determine when the robot's posture changes from bottom cleaning to wall climbing and to initiate detection of

positional relationship relative to the waterline. **Wang**, in turn, provides the **specific sensing and actuation structure** for that waterline detection and ascent process, including the **first sensor** for depth measurement, the **second sensor** for detecting whether the air inlet is in air, and the **control of the buoyancy pump (5112)** to transition from the second (wall-climbing) to the third (surface-cleaning) motion state. *See, e.g.*, **Wang at [0113]-[0115]; Wang '040 at p.12:39-65.**

322. It is my opinion that a POSITA would have found it obvious to integrate Zhao's posture-based triggering with Wang's transitions between the bottom and side walls, as both are solving substantively the same problem. Once climbing the wall, Wang's waterline-detection and buoyancy-control mechanisms kick in, so that, upon detecting that the robot has changed posture to a wall-climbing orientation, the main control unit would begin monitoring the robot's position relative to the waterline and initiate buoyancy adjustment based on feedback from the waterline detection unit. The combination yields a predictable improvement—automated, sensor-driven coordination between posture detection and waterline control—consistent with the design goals of both references and the same functional relationship as that described and recited in the '196 Patent.

3. Claim 3: "The controllable sinking and floating swimming pool robot according to claim 1, wherein the operational requirement information comprises remote control command information sent by a user, clock information, operational task progress information, fault information,

power information or swimming pool bottom environment information."

323. **Wang** discloses a task-acquisition module that receives a target cleaning assignment from a user for a swimming pool. The assignment may include water-surface cleaning, underwater cleaning, or both, and can further specify sub-tasks such as bottom or wall cleaning. *See, e.g.,* **Wang at [0182]**: "Step 1010: Obtain a **target task** of cleaning a target swimming pool." *See also* **Wang '040 at p.19:21.**

324. Wang further teaches that the target task can include surface cleaning and/or underwater cleaning. *See, e.g.,* **Wang at [0183]**: "The target swimming pool may be a to-be-cleaned swimming pool. The target task may be a task of cleaning the target swimming pool. **The target task may include water surface cleaning and/or underwater cleaning.** The water surface cleaning may mean cleaning a water surface of the target swimming pool. The underwater cleaning may mean cleaning an underwater part of the target swimming pool (such as water in the swimming pool and a wall of the swimming pool). In some embodiments, the target task may further include a specific to-be-cleaned part. For example, the underwater cleaning may further include, but is not limited to, cleaning the water, cleaning the bottom of the pool, cleaning each wall of the pool, and the like." *See also* **Wang '040 at p.19:22-27.**

325. **Wang** teaches that the target task may be user-selected, or pre-scheduled. *See, e.g.,* **Wang at [0184]**: "The control member may obtain the target task in various manners. For example, **the control member may obtain the target task input by a user.** For another example, **the control member may be configured to perform the target task periodically**, such as perform water surface cleaning once every three days and perform underwater cleaning once every two days." *See also* **Wang '040 at p.19:28-30.**

4. Claim 4: "The controllable sinking and floating swimming pool robot according to claim 1, further comprising a distance measurement unit or a map storage unit, wherein the main control unit controls the swimming pool robot to find the nearest side wall or the nearest slope based on distance measurement results of the distance measurement unit or map data in the map storage unit."

326. **Wang**, alone or in view of **Zhao**, discloses this limitation.

327. **Wang** discloses a controllable pool-cleaning robot with a position-sensing unit; the control member plans a route from the sensed current position to the task-start position and then drives the robot along it. For example, the robot may switch to a motion state in which it travels along the pool side wall while executing the planned route toward the target task location. *See, e.g.,* **Wang at [0068]**: "A second motion state is defined as a state in which **the cleaning device 10 moves on the side wall 402**, **or the overall direction of the cleaning device 10**

is substantially parallel to the side wall 402, as shown in FIG. 7 and FIG. 12."

See also **Wang '040 at p.7:32-34.**

328. **Wang** further teaches that the moving mechanism is adjusted based on the target task and the current position of the device. *See, e.g.,* **Wang at [0185]:** "Step 1020: **Determine an adjustment parameter** of a moving mechanism **based on the target task and a current position** of the cleaning device 10." *See also* **Wang '040 at p.19:41-42.**

329. Position is determined using the first sensor of **Wang**. *See, e.g.,* **Wang at [0186]:** "The control member may **obtain the current position of the cleaning device 10**. For more details about obtaining the **current position** of the cleaning device 10, refer to the above description of the first sensor." *See also* **Wang '040 at p.19:43-44.**

330. The adjustment parameter may also include route information relating the current position of the cleaning device to the position where the task is to be performed. *See, e.g.,* **Wang at [0187]:** "The adjustment parameter may include **information of a route** from the current position to a position, in the target swimming pool, at which the target task needs to be performed and route information required to complete the target task." *See also* **Wang '040 at p.19:45-46.**

331. These operations are performed under control of the control member. *See, e.g.,* **Wang at [0188]:** "The control member may determine, based on the target task, **a starting position**, in the target swimming pool, **at which the target task needs to be performed**; determine, based on the **starting position and the current position**, the information of the route of the cleaning device 10 from the current position to the position, in the target swimming pool, at which the target task needs to be performed; and determine, based on the target task for the target swimming pool, the route information required to complete the target task, to determine the adjustment parameter of the moving mechanism." *See also* **Wang '040 at p.19:47-50.**

332. The moving mechanism is controlled on the basis of the adjustment parameter determined above. *See, e.g.,* **Wang at [0189]: "**Step 1030: **Control**, based on the **adjustment parameter**, **the moving mechanism to drive the cleaning device 10** to move and perform cleaning to complete the target task." *See also* **Wang '040 at p.19:51-52.**

333. Accordingly, **Wang** can be understood to disclose a control logic that allows the processor to (1) sense the robot's current position through onboard sensors, (2) plan a path from that position to a target task location (e.g., a wall or slope), and (3) command the motion components to follow that path. For example, **Wang** describes a **second motion state** in which the robot moves "along or

substantially parallel to the side wall 402" to perform sidewall cleaning. *See, e.g.*, **Wang at [0068]-[0070]**; **Wang '040 at p.7:29-51**. A POSITA would understand that to enter and execute this wall-cleaning state, the control unit must first determine which wall or slope is nearest and then navigate the robot toward that wall, steps that inherently depend on distance or positional information.

334. To the extent that Wang does not explicitly mention a "nearest wall," **Zhao** complements Wang by disclosing the specific sensing and data sources used to determine and approach the **nearest wall**. **Zhao** discloses a distance measurement unit or a map storage unit, wherein the main control unit controls the swimming pool robot to find the nearest side wall or the nearest slope based on distance measurement results of the distance measurement unit or map data in the map storage unit.

335. For example, **Zhao** teaches that the robot body includes a sensor unit with **ultrasonic distance sensors and gyroscopes**, and that based on distance measurement results or **3D map information**, the robot **determines the closest pool wall** relative to its position and enables the robot to move toward that closest pool wall.

336. Specifically, **Zhao** describes ultrasonic distance sensors located on sides and/or the top of the robot. *See, e.g.,* **Zhao at 4:6-17**: "The sensor unit provided on the pool cleaning robot includes various types of sensors, such as

collision sensors, distance sensors, counters, and gyroscopes. The distance sensors can include, for example, **ultrasonic distance sensors**, which can be configured to **measure a distance from an obstacle to the ultrasonic distance sensor**. The distance sensors can be provided on the front side, back side, right side and left side of the pool cleaning robot. The distance sensor can also be provided on the top of the pool cleaning robot to measure distance by rotating, such that a distance from an obstacle near the pool cleaning robot to the distance sensor can be measured through the distance sensor."

337. Likewise, **Zhao** describes gyroscopes and a counter that can be used to calculate distances moved by the robot. *See, e.g.,* **Zhao at 4:18-25**: "The inside of the pool cleaning robot is also provided with **a counter** and a gyroscope. The counter is configured to accumulate a total number of rotation angles (or cycles) of the driving wheel of the moving unit, so as to **calculate a distance length that the pool cleaning robot, drove by the driving wheel, have moved**. The gyroscope is configured to measure a rotation angle of the pool cleaning robot, such that a direction of the pool cleaning robot can be determined."

338. **Zhao** describes use of a pool map to be used by the robot in combination with the movement sensors like the gyroscope to determine a location of the robot in relation to the pool map. *See, e.g.,* **Zhao at 7:1-7**: "Before cleaning, a **3D map of the pool has been transmitted to the pool cleaning robot**.

According to the data of the gyroscope of the pool cleaning robot, the pool cleaning robot can determine its own position, for example, the pool cleaning robot can determine that the pool cleaning robot is located on the bottom wall of the pool, or on the pool wall of the pool."

339. **Zhao** explicitly describes locating a "closest pool wall." *See, e.g.,* **Zhao at 1:38-42**: "A first aspect of the present disclosure provides a method of automatic docking a pool cleaning robot, the method includes: placing the pool cleaning robot into a pool; upon receiving a docking instruction, **determining a closest pool wall relative to the pool cleaning robot, and enabling the pool cleaning robot to move towards the closest pool wall**."

340. **Zhao** likewise more generally describes determining distances to any pool wall. *See, e.g.,* **Zhao at 4:33-40**: "As shown in FIG. 1, in an embodiment of the present disclosure, the method of a pool cleaning robot docking includes steps S110 to S140. At step S110, the pool cleaning robot is placed into the pool. At step S120, after the pool cleaning robot falls on a bottom wall of the pool, **the pool cleaning robot determines a distance between the pool cleaning robot and the pool wall of the pool** while moving on the bottom wall of the pool."

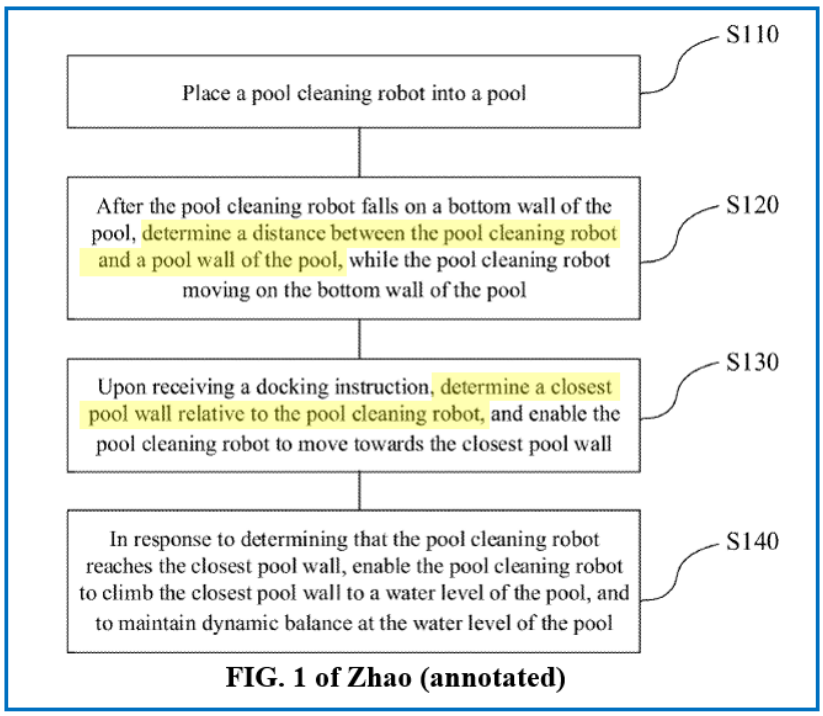


FIG. 1 of Zhao (annotated)

341. Using the distances determined in step S120, **Zhao** teaches that a closest wall can be identified. *See, e.g.,* **Zhao at 4:62-65**: "At step S130, when the pool cleaning robot receives the docking instruction, the pool cleaning robot stops moving, **determines the closest pool wall relative to the pool cleaning robot**, and moves towards the closest pool wall."

342. Once the docking instruction is received, the robot can take one of several possible actions. *See, e.g.,* **Zhao at 6:33-37**: "In practical applications, the pool cleaning robot can stop moving in response to receiving the docking instruction, **rotate in place, and determine the closest pool wall**; or the pool cleaning robot can also turn around during the moving process to find the closest pool wall."

343. **Zhao** further describes specific aspects of using the robot's sensors to navigate with respect to the closest pool wall, both in determining which wall is closest and how to orient the robot with respect to the closest wall. *See, e.g.,* **Zhao at 7:11-18**: "Based on the pose of the pool cleaning robot determined by the gyroscope of the pool cleaning robot, the pool cleaning robot can use a pool bottom turn mode. When the pool cleaning robot determines that the pool cleaning robot is on the bottom wall of the pool, the pool cleaning robot **combines the data of the rotatable scanning ultrasonic sensor** configured on the top of the pool cleaning robot **to determine the closest route to the pool wall."** *See also,* **Zhao at 7:19-21**: "In the pool bottom turn mode, the pool cleaning robot is **turned to the closest pool wall determined by the rotatable scanning ultrasonic sensor**."

344. Taken together, I understand the two references to describe complementary aspects of the claimed control system. **Wang** provides the **task-based control architecture and route-planning logic** by which the main control unit directs the robot toward a wall or slope for cleaning, while **Zhao** provides the **distance- and map-based sensing mechanisms** that enable the robot to identify which wall or slope is nearest.

345. In my opinion, a POSITA would have found it obvious to integrate **Zhao**'s distance-sensing and wall-finding techniques with **Wang**'s route-planning and motion-control framework, so that the robot can automatically: (1) detect its

current position through sensors, (2) determine the nearest wall or slope based on distance measurement results or stored map data, and (3) plan and execute a route toward that wall or slope to perform the designated cleaning task.

346. Such a combination would have been straightforward to implement and yield a predictable improvement—namely, enhanced autonomy and navigation efficiency in the robot's movement between cleaning regions—fully consistent with the control objectives described in both **Wang** and **Zhao**.

5. Claim 5: "The controllable sinking and floating swimming pool robot according to claim 1, wherein the waterline detection unit comprises an outlet water detection subunit configured to detect whether at least a part of the swimming pool robot has come out of water."

347. **Wang** discloses a **second sensor** that detects whether the air inlet is exposed to the air and at least a part of the robot has come out of the water. *See, e.g.*, **Wang at [0115]**: "In some embodiments, the cleaning device 10 may further include a second sensor (not shown in the figure). **The second sensor may be configured to detect in real time whether the air inlet 5113 of the buoyancy cavity 5111 is exposed to the air.**" *See also* **Wang '040 at p.12:62-63**.

6. Claim 6: "The controllable sinking and floating swimming pool robot according to claim 1, wherein the waterline detection unit further comprises a proximity waterline detection subunit configured to detect whether the swimming pool robot has crawled to a distance less than or equal to a predetermined distance from the waterline."

348. **Wang** discloses that the cleaning device includes a first sensor configured to determine the robot's position in real time, particularly its vertical position (depth) in the pool. The first sensor, which may be a pressure sensor, an ultrasonic sensor, or an optical sensor, detects the robot's current depth and transmits the positional data to the processor. **Wang** further explains that this first sensor cooperates with the mode switching member to enable the robot to maintain or move at a predetermined depth. *See, e.g.*, **Wang at [0113]**: "In some embodiments, the cleaning device 10 may include a first sensor (not shown in the figure). **The first sensor may be configured to determine a position of the cleaning device 10 in real time. The position may be a vertical position (or referred to as a depth) of the cleaning device 10 in the liquid.** For example, the first sensor may be disposed at a central position of the cleaning device 10, and the position may be a depth of the central position of the cleaning device 10 in the liquid. The first sensor may be, but is not limited to, a pressure sensor, an ultrasonic sensor, or an optical sensor. **The first sensor and the mode switching member 510 may further control the cleaning device 10 to move at a predetermined depth.** For example, the cleaning device 10 performs underwater cleaning at the predetermined depth or moves at the predetermined depth towards a charging apparatus disposed at the wall of the pool." *See also* **Wang '040 at p.12:39-45**.

349. Furthermore, **Wang** discloses that when the robot needs to switch from an underwater position to a surface position, the **processor obtains real-time position data from the first sensor** and determines whether the measured position satisfies a **preset condition**, such as the robot being **higher than a preset height**. When this condition is met, the processor concludes that the **air inlet (5113)** of the buoyancy cavity is above the water surface and controls the buoyancy pump to begin draining liquid and admitting air. *See, e.g.*, **Wang at [0114]**: "When the cleaning device 10 needs to be switched from the position under the liquid surface 30 to the position on the liquid surface 30, **the processor 52 may obtain the position of the cleaning device 10 in real time from the first sensor**. When the position of the cleaning device 10 meets a preset condition, the processor 52 may control the buoyancy adjustment part to increase the volume of the gas in the buoyancy cavity 5111. **The preset condition may be that the position of the cleaning device 10 is higher than a preset height**. When a depth of the liquid in the target region 40 is fixed, the processor 52 may determine whether the position of the cleaning device 10 meets the preset condition to determine whether the air inlet 5113 of the cleaning device 10 is above the liquid surface 30. **When the position of the cleaning device 10 shown in FIG. 7 meets the preset condition, the processor 52 may determine that the air inlet 5113 of the cleaning device 10 is above the liquid surface 30**, the processor 52 may control the buoyancy

cavity pump 5112 to drain the liquid from the buoyancy cavity 5111, and air may enter the buoyancy cavity 5111 through the air inlet 5113, to increase the volume of the gas in the buoyancy cavity 5111 and increase the buoyancy force applied to the cleaning device 10." *See also* **Wang '040 at p.12:49-59**.

350. This control process directly corresponds to the claimed **proximity waterline detection** functionality: the first sensor continuously monitors the robot's vertical position, and when it detects that the robot has ascended to within a predefined threshold distance from the waterline (i.e., the position is higher than a preset depth), the processor recognizes that proximity condition and triggers the buoyancy adjustment sequence. To a POSITA, the "preset height" disclosed by **Wang** would be understood as a **predetermined distance** threshold relative to the water surface, and the sensor's function—to detect that the robot has reached or is within that threshold—is functionally equivalent to "detecting whether the swimming pool robot has crawled to a distance less than or equal to a predetermined distance from the waterline."

7. Claim 7

a. Element [7a]: "The controllable sinking and floating swimming pool robot according to claim 5, wherein the sinking and floating control unit comprises an inflation and deflation subunit and a switch subunit,"

351. **Wang** discloses the sinking and floating control unit comprises an inflation and deflation subunit and a switch subunit. Specifically, **Wang** discloses

the **buoyancy adjustment assembly** (included in the mode switching member 510) comprises a **buoyancy cavity pump** 5112 (i.e., inflation and deflation subunit) and a **one-way valve** (i.e., switch subunit).

352. The buoyancy cavity pump is controlled to inject air/gas into or draw air/gas out of the buoyancy cavity to regulate the robot's buoyancy and thereby cause the robot to float or sink. The one-way valve seated at the air inlet automatically closes when the cavity pump stops, blocking external water from back-flowing into the cavity and locking the robot at its preset buoyancy. *See, e.g.,* **Wang at [0109]:** "When the air inlet 5113 does not communicate with the gas, **a one-way valve may be disposed at the air inlet 5113**. The **one-way valve can prevent external water of the cleaning device body 101 from entering the buoyancy cavity 5111 through the air inlet 5113**... The buoyancy adjustment part may be any structure that can adjust the gas and/or the liquid in the buoyancy cavity 5111. As shown in FIG. 6, **the buoyancy adjustment part may include a buoyancy cavity pump 5112**. The buoyancy cavity pump 5112 can drive the buoyancy cavity 5111 to drain the liquid therefrom. The buoyancy cavity pump 5112 may be, but is not limited to, **a pneumatic pump, a hydraulic pump, or an electric pump**. In **an operating state, the buoyancy cavity pump 5112 can adjust the liquid and/or the gas in the buoyancy cavity 5111**. In a non-operating state, the buoyancy cavity pump 5112 can prevent any external liquid and/or gas of

the cleaning device 10 from entering the buoyancy cavity 5111, so that the buoyancy cavity 5111 is not affected by the external liquid and/or gas." *See also* **Wang '040 at p.11:68-76, p.12:1-5.**

353. **Wang** teaches an alternate configuration for providing the same functionality. *See, e.g.,* **Wang at [0111]:** "As shown in FIG. 6, the buoyancy adjustment part 511 may include two buoyancy cavities 5111, the buoyancy cavity pump 5112, the air inlet 5113, and the connection duct 5114. **The buoyancy cavities 5111 may be connected to the buoyancy cavity pump 5112** through the connection duct 5114. The **buoyancy cavity pump 5112 may be connected to the air inlet 5113** through the connection duct 5114. In the non-operating state, the buoyancy cavity pump 5112 has the same function as the one-way valve and can prevent the external liquid and/or gas from entering the buoyancy cavity 5111 through the air inlet 5113. In some other embodiments, when the buoyancy adjustment part is a centrifugal pump or the like, **the one-way valve is disposed at the connection duct 5114 to prevent the external liquid and/or gas from entering the buoyancy cavity 5111 through the air inlet 5113**." *See also* **Wang '040 at p.12:19-26.**

b. Element [7b]: "wherein in response to the outlet water detection subunit detecting that at least a part of the swimming pool robot has come out of the water, the inflation and deflation subunit is controlled to start sucking air and the switch subunit is controlled to

open, so that the sinking and floating control unit enters the floating working state."

354. **Wang** discloses this limitation. Wang discloses an outlet water detection subunit that, upon sensing part of the robot emerging from the water, triggers the inflation-deflation subunit to begin sucking air while the switch subunit is opened. *See, e.g.,* **Wang at [0112]:** "As shown in FIG. 5 and FIG. 6, when the cleaning device 10 needs to be switched from the position under the liquid surface 30 to the position on the liquid surface 30, the cleaning device 10 may move to a position close to the liquid surface 30 and determine when to control the **buoyancy cavity pump 5112 to inject gas into the buoyancy cavity 5111**." *See also* **Wang '040 at p.12:27-29.**

355. For example, **Wang** discloses a second sensor (i.e., outlet water detection subunit) that monitors in real time whether the air inlet 5113 is above the pool water surface. Upon detecting that the air inlet has emerged from the water, the processor activates the buoyancy cavity pump 5112 (i.e., inflation and deflation subunit) to open the switch and begin drawing air. *See, e.g.,* **Wang at [0115]:** "In some embodiments, the cleaning device 10 may further include a second sensor (not shown in the figure). **The second sensor may be configured to detect in real time whether** the **air inlet 5113** of the buoyancy cavity 5111 **is exposed to the air.** For example, the second sensor may be an ultrasonic sensor." *See also* **Wang '040 at p.12:62-64.**

356. **Wang** further discloses exactly **how** the detection of exposure to air of the buoyancy cavity can be used in controlling the gas volume. *See, e.g.,* **Wang at [0117]:** "In some embodiments, when the cleaning device 10 needs to be switched from the position under the liquid surface 30 to the position on the liquid surface 30, the processor 52 may obtain the detection result of whether the air inlet 5113 of the buoyancy cavity 5111 is exposed to the air. **When the detection result indicates that the air inlet 5113 is exposed to the air, the buoyancy adjustment part is controlled to increase the volume of the gas in the buoyancy cavity 5111 to switch the cleaning device 10 from the position under the liquid surface 30 to the position on the liquid surface 30.** For details about content that the processor 52 controls the buoyancy adjustment part to increase the volume of the gas in the buoyancy cavity 5111 to switch the cleaning device 10 from the position under the liquid surface 30 to the position on the liquid surface 30, refer to the above description." *See also* **Wang '040 at p.13:3-9.**

357. Likewise, **Wang** describes how the controller controls the pump to reduce buoyancy and move to a position under the liquid surface. *See, e.g.,* **Wang at [0118]**: "When the cleaning device 10 needs to be switched from the position on the liquid surface 30 to the position under the liquid surface 30, the processor 52 may control the buoyancy adjustment part to reduce the volume of the gas in the buoyancy cavity 5111. … As shown in FIG. 5 and FIG. 6**,** the **buoyancy cavity**

pump 5111 [sic; should be 5112] **may drain the gas from the buoyancy cavity 5111 through the connection duct** 5114 to reduce the volume of the gas in the buoyancy cavity 5111 to reduce the buoyancy force, to switch the cleaning device 10 from the position on the liquid surface 30 to the position under the liquid surface 30." *See also* **Wang '040 at p.13:10-15.**

358. Finally, **Wang** teaches an alternate approach to moving the cleaning device from a position under the liquid surface to a position on the liquid surface that still relies on detecting that an air inlet or outlet of the buoyancy cavity is above the surface. *See, e.g.,* **Wang at [0120]**: "When the buoyancy cavity 5111 adjusts the buoyancy force by using gas, and the air inlet 5113 or **an air outlet of the buoyancy cavity 5111 is located above the liquid surface**, **the buoyancy cavity pump 5112 is started to adjust the volume of the gas in the buoyancy cavity 5111**. In this case, the cleaning device 10 may be from the first motion state to the second motion state until the air inlet 5113 is exposed at the water surface. Then, the attitude of the cleaning device 10 is adjusted to be in the third motion state. In this way, the cleaning device 10 is switched from the position under the liquid surface to the position on the liquid surface." *See also* **Wang '040 at p.13:25-30.**

359. It is my opinion that a POSITA would understand that **Wang** discloses that once the air inlet 5113 is detected to be above the waterline, the air tube has to

be opened to allow the pump to increase the gas volume in the sealed buoyancy cavity, and admit air to the buoyancy cavity.

8. Claim 9

a. Element [9a]: "The controllable sinking and floating swimming pool robot according to claim 7, wherein the sinking and floating control unit further comprises an airbag subunit connected to the inflation and deflation subunit, wherein the airbag subunit is connected to or disconnected from outside atmosphere through the inflation and deflation subunit and the switch subunit,"

360. **Wang** discloses a control unit that further comprises an airbag subunit connected to the inflation and deflation subunit, wherein the airbag subunit is connected to or disconnected from the outside atmosphere through the inflation and deflation subunit and the switch subunit. Specifically, **Wang** discloses a buoyancy-adjustment assembly 511 having a buoyancy cavity 5111. A POSITA would recognize that the buoyancy cavity 5111 performs the same structural and functional role as the claimed *airbag subunit*. In particular, Wang describes the buoyancy cavity as an enclosed chamber designed to accommodate gas and/or liquid, made of flexible materials like rubber or PET, which allow for expansion and contraction in response to gas intake or discharge. This is the defining characteristic of an airbag structure—a sealed, inflatable vessel whose internal volume varies to control buoyant force. *See, e.g.,* **Wang at [0099]:** "In some embodiments, **the buoyancy adjustment assembly 511 may include a buoyancy**

cavity 5111 and a buoyancy adjustment part. **The buoyancy cavity 5111 is configured to accommodate liquid and/or gas.** The buoyancy cavity 5111 may be, but is not limited to, an inflatable buoyancy cavity, a liquid-containing buoyancy cavity, a partitioned buoyancy cavity, or the like. A volume of the buoyancy cavity 5111 may be preset. **The buoyancy cavity 5111 may be made of a flexible material and/or a rigid material. The flexible material may include, but is not limited to, polyvinyl alcohol resin, polyethylene glycol terephthalate, rubber, and the like. The rigid material may include, but is not limited to, glass, ceramic, phenolic plastic, polyurethane plastic, epoxy plastic, unsaturated polyester plastic, and the like."** *See also* **Wang '040 at p.11:5-11.**

361. **Wang** further discloses that the **buoyancy cavity 5111** is pneumatically connected to the external atmosphere through the **buoyancy cavity pump 5112** (i.e., inflation and deflation subunit) and the **one-way valve** (i.e., switch subunit) disposed at the **air inlet 5113**. *See, e.g.,* **Wang at [0109]:** "When the air inlet 5113 does not communicate with the gas, a one-way valve may be disposed at the air inlet 5113. **The one-way valve can prevent external water of the cleaning device body 101 from entering the buoyancy cavity 5111 through the air inlet 5113**. The air inlet 5113 may alternatively communicate with the gas. For example, the **air inlet 5113 may communicate with gas on the liquid surface 30** ... The buoyancy adjustment part may be any structure that can adjust the gas

and/or the liquid in the buoyancy cavity 5111. As shown in FIG. 6, the buoyancy adjustment part may include a buoyancy cavity pump 5112. The buoyancy cavity pump 5112 can drive the buoyancy cavity 5111 to drain the liquid therefrom. The buoyancy cavity pump 5112 may be, but is not limited to, a pneumatic pump, a hydraulic pump, or an electric pump. In **an operating state, the buoyancy cavity pump 5112 can adjust the liquid and/or the gas in the buoyancy cavity 5111**. In **a non-operating state, the buoyancy cavity pump 5112 can prevent any external liquid and/or gas of the cleaning device 10 from entering the buoyancy cavity 5111**, so that the buoyancy cavity 5111 is not affected by the external liquid and/or gas." *See also* **Wang '040 at p.11:68-76, p.12:1-5.**

362. During operation, the pump is energized to draw external air through the air inlet into the buoyancy cavity, thereby increasing buoyancy and causing the robot to rise toward the water surface. A POSITA would understand that once the pump is energized, the one-way valve at the air inlet 5113 opens to admit air while blocking backflow, allowing the cavity to fill with gas and increasing buoyancy. *See, e.g.,* **Wang at [0109]:** "When the air inlet 5113 does not communicate with the gas, a one-way valve may be disposed at the air inlet 5113. **The one-way valve can prevent external water of the cleaning device body 101 from entering the buoyancy cavity 5111 through the air inlet 5113**. The air inlet 5113 may alternatively communicate with the gas. For example, the **air inlet 5113 may**

communicate with gas on the liquid surface 30 ... The buoyancy adjustment part may be any structure that can adjust the gas and/or the liquid in the buoyancy cavity 5111. As shown in FIG. 6, the buoyancy adjustment part may include a buoyancy cavity pump 5112. The buoyancy cavity pump 5112 can drive the buoyancy cavity 5111 to drain the liquid therefrom. The buoyancy cavity pump 5112 may be, but is not limited to, a pneumatic pump, a hydraulic pump, or an electric pump. In **an operating state, the buoyancy cavity pump 5112 can adjust the liquid and/or the gas in the buoyancy cavity 5111**. In **a non-operating state, the buoyancy cavity pump 5112 can prevent any external liquid and/or gas of the cleaning device 10 from entering the buoyancy cavity 5111**, so that the buoyancy cavity 5111 is not affected by the external liquid and/or gas." *See also* **Wang '040 at p.11:68-76, p.12:1-5.**

363. Equally important, **Wang** explains that in a **non-operating state**, the same pneumatic path is closed, thereby **disconnecting the buoyancy cavity from the outside atmosphere.** *Id.* Specifically, **Wang** teaches that when the pump is not active, it "prevents any external liquid and/or gas from entering the buoyancy cavity," and that the pump itself "has the same function as the one-way valve," effectively isolating the cavity and maintaining internal pressure stability. (**Wang at [0109]-[0111]; Wang '040 at p.11:60-76, p.12:1-26**) This control ensures that the buoyancy cavity remains sealed from external influence once the robot reaches

equilibrium, thereby preserving the achieved buoyancy and preventing leakage or backflow.

364. **Wang** teaches that the inlet is provided on the housing of the device. *See, e.g.,* **Wang at [0110]:** "In some embodiments, the buoyancy adjustment assembly 511 may further include the air inlet 5113. The air inlet 5113 is configured for gas to enter the buoyancy cavity 5111. In some embodiments, the air inlet 5113 may further be configured for the gas to leave the buoyancy cavity 5111 or for liquid to enter or leave the buoyancy cavity 5111. In some embodiments, the buoyancy adjustment assembly 511 may further include another inlet and outlet for the gas to leave or for the liquid to enter or leave the buoyancy cavity 5111. The air inlet 5113 is directly provided on the buoyancy cavity 5111 or independent of the buoyancy cavity 5111. **The air inlet 5113 may be provided on a housing of the cleaning device 10 to communicate with the outside (such as external liquid or air) for gas and/or liquid exchanging**. As shown in FIG. 5, the air inlet 5113 may be provided at the top of a front tail part of the cleaning device 10, so that the air inlet 5113 can more quickly communicate with the external air above the liquid surface 30 during floating of the cleaning device 10." *See also* **Wang '040 at p.12:8-16.**

365. Wang further teaches an embodiment in which there are two buoyancy cavities, and the pump 5112 acts in the same manner as the one-way valve. *See,*

e.g., **Wang at [0111]:** "As shown in FIG. 6, the buoyancy adjustment part 511 may include two buoyancy cavities 5111, the buoyancy cavity pump 5112, the air inlet 5113, and the connection duct 5114. **The buoyancy cavities 5111 may be connected to the buoyancy cavity pump 5112 through the connection duct 5114**. The **buoyancy cavity pump 5112 may be connected to the air inlet 5113 through the connection duct 5114**. **In the non-operating state, the buoyancy cavity pump 5112 has the same function as the one-way valve and can prevent the external liquid and/or gas from entering the buoyancy cavity 5111 through the air inlet 5113**. In some other embodiments, when the buoyancy adjustment part is a centrifugal pump or the like, **the one-way valve is disposed at the connection duct 5114 to prevent the external liquid and/or gas from entering the buoyancy cavity 5111 through the air inlet 5113."** *See also* **Wang '040 at p.12:19-26.**

b. Element [9b]: "and wherein the sinking and floating control unit further comprises an air inlet and outlet subunit, wherein the switch subunit is connected to the outside atmosphere through the air inlet and outlet subunit."

366. **Wang** discloses a control unit that further comprises an air inlet and outlet subunit, wherein the switch subunit is connected to the outside atmosphere through the air inlet and outlet subunit. For example, **Wang** discloses that the switch subunit is realized by the buoyancy-cavity pump 5112 and the one-way

valve: when the pump is idle its sealed impeller housing closes the air path, so the inlet-outlet subunit (air inlet 5113 and connection duct 5114) is isolated from the external atmosphere and water is kept out; when the pump spins the seal is broken and ambient air is drawn through the same inlet-outlet subunit into the buoyancy cavity 5111, exemplifying the switch subunit being connected to the outside atmosphere through the inlet-and-outlet subunit. *See, e.g.,* **Wang at [0111]:** "As shown in FIG. 6, the buoyancy adjustment part 511 may include two buoyancy cavities 5111, the buoyancy cavity pump 5112, the air inlet 5113, and the connection duct 5114. The buoyancy cavities 5111 may be connected to the buoyancy cavity pump 5112 through the connection duct 5114. The **buoyancy cavity pump 5112 may be connected to the air inlet 5113 through the connection duct 5114**. **In the non-operating state, the buoyancy cavity pump 5112 has the same function as the one-way valve and can prevent the external liquid and/or gas from entering the buoyancy cavity 5111 through the air inlet 5113**. In some other embodiments, when the buoyancy adjustment part is a centrifugal pump or the like, **the one-way valve is disposed at the connection duct 5114 to prevent the external liquid and/or gas from entering the buoyancy cavity 5111 through the air inlet 5113**." *See also* **Wang '040 at p.12:19-26.** *See also*, discussion regarding limitation [8a], below.

9. Claim 10: "The controllable sinking and floating swimming pool robot according to claim 1, wherein the main control

unit is further capable of controlling the sinking and floating control unit to enter a sinking working state based on the operational requirement information of the swimming pool robot to realize a sinking of the swimming pool robot."

367. **Wang** discloses that the main control unit is further capable of controlling the sinking and floating control unit to enter a sinking working state based on the operational requirement information of the swimming pool robot to realize a sinking of the swimming pool robot. *See, e.g.,* **Wang at [0118]**: "When the cleaning device 10 needs to be switched from the position on the liquid surface 30 to the position under the liquid surface 30, the **processor 52 may control the buoyancy adjustment part to reduce the volume of the gas in the buoyancy cavity 5111**." *See also* **Wang '040 at p.13:10-11**.

368. **Wang** discloses that its control logic enables the robot to transition from a floating or surface-cleaning condition (third motion state) back to a submerged state (first motion state) by reducing buoyant force. Specifically, **Wang** teaches that when the robot needs to move from the liquid surface back underwater, the processor 52 controls the buoyancy adjustment part to reduce the volume of gas in the buoyancy cavity, thereby decreasing buoyancy and allowing gravity to pull the robot down. *See, e.g.,* **Wang at [0119]:** "In some embodiments, switching of the cleaning device 10 between the position on the liquid surface 30 and the position under the liquid surface 30 includes operating from the first

motion state to the third motion state and **operating from the third motion state to the first motion state.** It may be understood that switching of the cleaning device 10 between the first motion state and the third motion state may be implemented by using the mode switching member 510, the first sensor, and the second sensor that are disposed in the cleaning device 10." *See also* **Wang '040 at p.13:21-24**.

369. **Wang** provides additional description of the transition to the sinking working state. *See, e.g.,* **Wang at [0120]:** "After the cleaning device 10 completes water surface cleaning, the filtering box 711 is cleaned at the water surface, or the cleaning device 10 is charged at the water surface**,** the cleaning device 10 needs to be switched from the third motion state to the first motion state to continue cleaning the bottom of the pool. **In this case, the buoyancy cavity pump 5112 may be started or the volume of the gas in the buoyancy cavity 5111 may be adjusted when the cleaning device 10 is in the third motion state, to reduce the buoyancy force**. The cleaning device 10 is switched from the third motion state to the first motion state under the action of gravity thereof. In addition, an attitude sensor disposed on the cleaning device 10 may cooperate with a controller to control the attitude of the cleaning device 10 to be stable during state switching." *See also* **Wang '040 at p.13:30-36**.

370. **Wang** also discloses that the robot's control module can receive operational requirements or "target tasks" that include underwater cleaning. These tasks may be initiated based on user input, scheduled periodic routines, or sensor feedback such as water-quality data. A POSITA would understand that when an operational requirement calls for underwater cleaning, the processor would execute the corresponding sinking sequence—activating the buoyancy-control subsystem to discharge air and submerge the robot. *See, e.g.,* **Wang at [0182]**: "Step 1010: Obtain a **target task** of cleaning a target swimming pool." *See also* **Wang '040 at p.19:21**.

371. More generally, **Wang** describes a cleaning task that involves both surface and submerged cleaning. *See, e.g.,* **Wang at [0183]**: "The target swimming pool may be a to-be-cleaned swimming pool. The target task may be a task of cleaning the target swimming pool. **The target task may include water surface cleaning and/or underwater cleaning.** The water surface cleaning may mean cleaning a water surface of the target swimming pool. The underwater cleaning may mean cleaning an underwater part of the target swimming pool (such as water in the swimming pool and a wall of the swimming pool). In some embodiments, the target task may further include a specific to-be-cleaned part. For example, the underwater cleaning may further include, but is not limited to, cleaning the water,

cleaning the bottom of the pool, cleaning each wall of the pool, and the like." *See also* **Wang '040 at p.19:22-27**.

372. The task may be set by a user input or may be set to be performed according to a schedule. *See, e.g.,* **Wang at [0184]**: "The control member may obtain the target task in various manners. For example, **the control member may obtain the target task input by a user.** For another example, **the control member may be configured to perform the target task periodically**, such as perform water surface cleaning once every three days and perform underwater cleaning once every two days. For another example, the cleaning device 10 may further include a detection member. The detection member may detect water quality of the target swimming pool to obtain water quality data of the target swimming pool. **The control member may obtain the water quality data and determine the target task based on the water quality data.** The water quality data may be data reflecting a water quality condition of the target swimming pool." *See also* **Wang '040 at p.19:28-30**.

10. Claim 11: "The controllable sinking and floating swimming pool robot according to claim 10, wherein the sinking and floating control unit comprises an inflation and deflation subunit, a switch subunit and an airbag subunit connected to the inflation and deflation subunit, controlling the sinking and floating control unit to enter the sinking working state comprises controlling the switch subunit to open and controlling the inflation and deflation subunit to discharge air in the airbag subunit."

373. **Wang** discloses a control unit that comprises an inflation and deflation subunit, a switch subunit and an airbag subunit connected to the inflation and deflation subunit, controlling the sinking and floating control unit to enter the sinking working state comprises controlling the switch subunit to open and controlling the inflation and deflation subunit to discharge air in the airbag subunit.

374. As discussed for claim 7 above, **Wang** discloses that the sinking and floating control unit comprises a buoyancy cavity pump (the inflation and deflation subunit), a one-way valve (switch subunit), and a buoyancy cavity (airbag subunit). The pump and valve are pneumatically coupled to the buoyancy cavity and work together to increase or decrease gas volume, thereby controlling buoyancy.

375. **Wang** also discloses that the processor (main control unit) directs the robot to submerge based on a user-input task, follow a periodic schedule, or automatically generate the task from real-time water-quality data. *See, e.g.*, **Wang at [0182]-[0184]; Wang '040 at p.19:21-30**.

376. In my opinion, a POSITA would understand that these control inputs represent "operational requirement information" which instructs the control unit to initiate the sinking process when underwater cleaning is required.

377. To achieve submersion, **Wang** teaches that the controller actuates the buoyancy cavity pump and opens the one-way valve to allow airflow and to discharge air from the airbag. Specifically, when the cleaning device transitions

from the third motion state (water surface cleaning) to the first motion state (underwater cleaning), the buoyancy cavity pump 5112 is activated to decrease the gas volume inside the buoyancy cavity 5111, lowering buoyant force; gravity then causes the robot to sink. *See, e.g.,* **Wang at [0118]**: "When the cleaning device 10 needs to be switched from the position on the liquid surface 30 to the position under the liquid surface 30, the **processor 52 may control the buoyancy adjustment part to reduce the volume of the gas in the buoyancy cavity 5111**." *See also* **Wang '040 at p.13:10-11.**

378. **Wang** further describes controlling the motion state and buoyancy based on completion of a surface cleaning task. *See, e.g.,* **Wang at [0120]:** "After the cleaning device 10 completes water surface cleaning, the filtering box 711 is cleaned at the water surface, or the cleaning device 10 is charged at the water surface, **the cleaning device 10 needs to be switched from the third motion state to the first motion state to continue cleaning the bottom of the pool. In this case, the buoyancy cavity pump 5112 may be started or the volume of the gas in the buoyancy cavity 5111 may be adjusted when the cleaning device 10 is in the third motion state, to reduce the buoyancy force.** The cleaning device 10 is switched from the third motion state to the first motion state under the action of gravity thereof. In addition, an attitude sensor disposed on the cleaning device

10 may cooperate with a controller to control the attitude of the cleaning device 10 to be stable during state switching." *See also* **Wang '040 at p.13:30-36.**

11. Claim 13: "The controllable sinking and floating swimming pool robot according to claim 7, wherein in response to the outlet water detection subunit detecting that at least a part of the swimming pool robot enters underwater again and/or the posture detection unit detecting that the posture of the swimming pool robot meets a second predetermined condition, the inflation and deflation subunit and the switch subunit are controlled to be closed."

379. **Wang** discloses the additional limitation recited in claim 13.

380. The '196 Patent specification indicates that a "second predetermined condition" could be "changing from a state parallel to the side wall of the swimming pool to a state parallel to the bottom surface of the swimming pool." ('196 Patent, at 9:43-46.)

381. **Wang** likewise discloses using sensors to detect whether this posture condition is satisfied and to initiate subsequent control actions. Specifically, **Wang** describes that the cleaning device includes a **gyroscope** for determining its real-time posture in the pool. The control system divides the robot's operation into multiple motion states, including a **first motion state** (bottom cleaning), a **second motion state** (wall climbing), and a **third motion state** (surface cleaning). *See, e.g.*, **Wang at [0068]-[0070], [0138]-[0139]; Wang' 040 at p.7:29-51, p.15:25-62.** **Wang** explains that by **adjusting the "attitude" of the cleaning device**, the robot

is switched from the second state to the third motion state, i.e., when the "second predetermined condition" is met.

382. **Wang** additionally discloses that the cleaning device may have its attitude adjusted as it shifts between motion states, and that the motion state and attitude can be adjusted based on detection that an air inlet is exposed at a water surface. *See, e.g.,* **Wang at [0120]:** "When the buoyancy cavity 5111 adjusts the buoyancy force by using gas, and the air inlet 5113 or an air outlet of the buoyancy cavity 5111 is located above the liquid surface, the buoyancy cavity pump 5112 is started to adjust the volume of the gas in the buoyancy cavity 5111. In this case, the cleaning device 10 may be from the first motion state to **the second motion state until the air inlet 5113 is exposed at the water surface**. Then, **the attitude of the cleaning device 10 is adjusted to be in the third motion state**. In this way, **the cleaning device 10 is switched from the position under the liquid surface to the position on the liquid surface**. … In addition, an **attitude sensor** disposed on the cleaning device 10 may **cooperate with a controller to control the attitude** of the cleaning device 10 **to be stable** during state switching." *See also* **Wang '040 at p.13:25-36.**

383. It is my opinion that a POSITA would therefore understand that **Wang**'s control logic uses posture feedback to identify when the robot transitions from wall climbing to water surface cleaning, i.e., when the "second predetermined

condition" is met. A POSITA would also understand that this detection result can be used as a basis for the controller to determine when to close the cavity pump and valve after surfacing, to stabilize buoyancy and prevent overinflation.

12. Claim 14

a. Element [14a]: "The controllable sinking and floating swimming pool robot according to claim 7, further comprising a water pump unit configured to pump liquid in the swimming pool where the swimming pool robot is located and discharge the liquid to drive the swimming pool robot,"

384. **Wang** discloses a water pump unit configured to pump liquid in the swimming pool where the swimming pool robot is located and discharge the liquid to drive the swimming pool robot. For example, **Wang** discloses that the **main water-pump 210** draws pool water through the liquid-inlet portion 103 (e.g., first and second water inlets 1031/1032) and expels it via the liquid-outlet portion 104, so the reaction thrust propels and steers the robot while simultaneously conveying surface debris into the cleaning device. *See, e.g.,* **Wang at [0139]:** "In some embodiments, the cleaning device 10 may further include the main water pump 210. **The main water pump 210 may be configured to drive the cleaning device 10 to suck the liquid from the liquid inlet portion 103 and drain the liquid from the liquid outlet portion 104.** The liquid inlet portion 103 may include one or more inlets for liquid to enter the cleaning device 10, such as the first water inlet 1031 and the second water inlet 1032." *See also* **Wang '040 at p.15:51-55.**

385. **Wang** explains that the water pump not only pumps pool water but also discharges it to create a driving force that moves and positions the robot within the pool. For example, **Wang** explains that the main pump water outlet 214, which is angled rearward relative to the housing, serves as the discharge outlet through which water is expelled from the cleaning device into the pool region. The discharged flow generates a reaction thrust that propels the cleaning device. *See, e.g.,* **Wang at [0139]:** "As shown in FIG. 9, FIG. 13, FIG. 14, and FIG. 15, the **main pump water outlet 214** of the cleaning device 10 may serve as an outlet for the liquid in the cleaning device 10 to be drained from the cleaning device 10 into the target region 40." *See also* **Wang '040 at p.15:60-62.**

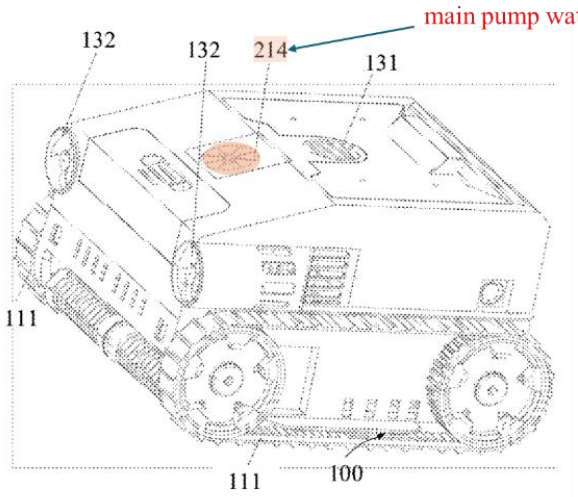


FIG. 9 of Wang (annotated)

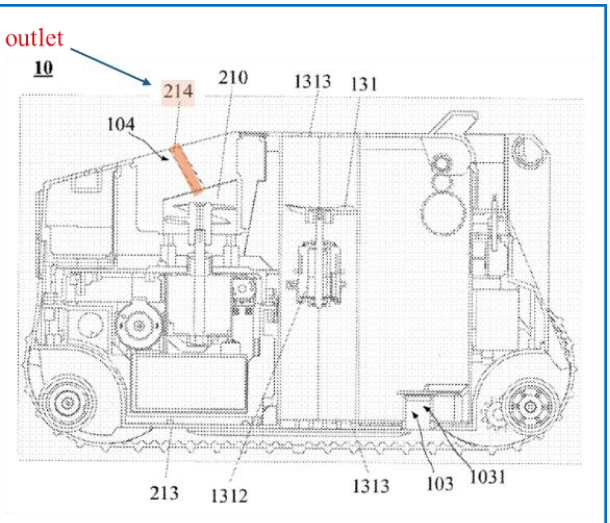


FIG. 13 of Wang (annotated)

386. As described in **Wang**, the water outlet 214 is angled to apply particular driving forces, for example to ensure good contact between the treads and a wall along which the robot is crawling. *See, e.g.,* **Wang at [0143]:** "In some

embodiments, when the cleaning device 10 needs to move on the target side wall 402, the main pump water outlet 214 may face towards the target region 40. When the **main pump water outlet 214 tilts downward along the vertical direction**, the **third driving force applied to the cleaning device 10** has a **horizontal component force** facing towards the target side wall 402, so that the cleaning device 10 can be tightly attached to the target side wall 402. In addition, the third driving force further has an **upward component force in the vertical direction, so that the cleaning device 10 can move upward along the target side wall 402**." *See also* **Wang '040 at p.16:4-8.**

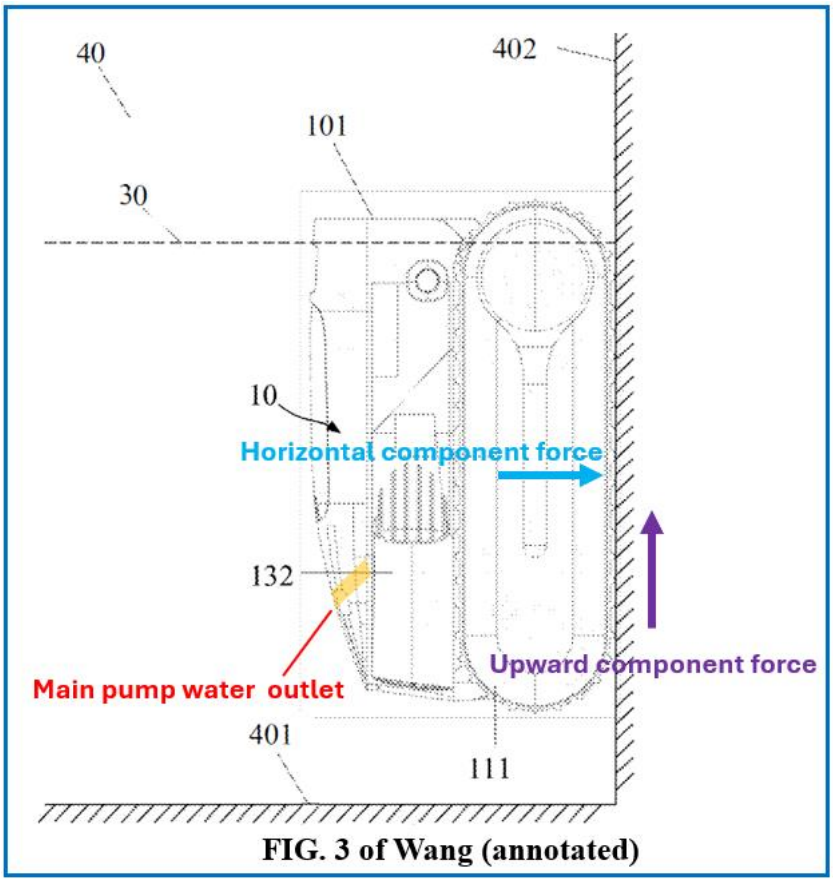


FIG. 3 of Wang (annotated)

b. Element [14b]: "wherein a power of the water pump unit is changed after the sinking and floating control unit enters the floating working state or after the swimming pool robot climbs the side wall or the slope."

387. **Wang** discloses the main water pump drives the cleaning device to be tightly attached to the side wall during wall-climbing operation. *See, e.g.,* **Wang at [0144]:** "In some embodiments, the main pump water inlet 213 may be provided at the bottom of the cleaning device 10. When the cleaning device 10 needs to move on the target side wall 402, **the main water pump 210** may suck the liquid through the main pump water inlet 213 to **obtain a fourth driving force to drive the cleaning device 10 to be tightly attached to the target side wall 402**. The fourth driving force may be a suction force generated by the main water pump 210 sucking the liquid through the main pump water inlet 213. The suction force may drive the cleaning device 10 to be tightly attached to the target side wall 402." *See also* **Wang '040 at p.16:12-16**. *See, e.g.,* **Wang at [0145]**: "In some embodiments, when the cleaning device 10 needs to move on the target side wall 402, **the main water pump 210** of the cleaning device 10 may drive the cleaning device 10 **to be tightly attached to the target side wall 402**." *See also* **Wang '040 at p.16:17-18.**

388. It is my opinion therefore that a POSITA would understand that, when the cleaning device needs to leave the side wall (second motion state) and switch to

the liquid surface (third motion state), the suction force produced by the main water pump must be reduced. In other words, the power of the main water pump necessarily changes in coordination with the transition from the wall-climbing state to the floating working state.

389. It is my opinion that a POSITA would further recognize that this adjustment is consistent with Wang's general control framework, where the controller coordinates multiple subsystems—including the buoyancy control and propulsion units—to achieve stable motion between the sidewall, bottom, and surface. Accordingly, a POSITA would have found it implicit and technically necessary that the pump output be decreased once the robot begins to float, to eliminate adhesion and allow buoyant ascent.

13. Claim 15

a. Element [15pre]: "A sinking and floating control method for a swimming pool robot, comprising:"

390. Based on exemplary disclosures for limitation [1pre] above, it is my opinion that **Wang** discloses a sinking and floating control method for a swimming pool robot.

b. Element [15a]: "controlling a swimming pool robot to find a side wall or a slope based on operational requirement information of the swimming pool robot, and enabling the swimming pool robot to crawl along the side wall or the slope;"

391. Based on exemplary disclosures for limitation [1d] above, it is my opinion that **Wang**, alone or in view of **Zhao**, discloses controlling a swimming pool robot to find a side wall or a slope based on operational requirement information of the swimming pool robot, and enabling the swimming pool robot to crawl along the side wall or the slope.

c. Element [15b]: "detecting a positional relationship between the swimming pool robot and a waterline of a liquid surface of a swimming pool where the swimming pool robot is located;"

392. Based on exemplary disclosures for limitation [1e] above, it is my opinion that **Wang** discloses detecting a positional relationship between the swimming pool robot and a waterline of a liquid surface of a swimming pool where the swimming pool robot is located.

d. Element [15c]: "controlling a sinking and floating control unit to enter a floating working state based on detection results to realize a floating of the swimming pool robot; and"

393. Based on exemplary disclosures for limitation [1f] above, it is my opinion that **Wang** discloses controlling a sinking and floating control unit to enter a floating working state based on detection results to realize a floating of the swimming pool robot.

e. Element [15d]: "controlling the sinking and floating control unit to stop working after the sinking and floating control unit enters the floating working state for a predetermined time."

394. Based on exemplary disclosures for limitation [1g] above, it is my opinion that **Wang**, alone or in view of **Owen** discloses controlling the sinking and floating control unit to stop working after the sinking and floating control unit enters the floating working state for a predetermined time.

14. Claim 16: "The sinking and floating control method for the swimming pool robot according to claim 15, wherein detecting the positional relationship between the swimming pool robot and the waterline of the liquid surface of the swimming pool where the swimming pool robot is located comprises: starting detecting the positional relationship in response to a posture of the swimming pool robot meeting a first predetermined condition."

395. Based on exemplary disclosures for claim 2, it is my opinion that **Wang**, alone or in view of **Zhao**, discloses detecting the positional relationship between the swimming pool robot and the waterline of the liquid surface of the swimming pool where the swimming pool robot is located comprises: starting detecting the positional relationship in response to a posture of the swimming pool robot meeting a first predetermined condition.

15. Claim 17: "The sinking and floating control method for the swimming pool robot according to claim 16, wherein the operational requirement information comprises remote control command information sent by a user, clock information, operational task progress information, fault information, power information or swimming pool bottom environment information."

396. Based on exemplary disclosures for claim 3 above, it is my opinion that **Wang** discloses the operational requirement information comprises remote

control command information sent by a user, clock information, operational task progress information, fault information, power information or swimming pool bottom environment information.

16. Claim 18: "The sinking and floating control method for the swimming pool robot according to claim 17, wherein controlling the sinking and floating control unit to enter the floating working state based on detection results to realize the floating of the swimming pool robot comprises: controlling the sinking and floating control unit to enter the floating working state in response to detecting that at least a part of the swimming pool robot has come out of water."

397. Based on exemplary disclosures for claim 7 above, it is my opinion that **Wang**, discloses controlling the sinking and floating control unit to enter the floating working state based on detection results to realize the floating of the swimming pool robot comprises: controlling the sinking and floating control unit to enter the floating working state in response to detecting that at least a part of the swimming pool robot has come out of water.

17. Claim 19: "The sinking and floating control method for the swimming pool robot according to claim 17, further comprising: controlling the sinking and floating control unit to stop working in response to detecting that at least a part of the swimming pool robot enters underwater again and/or detecting that the posture of the swimming pool robot meets a second predetermined condition."

398. Based on exemplary disclosures for claim 13 above, it is my opinion that Wang discloses controlling the sinking and floating control unit to stop working in response to detecting that at least a part of the swimming pool robot

enters underwater again and/or detecting that the posture of the swimming pool robot meets a second predetermined condition.

B. Ground 2: *Wang,* in view of *Zhao*, *Owen,* and *Guo,* Renders Claims 8 and 12 Obvious

1. Claim 8

a. Element [8a]: "The controllable sinking and floating swimming pool robot according to claim 5, wherein the sinking and floating control unit comprises an inflation and deflation subunit and a switch subunit,"

399. Based on exemplary disclosures for claim element [7a] above, **Wang** discloses that the robot sinking and floating control unit comprises an inflation and deflation subunit and a switch subunit.

b. Element [8b]: "wherein in response to the proximity waterline detection subunit detecting that the swimming pool robot has crawled to the distance less than or equal to the predetermined distance from the waterline, the inflation and deflation subunit is controlled to start sucking air,"

400. **Wang**, alone or in view of **Guo**, discloses this limitation.

401. **Wang** describes a control process in which the processor receives input from a **first sensor** configured to determine the robot's real-time position (depth) in the pool. When the robot's detected position meets a **preset condition**, such as being "**higher than a preset height**," the processor determines that the robot is near the surface and begins controlling the buoyancy adjustment part to increase the gas volume within the buoyancy cavity, thereby initiating the ascent to

the waterline. *See, e.g.,* **Wang at [0114]**: "When the cleaning device 10 needs to be switched from the position under the liquid surface 30 to the position on the liquid surface 30, **the processor 52 may obtain the position of the cleaning device 10 in real time from the first sensor**. **When the position of the cleaning device 10 meets a preset condition**, the processor 52 may control the buoyancy adjustment part to increase the volume of the gas in the buoyancy cavity 5111. **The preset condition may be that the position of the cleaning device 10 is higher than a preset height**. When a depth of the liquid in the target region 40 is fixed, the processor 52 may determine whether the position of the cleaning device 10 meets the preset condition to determine whether the air inlet 5113 of the cleaning device 10 is above the liquid surface 30. **When the position of the cleaning device 10 shown in FIG. 7 meets the preset condition,** the processor 52 may determine that the air inlet 5113 of the cleaning device 10 is above the liquid surface 30, the **processor 52 may control the buoyancy cavity pump 5112 to drain the liquid from the buoyancy cavity 5111, and air may enter the buoyancy cavity 5111 through the air inlet 5113, to increase the volume of the gas in the buoyancy cavity 5111 and increase the buoyancy force applied to the cleaning device 10**." *See also* **Wang '040 at p.12:49-59**.

402. As discussed for claim 6 above, a POSITA would understand that the first sensor effectively serves as a **proximity waterline detection subunit**, since it

determines when the robot's distance from the surface is less than a set threshold and triggers the inflation process. As the robot ascends, the first sensor continuously monitors the vertical distance from the surface; when that distance becomes less than or equal to a predetermined threshold (the "preset height"), the controller interprets the condition as proximity to the waterline and activates the buoyancy cavity pump (5112) to begin air intake.

403. Importantly, **Wang further discloses multiple sources of the gas** used for buoyancy adjustment, including both **external** and **internal** supply options. For example, in addition to obtaining air directly from the atmosphere once the robot reaches the surface, **Wang** teaches **an internal gas-generation assembly** located inside the robot, which can generate or release gas to adjust buoyancy even while the device remains submerged. *See, e.g.,* **Wang at [0107]**: "For a third **source of the gas**, a gas generation assembly (not shown) is **disposed inside the cleaning device 10**. The gas generation assembly can generate gas to change the volume of the gas in the buoyancy cavity 5111. In this way, **the cleaning device 10 is prevented from climbing the wall from the target region 40 to the liquid surface 30 before changing the volume of the gas in the buoyancy cavity 5111**. This improves convenience. The gas generation assembly may generate gas through a chemical reaction, electrolysis, water boiling, and the

like to increase or reduce the volume of the gas in the buoyancy cavity 5111." *See also* **Wang '040 at p.11:47-52.**

404. Thus, **Wang** explains that the internal gas source enables the robot to change the volume of gas in the buoyancy cavity before climbing from the underwater region to the surface, thus improving operational convenience and efficiency. This teaching demonstrates that Wang's system is capable of initiating buoyancy adjustment **while still underwater**—that is, once the proximity condition to the waterline is satisfied, but before any portion of the robot emerges from the surface.

405. **Guo** provides complementary structural detail and implementation. Guo teaches "a swimming pool cleaning robot capable of autonomous floating and diving underwater." (**Guo at [0004]**.) The robot includes "a **floating and diving assembly** comprising an airbag and an inflation/deflation device, the inflation/deflation device being connected to the airbag via an air tube." (**Guo at [0008]**.) The floating and diving assembly "**is configured to drive the swimming pool cleaning robot 100 to ascend, descend, or suspend vertically**." (**Guo at [0031]**.)

406. **Guo** further teaches that the airbag is connected to a sealed **driving cabin** that serves as an internal gas source, and an inflation/deflation device that draws gas from the cabin into the airbag to increase buoyancy or returns it to the

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cabin to decrease buoyancy. *See, e.g.*, **Guo at [0034]:** "In the swimming pool cleaning robot 100 of the present disclosure, the airbag 121 is connected to the driving cabin 131 via the inflation/deflation device 122, **and the driving cabin 131 of the swimming pool cleaning robot 100 serves as the gas source for the floating and diving assembly 120.** When it is necessary to control the robot 100 to surface**,** the **inflation/deflation device 122 draws gas from the driving cabin 131 into the airbag 121**. When it is necessary to control the robot 100 to dive, **the inflation/deflation device 122 discharges gas from the airbag 121 into the driving cabin 131**. In this way, the robot 100 can be made to surface or dive as required. At the same time, since the driving cabin 131 also serves as the compartment for installing the driving assembly 130, there is no need to occupy additional space within the housing 110, resulting in a more compact overall layout, a smaller overall size, improved flexibility, and reduced manufacturing costs for the swimming pool cleaning robot 100."

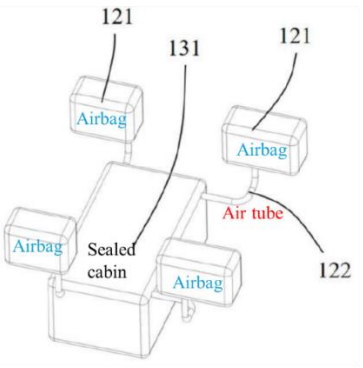


FIG. 4 of Guo (annotated)

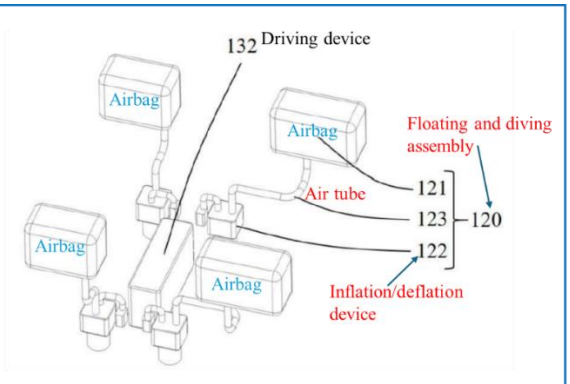


FIG. 5 of Guo (annotated)

407. Because the gas is circulated internally within the sealed structure, **Guo**'s design allows the robot to begin inflating its airbag **before any portion of the robot emerges from the water**, relying entirely on internal pressure transfer rather than external air intake.

408. A POSITA would have been motivated to combine the teachings of **Wang** and **Guo** to achieve a more effective and reliable buoyancy-control system. Both references address the same engineering challenge—controlling a submerged cleaning robot's buoyancy to enable smooth transitions between underwater operation and surface floating. **Wang** provides the **control logic**, using sensor feedback to determine proximity to the waterline and trigger buoyancy adjustment. **Guo**, in turn, provides a **mechanically robust solution** for implementing that control logic by introducing an internally circulating gas system that can inflate or deflate an airbag without requiring exposure to external air.

409. This combination would have been straightforward and predictable to a POSITA for several reasons. **First**, Wang expressly recognizes the need to change the volume of the gas in the buoyancy cavity before climbing from the underwater region to the surface, and even contemplates an **internal gas generation mechanism** to enable such underwater buoyancy adjustment. **Guo** provides exactly this type of structure—a sealed driving cabin serving as an internal gas source—thereby supplying a well-known and practical way to realize

Wang's proposed function. **Second**, using **Guo**'s internal gas source in **Wang**'s system eliminates the delay and instability associated with waiting for the air inlet to reach the atmosphere before inflation can begin. A POSITA would recognize that initiating inflation earlier—when proximity sensors detect the robot is close to the surface—provides smoother motion, less mechanical stress on seals, and improved energy efficiency. **Third**, both systems rely on standard pump-valve architectures and closed pneumatic circuits that are readily compatible. Integrating **Guo**'s teaching that the driving cabin alone can inflate/deflate an external bladder into **Wang**'s depth-triggered ascent—where the buoyancy pump starts as soon as sensor feedback shows the robot has reached a specific depth—would have required only routine design work and no change in the underlying principles of operation. The expected result of this combination would have been entirely predictable: a buoyancy-control system capable of beginning inflation immediately upon proximity detection, thereby allowing the robot to approach and stabilize at the surface in a continuous, controlled manner.

c. Element [8c]: "and in response to the outlet water detection subunit detecting that at least a part of the swimming pool robot has come out of the water, the switch subunit is controlled to open, so that the sinking and floating control unit enters the floating working state."

410. Based on exemplary disclosures for claim element [7b] above, it is my opinion that **Wang** discloses this feature.

2. Claim 12

a. Element 12[a]: "The controllable sinking and floating swimming pool robot according to claim 7, wherein the inflation and deflation subunit comprises an air pump assembly"

411. **Wang** discloses an inflation and deflation subunit that comprises an air pump assembly. For example, **Wang** discloses that the buoyancy cavity pump 5112 can drive the buoyancy cavity 5111 to drain liquid/air therefrom, thereby adjusting the liquid and/or gas within the cavity and functioning as the inflation/deflation subunit. *See, e.g.,* **Wang at [0109]:** "The buoyancy adjustment part may be any structure that can adjust the gas and/or the liquid in the buoyancy cavity 5111. As shown in FIG. 6, the buoyancy adjustment part may include a buoyancy cavity pump 5112. The buoyancy cavity pump 5112 can drive the buoyancy cavity 5111 to drain the liquid therefrom. **The buoyancy cavity pump 5112 may be**, but is not limited to, **a pneumatic pump**, a hydraulic pump, or an electric pump. In an operating state, the buoyancy cavity pump 5112 can adjust the liquid and/or the gas in the buoyancy cavity 5111. In a non-operating state, the buoyancy cavity pump 5112 can prevent any external liquid and/or gas of the cleaning device 10 from entering the buoyancy cavity 5111, so that the buoyancy cavity 5111 is not affected by the external liquid and/or gas." *See also* **Wang '040 at p.11:74-76, p.12:1-5.**

b. Element 12[b]: "and the switch subunit comprises an electromagnetic valve assembly or a two-position three-way valve assembly."

412. **Wang**, alone or in view of **Guo**, discloses this limitation.

413. **Wang** discloses a one-way valve that isolates the buoyancy cavity from external water whenever the air inlet is not exposed to air, thereby providing an automatic seal that functions as the switch subunit. *See, e.g.,* **Wang at [0109]:** "When the air inlet 5113 does not communicate with the gas, **a one-way valve** may be disposed at the air inlet 5113. **The one-way valve** can prevent external water of the cleaning device body 101 from entering the buoyancy cavity 5111 through the air inlet 5113." *See also* **Wang '040 at p.11:68.**

414. Similarly, **Guo** provides embodiments identifying the types of components that constitute the inflation/deflation device 122 (inflation and deflation subunit), including a power mechanism being one of a **peristaltic pump**, a **gear pump** or a **Roots blower** (i.e., an air pump assembly) and an **electromagnetic valve** (i.e., switch subunit). *See, e.g.,* **Guo at [0048]**: "In this embodiment, the inflation/deflation device 122 comprises a **power mechanism, which may be a peristaltic pump, a gear pump, or a Roots blower.** The airbag 121 is connected to the power mechanism, which is capable of rotating in both forward and reverse directions. When it is necessary to control the swimming pool cleaning robot 100 to ascend, the power mechanism rotates forward, causing gas

from the driving cabin 131 to be injected into the airbag 121. When it is necessary to control the swimming pool cleaning robot 100 to dive, the power mechanism rotates in reverse, causing the gas in the airbag 121 to be discharged into the driving cabin 131."

415. **Guo** further teaches the use of an electromagnetic valve to control the driving cabin that is open when powered on and closed when powered off. *See, e.g.,* **Guo at [0049]**: "To further enhance the sealing performance of the driving cabin 131, in this embodiment, **the inflation/deflation device 122 further comprises a solenoid valve connected to the power mechanism**. When **the power mechanism is operating, the solenoid valve is open**; when the power mechanism is not operating, the solenoid valve is closed, thereby ensuring better sealing of the driving cabin 131."

416. It is my opinion that a POSITA would have found it obvious to combine **Wang**'s disclosure of a valve placed at the air inlet with **Guo**'s teaching of an electromagnetic valve that is open only while the power mechanism is running. Both systems share the same design objective—**maintaining airtight separation between the air cavity and pool water while permitting controlled airflow during inflation or deflation**—and operate in sealed aquatic environments where backflow prevention is essential.

417. Moreover, both **Wang** and **Guo** rely on **peristaltic or equivalent positive-displacement pumps** that inherently create suction by compressing and releasing flexible tubing. Because such pumps already produce a partial sealing effect when idle, coupling them with an actively controlled electromagnetic valve, as taught by Guo, would have been an obvious engineering improvement over Wang's purely passive one-way valve. This combination provides redundant sealing protection: the valve closes automatically when the pump stops, while the peristaltic pump's rollers pinch the tubing to further block fluid ingress.

C. Ground 3: *Zhang,* in view of *Zhao* and *Owen,* Renders Claims 1-6, 10, and 14-17 Obvious

1. Independent Claim 1

a. Element [1pre]: "A controllable sinking and floating swimming pool robot, comprising:"

418. **Zhang** discloses a controllable sinking and floating swimming pool robot. Specifically, **Zhang** teaches a controllable pool cleaning robot that can switch between operating above the liquid surface (*floating*) and below the liquid surface (*sinking*) for flexible cleaning. *See, e.g.,* **Zhang at 1:51-57:** "The **pool cleaning robot** includes … **a control member** configured to control the pool cleaning robot to perform a water surface cleaning of a pool or an underwater cleaning of the pool." *See, e.g.,* **Zhang at 5:46-52**: "The action force of the moving device **includes a buoyancy force**, and the mode switching member includes a **buoyancy-force adjustment assembly** configured to **adjust a**

magnitude of the buoyancy force to which the moving device is subjected in the vertical direction." *See, e.g.,* **Zhang at 4:1-9**: "A moving device 100 may be configured to move in a target region 300 containing liquid and may **switch a position above a liquid surface and below the liquid surface**. The target region 300 may be a region containing the liquid in which the moving device 100 performs its movement. The target region 300 may include a pool. For example, the **moving device 100 may move in a water body of the pool and switch a position on a water surface of the pool and in the water of the pool**." *See, e.g.,* **Zhang at 4:48-56**: "In some embodiments of the present disclosure, by providing the mode switching member 110, the moving device 100 may achieve the position switching above the liquid surface and below the liquid surface so that **the moving device 100 may adjust its position above the liquid surface and below the liquid surface** according to different liquid environments and needs, and be **able to perform corresponding operations in different positions in the liquid more flexibly**."

b. Element [1a]: "a sinking and floating control unit configured to control a swimming pool robot to float and sink;"

419. **Zhang** discloses a sinking and floating control unit configured to control a swimming pool robot to float and sink. For example, **Zhang** discloses a **mode switching member (including a buoyancy force adjustment assembly,**

which in turn includes a buoyancy cavity and a buoyancy adjustment part) that controls the robotic cleaning device between cleaning on the pool water surface and cleaning beneath the pool water surface. *See, e.g.,* **Zhang at 4:24-30**: "In some embodiments, the moving device 100 may include a mode switching member 110. **The mode switching member 110 may be configured to achieve a position switching of the moving device 100 above the liquid surface and below the liquid surface**. The mode switching member 110 may move in a vertical direction of the target region 300, thus enabling the position switching of the moving device 100 above the liquid surface and below the liquid surface."

420. **Zhang** additionally discloses that the mode switching member includes a buoyancy force adjustment assembly. *See, e.g.,* **Zhang at 4:57-5:3**: "In some embodiments, the action force received by the moving device 100 in the vertical direction may include a buoyancy force to which the moving device 100 is subjected in the vertical direction. When the aforementioned action force includes a buoyancy force to which the moving device 100 is subjected in the vertical direction, **the mode switching member 110 may include a buoyancy force adjustment assembly 111**. The buoyancy force adjustment assembly 111 may be configured to adjust the magnitude of the buoyancy force to which the moving device 100 is subjected in the vertical direction. In some embodiments, the

buoyancy force adjustment assembly 111 may include a buoyancy cavity 1111 and a buoyancy force adjustment member."

421. **Zhang** discloses a control member that controls the moving device to switch from a surface to an underwater cleaning. That is, the control member causes the robot to float and sink. *See, e.g.,* **Zhang at 13:58-61**: "The **control member** in the aforementioned pool cleaning robot 400 **controls the moving device 100 to switch positions in the water surface of the pool and underwater to achieve the water surface cleaning or underwater cleaning**." *See, e.g.,* **Zhang at 8:21-31**: "In some embodiments, when the moving device 100 needs to be switched from below the liquid surface to above the liquid surface, the processor may obtain a detection result of whether the air inlet of the buoyancy cavity 1111 is located in the air, and when the detection result characterizes that the aforementioned air inlet is located in the air, the **buoyancy force adjustment member is controlled to increase the volume of the gas in the buoyancy cavity 1111 to achieve the switching of the moving device 100 from below the liquid surface to above the liquid surface."**

422. **Zhang** also discloses that the buoyancy control is achieved by the processor discharging gas from a buoyancy cavity to reduce a buoyancy force. *See, e.g.,* **Zhang at 8:44-49**: "As shown in FIGS. 2 and 3, the processor may **discharge gas from the buoyancy cavity 1111** via the connection pipeline 1114,

thereby **reducing the volume of the gas in the buoyancy cavity 1111 to reduce the buoyancy force to allow the moving device 100 to be switched from above the liquid surface to below the liquid surface**."

c. Element [1b]: "a waterline detection unit configured to detect a positional relationship between the swimming pool robot and a waterline of a liquid surface of a swimming pool where the swimming pool robot is located; and"

423. **Zhang** discloses a waterline detection unit configured to detect a positional relationship between the swimming pool robot and a waterline of a liquid surface of a swimming pool where the swimming pool robot is located. For example, **Zhang** discloses a waterline-detection unit where a first sensor continuously detects the robot's vertical position (depth) relative to the waterline, and a second sensor continuously detects whether the buoyancy-cavity air inlet is above the waterline. Each sensor is configured to detect the robot's positional relationship to the waterline. *See, e.g.,* **Zhang at 7:34-44**: "In some embodiments, the moving device 100 may include a first sensor (not shown). The **first sensor may be configured to determine the position of the moving device 100 in real time**. The aforementioned position may include a **vertical position (or depth) of the moving device 100 in the liquid**. For example, the first sensor may be provided at a central position of the moving device, and the aforementioned position may be a depth of the central position of the moving device 100 in the

liquid. The first sensor may include, but is not limited to, a pressure sensor, an **ultrasonic sensor**, an optical sensor, etc."

424. **Zhang** teaches that in order to control the buoyancy force adjustment member, the processor obtains a position in real time from the first sensor, and that it determines when at least part of the moving device (an air inlet 1113) is above the liquid surface. *See, e.g.,* **Zhang at 7:51-8:11**: "When the moving device 100 needs to be switched from below the liquid surface to above the liquid surface, **the processor may obtain the position of the moving device 100 in real time from the first sensor**, and when the position of the moving device 100 meets a preset condition, the processor may **control the buoyancy force adjustment member to increase the volume of the gas in the buoyancy cavity 1111**. The preset condition may include **a position of the moving device 100 above a preset height**. When the depth of the liquid in the target region 300 is fixed, the processor may determine whether the air inlet 1113 in the moving device 100 is above the liquid surface 200 by determining whether the position of the moving device 100 meets the preset condition. **When the position of the moving device 100 shown in FIG. 4A meets the preset condition, the processor may determine that the air inlet 1113 on the moving device 100 is above the liquid surface 200**, and the processor may control the buoyancy cavity pump 1112 to discharge the liquid in the buoyancy cavity 1111, and the air may enter the buoyancy cavity 1111 through

the air inlet 1113, so that the volume of the gas in the buoyancy cavity 1111 can be increased and the buoyancy force of the moving device 100 can be increased. When the buoyancy force of the moving device 100 in the vertical direction is greater than the gravity of the moving device 100, the moving device 100 as shown in FIG. 4A may be switched to the moving device 100 as shown in FIG. 4B."

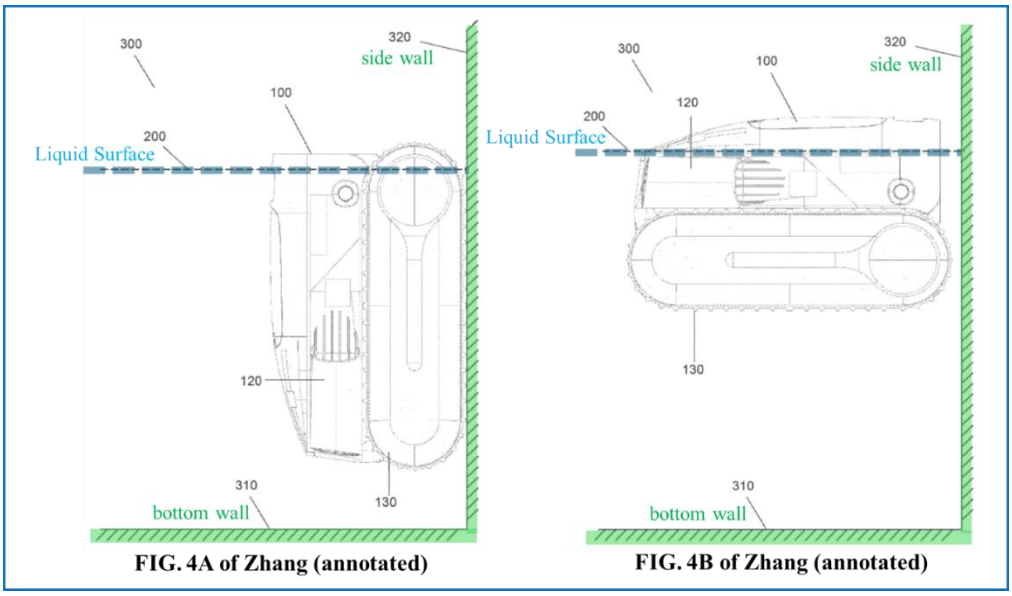


FIG. 4A of Zhang (annotated)

FIG. 4B of Zhang (annotated)

425. **Zhang** discloses a second sensor that continuously detects whether the buoyancy-cavity air inlet is above the waterline. *See, e.g.,* **Zhang at 8:12-16**: "In some embodiments, the moving device 100 may also include a second sensor (not shown). **The second sensor may be configured to detect in real time whether the air inlet of the buoyancy cavity 1111 is positioned in air**. For example, the second sensor may include an **ultrasonic sensor**."

d. Element [1c]: "a main control unit configured to control a working state of the sinking and floating control unit,"

426. **Zhang** discloses a main control unit configured to control a working state of the sinking and floating control unit. For example, **Zhang** discloses **a processor** (a microcontroller, embedded processor, or ASIC) that controls the buoyancy force adjustment member of the mode switching member to adjust gas volume in the buoyancy cavity 1111, thereby changing buoyancy and switching the robot's state between underwater cleaning and surface cleaning. In particular, **Zhang's processor** functions as the main control unit that obtains data from sensors, determines when the cleaning device meets preset conditions, and controls the buoyancy force adjustment assembly of the mode switching member (the sinking and floating control unit) by operating the buoyancy cavity pump 1112 and air inlet 1113 to adjust gas volume within the buoyancy cavity 1111. Through these operations, the processor controls the transition of the pool cleaning robot between submerged and floating states. *See, e.g.,* **Zhang at 7:45-81:** "In some embodiments, the moving device 100 may also include a processor (not shown). **The processor may be a microcontroller, an embedded processor, or an application-specific integrated circuit (ASIC)**, etc. The processor may obtain various data information of the moving device 100 and analyze and process the data information to **control the various components in the moving device 100**. When the moving device 100 needs to be switched from below the liquid surface to above the liquid surface, the processor may obtain the position of the moving

device 100 in real time from the first sensor, and when the position of the moving device 100 meets a preset condition, **the processor may control the buoyancy force adjustment member to increase the volume of the gas in the buoyancy cavity 1111**. The preset condition may include a position of the moving device 100 above a preset height. When the depth of the liquid in the target region 300 is fixed, the processor may determine whether the air inlet 1113 in the moving device 100 is above the liquid surface 200 by determining whether the position of the moving device 100 meets the preset condition. **When the position of the moving device 100 shown in FIG. 4A meets the preset condition, the processor may determine that the air inlet 1113 on the moving device 100 is above the liquid surface 200**, and the **processor may control the buoyancy cavity pump 1112 to discharge the liquid in the buoyancy cavity 1111, and the air may enter the buoyancy cavity 1111 through the air inlet 1113, so that the volume of the gas in the buoyancy cavity 1111 can be increased and the buoyancy force of the moving device 100 can be increased**. When the buoyancy force of the moving device 100 in the vertical direction is greater than the gravity of the moving device 100, the moving device 100 as shown in FIG. 4A may be switched to the moving device 100 as shown in FIG. 4B."

427. **Zhang** further discloses that the **processor** can rely on detection of whether the air inlet of the buoyancy cavity is in the air, and control buoyancy in

response. *See, e.g.,* **Zhang at 8:21-31**: "In some embodiments, when the moving device 100 needs to be switched from below the liquid surface to above the liquid surface, **the processor may obtain a detection result of whether the air inlet of the buoyancy cavity 1111 is located in the air**, and when the detection result characterizes that the aforementioned air inlet is located in the air, the **buoyancy force adjustment member is controlled to increase the volume of the gas in the buoyancy cavity 1111 to achieve the switching of the moving device 100 from below the liquid surface to above the liquid surface**."

428. **Zhang** also teaches that the processor is used to control buoyancy force adjustments to facilitate switching between a working state above the liquid surface to a working state below the working surface. *See, e.g.,* **Zhang at 8:37-40**: "When the moving device 100 needs to be switched from above the liquid surface to below the liquid surface, the **processor may control the buoyancy force adjustment member to reduce the volume of gas in the buoyancy cavity 1111**."

e. Element [1d]: "wherein the main control unit is capable of controlling the swimming pool robot to find a side wall or a slope based on operational requirement information of the swimming pool robot and enabling the swimming pool robot to crawl along the side wall or the slope;"

429. **Zhang**, alone or in view of **Zhao**, discloses that the main control unit is capable of controlling the swimming pool robot to find a side wall or a slope

based on operational requirement information of the swimming pool robot and enabling the swimming pool robot to crawl along the side wall or the slope.

430. **Zhang** discloses that the pool cleaning robot is capable of cleaning the pool based on operational requirement information, including user-input cleaning tasks. *See, e.g.,* step 1010 as shown in Fig. 10 of Zhang.

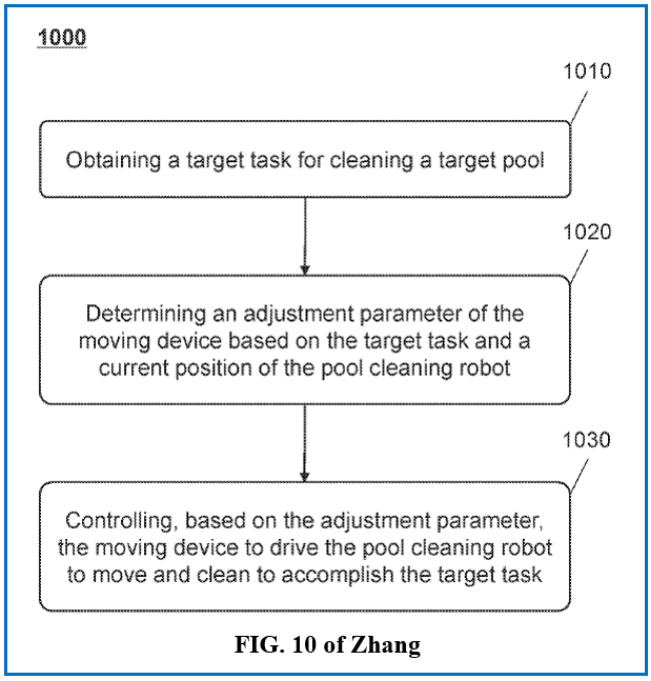


FIG. 10 of Zhang

431. This is described as well in the specification. *See, e.g.,* **Zhang at 16:40-41**: "In 1010, a **target task** for cleaning a target pool may be obtained."

432. **Zhang** teaches that a target task can include a water surface cleaning and/or an underwater cleaning. *See, e.g.,* **Zhang at 16:42-53**: "The target pool may be a pool that needs to be cleaned. The target task may be a cleaning task that needs to be performed on the target pool. **The target task may include a water surface cleaning and/or an underwater cleaning**. The water surface cleaning

may refer to cleaning the water surface of the target pool, and the **underwater cleaning may refer to cleaning the underwater (e.g., the water body, the walls of the pool, etc.)** of the target pool. In some embodiments, the target task may also include a specific cleaning site. For example, the **underwater cleaning may also include**, **but is not limited to, a water body cleaning, a pool bottom cleaning, an individual pool wall cleaning, etc."**

433. **Zhang** teaches that the target task may include task input from a user. *See, e.g.,* **Zhang at 16:54-17:13**: "The control member may obtain the target task in a variety of ways. For example, **the control member may obtain a target task input by a user**. As another example, the control member can be set to perform the target task at regular intervals, e.g., once every 3 days for the water surface cleaning and once every 2 days for the underwater cleaning."

434. **Zhang** also discloses that, after obtaining the target task (e.g., pool wall cleaning task), the processor determines a **route** and **movement parameters necessary to complete that task**. *See e.g.,* step 1020 as shown in Fig. 10 of Zhang. *See, e.g.,* **Zhang at 17:20-31**: "In 1020, an **adjustment parameter of the moving device may be determined based on the target task** and a current position of the pool cleaning robot. The control member may obtain the current position of the pool cleaning robot 400, and for more information about obtaining the current position of the pool cleaning robot 400, please refer to the first sensor

above in the present disclosure. **The adjustment parameter may include route information for moving from the current position to a position of the target pool where the target task needs to be performed and route information required to complete the target task**." *See, e.g.,* **Zhang at 17:31-41**: "The control member may determine a starting position in the target pool where the target task needs to be performed **based on the target task, determine the route information for the pool cleaning robot 400 to move from the current position to the position of the target pool where the target task needs to be performed** based on the aforementioned starting position and the current position, and then **determine the route information required to complete the target task** based on the target task of the target pool, thereby determining the adjustment parameter of the moving device 100."

435. Therefore, the control logic disclosed by **Zhang** enables the processor (i.e., main control unit) to **plan and direct the robot's movement based on operational task information**, for example, to **travel from its current location to the sidewall or slope region when the assigned task is to clean those surfaces.**

436. It is my opinion that to the extent that Zhang does not explicitly describe this feature, it would be understood by a POSITA based on the disclosures discussed above, or it is inherent in such disclosures.

437. Once the planned route brings the robot into contact with the pool wall, **Zhang** discloses that the processor controls it to crawl upward along the wall or slope and perform the corresponding cleaning operation. *See e.g.,* step 1030 as shown in Fig. 10 of Zhang. *See also,* **Zhang at 17:42-55**: "In 1030, the moving device may be controlled, based on the adjustment parameter, to drive the pool cleaning robot to move and clean to accomplish the target task. **The control member may control the moving device 100 to drive the pool cleaning robot 400 to move from the current position to the starting position where the target task needs to be performed** based on the route information in the adjustment parameter for moving from the current position to the position of the target pool where the target task needs to be performed, and then open the dust box 410 in the pool cleaning robot 400 and the main roller brush 430 for cleaning to complete the target task based on the route information in the adjustment parameter, thereby completing the target task."

438. **Zhang** further provides detailed structural disclosure supporting this control process. *See, e.g.,* **Zhang at 7:14-21**: "As shown in FIG. 4A, when the moving device 100 needs to be switched from below the liquid 15 surface to above the liquid surface, the moving device 100 **may move against the side wall 320 of the target region 300** to a position close to the liquid surface 200 and determine

when it is necessary to control the buoyancy force adjustment member to increase the volume of gas in the buoyancy cavity 1111."

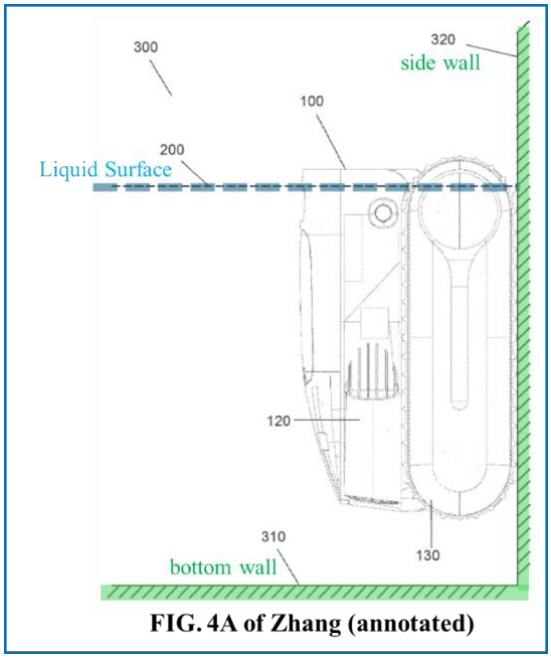


FIG. 4A of Zhang (annotated)

439. The specification provides an extensive description of operating the track to drive the device on the side wall. *See, e.g.,* **Zhang at 11:45-49**: "The track 130 may also drive the moving device 100 in the vertical direction. As shown in FIGS. 4A and 6C, **the operation of the track 130 also drives the moving device 100 on the side wall 320** of the target region 300 when the moving device 100 is pressed against the side wall 320." *See also,* **Zhang at 11:54-56**: "In some embodiments, the track 130 may also **enable a transition** of a moving region of the moving device 100 **from the bottom wall 310 to the side wall 320**. As shown in FIG. 6B, when the track 130 moves to a point where the bottom wall 310 meets the side wall 320, a portion of the track 130 moves on the side wall 320 and a

portion moves on the bottom wall 310. A portion of the track 130 at the side wall 320 may drive the moving device 100 upward **until the moving region of the moving device 100 transitions from the bottom wall 310 to the side wall 320**. When the moving region of the moving device 100 is converted from the bottom wall 310 to the side wall 320, the moving device 100 may move on the side wall 320 driven by the track 130, the moving device 100 may also move on the side wall 320 under the action of the second drive force provided by the second propeller 120 after steering, and the moving device 100 may also move on the side wall 320 based on the action of a third drive force provided by a main water pump 140." *See also,* **Zhang at 13:23-33**: "In some embodiments, when the moving device 100 needs to move on the side wall 320, the main water pump 140 in the moving device 100 may drive the moving device 100 to press against the side wall 320. At least **one of the track 130, the second propeller 120, and the main water pump 140 in the moving device 100 may provide a driving force upward in the vertical direction to drive the moving device 100 move upward on the side wall**, and at least one of the track 130 and the second propeller 120 may provide a driving force downward in the vertical direction to drive the moving device 100 to move downward on the side wall."

440. Accordingly, **Zhang** teaches both the **control-level behavior** (path planning and task-based actuation) and the **mechanical implementation** (track

system) necessary for the robot to find and climb the pool wall or slope based on operational requirement information. Therefore, **Zhang** discloses that the main control unit is capable of controlling the swimming pool robot to find a side wall or a slope based on operational requirement information of the swimming pool robot and enabling the swimming pool robot to crawl along the side wall or the slope.

441. Furthermore, **Zhao** discloses a robotic pool cleaner that includes a distance measurement unit, wherein the main control unit controls the swimming pool robot to find the nearest side wall based on distance measurement results. Specifically, **Zhao** discloses "when the pool cleaning robot **receives the docking instruction**, the pool cleaning robot stops moving, **determines the closest pool wall** relative to the pool cleaning robot, and **moves towards the closest pool wall**." (**Zhao at 4:62-65; FIG. 1**.)

442. For example, **Zhao** teaches that the robot body includes a set of ultrasonic sensors, and that based on docking instructions, the pool robot uses the ultrasonic sensors to measure distance to the pool walls and determine the closest pool wall relative to its position, enabling the robot to move toward that closest pool wall. *See, e.g.,* **Zhao at 4:62-5:2**: "At step S130, **when the pool cleaning robot receives the docking instruction**, the pool cleaning robot stops moving, **determines the closest pool wall relative to the pool cleaning 65 robot, and moves towards the closest pool wall**. FIG. 2a to FIG. 2d illustrate schematic

diagrams of a process of the pool cleaning robot turning to dock upon receiving a docking instruction according to embodiments, but the scope of the present disclosure is not limited thereto." *See also,* **Zhao at 4:6-17**: "The sensor unit provided on the pool cleaning robot includes various types of sensors, such as collision sensors, distance sensors, counters, and gyroscopes. The distance sensors can include, for example, **ultrasonic distance sensors**, which can be configured to **measure a distance from an obstacle to the ultrasonic distance sensor**. The distance sensors can be provided on the front side, back side, right side and left side of the pool cleaning robot. The distance sensor can also be provided on the top of the pool cleaning robot to measure distance by rotating, such that a distance from an obstacle near the pool cleaning robot to the distance sensor can be measured through the distance sensor."

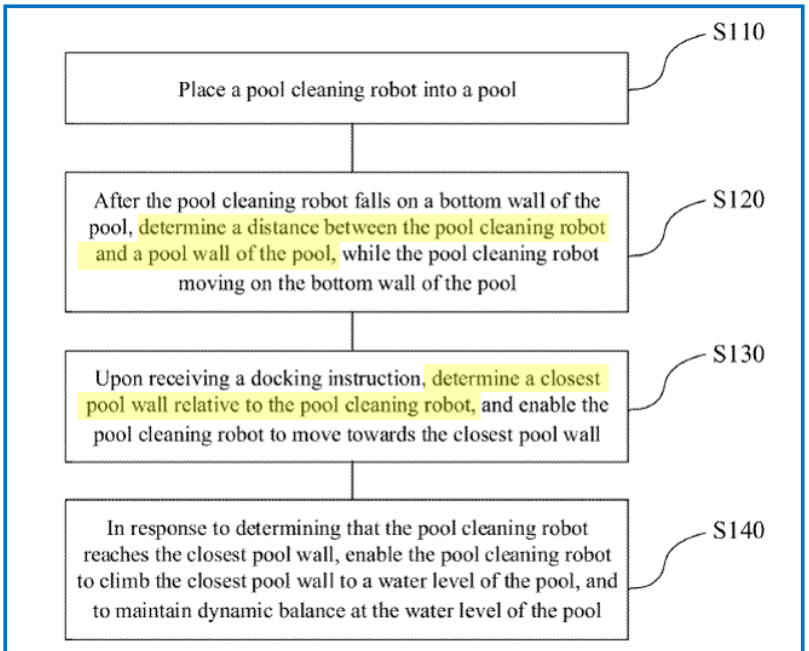


FIG. 1 of Zhao (annotated)

443. In my opinion, a POSITA would have had a clear and logical motivation to combine the teachings of **Zhao** and **Zhang** to improve the robot's navigation and wall-cleaning capabilities. Both references address **autonomous pool cleaning robots** operating underwater and along pool walls, and both seek to enhance efficiency by enabling the robot to **locate, approach, and climb side walls** to perform wall cleaning or to achieve docking.

444. **Zhao** teaches that the robot uses **distance sensors** (e.g., ultrasonic sensors) to detect nearby walls and determine the closest pool wall before initiating docking. *See*, *e.g.*, **Zhao at 4:62-65** ("the pool cleaning robot stops moving, determines the closest pool wall… and moves towards the closest pool wall"). **Zhang** complements this by describing a **control system and mechanical configuration** that allows the robot to **crawl along the wall once contact is established**, transitioning from bottom-wall cleaning to wall cleaning. *See, e.g.*, **Zhang at 11:45-56; 13:23-33**.

445. In my opinion, a POSITA would have recognized that **Zhao's distance-based detection logic** and **Zhang's wall-climbing control mechanism** are directly compatible and serve complementary purposes: Zhao's sensor system provides **real-time feedback to locate and orient toward the wall**, while Zhang's motion-state control and tracked drive mechanism enable the robot to **engage and ascend the wall once contact is made**. Combining the two would yield a more

complete, reliable control architecture, i.e., **Zhao** providing the sensing and approach algorithm, **Zhang** providing the physical actuation and control logic for climbing.

446. It is further my opinion that a POSITA implementing Zhao's control scheme would therefore have found it **obvious and advantageous** to incorporate Zhang's task-based control to provide a complete cycle of bottom, wall, and waterline cleaning. Conversely, a POSITA implementing Zhang's robot would have found it **obvious to add Zhao's distance-sensing and wall-finding logic** to automate the initiation of wall-climbing behavior. Both yield predictable and beneficial results—enhanced autonomy and cleaning efficiency.

f. Element [1e]: "controlling the waterline detection unit to detect the positional relationship between the swimming pool robot and the waterline of the liquid surface of the swimming pool where the swimming pool robot is located; and"

447. **Zhang** discloses that the main control unit controls the waterline detection unit to detect the positional relationship between the swimming pool robot and the waterline of the liquid surface of the swimming pool where the swimming pool robot is located. Specifically, **Zhang** describes that the processor (i.e., the main control unit) obtains, in real time, position data of the cleaning device 10 from **a first sensor or a second sensor** (i.e., the waterline detection unit) when transitioning between submerged and water surface positions. The processor

uses this sensor data to determine whether the cleaning device meets a preset condition—such as **being above a preset height or whether the air inlet is above the liquid surface**—and based on that determination, controls the buoyancy adjustment part accordingly. *See, e.g.,* **Zhang at 7:34-44**: "In some embodiments, the moving device 100 may include a first sensor (not shown). The **first sensor may be configured to determine the position of the moving device 100 in real time**. The aforementioned position may include a **vertical position (or depth) of the moving device 100 in the liquid**. For example, the first sensor may be provided at a central position of the moving device, and the aforementioned position may be a depth of the central position of the moving device 100 in the liquid. The first sensor may include, but is not limited to, a pressure sensor, an **ultrasonic sensor**, an optical sensor, etc." *See also,* **Zhang at 7:51-8:11**: "When the moving device 100 needs to be switched from below the liquid surface to above the liquid surface, **the processor may obtain the position of the moving device 100 in real time from the first sensor**, and when the position of the moving device 100 meets a preset condition, the processor may **control the buoyancy force adjustment member to increase the volume of the gas in the buoyancy cavity 1111**. The preset condition may include **a position of the moving device 100 above a preset height**. When the depth of the liquid in the target region 300 is fixed, the processor may determine whether the air inlet 1113 in the

moving device 100 is above the liquid surface 200 by determining whether the position of the moving device 100 meets the preset condition. **When the position of the moving device 100 shown in FIG. 4A meets the preset condition, the processor may determine that the air inlet 1113 on the moving device 100 is above the liquid surface 200**, and the processor may control the buoyancy cavity pump 1112 to discharge the liquid in the buoyancy cavity 1111, and the air may enter the buoyancy cavity 1111 through the air inlet 1113, so that the volume of the gas in the buoyancy cavity 1111 can be increased and the buoyancy force of the moving device 100 can be increased. When the buoyancy force of the moving device 100 in the vertical direction is greater than the gravity of the moving device 100, the moving device 100 as shown in FIG. 4A may be switched to the moving device 100 as shown in FIG. 4B." *See also,* **Zhang at 8:12-16**: "In some embodiments, the moving device 100 may also include a second sensor (not shown). **The second sensor may be configured to detect in real time whether the air inlet of the buoyancy cavity 1111 is positioned in air**. For example, the second sensor may include an **ultrasonic sensor**."

g. Element [1f]: "controlling the sinking and floating control unit to enter a floating working state based on detection results to realize a floating of the swimming pool robot,"

448. **Zhang** discloses that the main control unit controls the sinking and floating control unit to enter a floating working state based on detection results to

realize a floating of the swimming pool robot. First, **Zhang** teaches that when the depth is shallower than a preset height, processor starts pump 1112 to fill cavity 1111 with air, lifting inlet 1113 above the surface and enabling the cleaning device to float. *See, e.g.,* **Zhang at 7:51-8:11**: "When the moving device 100 needs to be switched from below the liquid surface to above the liquid surface, the processor may obtain the position of the moving device 100 in real time from the first sensor, and **when the position of the moving device 100 meets a preset condition, the processor may control the buoyancy force adjustment member to increase the volume of the gas in the buoyancy cavity 1111**. The preset condition may include **a position of the moving device 100 above a preset height**. When the depth of the liquid in the target region 300 is fixed, **the processor may determine whether the air inlet 1113 in the moving device 100 is above the liquid surface 200 by determining whether the position of the moving device 100 meets the preset condition**. **When the position of the moving device 100 shown in FIG. 4A meets the preset condition,** the processor may determine that the air inlet 1113 on the moving device 100 is above the liquid surface 200, and **the processor may control the buoyancy cavity pump 1112 to discharge the liquid in the buoyancy cavity 1111, and the air may enter the buoyancy cavity 1111 through the air inlet 1113, so that the volume of the gas in the buoyancy cavity 1111 can be increased and the buoyancy force of the moving device 100 can be**

increased. When the buoyancy force of the moving device 100 in the vertical direction is greater than the gravity of the moving device 100, the moving device 100 as shown in FIG. 4A may be switched to the moving device 100 as shown in FIG. 4B."

449. **Zhang** additionally teaches control based on detecting whether the air inlet is located in the air. *See, e.g.,* **Zhang at 8:21-31**: "In some embodiments, when the moving device 100 needs to be switched from below the liquid surface to above the liquid surface, **the processor may obtain a detection result of whether the air inlet of the buoyancy cavity 1111 is located in the air**, and when the detection result characterizes that the aforementioned air inlet is located in the air, the **buoyancy force adjustment member is controlled to increase the volume of the gas in the buoyancy cavity 1111 to achieve the switching of the moving device 100 from below the liquid surface to above the liquid surface**."

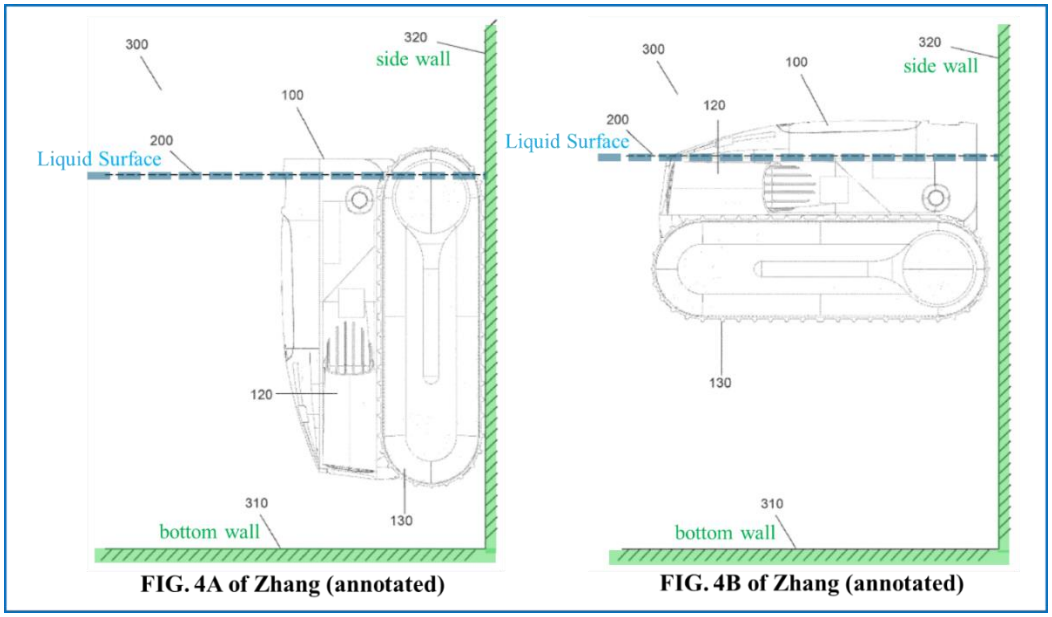


FIG. 4A of Zhang (annotated)

FIG. 4B of Zhang (annotated)

450. Furthermore, **Zhang** discloses the specific pneumatic mechanism by which the robot's buoyancy is actively increased to enter the floating working state. Zhang teaches that the buoyancy adjustment includes a **buoyancy cavity pump (1112)** connected to the **air inlet (1113)**. In the operating state, the pump drives air or gas into the buoyancy cavity (1111), thereby increasing the buoyancy of the robot and causing it to rise toward the water surface. *See, e.g.,* **Zhang at 6:25-32**: "The buoyancy force adjustment member may be any structure that can adjust gas in the buoyancy cavity 1111. As shown in FIG. 3, the buoyancy force adjustment member may include a **buoyancy cavity pump 1112**. The buoyancy cavity pump 1112 may drive the buoyancy cavity 1111 to discharge the liquid therein. **The buoyancy cavity pump 1112 may include, but is not limited to, a pneumatic pump, a hydraulic pump, an electric pump**, etc." *See also,* **Zhang at 6:64-7:11**: "As shown in FIG. 3, the moving device 100 may include two buoyancy cavities 1111, the buoyancy cavity pump 1112, the air inlet 1113, and the connection pipeline 1114. The **buoyancy cavity 1111 may be connected to the buoyancy cavity pump 1112 through the connection pipeline 1114, and the buoyancy cavity pump 1112 may be connected to the air inlet 1113 through the connection pipeline 1114**. Based on the moving device 100 as shown in FIGS. 2 and 3 , when the moving device 100 needs to be switched from below the liquid surface to above the liquid surface, the moving device 100 may move to a position

close to the liquid surface 200 and **determine when to control the buoyancy cavity pump 1112 to inject gas into the buoyancy cavity 1111**."

h. Element [1g]: "wherein the sinking and floating control unit is controlled to stop working after the sinking and floating control unit enters the floating working state for a predetermined time."

451. **Zhang**, in view of **Owen**, discloses a main control unit that controls the sinking and floating control unit to stop working after entering the floating working state for a predetermined time. Specifically, **Zhang** describes that when the cleaning device reaches the water surface and the air inlet 1113 is exposed to air, the processor controls the buoyancy cavity pump 1112 to increase the gas volume within the buoyancy cavity 1111, thereby switching the device from the submerged to the floating state. **Zhang** further explains that the volume of the buoyancy cavity can be preset. In my opinion, a POSITA would understand that this preset volume threshold requires the buoyancy cavity pump to stop working after a predetermined time to prevent overinflation or damage to the buoyancy cavity or pump. It is my opinion that to the extent that Zhang does not explicitly describe this feature, it would be understood by a POSITA based on the disclosures discussed above, or it is inherent in such disclosures. *See, e.g.,* **Zhang at 8:21-31**: "In some embodiments, when the moving device 100 needs to be switched from below the liquid surface to above the liquid surface, the processor may obtain a detection result of whether the air inlet of the buoyancy cavity 1111 is located in

the air, and when the detection result characterizes that the aforementioned air inlet is located in the air, the **buoyancy force adjustment member is controlled to increase the volume of the gas in the buoyancy cavity 1111 to achieve the switching of the moving device 100 from below the liquid surface to above the liquid surface."** *See also,* **Zhang at 5:4-21**: "The buoyancy cavity 1111 may be configured to accommodate liquid and/or gas. The buoyancy cavity 1111 may also include, but is not limited to, an **inflatable buoyancy cavity**, a liquid container type buoyancy cavity, a separated buoyancy cavity, etc. **A volume of the buoyancy cavity 1111 may be preset**. The **buoyancy cavity 1111 may be made of a flexible material** and/or a rigid material. The aforementioned flexible material may include, but is not limited to, polyvinyl alcohol resin, polyethylene terephthalate, rubber, etc. The rigid material may include but is not limited to, glass, ceramics, phenolic plastics, polyurethane plastics, epoxy plastics, unsaturated polyester plastics, etc. For example, the buoyancy cavity 1111 may include **a double structured buoyancy cavity containing an inner layer and an outer layer**. The inner layer may be made of a flexible material for loading gas and/or liquid, and the outer layer may be a rigid protective housing that provides protection and stability for the inner layer."

452. Because the buoyancy cavity is inflatable and made of flexible material, it is my opinion that a POSITA would recognize the risk of overinflation

if the buoyancy force adjustment assembly were continuously operated without limitation. A POSITA would have understood **Zhang**'s disclosure regarding setting a volume threshold is also a safety mechanism designed to prevent overinflating or damaging the airbag or gas cavity. As such, a POSITA would have understood that Zhang inherently discloses filling the cavity with air for a predetermined time to avoid exceeding the gas volume threshold and damaging the cavity (e.g., airbag).

453. A POSITA would understand that when an airbag is filled by a pump operating at a constant volumetric flow rate (Q), and while back-pressure remains low (i.e., the bag is still compliant and far below its geometric or pressure limit), the volume (V) of the airbag grows roughly linearly with time (t). This basic relationship is expressed as:

$$\mathbf{V \approx Q \times t}$$

454. As the airbag nears its maximum capacity, the internal pressure rises due to membrane tension and hydrostatic head. This increased back-pressure causes the pump's effective flow rate to decay toward zero, and consequently, the airbag's volume asymptotically approaches a limiting value rather than increasing indefinitely.

455. Given this relationship, a POSITA would readily appreciate that a **predetermined inflation time** can be selected to deliver a target gas volume that reliably exceeds the minimum buoyancy requirement of Zhang while remaining

safely below the airbag's structural or pressure limit. In practice, this predetermined time provides a robust operational margin—ensuring consistent buoyancy performance while preventing overinflation or mechanical damage to the airbag.

456. This concept is illustrated by the simulation shown in Figure 1 (Ex. 1021). The simulation models airbag volume versus time for a pump delivering approximately 4.0 L/min of air into a compliant airbag. The **Gas Volume Threshold** (1.75 L; green dashed line), i.e. the minimum air volume necessary to float, is reached at about t = 27.5 sec. The system continues inflating until the **Predetermined Time** of 40 seconds (magenta dashed line), reaching the **Predetermined Volume**, which remains below the asymptotic capacity (black dotted line).

457. In my opinion, a POSITA would understand that this control principle—operation of a motor–pump assembly for a fixed duration of time to achieve a desired buoyancy threshold—applies to air bags, ballast systems, and other buoyancy subsystems where a fluid is moved into or out of a container or bag with a finite volume. This behavior reflects fundamental pneumatic or hydraulic system dynamics that a POSITA would find trivial to implement. The pneumatic simulation in Ex. 1021 merely visualizes these well-understood relations; in practice, the precise parameters—such as the time duration, target volume, and

pump flow rate—would be routinely selected based on design constraints like airbag geometry, material limits, desired buoyancy, and overall robot mass and cost.

458. Accordingly, a POSITA reviewing Zhang would understand that its disclosure of achieving inflating buoyancy of a **preset volume** (see, e.g., Zhang at 5:8-10) inherently teaches the corresponding use of a **predetermined inflation interval**—chosen to reach the required buoyancy margin. A POSITA reviewing Zhang would further understand that the **predetermined inflation interval** would avoid overfilling or damaging the gas cavity (i.e., airbag), or overheating or damaging the motor. This approach reflects an elementary control principle that naturally arises from the saturating Q–V relationship shown above.

459. A POSITA would have been thoroughly familiar with using **timers** and **timeouts** to control actuators such as pumps and motors. Standard industrial control systems, including programmable logic controllers ("**PLCs**"), have long incorporated built-in timer functions to **start, stop, or modulate motors and pumps for predetermined durations** based on preset intervals or program logic.

460. As discussed in Chapter 9: "Timers" of *Programmable Logic Controllers*, 6th Edition (Ex. 1022), timers are described as fundamental components of automation systems used "**a motor or a pump might need to be controlled to operate for a particular interval of time**." The chapter explains

how **on-delay (TON), off-delay (TOF), and pulse (TP) timers** generate controlled-duration outputs that energize or de-energize motors, pumps, or valves after fixed time intervals. These timers rely on the PLC's internal clock and are programmed to execute self-terminating operations when a preset value is reached, providing a timeout feature that ensures reliable, repeatable, and safe device operation. Ladder-diagram examples illustrate common applications such as starting and stopping pumps and motors after defined intervals (e.g., Fig. 9.6 and Fig. 9.19), sequencing multiple motors, and maintaining output states for timed periods.

461. **Owen** additionally teaches interchangeability between a circuit board and a timer switch for the purpose of inflation control. *See, e.g.,* **Owen at 4, 7-10**: "Alternatively, instead of the circuit board, a mechanism such as a timer switch (not shown) could be used to automatically shut off the pump. If such a timer switch is used, **the switch can be set to allow the pump to run for a set period of time once it is activated**, in the same fashion as the circuit board already described."

462. Finally, **Owen** teaches that a pressure sensor may be added to provide feedback control to the timer or circuit board. *See, e.g.,* **Owen at 4, 20-26**: "In yet another embodiment, a combination of a circuit board and/or **an integrated circuit (IC) chip may be used as a timing circuit along with a pressure sensor to**

provide the timing signal that indicates when terminate pumping. The IC chip may include a controlled switch (not shown) in electrical communication with the pressure sensor, wherein the controlled switch is triggered by signals from the pressure sensor that include threshold pressures, which indicate when the pump is done pumping and should be automatically turned off."

463. In my opinion, a POSITA would have recognized that **Zhang**'s robotic pool cleaner teaches a buoyancy-adjustment assembly in which the "adjustment assembly" may be an air bag, foam, or hollow body. The purpose of this element is to create a buoyant force greater than its weight.

464. Selecting the "air bag" embodiment in **Zhang** naturally raises the engineering question of how to control inflation safely and predictably, because an unregulated air pump could easily overinflate the bag, tear seals, or drain the battery.

465. **Owen** directly addresses this same control problem. It discloses a compact pump system with both a timer that runs the pump for a preset period and a pressure sensor that shuts it off when a threshold pressure is reached, with each functioning independently as a failsafe. These simple, low-cost control methods were well known by a POSITA and routinely used in small pumps and inflatable systems to prevent damage or over-inflation. Applying **Owen**'s timer-based shutoff to **Zhang**'s air-bag buoyancy assembly would have been a straightforward,

predictable design choice for a POSITA facing the need to regulate inflation in a battery-powered, sealed submersible cleaner. The combination would yield a predictable result, which is a reliable, energy-efficient buoyancy actuator that inflates just enough to move the cover, then stops before causing damage.

466. In my opinion, **Owen** is analogous art to **Zhang** for the same reasons I discussed above regarding **Owen** and **Wang**. *See* ¶¶290 – 302 above. Furthermore, the motivation to combine arises from standard engineering goals: (1) preventing overinflation of the air bag and connected parts, (2) conserving battery power by avoiding continuous pumping, and (3) achieving repeatable actuation under varying water depths and temperatures.

467. In light of the elementary physical principles discussed of pump-based inflation, a POSITA would have found it obvious to incorporate **Owen**'s timer shutoff circuit into **Zhang**'s buoyancy control, as both systems operate in gas cavity (e.g., airbag) environments and rely on the same pump–bladder principle. Combining **Zhang**'s airbag system with **Owen**'s fail-safe timer design would have involved using known, interchangeable components—such as off-the-shelf timers and sensors—to achieve predictable results. In short, substituting **Owen**'s control logic into **Zhang**'s air-bag embodiment would have required only routine design work, with a clear expectation of success and no teaching away in either reference.

2. Claim 2

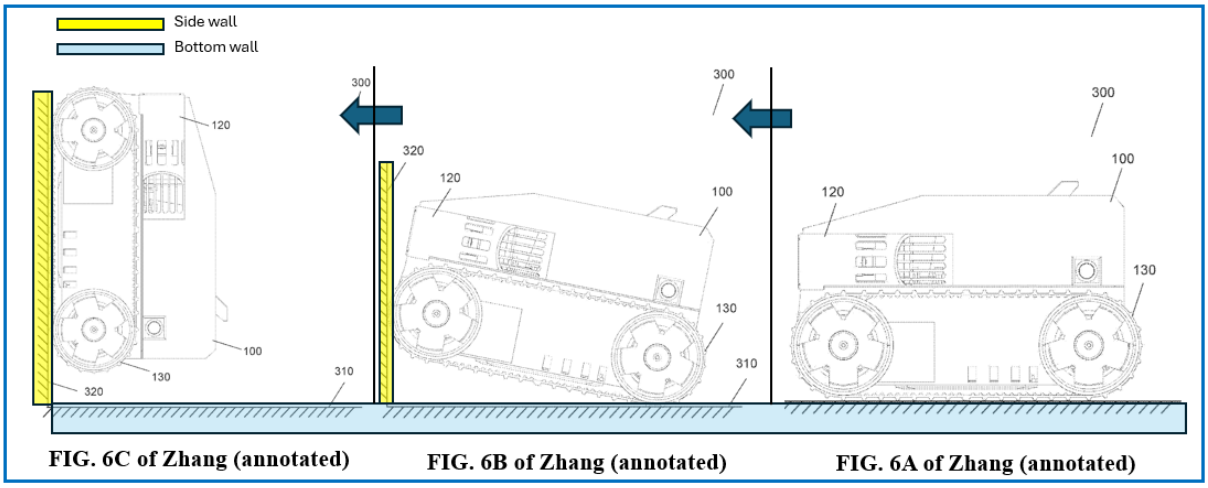
a. Element [2a]: "The controllable sinking and floating swimming pool robot according to claim 1, further comprising a posture detection unit configured to detect a posture of the swimming pool robot,"

468. **Zhang**, in view of **Zhao**, discloses this limitation. Specifically, **Zhang** teaches a pool-cleaning robot that transitions from underwater cleaning to surfacing by moving along the pool wall under the control of a buoyancy-adjustment and propulsion system. *See, e.g.,* **Zhang at 7:14-21**: "As shown in FIG. 4A, when the moving device 100 **needs to be switched from below the liquid 15 surface to above the liquid surface**, the moving device 100 **may move against the side wall 320 of the target region 300** to a position close to the liquid surface 200 and **determine when it is necessary to control the buoyancy force adjustment member to increase the volume of gas in the buoyancy cavity 1111**."

469. In particular, **Zhang** discloses that upon receiving a water surface cleaning instruction, the robot determines its position at the pool bottom, determines the route information, finds and climbs along the wall toward the water surface until part of the robot emerges from the water. *See, e.g.,* **Zhang at 16:42-53**: "The target pool may be a pool that needs to be cleaned. The target task may be a cleaning task that needs to be performed on the target pool. **The target task may include a water surface cleaning and/or an underwater cleaning**. **The water surface cleaning may refer to cleaning the water surface of the target pool**, and

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the underwater cleaning may refer to cleaning the underwater (e.g., the water body, the walls of the pool, etc.) of the target pool. In some embodiments, the target task may also include a specific cleaning site. For example, the underwater cleaning may also include, but is not limited to, a water body cleaning, a pool bottom cleaning, an individual pool wall cleaning, etc." *See also,* **Zhang at 17:32-41**: "The control member may determine a starting position in the target pool where the target task needs to be performed **based on the target task, determine the route information for the pool cleaning robot 400 to move from the current position to the position of the target pool where the target task needs to be performed** based on the aforementioned starting position and the current position, and then **determine the route information required to complete the target task** based on the target task of the target pool, thereby determining the adjustment parameter of the moving device 100."



470. In my opinion, a POSITA would have recognized that as **Zhang**'s robot climbs vertically from the pool bottom toward the surface, the system must first sense that a wall-climbing posture has been achieved, i.e., a change from a state parallel to the pool bottom to a state parallel to the pool wall, before it can initiate other sensing operations such as depth measurement via first sensor and air-intake control. Without detecting this posture change, the system would be unable to coordinate subsequent actions like measuring its vertical distance from the waterline or activating the buoyancy-control mechanism for surfacing. Therefore, **Zhang** inherently teaches a posture detection unit configured to detect a posture of the swimming pool robot.

471. To the extent that Zhang does not teach the posture detection unit, that feature is disclosed in **Zhao**. In particular, **Zhao** discloses using a **gyroscope** to detect the posture of the swimming pool robot (e.g., whether the robot is located on the bottom wall or the side wall of the pool). *See, e.g.*, **Zhao at 7:1-7**: "Before cleaning, a 3D map of the pool has been transmitted to the pool cleaning robot. According to the data of the **gyroscope** of the pool cleaning robot, the pool cleaning robot can determine its own position, for example, the pool cleaning robot can **determine that the pool cleaning robot is located on the bottom wall of the pool, or on the pool wall of the pool**." *See also*, **Zhao at 8:15-24**: "**A gyroscope** and a counter built-in the pool cleaning robot 620 can **record an angle** and a rising

height of the pool cleaning robot. In FIG. 20 6a to FIG. 6d, the pool wall 631 is gridded, the dark gray area is a stay area for a water level, the medium gray area is an area near the water level, and the light gray area is an underwater area."

472. **Zhao** further teaches sensing an angle (posture) of the robot for the purpose of controlling the robot to climb the pool wall. *See, e.g.,* **Zhao at 6:16-32**: "In the case of receiving the docking instruction, at step S**140**, after the pool cleaning robot collides with the pool wall, the driving motor increases power, controls the pool cleaning robot to climb the pool wall to the water level of the pool, and controls the pool cleaning robot to maintain dynamic balance at the water level. In addition, **controlling the pool cleaning robot to climb the pool wall can further include sensing a change of an inclination angle of the pool cleaning robot through the gyroscope to cause the pool cleaning robot to enter a wall climbing mode**. Maintaining dynamic balance at the water level can include sensing that the pool cleaning robot reaches the water level through sensors, the pool cleaning robot staying and timing; when the pool cleaning robot stays for more than a predetermined time period, the timing is stopped and the pool cleaning robot moves to underwater, but the present disclosure is not limited thereto."

473. This inclination angle can be measured using the gyroscope. *See, e.g.*, **Zhao at 4:23-25**: "The **gyroscope is configured to measure a rotation angle** of

the pool cleaning robot, such that 25 a direction of the pool cleaning robot can be determined."

474. In my opinion, a POSITA would have found it obvious to incorporate **Zhao**'s gyroscope-based posture detection into **Zhang**'s system to achieve coordinated control between the robot's mechanical climbing motion and its buoyancy-adjustment operations. Both **Zhang** and **Zhao** share the same design objective, i.e., autonomously transitioning from underwater cleaning to surfacing at the waterline. **Zhang** provides the mechanical structure and control logic for wall climbing and surfacing, while **Zhao** provides the sensor-based posture detection and feedback necessary for timing the initiation of buoyancy adjustment. Combining these teachings would have been a straightforward and predictable improvement that allows Zhang's robot to sense when wall-climbing begins and use that posture information to trigger depth detection and air-intake control, resulting in a more reliable and automated surfacing process.

b. Element [2b]: "wherein the main control unit controls the waterline detection unit to start detecting the positional relationship in response to the posture meeting a first predetermined condition."

475. **Zhang**, in view of **Zhao**, discloses this limitation as it is used in the context of the '196 Patent.

476. The '196 Patent provides that a "first predetermined condition" could be "changing from a state parallel to the bottom surface of the swimming pool to a state parallel to the side wall of the swimming pool." ('196 Patent, at 9:37-40.)

477. **Zhang** teaches a pool-cleaning robot that transitions from underwater cleaning to surfacing by moving along the pool wall under the control of a buoyancy-adjustment and propulsion system. As discussed in detail above with respect to element [1d], **Zhang** discloses that upon receiving a water surface cleaning instruction, the robot determines its position at the pool bottom, determines the route information, finds and climbs along the wall toward the water surface until part of the robot emerges from the water. In my opinion, a POSITA would recognize that for **Zhang**'s robot to execute these sequential actions, it needs to sense that the robot's posture satisfies a specific condition (i.e., the transition from bottom cleaning to wall climbing) and in response initiate other sensing operations such as depth measurement and air-intake control.

478. Furthermore, **Zhao** provides precisely this control logic. For example, the robot of Zhao can determine whether it is on the bottom wall or side wall of the pool (i.e., whether it has transitioned into a wall climbing mode) according to the data of the gyroscope (i.e., posture detection unit). *See, e.g.,* **Zhao at 7:1-7**: "Before cleaning, a 3D map of the pool has been transmitted to the pool cleaning robot. **According to the data of the gyroscope of the pool cleaning**

robot, the pool cleaning robot can determine its own position, for example, the pool cleaning robot can determine that the pool cleaning robot is located on the bottom wall of the pool, or **on the pool wall of the pool**."

479. Once Zhao's the robot determines that it has transitioned from the horizontal bottom surface to a vertical pool wall, i.e., when the posture meets the first predetermined condition, **Zhao** teaches that it begins its **docking and climbing sequence**, which necessarily requires detecting its positional relationship relative to the waterline. This control logic is further illustrated in FIG. 3 of Zhao, below.

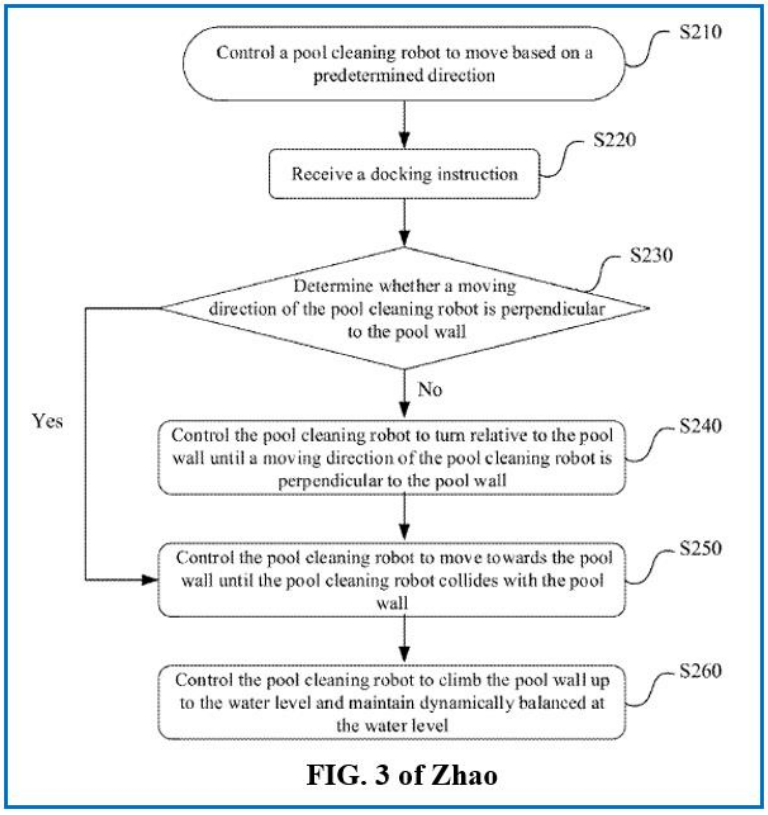


FIG. 3 of Zhao

480. This is also described in the specification. *See, e.g.,* **Zhao at 6:42-60**: "As shown in FIG. **3**, embodiments of the present disclosure provide another method of a pool cleaning robot automatically docking, the method includes steps S**210** to S**260**. At S**210**, the pool cleaning robot is controlled to move based on a predetermined direction. At S**220**, a docking instruction is received. At S**230**, **whether the moving direction of the pool cleaning robot is perpendicular to the pool wall is determined**; if yes, proceed to S**250**; if not, proceed to S**240**. At S**240**, the pool cleaning robot is controlled to turn relative to the pool wall until a moving direction of the pool cleaning robot is perpendicular to the pool wall. At S**250**, **the pool cleaning robot is controlled to move towards the pool wall until the pool cleaning robot collides with the pool wall. At S260, the pool cleaning robot is controlled to climb the pool wall up to the water level and maintain dynamically balanced at the water level."**

481. **Zhao** further explains that during the climb, the gyroscope and counter are used to record an angle and a rising height (i.e., the positional relationship). **Zhao** also describes tracking the distance to the water level and completion degree as the robot ascends through the underwater, near-water, and stay-at-water-level regions. *See, e.g.,* **Zhao at 8:11-23**: "FIG. 6a to FIG. 6d are schematic diagrams of an interface of a control device coupled with a pool cleaning robot, showing a visual interface of the pool cleaning robot automatically

climbing to a water level, according to embodiments of the present disclosure. After the pool cleaning robot 620 receives a docking instruction, the pool cleaning robot 620 docks and climbs up the pool wall 631. **A gyroscope and a counter built-in the pool cleaning robot 620 can record an angle and a rising height of the pool cleaning robot**. In FIG. 6a to FIG. 6d, the pool wall 631 is gridded, the dark gray area is a stay area for a water level, the medium gray area is an area near the water level, and the light gray area is an underwater area." *See, e.g.,* **Zhao at 8:24-42**: "**A completion degree mark 611 represents the docking completion degree calculated according to the moving speed of the pool cleaning robot 620 and a distance between the pool cleaning robot and the water level**. Timer 610 represents a remaining time for the docking instruction. For example, in FIG. 6a , the pool cleaning robot 620 is in the underwater area, the timer 610 shows that the remaining time for the docking instruction is 80s, and the docking completion degree is 30%; in FIG. 6b , the pool cleaning robot 620 enters the area near the water level, and the remaining time for the docking instruction is 70s, and the docking completion degree is 70%; in FIG. 6c , the pool cleaning robot 620 enters the stay area for the water level, and the remaining time for the docking instruction is 60s, the docking completion degree is 100%; in FIG. 6d , the pool cleaning robot 620 waits in the stay area for a timeout and retreats to the underwater, the

remaining time for the docking command is 0s, and the docking completion degree is 100%."

482. Accordingly, it is my opinion that, a POSITA would understand that **Zhao** teaches controlling the waterline detection unit to start detecting the positional relationship in response to the posture meeting a first predetermined condition, where the posture triggers the beginning of the waterline-detection and climbing sequence.

483. **Zhang** provides the **mechanical framework** for climbing from the bottom wall to the water surface, while **Zhao** provides the **sensor-based control logic** that determines when such climbing begins and when positional detection relative to the waterline should start. A POSITA would have found it obvious to integrate **Zhao**'s gyroscope-based posture detection into **Zhang**'s wall-climbing process to automatically trigger waterline detection once the robot tilts from horizontal to vertical. This combination produces a predictable and improved system, enabling the robot to autonomously coordinate posture recognition, waterline detection, and subsequent buoyancy control for a smooth transition from underwater cleaning to floating at the water surface.

3. Claim 3: "The controllable sinking and floating swimming pool robot according to claim 1, wherein the operational requirement information comprises remote control command information sent by a user, clock information, operational task progress information, fault information,

power information or swimming pool bottom environment information."

484. **Zhang** discloses this limitation. For example, **Zhang** discloses a task-acquisition module that receives a target cleaning assignment from a user for a swimming pool. The assignment may include water-surface cleaning, underwater cleaning, or both, and can further specify sub-tasks such as bottom or wall cleaning. *See, e.g.,* **Zhang at 16:40-41**: "In 1010, a **target task** for cleaning a target pool may be obtained." *See, e.g.,* **Zhang at 16:42-53**: "The target pool may be a pool that needs to be cleaned. The target task may be a cleaning task that needs to be performed on the target pool. **The target task may include a water surface cleaning and/or an underwater cleaning**. The water surface cleaning may refer to cleaning the water surface of the target pool, and the **underwater cleaning may refer to cleaning the underwater (e.g., the water body, the walls of the pool, etc.)** of the target pool. In some embodiments, the target task may also include a specific cleaning site. For example, the **underwater cleaning may also include**, **but is not limited to, a water body cleaning, a pool bottom cleaning, an individual pool wall cleaning**, etc."

485. The target task information (command information) may be sent by a user. *See, e.g.,* **Zhang at 16:54-17:13**: "The control member may obtain the target task in a variety of ways. For example, **the control member may obtain a target task input by a user**. As another example, the control member can be set to

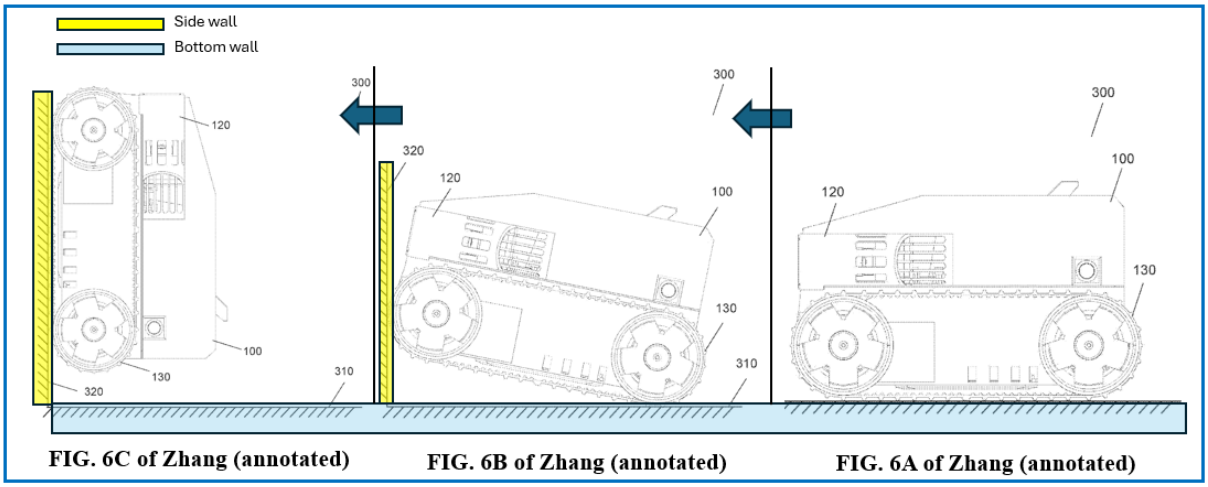
perform the target task at regular intervals, e.g., once every 3 days for the water surface cleaning and once every 2 days for the underwater cleaning."

4. Claim 4: "The controllable sinking and floating swimming pool robot according to claim 1, further comprising a distance measurement unit or a map storage unit, wherein the main control unit controls the swimming pool robot to find the nearest side wall or the nearest slope based on distance measurement results of the distance measurement unit or map data in the map storage unit."

486. **Zhang**, alone or in view of **Zhao**, discloses this claim.

487. **Zhang** discloses a controllable pool-cleaning robot with a position-sensing unit; the control member plans a route from the sensed current position to the task-start position and then drives the robot along it. For example, the robot may switch to a motion state in which it travels along the pool side wall while executing the planned route toward the target task location. *See, e.g.,* **Zhang at 15:31-43**: "The control member may be configured to control the pool cleaning robot 400 for the water surface cleaning or underwater cleaning of the pool. In some embodiments, the control member may obtain a target task for cleaning a target pool, the target task including a water surface cleaning and an underwater cleaning; **determine an adjustment parameter of the moving device 100 based on the target task and a current position of the pool cleaning robot 400**; control the **moving device 100 to move, based on the adjustment parameter, the pool cleaning robot 400 to a target position to complete the target task**. For more

information about the above embodiments, please refer to FIG. 10 and its related description." *See also,* **Zhang at 17:20-31**: "In 1020, an **adjustment parameter of the moving device may be determined based on the target task** and a current position of the pool cleaning robot. The control member may obtain the current position of the pool cleaning robot 400, and for more information about obtaining the current position of the pool cleaning robot 400, please refer to the first sensor above in the present disclosure. **The adjustment parameter may include route information for moving from the current position to a position of the target pool where the target task needs to be performed and route information required to complete the target task**." *See also,* **Zhang at 17:32-41**: "The control member may determine a starting position in the target pool where the target task needs to be performed **based on the target task, determine the route information for the pool cleaning robot 400 to move from the current position to the position of the target pool where the target task needs to be performed** based on the aforementioned starting position and the current position, and then **determine the route information required to complete the target task based on the target task of the target pool, thereby determining the adjustment parameter of the moving device 100."**



488. Accordingly, **Zhang** discloses a control logic that allows the processor to (1) sense the robot's current position through onboard sensors, (2) plan a path from that position to a target task location (e.g., a wall or slope), and (3) command the motion components to follow that path. In my opinion a POSITA would understand that to enter and execute this wall-cleaning task, the control unit must first determine which wall or slope is nearest and then navigate the robot toward that wall, steps that inherently depend on distance or positional information.

489. **Zhao** complements Zhang by disclosing the specific sensing and data sources used to determine and approach the **nearest wall**. **Zhao** discloses a distance measurement unit or a map storage unit, wherein the main control unit controls the swimming pool robot to find the nearest side wall or the nearest slope based on distance measurement results of the distance measurement unit or map data in the map storage unit.

490. For example, **Zhao** teaches that the robot body includes a sensor unit with **ultrasonic distance sensors and gyroscopes**, and that based on distance measurement results or **3D map information**, the robot **determines the closest pool wall** relative to its position and enables the robot to move toward that closest pool wall.

491. Specifically, **Zhao** describes ultrasonic distance sensors located on sides and/or the top of the robot. *See, e.g.,* **Zhao at 4:6-17**: "The sensor unit provided on the pool cleaning robot includes various types of sensors, such as collision sensors, distance sensors, counters, and gyroscopes. The distance sensors can include, for example, **ultrasonic distance sensors**, which can be configured to **measure a distance from an obstacle to the ultrasonic distance sensor**. The distance sensors can be provided on the front side, back side, right side and left side of the pool cleaning robot. The distance sensor can also be provided on the top of the pool cleaning robot to measure distance by rotating, such that a distance from an obstacle near the pool cleaning robot to the distance sensor can be measured through the distance sensor."

492. Likewise, **Zhao** describes gyroscopes and a counter that can be used to calculate distances moved by the robot. *See, e.g.,* **Zhao at 4:18-25**: "The inside of the pool cleaning robot is also provided with **a counter** and a gyroscope. The counter is configured to accumulate a total number of rotation angles (or cycles) of

the driving wheel of the moving unit, so as to **calculate a distance length that the pool cleaning robot, drove by the driving wheel, have moved**. The gyroscope is configured to measure a rotation angle of the pool cleaning robot, such that a direction of the pool cleaning robot can be determined."

493. **Zhao** describes use of a pool map to be used by the robot in combination with the movement sensors like the gyroscope to determine a location of the robot in relation to the pool map. *See, e.g.,* **Zhao at 7:1-7**: "Before cleaning, a **3D map of the pool has been transmitted to the pool cleaning robot**. According to the data of the gyroscope of the pool cleaning robot, the pool cleaning robot can determine its own position, for example, the pool cleaning robot can determine that the pool cleaning robot is located on the bottom wall of the pool, or on the pool wall of the pool."

494. **Zhao** explicitly describes locating a "closest pool wall." *See, e.g.,* **Zhao at 1:38-42**: "A first aspect of the present disclosure provides a method of automatic docking a pool cleaning robot, the method includes: placing the pool cleaning robot into a pool; upon receiving a docking instruction, **determining a closest pool wall relative to the pool cleaning robot, and enabling the pool cleaning robot to move towards the closest pool wall**."

495. **Zhao** likewise more generally describes determining distances to any pool wall. *See, e.g.,* **Zhao at 4:33-40**: "As shown in FIG. 1, in an embodiment of

the present disclosure, the method of a pool cleaning robot docking includes steps S110 to S140. At step S110, the pool cleaning robot is placed into the pool. At step S120, after the pool cleaning robot falls on a bottom wall of the pool, **the pool cleaning robot determines a distance between the pool cleaning robot and the pool wall of the pool** while moving on the bottom wall of the pool."

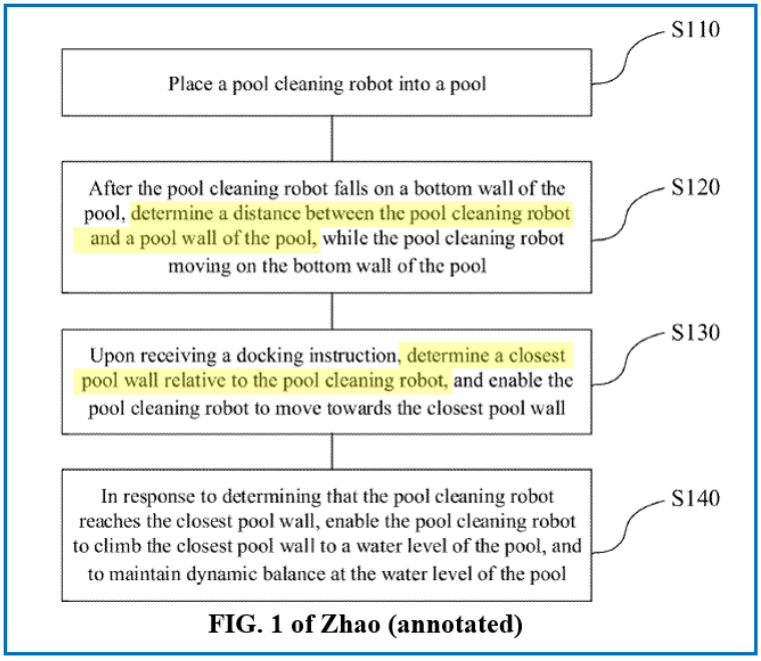


FIG. 1 of Zhao (annotated)

496. Using the distances determined in step S120, **Zhao** teaches that a closest wall can be identified. *See, e.g.,* **Zhao at 4:62-65**: "At step S130, when the pool cleaning robot receives the docking instruction, the pool cleaning robot stops moving, **determines the closest pool wall relative to the pool cleaning robot**, and moves towards the closest pool wall."

497. Once the docking instruction is received, the robot can take one of several possible actions. *See, e.g.,* **Zhao at 6:33-37**: "In practical applications, the

pool cleaning robot can stop moving in response to receiving the docking instruction, **rotate in place, and determine the closest pool wall**; or the pool cleaning robot can also turn around during the moving process to find the closest pool wall."

498. **Zhao** further describes specific aspects of using the robot's sensors to navigate with respect to the closest pool wall, both in determining which wall is closest and how to orient the robot with respect to the closest wall. *See, e.g.,* **Zhao at 7:11-18**: "Based on the pose of the pool cleaning robot determined by the gyroscope of the pool cleaning robot, the pool cleaning robot can use a pool bottom turn mode. When the pool cleaning robot determines that the pool cleaning robot is on the bottom wall of the pool, the pool cleaning robot **combines the data of the rotatable scanning ultrasonic sensor** configured on the top of the pool cleaning robot **to determine the closest route to the pool wall."** *See, also,* **Zhao at 7:19-21**: "In the pool bottom turn mode, the pool cleaning robot is **turned to the closest pool wall determined by the rotatable scanning ultrasonic sensor**."

499. Taken together, the two references describe complementary aspects of the claimed control system. **Zhang** provides the **task-based control architecture and route-planning logic** by which the main control unit directs the robot toward a wall or slope for cleaning, while **Zhao** provides the **distance- and map-based**

sensing mechanisms that enable the robot to identify which wall or slope is nearest.

500. In my opinion, a POSITA would have found it obvious to integrate **Zhao**'s distance-sensing and wall-finding techniques with **Zhang**'s route-planning and motion-control framework, so that the robot can automatically: (1) detect its current position through sensors, (2) determine the nearest wall or slope based on distance measurement results or stored map data, and (3) plan and execute a route toward that wall or slope to perform the designated cleaning task.

501. Such a combination would have been straightforward to implement and yield a predictable improvement—namely, enhanced autonomy and navigation efficiency in the robot's movement between cleaning regions—fully consistent with the control objectives described in both Zhang and Zhao.

5. Claim 5: "The controllable sinking and floating swimming pool robot according to claim 1, wherein the waterline detection unit comprises an outlet water detection subunit configured to detect whether at least a part of the swimming pool robot has come out of water."

502. **Zhang** discloses this claim. For example, Zhang discloses a **second sensor** that detects whether the air inlet is exposed to the air and at least a part of the robot has come out of the water. *See, e.g.,* **Zhang at 8:12-16**: "In some embodiments, the moving device 100 may also include a second sensor (not shown). **The second sensor may be configured to detect in real time whether**

the air inlet of the buoyancy cavity 1111 is positioned in air. For example, the second sensor may include an ultrasonic sensor. The second sensor may be provided at the position of the air inlet of the buoyancy cavity 1111."

6. Claim 6: "The controllable sinking and floating swimming pool robot according to claim 1, wherein the waterline detection unit further comprises a proximity waterline detection subunit configured to detect whether the swimming pool robot has crawled to a distance less than or equal to a predetermined distance from the waterline."

503. **Zhang** discloses this limitation. **Zhang** describes that the cleaning device includes a **first sensor** configured to determine the robot's position in real time, particularly its vertical position (depth) in the pool. The first sensor, which may be a pressure sensor, an ultrasonic sensor, or an optical sensor, detects the robot's current depth and transmits the positional data to the processor. *See, e.g.,* **Zhang at 7:34-44**: "In some embodiments, the moving device 100 may include a first sensor (not shown). The **first sensor may be configured to determine the position of the moving device 100 in real time**. The aforementioned position may include a **vertical position (or depth) of the moving device 100 in the liquid**. For example, the first sensor may be provided at a central position of the moving device, and the aforementioned position may be a depth of the central position of the moving device 100 in the liquid. The first sensor may include, but is not limited to, a pressure sensor, an ultrasonic sensor, an optical sensor, etc."

504. Furthermore, **Zhang** discloses that when the robot needs to switch from an underwater position to a surface position, the **processor obtains real-time position data from the first sensor** and determines whether the measured position satisfies a **preset condition**, such as the robot being **higher than a preset height**. When this condition is met, the processor concludes that the **air inlet (1113)** of the buoyancy cavity is above the water surface and controls the buoyancy pump to begin draining liquid and admitting air. *See, e.g.,* **Zhang at 7:51-8:11**: "When the moving device 100 needs to be switched from below the liquid surface to above the liquid surface, **the processor may obtain the position of the moving device 100 in real time from the first sensor**, and when the position of the moving device 100 **meets a preset condition, the processor may control the buoyancy force adjustment member to increase the volume of the gas in the buoyancy cavity 1111**. The preset condition may include **a position of the moving device 100 above a preset height**. When the depth of the liquid in the target region 300 is fixed, the processor may determine whether the air inlet 1113 in the moving device 100 is above the liquid surface 200 by determining whether the position of the moving device 100 meets the preset condition. **When the position of the moving device 100 shown in FIG. 4A meets the preset condition, the processor may determine that the air inlet 1113 on the moving device 100 is above the liquid surface 200**, and the processor may control the buoyancy cavity pump 1112 to

discharge the liquid in the buoyancy cavity 1111, and the air may enter the buoyancy cavity 1111 through the air inlet 1113, so that the volume of the gas in the buoyancy cavity 1111 can be increased and the buoyancy force of the moving device 100 can be increased. When the buoyancy force of the moving device 100 in the vertical direction is greater than the gravity of the moving device 100, the moving device 100 as shown in FIG. 4A may be switched to the moving device 100 as shown in FIG. 4B."

505. This control process directly corresponds to the claimed **proximity waterline detection** functionality: the first sensor continuously monitors the robot's vertical position, and when it detects that the robot has ascended to within a predefined threshold distance from the waterline (i.e., the position is higher than a preset depth), the processor recognizes that proximity condition and triggers the buoyancy adjustment sequence.

506. It is my opinion that to a POSITA, the "preset height" disclosed by Zhang would be understood as a **predetermined distance** threshold relative to the water surface, and the sensor's function—to detect that the robot has reached or is within that threshold—is functionally equivalent to "detecting whether the swimming pool robot has crawled to a distance less than or equal to a predetermined distance from the waterline."

7. Claim 10: "The controllable sinking and floating swimming pool robot according to claim 1, wherein the main control

unit is further capable of controlling the sinking and floating control unit to enter a sinking working state based on the operational requirement information of the swimming pool robot to realize a sinking of the swimming pool robot."

507. **Zhang** discloses that the main control unit is further capable of controlling the sinking and floating control unit to enter a sinking working state based on the operational requirement information of the swimming pool robot to realize a sinking of the swimming pool robot. **Zhang** discloses that its control logic enables the robot to transition from a floating or surface-cleaning condition back to a submerged state by reducing buoyant force. Specifically, **Zhang** teaches that when the robot needs to move from the liquid surface back underwater, the processor controls the buoyancy adjustment part to reduce the volume of gas in the buoyancy cavity, thereby decreasing buoyancy and allowing gravity to pull the robot down. *See, e.g.,* **Zhang at 16:42-53**: "The target pool may be a pool that needs to be cleaned. The target task may be a cleaning task that needs to be performed on the target pool. **The target task may include a water surface cleaning and/or an underwater cleaning**. The water surface cleaning may refer to cleaning the water surface of the target pool, and the underwater cleaning may refer to cleaning the underwater (e.g., the water body, the walls of the pool, etc.) of the target pool. In some embodiments, the target task may also include a specific cleaning site. For example, the **underwater cleaning may also include**, but is not

limited to, a water body cleaning**, a pool bottom cleaning**, an individual pool wall cleaning, etc." *See also,* **Zhang at 8:37-49**: "When the moving device 100 needs to be switched from above the liquid surface to below the liquid surface, the processor may control the buoyancy force adjustment member to reduce the volume of gas in the buoyancy cavity 1111. For more information about when the moving device 100 needs to be switched from above the liquid surface to below the liquid surface, please refer to FIG. 10 and its related description. As shown in FIGS. 2 and 3, **the processor may discharge gas from the buoyancy cavity 1111 via the connection pipeline 1114, thereby reducing the volume of the gas in the buoyancy cavity 1111 to reduce the buoyancy force to allow the moving device 100 to be switched from above the liquid surface to below the liquid surface**."

8. Claim 14

a. Element [14a]: "The controllable sinking and floating swimming pool robot according to claim 7, further comprising a water pump unit configured to pump liquid in the swimming pool where the swimming pool robot is located and discharge the liquid to drive the swimming pool robot,"

508. **Zhang** discloses a water pump unit configured to pump liquid in the swimming pool where the swimming pool robot is located and discharges the liquid to drive the swimming pool robot. For example, **Zhang** discloses **a water pump 140** that draws pool water through the liquid-inlet portion and expels it via the liquid-outlet portion, so the reaction thrust propels and steers the robot while

simultaneously conveying surface debris into the cleaning device. *See, e.g.,* **Zhang at 12:13-29**: "In some embodiments, the moving device 100 may also include the main **water pump 140**. **The main water pump 140 may be configured to drive the moving device 100 to absorb the liquid from a water inlet and discharge it from a water outlet**. The water inlet may include one or more inlets for the liquid to enter the moving device 100. As shown in FIG. 5, FIG. 7A, FIG. 7B, and FIG. 8, the main water pump inlet 141 in the moving device 100 may serve as an inlet (i.e., a water inlet) for the liquid to enter the inside of the moving device 100. The water outlet may include one or more outlets in the moving device 100 where the **liquid leaves the moving device 100 and enters the target region 300**. As shown in FIG. 5, FIG. 7A, FIG. 7B, and FIG. 8, the **main water pump outlet 142 in the moving device 100 may serve as an outlet (i.e., a water outlet) for the liquid in the moving device 100 to leave the moving device 100 and enter the target region 300."**

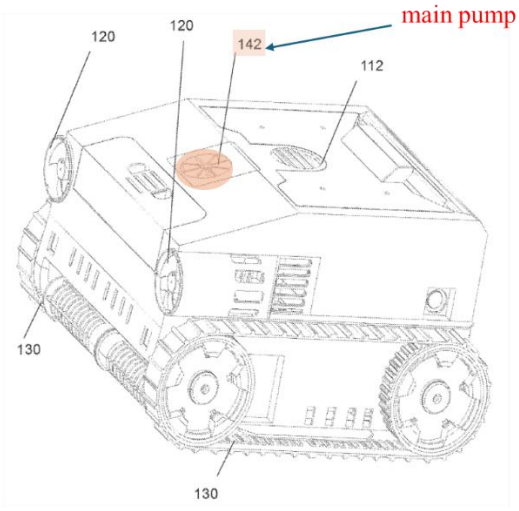


FIG. 5 of Zhang (annotated)

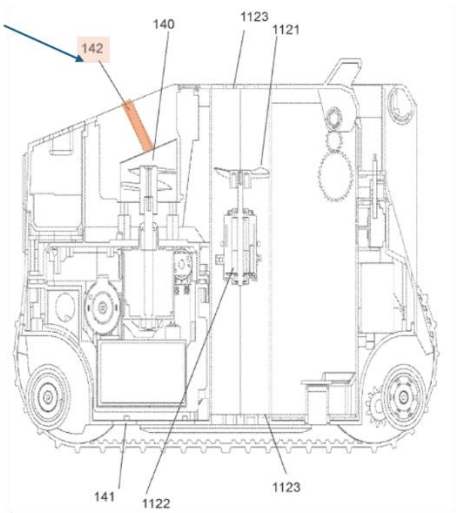


FIG. 7A of Zhang (annotated)

509. As described in **Zhang,** the main pump water outlet 142 is angled to apply particular driving forces, for example to ensure good contact between the treads and a wall along which the robot is crawling. *See, e.g.,* **Zhang at 12:61-13:5**: "In some embodiments, when the moving device 100 needs to move on the side wall 320, the main water pump outlet 142 may be directed within the target region 300. **When there is a downward slope in the vertical direction**, on the one hand, the **third drive force obtained by the moving device** 100 may exist a **component force in the horizontal direction towards the side wall** 320, which may cause the moving device 100 to press against the side wall 320; on the other hand, the aforementioned third drive force may also exist a **component force in the vertical direction with an upward division force**, thereby also allowing the moving device 100 to move upwardly along the side wall 320."

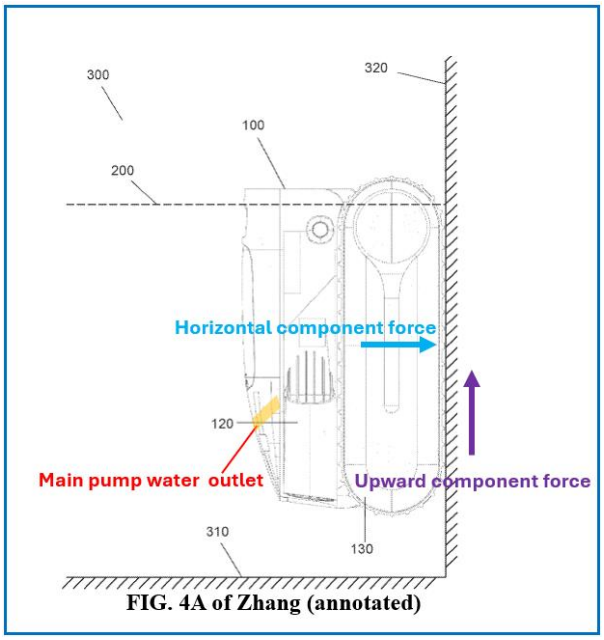


FIG. 4A of Zhang (annotated)

b. Element [14b]: "wherein a power of the water pump unit is changed after the sinking and floating control unit enters the floating working state or after the swimming pool robot climbs the side wall or the slope."

510. **Zhang** discloses the main water pump drives the cleaning device to press against the side wall with a horizontal force component during wall-climbing operation. *See, e.g.,* **Zhang at 12:44-55**: "In some embodiments, when the moving device 100 is located on the side wall 320, the water outlet (e.g., the main pump outlet 142) may be oriented at least within the target region 300 and parallel to a horizontal direction or with a downward slope in a vertical direction, thereby guaranteeing that **when the main water pump 140 is in operation and the liquid is discharged from the main pump outlet 142, the moving device 100 may receive the third drive force to drive the moving device 100 to press against**

the side wall 320. The third drive force may include a reaction force obtained by the moving device 100 when the main water pump 140 discharges the liquid from the main water pump outlet 142."

511. In my opinion, a POSITA would therefore understand that, when the cleaning device needs to leave the side wall and switch to the liquid surface, the suction force produced by the main water pump must be reduced. In other words, the power of the main water pump necessarily changes in coordination with the transition from the wall-climbing state to the floating working state.

512. In my opinion a POSITA would further recognize that this adjustment is consistent with **Zhang**'s general control framework, where the controller coordinates multiple subsystems—including the buoyancy control and propulsion units—to achieve stable motion between the sidewall, bottom, and surface.

513. Accordingly, a POSITA would have found it implicit and technically necessary that the pump output be decreased once the robot begins to float, to eliminate adhesion and allow buoyant ascent.

9. Claim 15

a. Element [15pre]: "A sinking and floating control method for a swimming pool robot, comprising:"

514. Based on exemplary disclosures for limitation [1pre] above, it is my opinion that **Zhang** discloses a sinking and floating control method for a swimming pool robot.

b. Element [15a]: "controlling a swimming pool robot to find a side wall or a slope based on operational requirement information of the swimming pool robot, and enabling the swimming pool robot to crawl along the side wall or the slope;"

515. Based on exemplary disclosures for limitation [1d] above, it is my opinion that **Zhang**, alone or in view of **Zhao**, discloses controlling a swimming pool robot to find a side wall or a slope based on operational requirement information of the swimming pool robot, and enabling the swimming pool robot to crawl along the side wall or the slope.

c. Element [15b]: "detecting a positional relationship between the swimming pool robot and a waterline of a liquid surface of a swimming pool where the swimming pool robot is located;"

516. Based on exemplary disclosures for limitation [1e] above, it is my opinion that **Zhang** discloses detecting a positional relationship between the swimming pool robot and a waterline of a liquid surface of a swimming pool where the swimming pool robot is located.

d. Element [15c]: "controlling a sinking and floating control unit to enter a floating working state based on detection results to realize a floating of the swimming pool robot; and"

517. Based on exemplary disclosures for limitation [1f] above, it is my opinion that **Zhang** discloses controlling a sinking and floating control unit to enter a floating working state based on detection results to realize a floating of the swimming pool robot.

e. Element [15d]: "controlling the sinking and floating control unit to stop working after the sinking and floating control unit enters the floating working state for a predetermined time."

518. Based on exemplary disclosures for limitation [1g] above, it is my opinion that **Zhang** in view of **Owen** discloses controlling the sinking and floating control unit to stop working after the sinking and floating control unit enters the floating working state for a predetermined time.

10. Claim 16: "The sinking and floating control method for the swimming pool robot according to claim 15, wherein detecting the positional relationship between the swimming pool robot and the waterline of the liquid surface of the swimming pool where the swimming pool robot is located comprises: starting detecting the positional relationship in response to a posture of the swimming pool robot meeting a first predetermined condition."

519. Based on exemplary disclosures for claim 2, it is my opinion that **Zhang** in view of **Zhao** discloses detecting the positional relationship between the swimming pool robot and the waterline of the liquid surface of the swimming pool where the swimming pool robot is located comprises: starting detecting the positional relationship in response to a posture of the swimming pool robot meeting a first predetermined condition.

11. Claim 17: "The sinking and floating control method for the swimming pool robot according to claim 16, wherein the operational requirement information comprises remote control command information sent by a user, clock information, operational task progress information, fault information, power information or swimming pool bottom environment information."

520. Based on exemplary disclosures for claim 3 above, it is my opinion that **Zhang** discloses the operational requirement information comprises remote control command information sent by a user, clock information, operational task progress information, fault information, power information or swimming pool bottom environment information.

D. Ground 4: *Zhang,* in view of *Zhao*, *Owen,* and *Guo,* Renders Claims 7-9, 11-13, and 18-19 Obvious

1. Claim 7

a. Element [7a]: "The controllable sinking and floating swimming pool robot according to claim 5, wherein the sinking and floating control unit comprises an inflation and deflation subunit and a switch subunit,"

521. **Zhang**, in view of **Guo**, discloses this limitation. Zhang discloses the **buoyancy force adjustment assembly** 111 (included in the mode switching member 110) comprises buoyancy force adjustment member which may further include a **buoyancy cavity pump** 1112. *See, e.g.,* **Zhang at 6:25-38**: "The buoyancy force adjustment member may be any structure that can adjust gas in the buoyancy cavity 1111. As shown in FIG. 3, **the buoyancy force adjustment member may include a buoyancy cavity pump 1112**. The buoyancy cavity pump 1112 may drive the buoyancy cavity 1111 to discharge the liquid therein. The buoyancy cavity pump 1112 may include, but is not limited to, **a pneumatic pump**, a hydraulic pump, an electric pump, etc. The buoyancy force adjustment member may also be other structures. For example, the buoyancy force adjustment

member may also be a piston assembly provided inside the buoyancy cavity 1111, and the volume of gas and/or liquid inside the buoyancy cavity 1111 can be adjusted by a movement of the piston assembly inside the buoyancy cavity 1111." *See also,* **Zhang at 6:64-7:4**: "As shown in FIG. 3, the moving device 100 may include two buoyancy cavities 1111, the buoyancy cavity pump 1112, the air inlet 1113, and the connection pipeline 1114. **The buoyancy cavity 1111 may be connected to the buoyancy cavity pump 1112** through the connection pipeline 1114, and **the buoyancy cavity pump 1112 may be connected to the air inlet 1113** through the connection pipeline 1114." *See also,* **Zhang at 7:5-11**: "Based on the moving device 100 as shown in FIGS. 2 and 3 , when the moving device 100 needs to be switched from below the liquid surface to above the liquid surface, the moving device 100 may move to a position close to the liquid surface 200 and determine when to **control the buoyancy cavity pump 1112 to inject gas into the buoyancy cavity 1111**."

522. **Guo** discloses a detailed structural embodiment of the same functional subsystem. In one embodiment, Guo teaches that the inflation and deflation device 122 includes **a first pump (i.e., inflation and deflation subunit) with a first valve (i.e., switch subunit) and a second pump (i.e., inflation and deflation subunit) with a second valve (i.e., switch subunit)**. During inflation, the first pump and valve draw gas from the drive cabin 131 into the airbag 121 and during

deflation, the second pump and valve release gas from the airbag back to the drive cabin 131. *See, e.g.,* **Guo at [0042]**: "In this embodiment, the inflation/deflation device 122 comprises a first air pump, **a first air valve**, a second air pump, and **a second air valve**. The airbag 121 is connected in sequence to the first air pump and the first air valve via one air tube 123, and to the second air pump and the second air valve via another air tube 123. **When it is necessary to control the swimming pool cleaning robot 100 to ascend, the first air pump and first air valve are activated to draw gas from the driving cabin 131 into the airbag 121**. When it is necessary to control the swimming pool cleaning robot 100 to descend, the second air pump and second air valve are activated to discharge gas from the airbag 121 into the driving cabin 131." *See, e.g.,* **Guo at [0043]**: "By means of the first air pump and first air valve, as well as the second air pump and second air valve, **the amount of gas in the airbag 121 can be precisely controlled**, **thereby enabling accurate control of the ascent and descent of the swimming pool cleaning robot 100**. This ensures the operational stability of the swimming pool cleaning robot 100 and avoids instability caused by uneven gas distribution."

523. In another embodiment, **Guo** discloses that the inflation and deflation device 122 includes a **pump (i.e., inflation and deflation subunit)** and **a check valve (i.e., switch subunit)**, where the pump injects gas into the airbag 121 and the one-way valve allows gas to leave the airbag while preventing reverse flow. *See,*

e.g., **Guo at [0045]**: "In this embodiment, **the inflation/deflation device 122 includes an air pump and a one-way valve**. The airbag 121 is connected to the air pump via one air tube 123 and to the one-way valve via another air tube 123. The one-way valve is configured such that gas can only flow from the airbag 121 into the driving cabin 131. **The air pump is activated to draw gas from the driving cabin 131 into the airbag 121, and the one-way valve is opened to discharge gas from the airbag 121 into the driving cabin 131**." *See also,* **Guo at [0046]**: "By controlling the switching of the air pump and the one-way valve, inflation and deflation of the airbag 121 can be conveniently achieved. The one-way valve effectively prevents backflow of gas, ensuring unidirectional gas flow. The overall structure is simple and easy to assemble."

524. In yet another embodiment, **Guo** discloses a swimming pool cleaning robot having an inflation and deflation device 122 that includes **a power mechanism (i.e., inflation and deflation subunit)** and **an electromagnetic valve (i.e., switch subunit)**. *See, e.g.,* **Guo at [0048]**: "In this embodiment, the inflation/deflation device 122 comprises a power mechanism, which may be a **peristaltic pump, a gear pump, or a Roots blower.** The airbag 121 is connected to the power mechanism, which is capable of rotating in both forward and reverse directions. **When it is necessary to control the swimming pool cleaning robot 100 to ascend, the power mechanism rotates forward, causing gas from the**

driving cabin 131 to be injected into the airbag 121. When it is necessary to control the swimming pool cleaning robot 100 to dive, the power mechanism rotates in reverse, causing the gas in the airbag 121 to be discharged into the driving cabin 131." *See, e.g.,* **Guo at [0049]**: "To further enhance the sealing performance of the driving cabin 131, in this embodiment, the inflation/deflation **device 122 further comprises a solenoid valve** connected to the power mechanism. When the power mechanism is operating, the solenoid valve is open; when the power mechanism is not operating, the solenoid valve is closed, thereby ensuring better sealing of the driving cabin 131." *See also,* **Guo at [0050]**: "Since the **power mechanism can rotate in both forward and reverse directions, it allows for flexible control of the gas flow direction**, meeting the control requirements for both ascending and diving. **The linkage between the solenoid valve and the power mechanism ensures the stability and accuracy of gas flow, preventing errors and instability caused by sealing issues**."

525. In my opinion, a POSITA would have been motivated to combine **Zhang** with **Guo** because both references are directed to swimming pool cleaning robots employing buoyancy-based sinking and floating control. **Zhang** teaches the buoyancy cavity and pump arrangement for inflating and deflating to adjust buoyancy. **Guo** addresses this same technical field and problem by disclosing an inflation and deflation device with a power mechanism (e.g., peristaltic pump, gear

pump, or roots blower) and a "first value," "second value," "check valve," or "electromagnetic valve" that functions as a switch to open or close gas flow depending on operating state.

526. Incorporating Guo's use of a "first value," "second value," "check valve," or "electromagnetic valve" into Zhang's buoyancy system would have been a predictable design choice to improve safety, reliability, and control precision, ensuring that gas only flows when intended. The combination would have been obvious to a POSITA seeking to refine Zhang's buoyancy control, with a reasonable expectation of success.

b. Element [7b]: "wherein in response to the outlet water detection subunit detecting that at least a part of the swimming pool robot has come out of the water, the inflation and deflation subunit is controlled to start sucking air and the switch subunit is controlled to open, so that the sinking and floating control unit enters the floating working state."

527. **Zhang**, in view of **Guo**, discloses this limitation.

528. **Zhang** discloses an outlet water detection subunit that, upon sensing part of the robot emerging from the water, triggers the inflation-deflation subunit to begin sucking air. For example, Zhang discloses a second sensor (i.e., outlet water detection subunit) that monitors in real time whether the air inlet 1113 is above the pool water surface. Upon detecting that the air inlet has emerged from the water, the processor activates the buoyancy cavity pump 1112 (i.e., inflation and deflation

subunit) to operate and begin drawing air. *See, e.g.,* **Zhang at 8:12-31**: "In some embodiments, the moving device 100 may also include a second sensor (not shown). The **second sensor may be configured to detect in real time whether the air inlet of the buoyancy cavity 1111 is positioned in air**. For example, the second sensor may include an ultrasonic sensor. The second sensor may be provided at the position of the air inlet of the buoyancy cavity 1111. In some embodiments, the second sensor may also be provided at other positions of the moving device 100 and obtain a detection result of whether the air inlet is located in the air by a position transition. In some embodiments, when the moving device 100 needs to be switched from below the liquid surface to above the liquid surface, **the processor may obtain a detection result of whether the air inlet of the buoyancy cavity 1111 is located in the air, and when the detection result characterizes that the aforementioned air inlet is located in the air, the buoyancy force adjustment member is controlled to increase the volume of the gas in the buoyancy cavity 1111 to achieve the switching of the moving device 100 from below the liquid surface to above the liquid surface."**

529. As discussed above for limitation [7a], **Guo** supplements a detailed structural mechanism for performing this control: an inflation and deflation subunit (pumps) and a switch subunit (valves) that cooperate to draw air from the drive

cabin into an airbag, thereby increasing buoyancy. *See, e.g.,* **Guo at [0041]-[0050]**.

530. In my opinion a POSITA would have found it obvious to integrate **Zhang**'s sensor-based surface detection with **Guo**'s airbag inflation subsystem. The motivation to combine arises from standard control-system design principles: (1) Zhang identifies a clear control event (partial emergence at the waterline); (2) Guo's system provides the actuators (pump and valve) that physically control buoyancy; and (3) coupling the two allows the robot to automatically initiate air intake and valve opening precisely when the robot reaches the water surface, ensuring smooth transition into a floating working state.

531. Implementing this control relationship would have been straightforward and predictable for a POSITA. The robot's controller could use the sensor signal described by **Zhang** (detecting "the air inlet is located in air") as the trigger to start **Guo**'s inflation/deflation pump and open the valve, causing the robot to enter and stabilize in the floating working state. Such event-driven control is standard in mechatronic and submersible systems, where sensor feedback directly triggers actuator commands to maintain desired buoyancy and stability.

532. Accordingly, **Zhang** in view of **Guo** teaches, or at minimum renders obvious, the limitation that "in response to the outlet water detection subunit detecting that at least a part of the swimming pool robot has come out of the water,

the inflation and deflation subunit is controlled to start sucking air and the switch subunit is controlled to open, so that the sinking and floating control unit enters the floating working state."

2. Claim 8

a. Element [8a]: "The controllable sinking and floating swimming pool robot according to claim 5, wherein the sinking and floating control unit comprises an inflation and deflation subunit and a switch subunit,"

533. Based on exemplary disclosures for limitation [7a] above, it is my opinion that **Zhang**, in view of **Guo**, discloses this limitation.

b. Element [8b]: "wherein in response to the proximity waterline detection subunit detecting that the swimming pool robot has crawled to the distance less than or equal to the predetermined distance from the waterline, the inflation and deflation subunit is controlled to start sucking air,"

534. **Zhang**, in view of **Guo**, discloses this limitation.

535. **Zhang** describes a control process in which the processor receives input from a **first sensor** configured to determine the robot's real-time position (depth) in the pool. When the robot's detected position meets a **preset condition**, such as being "**higher than a preset height**," the processor determines that the robot is near the surface and begins controlling the buoyancy adjustment part to increase the gas volume within the buoyancy cavity, thereby initiating the ascent to the waterline. *See, e.g.,* **Zhang at 7:51-8:11**: "When the moving device 100 needs to be switched from below the liquid surface to above the liquid surface, **the**

processor may obtain the position of the moving device 100 in real time from the first sensor, and when the position of the moving device 100 **meets a preset condition, the processor may control the buoyancy force adjustment member to increase the volume of the gas in the buoyancy cavity 1111**. The preset condition may include **a position of the moving device 100 above a preset height**. When the depth of the liquid in the target region 300 is fixed, the processor may determine whether the air inlet 1113 in the moving device 100 is above the liquid surface 200 by determining whether the position of the moving device 100 meets the preset condition. **When the position of the moving device 100 shown in FIG. 4A meets the preset condition,** the processor may determine that the air inlet 1113 on the moving device 100 is above the liquid surface 200, and **the processor may control the buoyancy cavity pump 1112 to discharge the liquid in the buoyancy cavity 1111, and the air may enter the buoyancy cavity 1111 through the air inlet 1113, so that the volume of the gas in the buoyancy cavity 1111 can be increased and the buoyancy force of the moving device 100 can be increased**. When the buoyancy force of the moving device 100 in the vertical direction is greater than the gravity of the moving device 100, the moving device 100 as shown in FIG. 4A may be switched to the moving device 100 as shown in FIG. 4B."

536. As discussed for claim 6 above, a POSITA would understand that the first sensor effectively serves as a **proximity waterline detection subunit**, since it determines when the robot's distance from the surface is less than a set threshold and triggers the inflation process. As the robot ascends, the first sensor continuously monitors the vertical distance from the surface; when that distance becomes less than or equal to a predetermined threshold (the "preset height"), the controller interprets the condition as proximity to the waterline and activates the buoyancy cavity pump (1112) to begin air intake.

537. **Guo** provides complementary structural detail and implementation. Guo teaches "a swimming pool cleaning robot capable of autonomous floating and diving." (**Guo at [0004]**.) The robot includes "a **floating and diving assembly**, the floating and diving assembly being installed within the housing, the floating and diving assembly comprising an airbag and an inflation/deflation device, the inflation/deflation device being connected to the airbag via an air tube." (**Guo at [0008]**.) The floating and diving assembly "**is configured to drive the swimming pool cleaning robot 100 to ascend, descend, or suspend vertically**." (**Guo at [0031]**.)

538. Guo further teaches that the airbag is connected to a sealed **driving cabin** that serves as an internal gas source, and an inflation/deflation device that

draws gas from the cabin into the airbag to increase buoyancy or returns it to the cabin to decrease buoyancy as illustrated in FIGS. 4 and 5.

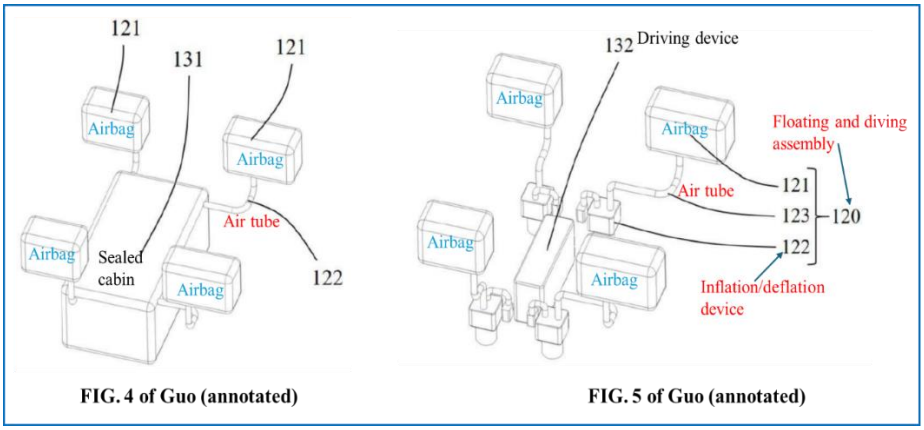


FIG. 4 of Guo (annotated) FIG. 5 of Guo (annotated)

539. The specification describes this structure in greater detail. *See, e.g.*, **Guo at [0034]:** "In the swimming pool cleaning robot 100 of the present disclosure, **the airbag 121 is connected to the driving cabin 131 via the inflation/deflation device 122, and the driving cabin 131 of the swimming pool cleaning robot 100 serves as the gas source for the floating and diving assembly 120. When it is necessary to control the robot 100 to surface, the inflation/deflation device 122 draws gas from the driving cabin 131 into the airbag 121**. When it is necessary to control the robot 100 to dive, the inflation/deflation device 122 discharges gas from the airbag 121 into the driving cabin 131. In this way, the robot 100 can be made to surface or dive as required. At the same time, since the driving cabin 131 also serves as the compartment for installing the driving assembly 130, there is no need to occupy additional space within the housing 110, resulting in a more compact overall layout, a smaller

overall size, improved flexibility, and reduced manufacturing costs for the swimming pool cleaning robot 100."

540. Because the gas is circulated internally within the sealed structure, Guo's design allows the robot to begin inflating its airbag **before any portion of the robot emerges from the water**, relying entirely on internal pressure transfer rather than external air intake.

541. In my opinion, a POSITA would have been motivated to combine the teachings of **Zhang** and **Guo** to achieve a more effective and reliable buoyancy-control system. Both references address the same engineering challenge—controlling a submerged cleaning robot's buoyancy to enable smooth transitions between underwater operation and surface floating. Zhang provides the **control logic**, using sensor feedback to determine proximity to the waterline and trigger buoyancy adjustment. Guo, in turn, provides a **mechanically robust solution** for implementing that control logic by introducing an internally circulating gas system that can inflate or deflate an airbag without requiring exposure to external air.

542. In my opinion, this combination would have been straightforward and predictable to a POSITA. Integrating **Guo**'s internal gas source in **Zhang**'s system eliminates the delay and instability associated with waiting for the air inlet to reach the atmosphere before inflation can begin. A POSITA would recognize that initiating inflation earlier—when proximity sensors detect the robot is close to the

surface—provides smoother motion, less mechanical stress on seals, and improved energy efficiency. In addition, both systems rely on standard pump-valve architectures that are readily compatible. Integrating Guo's teaching that the driving cabin alone can inflate/deflate an external bladder into Zhang's depth-triggered ascent—where the buoyancy pump starts as soon as sensor feedback shows the robot has reached a specific depth—would have required only routine design work and no change in the underlying principles of operation. The expected result of this combination would have been entirely predictable: a buoyancy-control system capable of beginning inflation immediately upon proximity detection, thereby allowing the robot to approach and stabilize at the surface in a continuous, controlled manner.

c. Element [8c]: "and in response to the outlet water detection subunit detecting that at least a part of the swimming pool robot has come out of the water, the switch subunit is controlled to open, so that the sinking and floating control unit enters the floating working state."

543. Based on exemplary disclosures for limitation [7b] above, it is my opinion that **Zhang**, in view of **Guo**, discloses this limitation.

3. Claim 9

a. Element [9a]: "The controllable sinking and floating swimming pool robot according to claim 7, wherein the sinking and floating control unit further comprises an airbag subunit connected to the inflation and deflation subunit, wherein the airbag subunit is connected to or disconnected from outside

atmosphere through the inflation and deflation subunit and the switch subunit,"

544. **Zhang**, in view of **Guo**, discloses a control unit that further comprises an airbag subunit connected to the inflation and deflation subunit, wherein the airbag subunit is connected to or disconnected from the outside atmosphere through the inflation and deflation subunit and the switch subunit.

545. For example, **Zhang** discloses a buoyancy force adjustment assembly 111 having a buoyancy cavity 1111. In my opinion, a POSITA would recognize that the buoyancy cavity 1111 performs the same structural and functional role as the claimed *airbag subunit*. In particular, **Zhang** describes the buoyancy cavity as an enclosed chamber designed to accommodate gas and/or liquid, made of flexible materials like rubber or PET, which allow for expansion and contraction in response to gas intake or discharge. This is the defining characteristic of an airbag structure—a sealed, inflatable vessel whose internal volume varies to control buoyant force. *See, e.g.,* **Zhang at 4:61-5:10**: "When the aforementioned action force includes a buoyancy force to which the moving device 100 is subjected in the vertical direction, the mode switching member 110 may include a buoyancy force adjustment assembly 111. The buoyancy force adjustment assembly 111 may be configured to adjust the magnitude of the buoyancy force to which the moving device 100 is subjected in the vertical direction. In some embodiments, the **buoyancy force adjustment assembly 111 may include a buoyancy cavity 1111**

and a buoyancy force adjustment member. **The buoyancy cavity 1111 may be configured to accommodate liquid and/or gas. The buoyancy cavity 1111 may also include**, but is not limited to, **an inflatable buoyancy cavity**, a liquid container type buoyancy cavity, a separated buoyancy cavity, etc. A volume of the buoyancy cavity 1111 may be preset. **The buoyancy cavity 1111 may be made of a flexible material and/or a rigid material**. The aforementioned flexible material may include, but is not limited to, **polyvinyl alcohol resin, polyethylene glycol terephthalate, rubber, etc**."

546. **Zhang** further discloses that the **buoyancy cavity 1111** is pneumatically connected to the external atmosphere through the **buoyancy cavity pump 1112** (i.e., inflation and deflation subunit) and **air inlet 111**. During operation, the pump is energized to draw external air through the air inlet into the buoyancy cavity, thereby increasing buoyancy and causing the robot to rise toward the water surface. *See, e.g.,* **Zhang at 6:59-7:3**: "In some embodiments, the buoyancy force adjustment assembly 111 may also include a connection pipeline 1114. The connection pipeline 1114 is configured to transport gas or liquid. The connection pipeline 1114 may connect one or more of the buoyancy cavity 1111, the buoyancy force adjustment member, and the air inlet 1113. As shown in FIG. 3, the moving device 100 may include two buoyancy cavities 1111, the buoyancy cavity pump 1112, the air inlet 1113, and the connection pipeline 1114. **The**

buoyancy cavity 1111 may be connected to the buoyancy cavity pump 1112 through the connection pipeline 1114, and the buoyancy cavity pump 1112 may be connected to the air inlet 1113 through the connection pipeline 1114."

547. **Zhang** further discloses that some embodiments the air inlet may also act as an air outlet, while in others separate inlets and outlets are provided. *See, e.g.,* **Zhang at 6:39-58**: "In some embodiments, the buoyancy force adjustment assembly 111 may also include an air inlet 1113. The aforementioned air inlet 1113 is configured to supply gas into the buoyancy cavity 1111. In some embodiments, the aforementioned air inlet 1113 may also be configured for the gas to leave the buoyancy cavity 1111, or for the liquid to enter or leave the buoyancy cavity 1111. In some embodiments, the buoyancy force adjustment assembly 111 may also include other inlets and outlets for the exit of the gas or the entry or exit of the liquid. The air inlet 1113 may be provided directly on the buoyancy cavity 1111 or may also be independent of the buoyancy cavity 1111. **The air inlet 1113 may be provided on a housing of the moving device 100 to facilitate connection to an external (e.g., external liquid or external air) for the exchange of gas and/or liquid**. As shown in FIG. 2, the **air inlet 1113 may be provided at a point above an end of a front section of the moving device 100, so that the air inlet 1113 can connect the external air** on the liquid surface more quickly during the uplifting of the moving device 100."

548. In my opinion, a POSITA would understand that in a **non-operating state**, the same pneumatic path is closed, thereby **disconnecting the buoyancy cavity from the outside atmosphere.** This control ensures that the buoyancy cavity remains sealed from external influence once the robot reaches equilibrium, thereby preserving the achieved buoyancy and preventing leakage or backflow.

549. While Zhang may not expressly disclose a distinct switch subunit, **Guo** teaches complementary structures that provide this exact functionality. **Guo** describes an inflation and deflation device 122 that includes a power mechanism (e.g., a peristaltic pump, gear pump, or Roots blower) and one or more valves that regulate airflow between an airbag and a sealed driving cabin. For example, Guo teaches (i) a first and second valve paired with pumps to control gas inflow and outflow (**Guo at [0042]**); (ii) a one-way valve that prevents backflow during discharge (**Guo at [0045]**); and (iii) a solenoid valve that opens during pump operation and automatically closes when idle to maintain airtightness (**Guo at [0048]-[0049]**).

550. In my opinion, a POSITA would have been motivated to incorporate **Guo**'s valve-based configuration into **Zhang**'s buoyancy-force adjustment assembly to achieve a more reliable, automatically sealed pneumatic control system. Zhang already recognizes the need for the buoyancy cavity 1111 to alternately connect to and isolate from the outside atmosphere via the pump and air

inlet 1113. However, **Zhang** does not describe a specific mechanism ensuring that this path closes when the pump stops. **Guo** provides the precise structural solution—a valve assembly synchronized with the pump's operation that allows airflow only when needed and seals the air path otherwise.

551. This combination would have been straightforward for a POSITA because both **Zhang** and **Guo** operate in the same technical field—submersible pool-cleaning robots using closed pneumatic systems for buoyancy control—and both rely on compatible hardware architectures (pumps, air ducts, and valves). Incorporating **Guo**'s valve mechanism into **Zhang**'s pump-driven buoyancy cavity would predictably yield a system where: (1) the buoyancy cavity 1111 (i.e., airbag subunit) is pneumatically connected to the pump (i.e., inflation and deflation subunit); (2) airflow is controlled through a valve (i.e., switch subunit); and (3) the cavity is automatically connected to or isolated from the outside atmosphere during operation and shutdown, thereby preventing leakage or backflow and maintaining stable buoyancy.

552. Accordingly, **Zhang** in view of **Guo** discloses, or at least renders obvious, a control unit in which the airbag subunit is connected to the inflation and deflation subunit, and through that subunit and an associated valve assembly, the airbag subunit is connected to or disconnected from the outside atmosphere.

b. Element [9b]: "and wherein the sinking and floating control unit further comprises an air inlet and outlet

subunit, wherein the switch subunit is connected to the outside atmosphere through the air inlet and outlet subunit."

553. **Zhang,** in view of **Guo,** discloses a control unit that further comprises an air inlet and outlet subunit, wherein the switch subunit is connected to the outside atmosphere through the air inlet and outlet subunit.

554. For example, **Zhang** discloses that the switch subunit is realized by the buoyancy-cavity pump 1112: when the pump is idle its sealed impeller housing closes the air path, so the inlet-outlet subunit (air inlet 1113 and connection duct 1114) is isolated from the external atmosphere and water is kept out; when the pump spins the seal is broken and ambient air is drawn through the same inlet-outlet subunit into the buoyancy cavity 1111, exemplifying the switch subunit being connected to the outside atmosphere through the inlet-and-outlet subunit. *See, e.g.,* **Zhang at 6:39-58**: "In some embodiments, the buoyancy force adjustment assembly 111 may also include an air inlet 1113. The aforementioned air inlet 1113 is configured to supply gas into the buoyancy cavity 1111. In some embodiments, the aforementioned air inlet 1113 may also be configured for the gas to leave the buoyancy cavity 1111, or for the liquid to enter or leave the buoyancy cavity 1111. In some embodiments, the buoyancy force adjustment assembly 111 may also include other inlets and outlets for the exit of the gas or the entry or exit of the liquid. The air inlet 1113 may be provided directly on the buoyancy cavity

1111 or may also be independent of the buoyancy cavity 1111. The air inlet 1113 may be provided on a housing of the moving device 100 to facilitate connection to an external (e.g., external liquid or external air) for the exchange of gas and/or liquid. As shown in FIG. 2, the air inlet 1113 may be provided at a point above an end of a front section of the moving device 100, so that the air inlet 1113 can connect the external air on the liquid surface more quickly during the uplifting of the moving device 100."

555. To the extent that **Zhang** does not expressly identify the valve structure (i.e., switch subunit) that enables selective opening or closing of the air path, **Guo** provides complementary structural embodiments for performing this function. **Guo** describes an inflation/deflation device (122) that includes both pumps and multiple valve types—such as electromagnetic valves and check valves—that regulate airflow and maintain sealing integrity. For example, Guo discloses (i) paired valves for bidirectional gas flow control (**Guo at [0042]**); (ii) a pump with a one-way valve to prevent backflow (**Guo at [0045]**); and (iii) an solenoid valve that opens during operation and closes to maintain airtightness when inactive (**Guo at [0048]-[0049]**).

556. In my opinion, a POSITA would have been motivated to combine Zhang and Guo to achieve a more robust and controllable buoyancy system. Zhang provides the control framework and describes the need to alternately

connect or isolate the buoyancy cavity from the external atmosphere, while Guo provides the specific structural mechanisms (pumps and valves) capable of achieving that function reliably in an underwater environment. The motivation to combine arises naturally from standard pneumatic control design principles: (1) Zhang identifies the operational need for selective air exchange to modulate buoyancy; (2) Guo supplies the proven valve-and-pump architecture for achieving such selective connection and isolation; and (3) combining the two allows the robot to precisely regulate air intake and sealing in synchronization with its buoyancy-control commands.

557. Implementing this combination would have been straightforward and predictable for a POSITA. The controller of **Zhang** could operate **Guo**'s pump and valve assemblies to open airflow paths during inflation and automatically seal the cavity when the target buoyancy is reached.

4. Claim 11: "The controllable sinking and floating swimming pool robot according to claim 10, wherein the sinking and floating control unit comprises an inflation and deflation subunit, a switch subunit and an airbag subunit connected to the inflation and deflation subunit, controlling the sinking and floating control unit to enter the sinking working state comprises controlling the switch subunit to open and controlling the inflation and deflation subunit to discharge air in the airbag subunit."

558. **Zhang**, in view of **Guo**, discloses a control unit that comprises an inflation and deflation subunit, a switch subunit and an airbag subunit connected to

the inflation and deflation subunit, controlling the sinking and floating control unit to enter the sinking working state comprises controlling the switch subunit to open and controlling the inflation and deflation subunit to discharge air in the airbag subunit.

559. As discussed for claim 7 above, **Zhang** in view of **Guo** teaches that the sinking and floating control unit comprises a buoyancy cavity pump (the inflation and deflation subunit), valves (switch subunit), and a buoyancy cavity (airbag subunit). The pump and valve are pneumatically coupled to the buoyancy cavity and work together to increase or decrease gas volume, thereby controlling buoyancy. **Zhang** also discloses that the processor (main control unit) directs the robot to submerge based on a user-input task, follow a periodic schedule, or automatically generate the task from real-time water-quality data. *See, e.g.*, **Zhang at 16:40-17:58**.

560. It is my opinion that a POSITA would understand that these control inputs represent "operational requirement information" which instructs the control unit to initiate the sinking process when underwater cleaning is required.

561. To achieve submersion, **Zhang** teaches that the controller actuates the buoyancy cavity pump to discharge air from the airbag. Specifically, when the cleaning device transitions from the water surface cleaning to the underwater cleaning, the buoyancy cavity pump 1112 is activated to decrease the gas volume

inside the buoyancy cavity 1111, lowering buoyant force; gravity then causes the robot to sink. *See, e.g.,* **Zhang at 8:44-49**: "As shown in FIGS. 2 and 3, the processor may **discharge gas from the buoyancy cavity 1111** via the connection pipeline 1114, thereby **reducing the volume of the gas in the buoyancy cavity 1111 to reduce the buoyancy force to allow the moving device 100 to be switched from above the liquid surface to below the liquid surface**."

562. **Guo** supplements Zhang by providing a detailed structural embodiment that employs dual pumps and valves to manage air exchange between the airbag and a sealed drive cabin. Specifically, Guo teaches a second pump and second valve that operate together to expel air from the airbag into the drive cabin. *See, e.g.,* **Guo at [0042]**: "In this embodiment, the inflation/deflation device 122 comprises a first air pump, **a first air valve**, a second air pump, and **a second air valve**. The airbag 121 is connected in sequence to the first air pump and the first air valve via one air tube 123, and to the second air pump and the second air valve via another air tube 123. **When it is necessary to control the swimming pool cleaning robot 100 to ascend, the first air pump and first air valve are activated to draw gas from the driving cabin 131 into the airbag 121**. When it is necessary to control the swimming pool cleaning robot 100 to descend, the second air pump and second air valve are activated to discharge gas from the airbag 121 into the driving cabin 131."

563. In my opinion, a POSITA would have been motivated to combine **Zhang** and **Guo** to obtain a more refined and responsive sinking control mechanism. **Zhang** provides the overall control logic and buoyancy structure, while **Guo** adds a robust pneumatic implementation using paired pumps and valves to ensure directional airflow and reliable sealing during operation.

564. The combination would have been straightforward and predictable for a POSITA, as both systems employ standard airbag–pump/valve architectures for buoyancy regulation. Integrating Guo's valve-based control mechanism into Zhang's pump-driven buoyancy assembly would yield a more complete, reliable control architecture.

5. Claim 12: "The controllable sinking and floating swimming pool robot according to claim 7, wherein the inflation and deflation subunit comprises an air pump assembly, and the switch subunit comprises an electromagnetic valve assembly or a two-position three-way valve assembly."

565. **Zhang,** in view of **Guo**, discloses this limitation.

566. **Zhang** discloses an inflation and deflation subunit that comprises an air pump assembly. For example, **Zhang** discloses that the buoyancy cavity pump 1112 can drive the buoyancy cavity 1111 to drain liquid/air therefrom, thereby adjusting the liquid and/or gas within the cavity and functioning as the inflation/deflation subunit. *See, e.g.,* **Zhang at 6:25-38**: "The buoyancy force adjustment member may be any structure that can adjust gas in the buoyancy

cavity 1111. As shown in FIG. 3, **the buoyancy force adjustment member may include a buoyancy cavity pump 1112. The buoyancy cavity pump 1112 may drive the buoyancy cavity 1111 to discharge the liquid therein.** The buoyancy cavity pump 1112 may include, but is not limited to, **a pneumatic pump, a hydraulic pump, an electric pump, etc.** The buoyancy force adjustment member may also be other structures. For example, the buoyancy force adjustment member may also be a piston assembly provided inside the buoyancy cavity 1111, and the volume of gas and/or liquid inside the buoyancy cavity 1111 can be adjusted by a movement of the piston assembly inside the buoyancy cavity 1111."

567. **Guo** supplements detailed embodiments identifying the types of components that constitute the inflation/deflation device 122 (inflation and deflation subunit), including a power mechanism being one of a **peristaltic pump**, a **gear pump** or a **Roots blower** (i.e., an air pump assembly) and an **electromagnetic valve** (i.e., switch subunit). *See, e.g.,* **Guo at [0048]**: "In this embodiment, the inflation/deflation device 122 comprises **a power mechanism**, which may be a **peristaltic pump, a gear pump, or a Roots blower.** The airbag 121 is connected to the power mechanism, which is capable of rotating in both forward and reverse directions. When it is necessary to control the swimming pool cleaning robot 100 to ascend, the power mechanism rotates forward, causing gas from the driving cabin 131 to be injected into the airbag 121. When it is necessary

to control the swimming pool cleaning robot 100 to dive, the power mechanism rotates in reverse, causing the gas in the airbag 121 to be discharged into the driving cabin 131." *See also*, **Guo at [0049]**: "To further enhance the sealing performance of the driving cabin 131, in this embodiment**, the inflation/deflation device 122 further comprises a solenoid valve** connected to the power mechanism. **When the power mechanism is operating, the solenoid valve is open**; when the power mechanism is not operating, the solenoid valve is closed, thereby ensuring better sealing of the driving cabin 131."

568. In my opinion, a POSITA would have readily recognized that **Guo**'s **peristaltic/gear/Roots pumps** and the **electromagnetic valve** are standard, commercially available components known for their compactness, reliability, and ability to maintain airtight sealing—characteristics particularly desirable in small underwater robots. It would therefore have been obvious to a POSITA to incorporate **Guo**'s valve structure into **Zhang**'s buoyancy-control system to achieve a more reliable and precisely regulated pneumatic circuit. **Zhang** already identifies the need to alternately connect and isolate the buoyancy cavity from the surrounding environment to control buoyancy, while **Guo** teaches a specific hardware solution (an electromagnetic valve assembly) that automatically coordinates with the pump's operation.

569. The combination would have been straightforward because both systems use comparable pneumatic components (e.g., positive-displacement pumps and flexible tubing) and address the same engineering challenges of air leakage and backflow prevention in submersible environments.

6. Claim 13: "The controllable sinking and floating swimming pool robot according to claim 7, wherein in response to the outlet water detection subunit detecting that at least a part of the swimming pool robot enters underwater again and/or the posture detection unit detecting that the posture of the swimming pool robot meets a second predetermined condition, the inflation and deflation subunit and the switch subunit are controlled to be closed."

570. **Zhang**, in view of **Zhao** and **Guo**, discloses the limitation of claim 13.

571. The '196 Patent provides that such a "second predetermined condition" could be "changing from a state parallel to the side wall of the swimming pool to a state parallel to the bottom surface of the swimming pool." ('196 Patent, at 9:43-46.)

572. **Zhao** similarly discloses this type of posture-based trigger. For example, the robot of Zhao can determine whether it is on the side wall of the pool or the bottom wall (i.e., whether it has transitioned into a floating working state) according to the data of the gyroscope (i.e., posture detection unit). *See, e.g.,* **Zhao at 7:1-7**: "Before cleaning, a 3D map of the pool has been transmitted to the pool cleaning robot. **According to the data of the gyroscope of the pool cleaning**

robot, the pool cleaning robot can determine its own position, for example, the pool cleaning robot can determine that the pool cleaning robot is **located on the bottom wall of the pool**, or **on the pool wall of the pool**."

573. Thus, a POSITA would understand that **Zhao**'s gyroscope readings provide the posture-based feedback necessary to detect when the robot transitions from a vertical climbing orientation (side wall) to a horizontal cleaning orientation (water surface)—corresponding to the claimed second predetermined condition. A POSITA would also understand that this detection result can be used by **Zhang** as a basis for the controller to determine when to close the cavity pump after surfacing, to stabilize buoyancy and prevent overinflation.

7. Claim 18: "The sinking and floating control method for the swimming pool robot according to claim 17, wherein controlling the sinking and floating control unit to enter the floating working state based on detection results to realize the floating of the swimming pool robot comprises: controlling the sinking and floating control unit to enter the floating working state in response to detecting that at least a part of the swimming pool robot has come out of water."

574. Based on exemplary disclosures for claim 7 above, it is my opinion that **Zhang** in view of **Guo** discloses controlling the sinking and floating control unit to enter the floating working state based on detection results to realize the floating of the swimming pool robot comprises: controlling the sinking and floating control unit to enter the floating working state in response to detecting that at least a part of the swimming pool robot has come out of water.

8. Claim 19: "The sinking and floating control method for the swimming pool robot according to claim 17, further comprising: controlling the sinking and floating control unit to stop working in response to detecting that at least a part of the swimming pool robot enters underwater again and/or detecting that the posture of the swimming pool robot meets a second predetermined condition."

575. Based on exemplary disclosures for claim 13 above, it is my opinion that **Zhang**, in view of **Zhao** and **Guo**, discloses controlling the sinking and floating control unit to stop working in response to detecting that at least a part of the swimming pool robot enters underwater again and/or detecting that the posture of the swimming pool robot meets a second predetermined condition.

E. Ground 5: *Guo,* in view of *Zhao* and *Owen,* Renders Claims 1-8, 10-13, and 15-19 Obvious

1. Independent Claim 1

a. Element [1pre]: "A controllable sinking and floating swimming pool robot, comprising:"

576. **Guo** provides complementary structural detail and implementation. Guo teaches "a swimming pool cleaning robot capable of autonomous floating and diving." (**Guo at [0004]**.) The robot includes "a **floating and diving assembly**, the floating and diving assembly being installed within the housing, the floating and diving assembly comprising an airbag and an inflation/deflation device, the inflation/deflation device being connected to the airbag via an air tube." (**Guo at [0008]**.) *See also,* **Guo at Abstract**: "The swimming pool cleaning robot can be suspended at any position in the water, **enabling cleaning of any position at the**

pool bottom, **mid-water, water surface, and pool wall**." *See also,* **Guo at [0031]**: "The swimming pool cleaning robot 100 comprises a housing 110 and a floating and diving assembly 120 disposed within the housing 110. The floating and diving assembly 120 is configured **to drive the swimming pool cleaning robot 100 to ascend, descend, or suspend vertically**."

b. Element [1a]: "a sinking and floating control unit configured to control a swimming pool robot to float and sink;"

577. **Guo** discloses a sinking and floating control unit configured to control a swimming pool robot to float and sink. For example, Guo discloses a **floating and diving assembly (including an airbag and an inflation/deflation device)** that controls the pool cleaning robot to surface and sink. (**Guo at [0031]**). *See, e.g.,* **Guo at [0033]**: "The **floating and diving assembly 120 comprises an airbag 121 and an inflation/deflation device 122**. The inflation/deflation device 122 is connected to the airbag 121 via an air tube 123. The swimming pool cleaning robot 100 further includes a driving assembly 130, which comprises a sealed driving cabin 131 and a driving device 132 disposed within the driving cabin 131. The driving cabin 131 is installed inside the housing 110, and **the inflation/deflation device 122 is also installed within the driving cabin 131**. The inflation/deflation device 122 is **configured to draw gas from the driving**

cabin 131 into the airbag 121, or to discharge gas from the airbag 121 into the driving cabin 131."

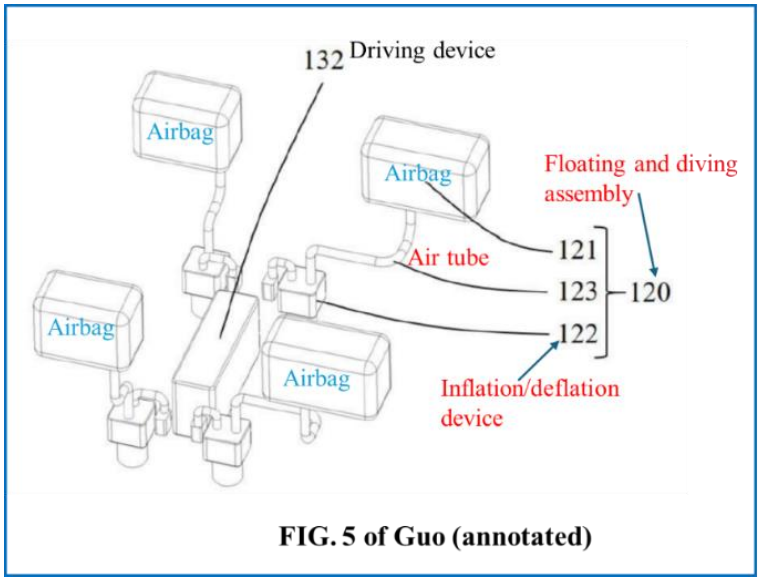


FIG. 5 of Guo (annotated)

578. **Guo** further describes these features in the specification in additional detail. *See, e.g.,* **Guo at [0034]**: "In the swimming pool cleaning robot 100 of the present disclosure, the airbag 121 is connected to the driving cabin 131 via the inflation/deflation device 122, and the driving cabin 131 of the swimming pool cleaning robot 100 serves as the gas source for the floating and diving assembly 120. When it is necessary to control the robot 100 to surface, the inflation/deflation device 122 draws gas from the driving cabin 131 into the airbag 121. **When it is necessary to control the robot 100 to dive, the inflation/deflation device 122 discharges gas from the airbag 121 into the driving cabin 131**. In this way, the robot 100 can be made to surface or dive as required. At the same time, since the driving cabin 131 also serves as the compartment for installing the driving

assembly 130, there is no need to occupy additional space within the housing 110, resulting in a more compact overall layout, a smaller overall size, improved flexibility, and reduced manufacturing costs for the swimming pool cleaning robot 100."

c. Element [1b]: "a waterline detection unit configured to detect a positional relationship between the swimming pool robot and a waterline of a liquid surface of a swimming pool where the swimming pool robot is located; and"

579. **Guo**, in view of **Zhao**, discloses a waterline detection unit configured to detect a positional relationship between the swimming pool robot and a waterline of a liquid surface of a swimming pool where the swimming pool robot is located.

580. Specifically, **Guo** discloses a pool cleaning robot with an autonomous floating and diving assembly, capable of surfacing or diving by controlling air exchange between an internal airbag and a sealed driving cabin. (**Guo at [0031], [0033], [0034]**.) **Guo** further discloses that the swimming pool cleaning robot can be suspended at any position in the water, including the **water surface**, for cleaning operations. (**Guo at Abstract**.)

581. A POSITA would recognize that, for **Guo**'s robot to perform cleaning at the **water surface**, the robot must be able to accurately detect when it reaches or approaches the **waterline**. Without such detection, the robot could either fail to

reach the surface or rise too far above it, leading to instability or ineffective cleaning performance. Accordingly, **Guo** inherently requires a mechanism to determine the robot's positional relationship relative to the waterline to achieve precise buoyancy control and stable operation at the surface.

582. To the extent **Guo** does not explicitly disclose this limitation, **Zhao** teaches employing a waterline detection unit in a pool cleaning robot to detect a positional relationship between the robot and the waterline. **Zhao** teaches that the pool cleaning robot sinks underwater to clean pool surfaces and then returns to the water surface for docking or retrieval. (**Zhao at 3:9-11, 6:16-21.**) **Zhao** further discloses using ultrasonic distance sensors to measure the distance between the robot and an obstacle. The distance sensors can be provided on the front side, back side, right side, and left side of the pool cleaning robot.

583. In my opinion, a POSITA would understand that when an ultrasonic distance sensor is positioned on the front side of the robot, it inherently faces upward as the robot climbs the side wall toward the water surface for docking, allowing it to measure the distance between the robot and the air–water interface (waterline). In this configuration, the ultrasonic distance sensor effectively functions as a "waterline detection unit", detecting a positional relationship between the robot and a waterline. *See, e.g.,* **Zhao at 4:6-17**: "The sensor unit provided on the pool cleaning robot includes various types of sensors, such as

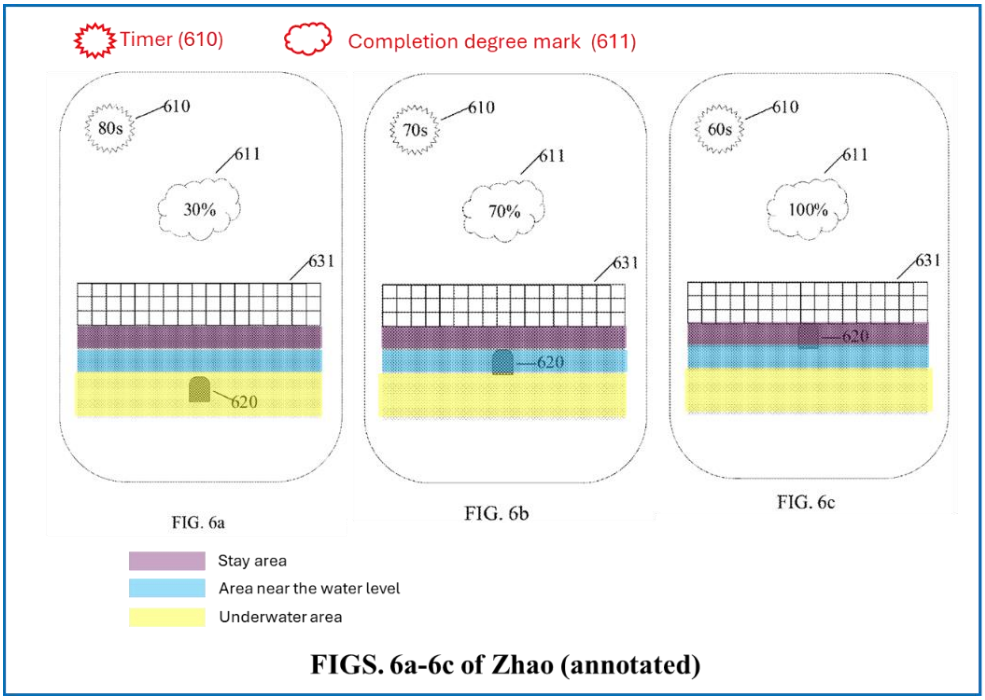
collision sensors, **distance sensors**, counters, and gyroscopes. The distance sensors can include, for example, **ultrasonic distance sensors**, which can be configured to **measure a distance from an obstacle to the ultrasonic distance sensor**. The distance sensors can be provided on the front side, back side, right side and left side of the pool cleaning robot. The distance sensor can also be provided on the top of the pool 15 cleaning robot to measure distance by rotating, such that a distance from an obstacle near the pool cleaning robot to the distance sensor can be measured through the distance sensor."

584. Importantly, the '196 Patent itself discloses using ultrasonic sensors for waterline detection, confirming that the ultrasonic sensors of **Zhao** are suited to performing this task, and that it was a conventional and well-understood implementation for detecting the robot's positional relationship relative to the waterline. (**'196 Patent, 8:29-47**).

585. In my opinion, a POSITA would therefore find it obvious that **Zhao**'s ultrasonic distance sensors could perform the same function in the context of waterline detection, particularly during the robot's ascent along the wall toward the surface.

586. **Zhao** further discloses using a gyroscope and a counter to detect distance and positional data, including determining whether the robot has reached a **predetermined distance from the waterline**. For example, **Zhao** teaches that

during wall climbing, the robot's distance to the waterline can be determined, and a completion degree mark (shown as a percentage) is calculated based on this distance. Thus, the robot's positional relationship to the waterline can be displayed as being in an **underwater area, near-water-level area, or stay area at the water level**. *See, e.g.,* **Zhao at 6:25-32**: "Maintaining dynamic balance at the water level can include **sensing that the pool cleaning robot reaches the water level through sensors**, the pool cleaning robot staying and timing; when the pool cleaning robot stays for more than a predetermined time period, the timing is stopped and the pool cleaning robot moves to underwater, but the present disclosure is not limited thereto."



FIGS. 6a-6c of Zhao (annotated)

587. The operation of the gyroscope to determine position is discussed in detail in the specification. *See, e.g.*, **Zhao at 7:1-7**: "Before cleaning, a 3D map of

the pool has been transmitted to the pool cleaning robot. According to the data of the **gyroscope** of the pool cleaning robot, the pool cleaning robot can determine its own position, for example, the pool cleaning robot can **determine that the pool cleaning robot is located on the bottom wall of the pool, or on the pool wall of the pool**." *See, e.g.,* **Zhao at 8:11-23**: "FIG. 6a to FIG. 6d are schematic diagrams of an interface of a control device coupled with a pool cleaning robot, showing a visual interface of the pool cleaning robot automatically climbing to a water level, according to embodiments of the present disclosure. After the pool cleaning robot 620 receives a docking instruction, the pool cleaning robot 620 docks and climbs up the pool wall 631. **A gyroscope and a counter built-in the pool cleaning robot 620 can record an angle and a rising height of the pool cleaning robot**. In FIG. 6a to FIG. 6d, the pool wall 631 is gridded, **the dark gray area is a stay area** for a water level, **the medium gray area is an area near the water level**, **and the light gray area is an underwater area**." *See, e.g.,* **Zhao at 8:24-42**: "**A completion degree mark 611 represents the docking completion degree calculated according to the moving speed of the pool cleaning robot 620 and a distance between the pool cleaning robot and the water level**. Timer 610 represents a remaining time for the docking instruction. For example, in FIG. 6a , the pool cleaning robot 620 is in the **underwater area**, the timer 610 shows that the remaining time for the docking instruction is 80s, and the docking completion

degree is 30%; in FIG. 6b , the pool cleaning robot 620 enters the **area near the water level**, and the remaining time for the docking instruction is 70s, and the docking completion degree is 70%; in FIG. 6c , the pool cleaning robot 620 enters the **stay area for the water level**, and the remaining time for the docking instruction is 60s, the docking completion degree is 100%; in FIG. 6d , the pool cleaning robot 620 waits in the stay area for a timeout and retreats to the underwater, the remaining time for the docking command is 0s, and the docking completion degree is 100%."

588. In my opinion, a POSITA would have had a clear motivation to combine the teachings of **Guo** and **Zhao** for several reasons. **First**, both references operate in the same technical field—autonomous swimming pool cleaning robots—and disclose operating the robot underwater and on the water surface. **Second**, the combination addresses a recognized engineering problem: how to enable a pool-cleaning robot to autonomously reach and maintain a stable position at the waterline for cleaning, docking or retrieval. Guo provides a compact and explicit buoyancy-control assembly—an airbag connected to an inflation/deflation device via an air tube—that allows a robot to float at the water surface or dive underwater. Zhao teaches a sensor-based positioning system, including ultrasonic distance sensors, a gyroscope, and a counter, that determines the robot's position relative to the waterline during wall-climbing and docking

operations. Zhao thus provides the sensing and feedback capability necessary for detecting proximity to the water surface and maintaining balance at the waterline. Integrating Zhao's waterline sensing subsystem in Guo's buoyancy-control robot would therefore supply the exact sinking and floating control capability Guo presupposes. **Finally**, the combination yields predictable results: a swimming pool robot capable of autonomously floating, maintaining stability, and cleaning at the waterline using well-understood buoyancy-control mechanisms.

589. The motivation to combine arises naturally from **shared design objectives** in the art. The integration would: (a) enhance stability during Guo's surface operation by applying Zhao's sensor-based feedback; (b) improve control accuracy through real-time waterline detection; (c) streamline transitions between submerged cleaning, wall climbing, and surface docking; and (d) employ well-understood, compact buoyancy hardware that is already part of Guo's design.

590. In my opinion, a POSITA would have readily implemented this combination by configuring Guo's inflation/deflation device to respond to Zhao's ultrasonic and gyroscopic feedback—inflating the airbag as the robot ascends toward the waterline, maintaining buoyancy for docking, and deflating for descent. The resulting system, **an autonomous pool-cleaning robot capable of controlled ascent, stable flotation, and efficient waterline cleaning**, represents a routine,

predictable improvement achieved by combining familiar elements for their known purpose, precisely the type of advancement recognized as obvious.

d. Element [1c]: "a main control unit configured to control a working state of the sinking and floating control unit,"

591. **Guo** alone, or in view of **Zhao**, discloses a main control unit configured to control a working state of the sinking and floating control unit.

592. For example, **Guo** discloses that the driving cabin houses a driving device including "a battery, **mainboard**, and drive motor, etc." (**Guo at [0052]**). A POSITA would recognize that the **mainboard** within the driving cabin would inherently serve as the main control unit configured to control the working state of the **floating and diving assembly** (i.e., sinking and floating control unit), as such control is necessary for the robot to autonomously perform the described floating and diving operations.

593. To the extent that **Guo** does not explicitly disclose a main control unit, **Zhao** teaches this limitation. For example, **Zhao** discloses a "controller" configured to "control the pool cleaning robot to perform specific operations." *See* Zhao at 3:41-42. *See, e.g.,* **Zhao at 3:42-47**: "The controller can be, for example, a **central processing unit (CPU)**, or a **microprocessor** and so on. The controller is **electrically connected with components** such as a battery, a memory, **a driving motor, a moving unit, and a sensor unit to control these components**."

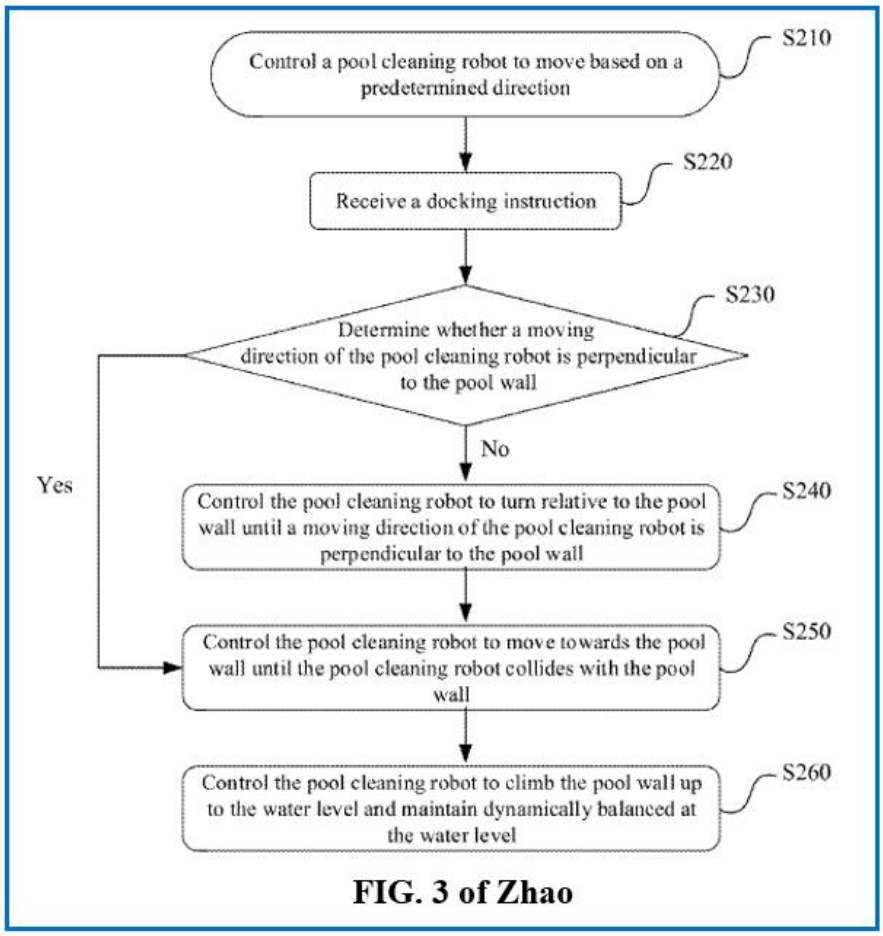


FIG. 3 of Zhao

594. **Zhao** further explicitly teaches that the processor is part of the system that controls movement of the robot. *See, e.g.,* **Zhao at claim 17**: "An electronic device comprising a **processor**; and a memory storing a program; wherein the program comprises instructions, and **the instructions, when executed by the processor, cause the processor to perform operations comprising**: controlling a pool cleaning robot to **move on a bottom wall of a pool**; … upon receiving a docking instruction, determining a closest pool wall relative to the pool cleaning robot, and enabling the pool cleaning robot to **move towards the closest pool wall** …"

595. In my opinion, a POSITA would have understood that the **mainboard** in **Guo**'s driving cabin and the **controller** disclosed in **Zhao** perform the same function, namely, controlling the operational state of the robot's buoyancy, propulsion, and sensor systems, and would have found it **obvious to implement Guo's floating and diving control using the controller structure and control logic taught by Zhao**.

e. Element [1d]: "wherein the main control unit is capable of controlling the swimming pool robot to find a side wall or a slope based on operational requirement information of the swimming pool robot and enabling the swimming pool robot to crawl along the side wall or the slope;"

596. **Guo**, in view of **Zhao**, discloses that the main control unit is capable of controlling the swimming pool robot to find a side wall or a slope based on operational requirement information of the swimming pool robot and enabling the swimming pool robot to crawl along the side wall or the slope.

597. **Guo** discloses that the pool cleaning robot is capable of cleaning the "bottom and **walls** of the pool." (**Guo at [0055]**.) A POSITA would understand that the Guo's **mainboard**, as the main control unit, must inherently enable the robot to locate and move along a side wall in order to perform wall-cleaning operations.

598. Similarly, **Zhao** provides explicit support for this functionality. Specifically, **Zhao** discloses "when the pool cleaning robot **receives the docking**

instruction, the pool cleaning robot stops moving, **determines the closest pool wall** relative to the pool cleaning robot, and **moves towards the closest pool wall**." (**Zhao at 4:62-65; FIG. 1**.)

599. **Zhao** further teaches that the robot body includes a set of ultrasonic sensors, and that based on docking instructions, the pool robot uses the ultrasonic sensors to measure distance to the pool walls and determine the closest pool wall relative to its position, enabling the robot to move toward that closest pool wall. *See, e.g.,* **Zhao at 4:62-67, 5:1-2**: "At step S130, **when the pool cleaning robot receives the docking instruction**, the pool cleaning robot stops moving, **determines the closest pool wall relative to the pool cleaning 65 robot, and moves towards the closest pool wall**. FIG. 2a to FIG. 2d illustrate schematic diagrams of a process of the pool cleaning robot turning to dock upon receiving a docking instruction according to embodiments, but the scope of the present disclosure is not limited thereto."

600. Finally, Zhao describes a set of sensors that provide the necessary information to allow the foregoing steps to be performed. *See, e.g.,* **Zhao at 4:6-17**: "The sensor unit provided on the pool cleaning robot includes various types of sensors, such as collision sensors, distance sensors, counters, and gyroscopes. The distance sensors can include, for example, **ultrasonic distance sensors**, which can be configured to **measure a distance from an obstacle to the ultrasonic distance**

sensor. The distance sensors can be provided on the front side, back side, right side and left side of the pool cleaning robot. The distance sensor can also be provided on the top of the pool cleaning robot to measure distance by rotating, such that a distance from an obstacle near the pool cleaning robot to the distance sensor can be measured through the distance sensor."

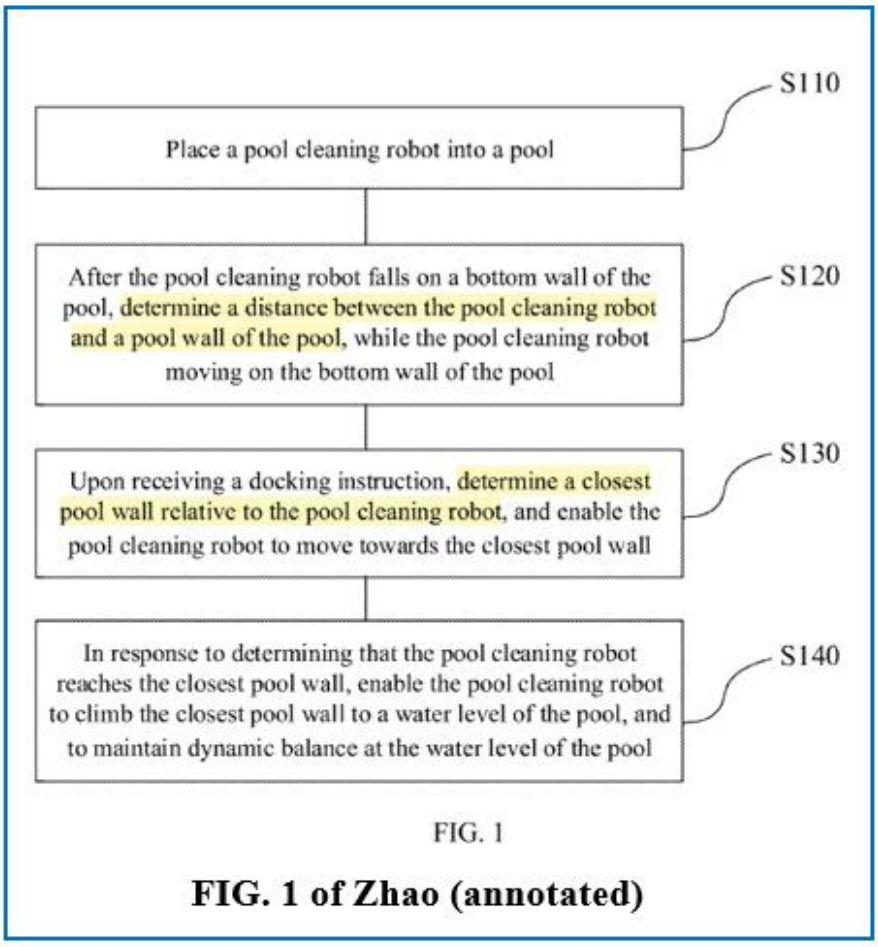


FIG. 1 of Zhao (annotated)

601. In my opinion, a POSITA would have found it obvious to incorporate **Zhao's wall-detection and navigation control** into **Guo's** buoyancy-controlled robot. Doing so would allow Guo's main control unit to process distance

information from sensors to identify a side wall or slope based on operational requirements and to command the robot to crawl along the wall for cleaning or docking—precisely the behavior described by the combined system. The integration would thus yield a predictable improvement: a pool cleaning robot capable of autonomously detecting, approaching, and cleaning along the pool's side walls and slopes.

f. Element [1e]: "controlling the waterline detection unit to detect the positional relationship between the swimming pool robot and the waterline of the liquid surface of the swimming pool where the swimming pool robot is located; and"

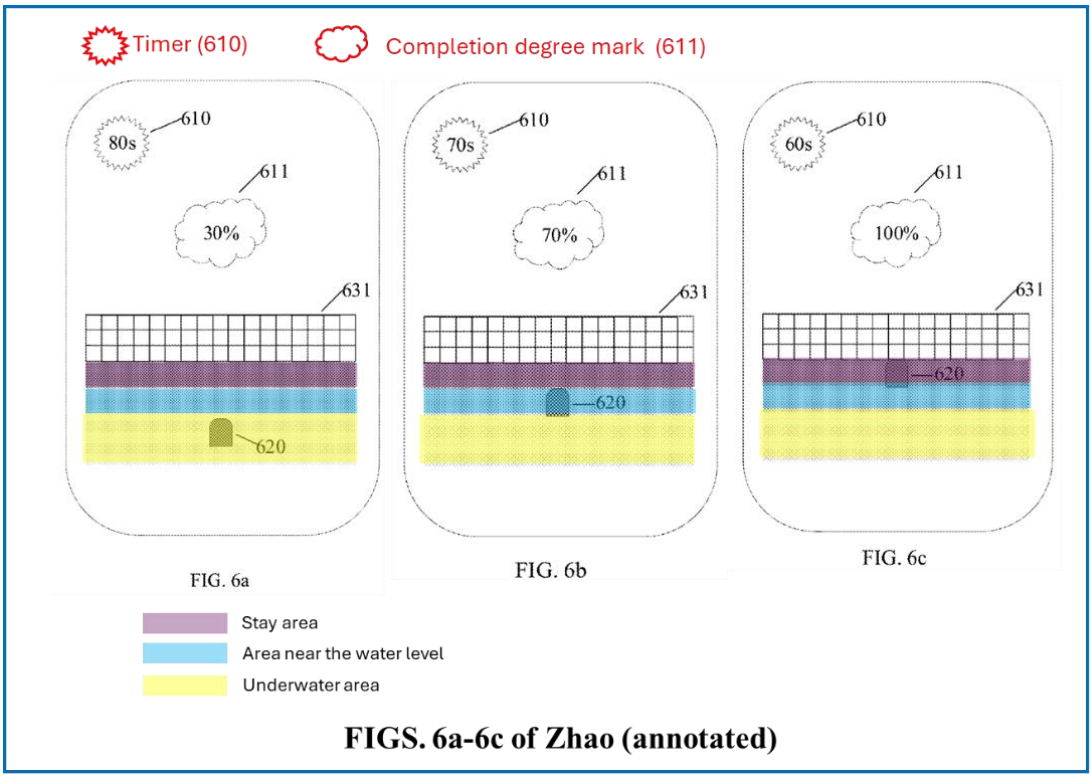
602. **Guo**, in view of **Zhao**, discloses that the main control unit controls the waterline detection unit to detect the positional relationship between the swimming pool robot and the waterline of the liquid surface of the swimming pool where the swimming pool robot is located. **Guo** further describes that the robot's floating and diving assembly enables it to autonomously surface, dive, or suspend at any depth, including the water surface, to perform cleaning operations. (**Guo at Abstract, [0033]-[0034]**.)

603. In my opinion, a POSITA would understand that, for the robot to achieve such automatic buoyancy and water-surface operation, its **main control unit** must necessarily control and receive feedback from sensors that monitor the robot's position relative to the water surface to ensure precise and stable operation

near the waterline. Accordingly, **Guo** inherently requires that its main control unit control a sensing or detection component to determine the robot's positional relationship relative to the waterline, even though such a sensor is not explicitly illustrated.

604. Additionally, **Zhao** provides explicit support for this control relationship by teaching that the controller (the main control unit) obtains, in real time, position data of the cleaning robot from an ultrasonic sensor or a gyroscope and a counter when transitioning between submerged and water surface positions. *See, e.g.,* **Zhao at 3:42-47**: "The **controller** can be, for example, a **central processing unit (CPU)**, or a **microprocessor** and so on. The controller is **electrically connected with** components such as a battery, a memory, a driving motor, a moving unit, and **a sensor unit to control** these components." *See also,* **Zhao at 4:6-8**: "The **sensor unit** provided on the pool cleaning robot includes various types of sensors, such as collision sensors, **distance sensors**, **counters, and gyroscopes**." *See also,* **Zhao at 8:11-23**: "FIG. 6a to FIG. 6d are schematic diagrams of an interface of a control device coupled with a pool cleaning robot, showing a visual interface of the pool cleaning robot automatically climbing to a water level, according to embodiments of the present disclosure. **After the pool cleaning robot 620 receives a docking instruction**, the pool cleaning robot 620 docks and climbs up the pool wall 631. **A gyroscope and a counter built-in the**

pool cleaning robot 620 can record an angle and a rising height of the pool cleaning robot. In FIG. 6a to FIG. 6d, the pool wall 631 is gridded, **the dark gray area is a stay area** for a water level, **the medium gray area is an area near the water level, and the light gray area is an underwater area**."



FIGS. 6a-6c of Zhao (annotated)

605. In my opinion, a POSITA would have been motivated to combine **Guo** and **Zhao** to achieve more precise and reliable control of the robot's position near the waterline. While **Guo** provides the buoyancy-control mechanism enabling floating and diving, **Zhao** supplies the sensor-based feedback and control logic necessary to monitor and adjust the robot's position relative to the water surface. Integrating Zhao's control and sensing system with Guo's buoyancy structure would predictably improve stability and automation at the waterline.

g. Element [1f]: "controlling the sinking and floating control unit to enter a floating working state based on detection results to realize a floating of the swimming pool robot,"

606. **Guo**, in view of **Zhao**, discloses that the main control unit controls the sinking and floating control unit to enter a floating working state based on detection results to realize a floating of the swimming pool robot.

607. For example, **Guo** teaches a floating and diving assembly 120 (i.e., sinking and floating control unit) comprising an airbag 121 connected to an inflation/deflation device 122, that performs the floating and sinking functions. *See, e.g.,* **Guo at [0034]**: "In the swimming pool cleaning robot 100 of the present disclosure, the airbag 121 is connected to the driving cabin 131 via the inflation/deflation device 122, and the driving cabin 131 of the swimming pool cleaning robot 100 serves as the gas source for the floating and diving assembly 120. **When it is necessary to control the robot 100 to surface, the inflation/deflation device 122 draws gas from the driving cabin 131 into the airbag 121**. When it is necessary to control the robot 100 to dive, the inflation/deflation device 122 discharges gas from the airbag 121 into the driving cabin 131. In this way, the robot 100 can be made to surface or dive as required. At the same time, since the driving cabin 131 also serves as the compartment for installing the driving assembly 130, there is no need to occupy additional space within the housing 110, resulting in a more compact overall layout, a smaller

overall size, improved flexibility, and reduced manufacturing costs for the swimming pool cleaning robot 100."

608. **Guo** further explains that the inflation/deflation device 122 includes air pumps and valves that activate to draw or discharge air depending on whether the robot needs to ascend or descend. *See, e.g.,* **Guo at [0042]**: "In this embodiment, the inflation/deflation device 122 comprises **a first air pump**, **a first air valve**, **a second air pump**, and **a second air valve**. The airbag 121 is connected in sequence to the first air pump and the first air valve via one air tube 123, and to the second air pump and the second air valve via another air tube 123. **When it is necessary to control the swimming pool cleaning robot 100 to ascend, the first air pump and first air valve are activated to draw gas from the driving cabin 131 into the airbag 121**. When it is necessary to control the swimming pool cleaning robot 100 to descend, the second air pump and second air valve are activated to discharge gas from the airbag 121 into the driving cabin 131."

609. Thus, **Guo** provides the **mechanical means** by which a main control unit can command the robot to enter a floating or diving state.

610. **Zhao** discloses the complementary **control logic** governing such operations. Zhao describes that the robot automatically ascends to the water surface, detects that the robot is in a floating position (e.g., the cleaning robot

reaches the water level) through sensors, maintains dynamic balance at the water level (i.e., floating) for a predetermined time, and then time out and descends underwater. *See, e.g.,* **Zhao at 6:25-32**: "**Maintaining dynamic balance** at the water level can include **sensing that the pool cleaning robot reaches the water level through sensors**, the pool cleaning robot staying and timing; when the pool cleaning robot stays for more than a predetermined time period, the timing is stopped and the pool cleaning robot moves to underwater, but the present disclosure is not limited thereto." *See also,* **Zhao at 8:59-9:4**: "In other embodiments of the present disclosure, the stay area for the water level, the area near to the water level, and the underwater area may not be distinguished. Because **when the pool cleaning robot moves to the water level, due to the effects of buoyancy and gravity, the sensor can sense that the pool cleaning robot has reached the water level**. Therefore, in a simplified embodiment of the present disclosure, when the pool cleaning robot **reaches the water level, the pool cleaning robot starts timing**. If the user does not lift the pool cleaning robot out of the water within a predetermined time, **the automatic docking procedure ends, and the pool cleaning robot retreat to continue cleaning work**."

611. These disclosures demonstrate that **Zhao**'s control system (1) **detects** via sensors that the robot has **reached the waterline**, (2) **enters a controlled surface-stay phase** (i.e., floating working state) during which the robot maintains

buoyancy and balance, and (3) **terminates that state after a predetermined time**, commanding the robot to return underwater. In functional terms, **Zhao** thus describes "controlling the sinking and floating control unit to enter a floating working state based on detection results to realize a floating of the swimming pool robot." Although Zhao does not explicitly disclose a "sinking and floating control unit," the disclosed control actions necessarily require such a subsystem to regulate buoyancy in response to sensor feedback.

612. In my opinion, a POSITA would have recognized that integrating **Zhao's sensor-based control logic and feedback system** into **Guo's airbag-based buoyancy structure** would provide the necessary control capability for automatically managing the robot's floating and submerging operations. By incorporating Zhao's real-time detection and timing functions, Guo's system would be able to determine when the robot reaches the waterline, maintain a stable floating state for a predetermined period, and then command descent as needed. The resulting combination would yield a predictable improvement—a pool-cleaning robot capable of autonomous, feedback-controlled buoyancy regulation at the water surface—achieved by integrating familiar elements for their known, complementary purposes.

h. Element [1g]: "wherein the sinking and floating control unit is controlled to stop working after the sinking and floating control unit enters the floating working state for a predetermined time."

613. **Guo**, in view of **Zhao** and **Owen**, discloses this limitation.

614. **Guo** provides the structural basis for sinking and floating control. Guo discloses an integrated sinking and floating control unit including an airbag and an inflation/deflation device (pumps and valves) connected by air tubing. *See, e.g.*, **Guo at [0008], [0031], and [0034]**. **Guo**'s system controls the robot's buoyancy by transferring air between the airbag and a sealed driving cabin. *See id.* **Guo** explains that "when it is necessary to control the robot to surface, the inflation/deflation device draws gas from the driving cabin into the airbag," and conversely, "when it is necessary to control the robot to dive, the inflation/deflation device discharges gas from the airbag into the driving cabin." (**Guo at [0034]**.) Guo thus provides the integrated mechanical system by which the robot's buoyancy is regulated.

615. Because the airbag is inflatable and made of flexible material, a POSITA would recognize the risk of overinflation if the inflation/deflation device were continuously operated without limitation. **Guo** itself admits that "Since the **material of the airbag 121 is relatively soft**, the protective cover can effectively prevent the airbag 121 from being punctured by foreign objects." (**Guo at [0037]**.) To prevent damage, it would have been obvious to control the inflation/deflation device so that, once the robot had already entered the floating working state (i.e., buoyancy exceeds gravity and the robot is floating on the water surface), the

inflation/deflation device would be **stopped after a predetermined time** to avoid further inflation.

616. Guo teaches the importance of controlling to a desired volume. See, e.g., Guo at [0039]: "In some embodiments, each airbag 121 is individually connected to an inflation/deflation device 122, and each inflation/deflation device 122 independently **controls the inflation or deflation of each airbag** 121. This allows **more precise control of the gas content in each airbag** 121, and thus **more precise control** of the ascent or descent speed of the underwater cleaning robot." However, Guo does not specify the control logic necessary to achieve this control over the air volume in the airbag system. Such control is trivial.

617. A POSITA would understand that when an airbag such as that disclosed by Guo is filled by a pump operating at a constant volumetric flow rate (Q), and while back-pressure remains low (i.e., the bag is still compliant and far below its geometric or pressure limit), the volume (V) of the airbag grows roughly linearly with time (t). This basic relationship is expressed as:

$$\mathbf{V \approx Q \times t}$$

618. As the airbag nears its maximum capacity, the internal pressure rises due to membrane tension and hydrostatic head. This increased back-pressure causes the pump's effective flow rate to decay toward zero, and consequently, the

airbag's volume asymptotically approaches a limiting value rather than increasing indefinitely.

619. Given this relationship, a POSITA would readily appreciate that a **predetermined inflation time** can be selected to deliver the target gas volume necessary to achieve buoyancy in Guo's robot while remaining safely below the airbag's structural or pressure limit. In practice, this predetermined time provides a robust operational margin—ensuring consistent buoyancy performance while preventing overinflation or mechanical damage to the airbag.

620. This concept is illustrated by the simulation shown in Figure 1 (Ex. 1021). The simulation models airbag volume versus time for a pump delivering approximately 4.0 L/min of air into a compliant airbag. The **Gas Volume Threshold** (1.75 L; green dashed line), i.e. the minimum air volume necessary to float, is reached at about t = 27.5 sec. The system continues inflating until the **Predetermined Time** of 40 seconds (magenta dashed line), reaching the **Predetermined Volume**, which remains below the asymptotic capacity (black dotted line).

621. In my opinion, a POSITA would understand that this control principle—operation of a motor–pump assembly for a fixed duration of time to achieve a desired buoyancy threshold—reflects fundamental pneumatic system dynamics in Guo that a POSITA would find trivial to implement. The pneumatic

simulation in Ex. 1021 merely visualizes these well-understood relations; in practice, the precise parameters—such as the time duration, target volume, and pump flow rate—would be routinely selected based on design constraints like airbag geometry, material limits, desired buoyancy, and overall robot mass and cost.

622. A POSITA would have been thoroughly familiar with using **timers** and **timeouts** to control actuators such as pumps and motors. Standard industrial control systems, including programmable logic controllers ("**PLCs**"), have long incorporated built-in timer functions to **start, stop, or modulate motors and pumps for predetermined durations** based on preset intervals or program logic.

623. As discussed in Chapter 9: "Timers" of *Programmable Logic Controllers*, 6th Edition (Ex. 1022), timers are described as fundamental components of automation systems used "**a motor or a pump might need to be controlled to operate for a particular interval of time**." The chapter explains how **on-delay (TON), off-delay (TOF), and pulse (TP) timers** generate controlled-duration outputs that energize or de-energize motors, pumps, or valves after fixed time intervals. These timers rely on the PLC's internal clock and are programmed to execute self-terminating operations when a preset value is reached, providing a timeout feature that ensures reliable, repeatable, and safe device operation. Ladder-diagram examples illustrate common applications such as

starting and stopping pumps and motors after defined intervals (e.g., Fig. 9.6 and Fig. 9.19), sequencing multiple motors, and maintaining output states for timed periods.

624. **Owen** discloses exactly this type of solution. **Owen** teaches using a timer circuit, an integrated chip, or a timer switch to allow a pump to run for a set period of time to inflate an airbag, and then automatically shut off. *See, e.g.,* **Owen at 3, 19-28**: "In one embodiment, a circuit board (not shown), or an integrated chip (not shown) that serves as a **timer** is mounted to such a circuit board, **is provided to control the pump**. The circuit board or chip is programmed to **allow the pump to run for a set period of time after it is activated**. For example, in one type of inflatable mattress 12, it may take 60 seconds to adequately inflate the mattress 12. In this case, **the circuit board is programmed to run the pump for at least 60 seconds before shutting it off**. The circuit board may also be programmed to include a buffer to make sure that the inflatable mattress 12 is adequately inflated. In the above example, the circuit board or chip could be programmed to operate the pump for 70 seconds to assure adequate inflation." *See also,* **Owen at 4, 7-10**: "Alternatively, instead of the circuit board, a mechanism such as a timer switch (not shown) could be used to automatically shut off the pump. If such a timer switch is used, **the switch can be set to allow the pump to run for a set period of time once it is activated**, in the same fashion as

the circuit board already described." *See, e.g.,* **Owen at 4, 20-26**: "In yet another embodiment, a combination of a circuit board and/or **an integrated circuit (IC) chip may be used as a timing circuit along with a pressure sensor to provide the timing signal that indicates when terminate pumping**. The IC chip may include a controlled switch (not shown) in electrical communication with the pressure sensor, wherein the controlled switch is triggered by signals from the pressure sensor that include threshold pressures, which indicate when the pump is done pumping and should be automatically turned off."

625. **Zhao** provides complementary control logic for coordinating these buoyancy operations on timing control. For example, **Zhao** discloses that the pool-cleaning robot detects when it reaches the waterline, remains there for a predetermined time interval, and then submerges to continue cleaning. *See, e.g.*, **Zhao at 6:25-32; 8:59-9:9**.

626. **Zhao** explains that when the pool cleaning robot reaches the waterline, a 60-second timer is activated, and after this predetermined time, the robot descends underwater to perform cleaning operations. *See, e.g.,* **Zhao at 8:35-42**: "in FIG. 6*c*, the pool cleaning robot 620 enters the stay area for the water level, and the remaining time for the docking instruction is 60s, the docking completion degree is 100%; in FIG. 6*d*, the pool cleaning robot 620 waits in the stay area for a timeout and retreats to the underwater, the remaining time for the

docking command is 0s, and the docking completion degree is 100%." *See also,* **Zhao at 8:65-9:4**: "Therefore, in a simplified embodiment of the present disclosure, when the pool cleaning robot **reaches the water level**, the pool cleaning robot **starts timing**. If the user does not lift the pool cleaning robot out of the water within a predetermined time, the **automatic docking procedure ends, and the pool cleaning robot retreat [] to continue cleaning work**." *See also,* **Zhao at 6:25-32**: "Maintaining dynamic balance at the water level can include sensing that the pool cleaning robot reaches the water level through sensors, the pool cleaning robot **staying and timing**; when the pool cleaning robot **stays for more than a predetermined time period**, the timing is stopped and the pool cleaning robot moves to underwater, but the present disclosure is not limited thereto." *See also,* **Zhao at Claim 2**: "in response to determining that the pool cleaning robot has reached the water level **for a preset time period** and the pool cleaning robot has not been lifted out of water, enabling the pool cleaning robot to retreat to continue cleaning work."

627. In my opinion, a POSITA would understand that once the pool cleaning robot of **Zhao** times out after floating at the water surface for a predetermined time period, the sinking and floating control unit of the robot would stop working in the floating state (e.g., stop inflating the buoyancy cavity) for the robot to submerge and return to the bottom of the pool.

628. In my opinion, a POSITA would have recognized a straightforward path to improve the operation of **Guo's** buoyancy-controlled pool-cleaning robot by incorporating the inflation control logic taught by **Owen** and timing-based operational logic of **Zhao**.

629. **Guo** provides a detailed buoyancy-control system that enables autonomous floating and diving. **Guo** discloses an airbag (or multiple airbags) positioned near the top of the robot housing, driven by an inflation and deflation device within a sealed drive cabin. The system pumps air from the cabin into the airbag to create positive buoyancy for floating and retracts the air to submerge the robot. **Guo** further teaches the use of pumps, solenoid valves, and independent control of multiple airbags to maintain balance as the robot ascends or descends. These teachings provide the precise structural and functional means required for stable floating operation near the waterline.

630. **Owen** complements **Guo** by teaching well-established and straightforward control logic for inflation systems: a timer that energizes the pump for a predetermined period and automatically shuts it off, and a pressure sensor that deactivates the pump upon reaching a threshold pressure. Each mechanism functions independently as a failsafe to prevent over-inflation or structural stress. These control strategies were widely used in small inflatable systems and would have been immediately applicable to **Guo**'s airbag assembly.

631. In my opinion, a POSITA would readily combine **Owen**'s timer or pressure-control scheme with **Guo**'s airbag flotation module to regulate inflation precisely and safely, limiting the inflation time or internal pressure to avoid damage while maintaining consistent buoyant performance. This combination is a routine, low-cost improvement fully consistent with the practical engineering needs of consumer pool robots.

632. **Zhao** provides complementary operational logic describing how a robot climbs to the pool's water level, "maintains dynamic balance at the water level," remains for a predetermined time, and retreats underwater if not retrieved.

633. In my opinion, a POSITA would have recognized that the control logic described by **Zhao**—sensing, maintaining, and timing surface-dwell behavior—could be readily implemented using **Guo** and **Owen**'s combined buoyancy-control and timing framework.

634. In my opinion, **Owen** is analogous art to **Zhao** and **Guo** for the same reasons I discussed above regarding **Owen** and **Wang**. *See* ¶¶290 – 302 above. The motivation to combine these teachings arises naturally from common design objectives in the art. The combination provides: (1) improved stability and control at the waterline through **Guo**'s variable-buoyancy mechanism, (2) enhanced safety and durability by preventing over-inflation of **Guo**'s airbags, (3) greater energy efficiency through time-limited inflation consistent with **Zhao**'s timed "stay then

retreat" sequence, and (4) straightforward integration since **Guo**'s architecture already accommodates the necessary pump and control components.

635. In my opinion, a POSITA would have easily implemented this combination by programming the robot's controller to inflate the airbags upon reaching the waterline, running the pump for a predetermined time (as taught by **Owen**), maintaining that state for a predetermined surface-stay duration, then deflating the bags for descent. The resulting system—stable, time-bounded flotation without risk of over-inflation—reflects a predictable outcome of combining well-known and familiar elements according to known principles.

2. Claim 2

a. Element [2a]: "The controllable sinking and floating swimming pool robot according to claim 1, further comprising a posture detection unit configured to detect a posture of the swimming pool robot,"

636. **Guo**, in view of **Zhao** discloses a posture detection unit configured to detect a posture of the swimming pool robot.

637. **Guo** teaches a robot that is designed to float, dive, and move along both the pool bottom and side walls. (**Guo at [0019]; [0055]-[0056]**.) Guo specifically teaches that the robot "can be suspended at any position in the water." (**Guo at Abstract**.) A POSITA would recognize that a posture detection unit, such as a gyroscope, would be necessary for Guo's robot to detect and maintain its

orientation, thereby ensuring stability, preventing capsizing, and enabling smooth transitions between these operational states.

638. Additionally, **Zhao** provides explicit support for this feature. For example, **Zhao** discloses using a **gyroscope** to detect the posture of the swimming pool robot (e.g., whether the robot is located on the bottom wall or the side wall of the pool). *See, e.g.*, **Zhao at 7:1-7**: "Before cleaning, a 3D map of the pool has been transmitted to the pool cleaning robot. According to the data of the **gyroscope** of the pool cleaning robot, the pool cleaning robot can determine its own position, for example, the pool cleaning robot can **determine that the pool cleaning robot is located on the bottom wall of the pool, or on the pool wall of the pool**." *See also*, **Zhao at 8:15-24**: "**A gyroscope** and a counter built-in the pool cleaning robot 620 can **record an angle** and a rising height of the pool cleaning robot. In FIG. 20 6a to FIG. 6d, the pool wall 631 is gridded, the dark gray area is a stay area for a water level, the medium gray area is an area near the water level, and the light gray area is an underwater area." *See also,* **Zhao at 6:16-32**: "In the case of receiving the docking instruction, at step **S140**, after the pool cleaning robot collides with the pool wall, the driving motor increases power, controls the pool cleaning robot to climb the pool wall to the water level of the pool, and controls the pool cleaning robot to maintain dynamic balance at the water level. In addition, **controlling the pool cleaning robot to climb the pool wall can**

further include sensing a change of an inclination angle of the pool cleaning robot through the gyroscope to cause the pool cleaning robot to enter a wall climbing mode. Maintaining dynamic balance at the water level can include sensing that the pool cleaning robot reaches the water level through sensors, the pool cleaning robot staying and timing; when the pool cleaning robot stays for more than a predetermined time period, the timing is stopped and the pool cleaning robot moves to underwater, but the present disclosure is not limited thereto." *See also*, **Zhao at 4:23-25**: "The **gyroscope is configured to measure a rotation angle** of the pool cleaning robot, such that 25 a direction of the pool cleaning robot can be determined."

639. In my opinion, a POSITA would have found it obvious to incorporate Zhao's gyroscope-based posture detection system into Guo's pool-cleaning robot to monitor the robot's inclination and orientation during floating, diving, and wall-cleaning operations. The integration would yield predictable and complementary benefits, including enhancing stability, navigation accuracy, and control, through the routine application of a well-known sensing component for its established purpose.

b. Element [2b]: "wherein the main control unit controls the waterline detection unit to start detecting the positional relationship in response to the posture meeting a first predetermined condition."

640. The '196 Patent provides that a "first predetermined condition" could be "changing from a state parallel to the bottom surface of the swimming pool to a state parallel to the side wall of the swimming pool." ('196 Patent, at 9:37-40.)

641. **Guo**, in view of **Zhao**, discloses that the main control unit controls the waterline detection unit to start detecting the positional relationship in response to the posture meeting a first predetermined condition.

642. **Guo** teaches a swimming pool cleaning robot capable of floating, diving, and moving along the pool bottom and side walls. (**Guo at [0019], [0055]-[0056]**.) Guo specifically describes that the robot "can be suspended at any position in the water." (**Guo at Abstract**.) Although Guo does not explicitly disclose a control sequence linking posture detection to activation of waterline detection, a POSITA would understand that these waterline-related detections occur **after** the posture change has been detected and the robot has entered the wall-climbing state, serving as feedback for the control unit to initiate buoyancy adjustment and transition into the surface-cleaning state.

643. **Zhao** provides explicit teaching of a posture-based trigger for initiating the wall-climbing and docking process. For example, the robot of Zhao can determine whether it is on the bottom wall or side wall of the pool (i.e., whether it has transitioned into a wall climbing mode) according to the data of the gyroscope (i.e., posture detection unit). *See, e.g.,* **Zhao at 7:1-7**: "Before cleaning,

a 3D map of the pool has been transmitted to the pool cleaning robot. According to the data of the gyroscope of the pool cleaning robot, **the pool cleaning robot can determine its own position**, for example, the pool cleaning robot can determine that the pool cleaning robot is located **on the bottom wall of the pool**, or **on the pool wall of the pool**."

644. Once the robot determines that it has transitioned from the horizontal bottom surface to a vertical pool wall, i.e., when the posture meets the first predetermined condition, Zhao teaches that it begins its **docking and climbing sequence**, which necessarily requires detecting its positional relationship relative to the waterline. This control logic is further illustrated in FIG. 3 of Zhao.

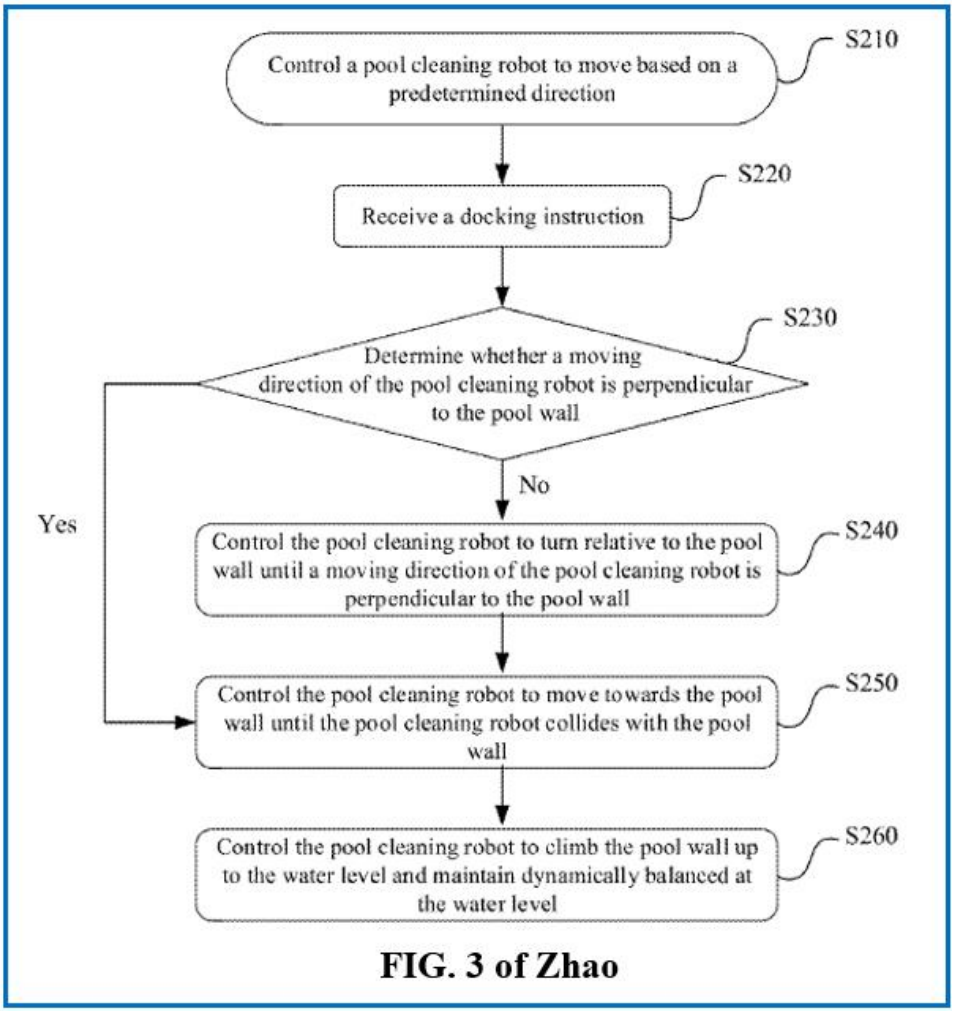


FIG. 3 of Zhao

645. FIG. 3 of **Zhao** is further explained in the specification. *See, e.g.,* **Zhao at 6:42-60**: "As shown in FIG. **3**, embodiments of the present disclosure provide another method of a pool cleaning robot automatically docking, the method includes steps S**210** to S**260**. At S**210**, the pool cleaning robot is controlled to move based on a predetermined direction. At S**220**, a docking instruction is received. At S**230**, **whether the moving direction of the pool cleaning robot is perpendicular to the pool wall is determined**; if yes, proceed to S**250**; if not, proceed to S**240**. At S**240**, the pool cleaning robot is controlled to

turn relative to the pool wall until a moving direction of the pool cleaning robot is perpendicular to the pool wall. At S**250**, **the pool cleaning robot is controlled to move towards the pool wall until the pool cleaning robot collides with the pool wall**. At S**260**, the pool cleaning robot is controlled to **climb the pool wall up to the water level** and maintain dynamically balanced at the water level."

646. **Zhao** further explains that during the climb, the gyroscope and counter are used to record an angle and a rising height (i.e., the positional relationship). Zhao also describes tracking the distance to the water level and the degree of completion as the robot ascends through the underwater, near-water, and stay-at-water-level regions. *See, e.g.,* **Zhao at 8:11-23**: "FIG. 6a to FIG. 6d are schematic diagrams of an interface of a control device coupled with a pool cleaning robot, showing a visual interface of the pool cleaning robot automatically climbing to a water level, according to embodiments of the present disclosure. After the pool cleaning robot 620 receives a docking instruction, the pool cleaning robot 620 docks and **climbs up the pool wall 631**. **A gyroscope and a counter built-in the pool cleaning robot 620 can record an angle and a rising height of the pool cleaning robot**. In FIG. 6a to FIG. 6d, the pool wall 631 is gridded, the dark gray area is a stay area for a water level, the medium gray area is an area near the water level, and the light gray area is an underwater area." *See also,* **Zhao at 8:24-42**: "**A completion degree mark 611 represents the docking completion**

degree calculated according to the moving speed of the pool cleaning robot 620 and a distance between the pool cleaning robot and the water level. Timer 610 represents a remaining time for the docking instruction. For example, in FIG. 6a , the pool cleaning robot 620 is in the underwater area, the timer 610 shows that the remaining time for the docking instruction is 80s, and the docking completion degree is 30%; in FIG. 6b , the pool cleaning robot 620 enters the area near the water level, and the remaining time for the docking instruction is 70s, and the docking completion degree is 70%; in FIG. 6c , the pool cleaning robot 620 enters the stay area for the water level, and the remaining time for the docking instruction is 60s, the docking completion degree is 100%; in FIG. 6d , the pool cleaning robot 620 waits in the stay area for a timeout and retreats to the underwater, the remaining time for the docking command is 0s, and the docking completion degree is 100%."

647. Accordingly, it is my opinion that a POSITA would understand that **Zhao** teaches controlling the waterline detection unit to start detecting the positional relationship in response to the posture meeting a first predetermined condition, where the posture triggers the beginning of the waterline-detection and climbing sequence.

648. It is my opinion that a POSITA would have been motivated to combine **Zhao's** posture-based control logic with **Guo's** buoyancy-controlled

swimming pool robot to improve automation and reliability during wall-climbing and surface-approach operations. **Guo**'s robot can float, dive, and move along pool walls, but it lacks the control coordination to determine precisely *when* to initiate surface detection or buoyancy adjustment. **Zhao** teaches that a change in posture—from horizontal movement along the pool bottom to vertical climbing along the wall—can serve as a reliable trigger for activating subsequent control functions, such as detecting the robot's positional relationship relative to the waterline. Incorporating **Zhao**'s posture-triggered detection into **Guo**'s system would provide logical sequencing for autonomous transitions between underwater navigation, wall climbing, and surface operations, ensuring more stable and efficient waterline approach. The combination represents a predictable and straightforward improvement using well-known components (posture sensing and control sequencing) for their established, complementary purposes.

3. Claim 3: "The controllable sinking and floating swimming pool robot according to claim 1, wherein the operational requirement information comprises remote control command information sent by a user, clock information, operational task progress information, fault information, power information or swimming pool bottom environment information."

649. **Guo**, in view of **Zhao**, discloses that the operational requirement information comprises both remote control command information sent by a user and operational task progress information.

650. **Guo** teaches a structurally complete autonomous pool-cleaning robot designed to perform underwater and surface cleaning through automated buoyancy control. (**Guo at [0019], [0031], [0052]**.) It is my opinion that a POSITA would understand that such a system naturally operates under various control inputs and environmental feedback, such as task progress, timing, and power status, to coordinate its operational stages.

651. **Zhao** provides complementary teachings detailing the types of operational information used for control and feedback. Specifically, Zhao discloses that the pool-cleaning robot is configured to receive user instructions and switch operating modes based on such commands. For example, Zhao teaches that the robot can receive a "docking instruction" transmitted from a user's terminal device through a Wi-Fi communication module. *See, e.g.,* **Zhao at 7:44-55**: **"**The communication unit is configured to allow the **docking locator 150 to communicate with an external device**, and the communication unit includes but is not limited to a wireless-fidelity (Wireless-Fidelity, WI-FI) communication module and a short-range communication module. The docking locator 150 can be coupled with a WI-FI router through a WI-FI communication module, so as to communicate with an external device such as a terminal device. **A terminal device** communicatively coupled with the pool cleaning robot 100 can simultaneously **send a docking instruction to the pool cleaning robot** 100 and a

starting instruction to the docking locator 150." *See also,* **Zhao at 8:6-10**: "**When receiving a docking instruction**, the pool cleaning robot of the present disclosure can automatically find the closest pool wall to dock on without manual intervention. With this method, **convenience is brought to the cleaning work of the user**, possible damage to the pool cleaning robot caused by dragging is avoided as much as possible, and the service life of the pool cleaning robot is improved."

652. **Zhao** also discloses operational task progress information during the execution of the docking process. Specifically, **Zhao** describes a graphical interface that displays real-time information regarding the robot's progress toward completing its docking task, including the remaining time and completion percentage. *See, e.g.,* **Zhao at 8:24-42**: "**A completion degree mark 611 represents the docking completion degree calculated according to the moving speed of the pool cleaning robot 620 and a distance between the pool cleaning robot and the water level**. Timer 610 represents a remaining time for the docking instruction. For example, in FIG. 6a , the pool cleaning robot 620 is in the underwater area, the timer 610 shows that the remaining time for the docking instruction is 80s, and the docking completion degree is 30%; in FIG. 6b , the pool cleaning robot 620 enters the area near the water level, and the remaining time for the docking instruction is 70s, and the docking completion degree is 70%; in FIG.

6c , the pool cleaning robot 620 enters the stay area for the water level, and the remaining time for the docking instruction is 60s, the docking completion degree is 100%; in FIG. 6d , the pool cleaning robot 620 waits in the stay area for a timeout and retreats to the underwater, the remaining time for the docking command is 0s, and the docking completion degree is 100%."

653. In my opinion, a POSITA would have been motivated to integrate **Zhao's** communication and feedback control framework into **Guo's** buoyancy-controlled robot to achieve a fully autonomous and user-interactive cleaning system. **Guo** already provides the mechanical infrastructure—a sealed driving cabin housing the main control unit and power supply—well suited for receiving and processing external control and status data. Incorporating **Zhao**'s user-command interface and task-progress feedback would enable real-time coordination between the robot's mechanical subsystems and user inputs, ensuring fault recovery and operational efficiency. The combination aligns with well-recognized engineering trends toward intelligent, connected pool-cleaning robots and represents a predictable enhancement using established wireless-control and feedback technologies for their intended purposes.

4. Claim 4: "The controllable sinking and floating swimming pool robot according to claim 1, further comprising a distance measurement unit or a map storage unit, wherein the main control unit controls the swimming pool robot to find the nearest side wall or the nearest slope based on

distance measurement results of the distance measurement unit or map data in the map storage unit."

654. **Guo**, in view of **Zhao**, discloses this claim limitation.

655. **Guo** provides the structural foundation for an autonomous swimming pool cleaning robot capable of floating, diving, and moving along both the pool bottom and side walls. (**Guo at [0019], [0031], [0034], [0055]-[0056]**.) As **Guo** explains, the robot's buoyancy-control assembly, including the airbag 121 and inflation/deflation device 122, allows it to navigate freely in three dimensions.

656. In my opinion a POSITA would recognize that, to perform effective wall-cleaning and positional control within a confined pool, the robot's main control unit would require spatial feedback, such as distance or mapping data, to locate and approach the nearest wall or slope.

657. Additionally, **Zhao** provides explicit teachings of such sensing and mapping functions. For example, **Zhao** teaches that the robot body includes a sensor unit with **ultrasonic distance sensors and gyroscopes**, and that based on distance measurement results or **3D map information**, the robot **determines the closest pool wall** relative to its position and enables the robot to move toward that closest pool wall. *See, e.g.,* **Zhao at 4:6-17**: "The sensor unit provided on the pool cleaning robot includes various types of sensors, such as collision sensors, distance sensors, counters, and gyroscopes. The distance sensors can include, for example, **ultrasonic distance sensors**, which can be configured to **measure a distance**

from an obstacle to the ultrasonic distance sensor. The distance sensors can be provided on the front side, back side, right side and left side of the pool cleaning robot. The distance sensor can also be provided on the top of the pool cleaning robot to measure distance by rotating, such that a distance from an obstacle near the pool cleaning robot to the distance sensor can be measured through the distance sensor." *See also,* **Zhao at 4:18-25**: "The inside of the pool cleaning robot is also provided with **a counter** and a gyroscope. The counter is configured to accumulate a total number of rotation angles (or cycles) of the driving wheel of the moving unit, so as to **calculate a distance length that the pool cleaning robot, drove by the driving wheel, have moved**. The gyroscope is configured to measure a rotation angle of the pool cleaning robot, such that a direction of the pool cleaning robot can be determined." *See also,* **Zhao at 7:1-7**: "Before cleaning, a **3D map of the pool has been transmitted to the pool cleaning robot**. According to the data of the gyroscope of the pool cleaning robot, the pool cleaning robot can determine its own position, for example, the pool cleaning robot can determine that the pool cleaning robot is located on the bottom wall of the pool, or on the pool wall of the pool." *See also,* **Zhao at 1:38-42**: "A first aspect of the present disclosure provides a method of automatic docking a pool cleaning robot, the method includes: placing the pool cleaning robot into a pool; upon receiving a docking instruction, **determining a closest pool wall relative to the**

pool cleaning robot, and enabling the pool cleaning robot to move towards the closest pool wall." *See also,* **Zhao at 4:33-40**: "As shown in FIG. 1, in an embodiment of the present disclosure, the method of a pool cleaning robot docking includes steps S110 to S140. At step S110, the pool cleaning robot is placed into the pool. At step S120, after the pool cleaning robot falls on a bottom wall of the pool, **the pool cleaning robot determines a distance between the pool cleaning robot and the pool wall of the pool** while moving on the bottom wall of the pool." *See also,* **Zhao at 4:62-65**: "At step S130, when the pool cleaning robot receives the docking instruction, the pool cleaning robot stops moving, **determines the closest pool wall relative to the pool cleaning robot**, and moves towards the closest pool wall."

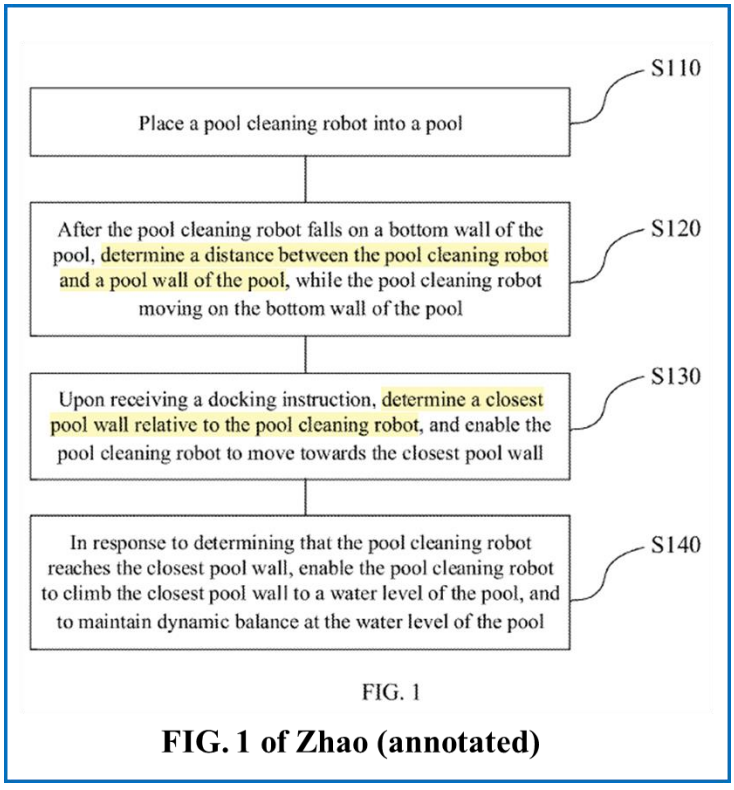


FIG. 1 of Zhao (annotated)

658. Zhao further describes specific aspects of using the robot's sensors to navigate with respect to the closest pool wall, both in determining which wall is closest and how to orient the robot with respect to the closest wall. *See, e.g.,* **Zhao at 6:33-37**: "In practical applications, the pool cleaning robot can stop moving in response to receiving the docking instruction, **rotate in place, and determine the closest pool wall**; or the pool cleaning robot can also turn around during the moving process to find the closest pool wall." *See also,* **Zhao at 7:11-18**: "Based on the pose of the pool cleaning robot determined by the gyroscope of the pool cleaning robot, the pool cleaning robot can use a pool bottom turn mode. When the pool cleaning robot determines that the pool cleaning robot is on the bottom wall of the pool, the pool cleaning robot **combines the data of the rotatable scanning ultrasonic sensor** configured on the top of the pool cleaning robot **to determine the closest route to the pool wall**." *See also,* **Zhao at 7:19-21**: "In the pool bottom turn mode, the pool cleaning robot is **turned to the closest pool wall determined by the rotatable scanning ultrasonic sensor**."

659. It is my opinion that a POSITA would have been motivated to incorporate **Zhao's distance-sensing and mapping logic** into **Guo's buoyancy-controlled robot** to improve its three-dimensional autonomy and precision. **Guo** already enables vertical and lateral movement through airbag-based buoyancy, while **Zhao** provides established control methods for horizontal navigation and

spatial awareness. Integrating **Zhao**'s distance or mapping system would therefore allow **Guo**'s robot to identify the nearest wall or slope based on distance measurements or stored map data, achieving a more intelligent and stable navigation system. This combination represents a predictable, complementary improvement—using well-known sensing and control technologies to enhance the functionality of **Guo**'s buoyancy-driven pool-cleaning robot.

5. Claim 5: "The controllable sinking and floating swimming pool robot according to claim 1, wherein the waterline detection unit comprises an outlet water detection subunit configured to detect whether at least a part of the swimming pool robot has come out of water."

660. **Guo**, in view of **Zhao**, discloses this claim limitation.

661. **Guo** discloses a pool cleaning robot with an autonomous floating and diving assembly, capable of surfacing or diving by controlling air exchange between an internal airbag and a sealed driving cabin. (**Guo at [0031], [0033], [0034]**.) **Guo** further discloses that the swimming pool cleaning robot can be suspended at any position in the water, including the **water surface**, for cleaning operations. (**Guo at Abstract**.)

662. It is my opinion that a POSITA would recognize that, for the robot to maintain stable operation near the waterline and transition between submerged and surface states, the control system would require feedback indicating when the robot begins to emerge from the water. Such feedback could be generated by an **outlet-**

water detection subunit sensing changes in buoyant force, pressure, or sensor readings as the robot crosses the water–air interface.

663. **Zhao** provides complementary teachings consistent with this functionality. Zhao describes that its sensor unit includes "various types of sensors, such as collision sensors, distance sensors, counters, and gyroscopes," which are used to determine the robot's position and operational state. *See e.g.*, **Zhao, 4:6-8**.

664. **Zhao** further teaches that when the robot moves to the waterline, the effects of buoyancy and gravity cause a detectable change in sensor readings, allowing the system to **recognize that the robot has reached the surface**. *See, e.g.,* **Zhao at 8:59-9:4**: "In other embodiments of the present disclosure, the stay area for the water level, the area near to the water level, and the underwater area may not be distinguished. Because **when the pool cleaning robot moves to the water level, due to the effects of buoyancy and gravity, the sensor can sense that the pool cleaning robot has reached the water level**. Therefore, in a simplified embodiment of the present disclosure, when the pool cleaning robot reaches the water level, the pool cleaning robot starts timing. If the user does not lift the pool cleaning robot out of the water within a predetermined time, the automatic docking procedure ends, and the pool cleaning robot retreat to continue cleaning work."

665. This detection relies on the physical principle that **buoyancy and gravity forces change measurably only when an object begins to cross the air–water interface.** When the robot is fully submerged, the buoyant force equals the weight of the displaced water and remains relatively constant. However, as the robot starts to emerge, part of its body displaces less water, reducing the buoyant force while gravity remains constant. The resulting imbalance produces detectable changes in pressure, tilt, or acceleration that can be sensed by Zhao's onboard sensors. A POSITA would understand that this "sensor" detecting the transition from underwater to water level necessarily senses when **a portion of the robot has emerged from the water**.

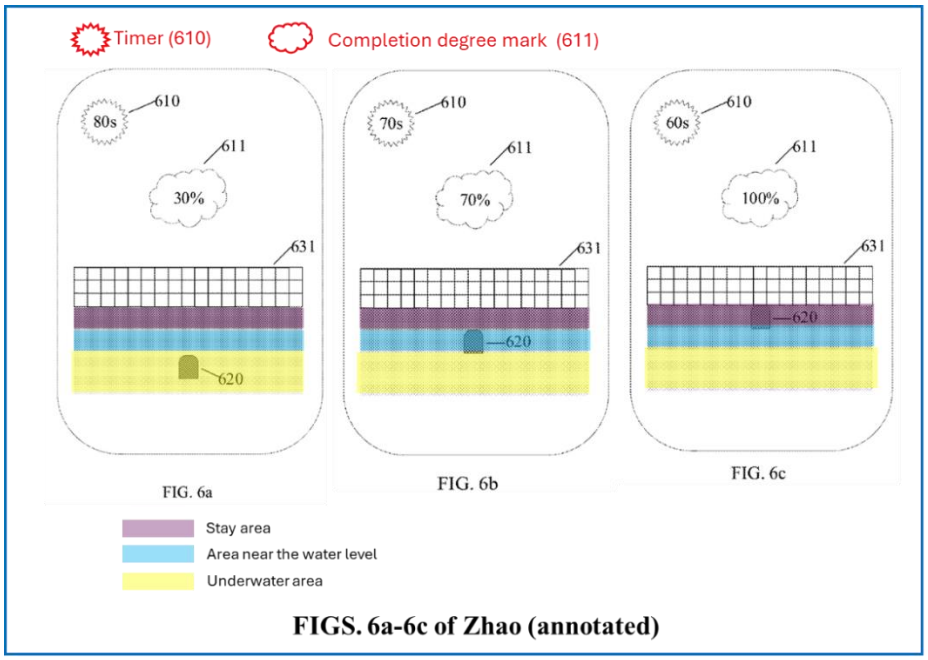
666. In my opinion, a POSITA would therefore understand that **Zhao**'s control logic inherently relies on a sensing function equivalent to an **outlet-water detection subunit**, which detects when at least a portion of the robot has come out of the water. Incorporating such a subunit into **Guo's** buoyancy-controlled system would provide real-time feedback to the main control unit for stabilizing the robot's transition across the air–water interface and maintaining balanced operation at the waterline—a predictable enhancement fully consistent with **Guo**'s design.

6. Claim 6: "The controllable sinking and floating swimming pool robot according to claim 1, wherein the waterline detection unit further comprises a proximity waterline detection subunit configured to detect whether the swimming pool robot has crawled to a distance less than or equal to a predetermined distance from the waterline."

667. **Guo**, in view of **Zhao**, discloses this claim limitation.

668. **Guo** teaches a buoyancy-controlled swimming-pool robot capable of floating, diving, and moving along the pool wall toward the water surface. (**Guo at [0034], [0055]-[0056]**.) To maintain stable operation during its ascent and to transition smoothly into a surface-cleaning or docking state, a POSITA would recognize the need for the control unit to determine when the robot has approached, but not yet reached, the waterline. Detecting proximity to the surface enables timely adjustment of buoyancy and propulsion parameters to prevent overshooting or instability at the waterline.

669. **Zhao** provides explicit teachings for this functionality. Zhao teaches how the robot determines when it is approaching the waterline. Specifically, Zhao discloses using a gyroscope and a counter (i.e., proximity waterline detection subunit) to detect distance and positional data so as to determine whether the robot has reached within a **predetermined distance from the waterline**. For example, Zhao teaches that during wall climbing, the robot's status is displayed as being in an **underwater area, near-water-level area, or stay area at the water level**, and that a completion degree mark is calculated based on the robot's distance from the waterline.



FIGS. 6a-6c of Zhao (annotated)

670. **Zhao** further describes the operation of the robot controller with respect to the water level. *See, e.g.,* **Zhao at 8:11-23**: "FIG. 6a to FIG. 6d are schematic diagrams of an interface of a control device coupled with a pool cleaning robot, showing a visual interface of the pool cleaning robot automatically climbing to a water level, according to embodiments of the present disclosure. After the pool cleaning robot 620 receives a docking instruction, the pool cleaning robot 620 docks and climbs up the pool wall 631. **A gyroscope and a counter built-in the pool cleaning robot 620 can record an angle and a rising height of the pool cleaning robot**. In FIG. 6a to FIG. 6d, the pool wall 631 is gridded, **the dark gray area is a stay area** for a water level, **the medium gray area is an area near the water level, and the light gray area is an underwater area**." *See also,* **Zhao at 8:24-42**: "**A completion degree mark 611 represents the docking**

completion degree calculated according to the moving speed of the pool cleaning robot 620 and a distance between the pool cleaning robot and the water level. Timer 610 represents a remaining time for the docking instruction. For example, in FIG. 6a, the pool cleaning robot 620 is in the **underwater area**, the timer 610 shows that the remaining time for the docking instruction is 80s, and the docking completion degree is 30%; in FIG. 6b , the pool cleaning robot 620 enters the **area near the water level**, and the remaining time for the docking instruction is 70s, and the docking completion degree is 70%; in FIG. 6c , the pool cleaning robot 620 enters the **stay area for the water level**, and the remaining time for the docking instruction is 60s, the docking completion degree is 100%; in FIG. 6d , the pool cleaning robot 620 waits in the stay area for a timeout and retreats to the underwater, the remaining time for the docking command is 0s, and the docking completion degree is 100%."

671. In my opinion, a POSITA would have been motivated to integrate **Zhao**'s gyroscope and counter based proximity-sensing logic into **Guo**'s buoyancy-control framework to improve the robot's ability to approach the surface safely and efficiently. **Guo**'s airbag system enables ascent by increasing buoyancy. Without feedback indicating the remaining distance to the waterline, the robot could over-inflate or lose stability as it nears the surface. **Zhao**'s sensing scheme provides precisely that feedback—real-time distance and angle data during wall

climbing—allowing the controller to moderate inflation and stabilize the robot as it transitions into its surface or docking state. The combination thus addresses a recognized control need in Guo and yields a predictable, reliability-enhancing improvement.

7. Claim 7

a. Element [7a]: "The controllable sinking and floating swimming pool robot according to claim 5, wherein the sinking and floating control unit comprises an inflation and deflation subunit and a switch subunit,"

672. **Guo** discloses this limitation. In one embodiment, Guo teaches that the inflation and deflation device 122 includes **a first pump (i.e., inflation and deflation subunit) with a first valve (i.e., switch subunit) and a second pump (i.e., inflation and deflation subunit) with a second valve (i.e., switch subunit)**. During inflation, the first pump and valve draw gas from the drive cabin 131 into the airbag 121 and during deflation, the second pump and valve release gas from the airbag back to the drive cabin 131. *See, e.g.,* **Guo at [0042]**: "In this embodiment, the inflation/deflation device 122 comprises a first air pump, **a first air valve**, a second air pump, and **a second air valve**. The airbag 121 is connected in sequence to the first air pump and the first air valve via one air tube 123, and to the second air pump and the second air valve via another air tube 123. **When it is necessary to control the swimming pool cleaning robot 100 to ascend, the first air pump and first air valve are activated to draw gas from the driving cabin**

131 into the airbag 121. When it is necessary to control the swimming pool cleaning robot 100 to descend, the second air pump and second air valve are activated to discharge gas from the airbag 121 into the driving cabin 131." *See, e.g.,* **Guo at [0043]**: "By means of the first air pump and first air valve, as well as the second air pump and second air valve, **the amount of gas in the airbag 121 can be precisely controlled**, **thereby enabling accurate control of the ascent and descent of the swimming pool cleaning robot 100**. This ensures the operational stability of the swimming pool cleaning robot 100 and avoids instability caused by uneven gas distribution."

673. In another embodiment, **Guo** discloses that the inflation and deflation device 122 includes a **pump (i.e., inflation and deflation subunit)** and **a check valve (i.e., switch subunit)**, where the pump injects gas into the airbag 121 and the one-way valve allows gas to leave the airbag while preventing reverse flow. *See, e.g.,* **Guo at [0045]**: "In this embodiment, **the inflation/deflation device 122 includes an air pump and a one-way valve**. The airbag 121 is connected to the air pump via one air tube 123 and to the one-way valve via another air tube 123. The one-way valve is configured such that gas can only flow from the airbag 121 into the driving cabin 131. **The air pump is activated to draw gas from the driving cabin 131 into the airbag 121, and the one-way valve is opened to discharge gas from the airbag 121 into the driving cabin 131**." *See also,* **Guo**

at [0046]: "By controlling the switching of the air pump and the one-way valve, inflation and deflation of the airbag 121 can be conveniently achieved. The one-way valve effectively prevents backflow of gas, ensuring unidirectional gas flow. The overall structure is simple and easy to assemble."

674. In yet another embodiment, **Guo** discloses a swimming pool cleaning robot having an inflation and deflation device 122 that includes **a power mechanism (i.e., inflation and deflation subunit)** and **an electromagnetic valve (i.e., switch subunit)**. *See, e.g.,* **Guo at [0048]**: "In this embodiment, the inflation/deflation device 122 comprises a power mechanism, which may be a **peristaltic pump, a gear pump, or a Roots blower.** The airbag 121 is connected to the power mechanism, which is capable of rotating in both forward and reverse directions. **When it is necessary to control the swimming pool cleaning robot 100 to ascend, the power mechanism rotates forward, causing gas from the driving cabin 131 to be injected into the airbag 121. When it is necessary to control the swimming pool cleaning robot 100 to dive, the power mechanism rotates in reverse, causing the gas in the airbag 121 to be discharged into the driving cabin 131**." *See, e.g.,* **Guo at [0049]**: "To further enhance the sealing performance of the driving cabin 131, in this embodiment, the inflation/deflation **device 122 further comprises a solenoid valve** connected to the power mechanism. When the power mechanism is operating, the solenoid valve is open;

when the power mechanism is not operating, the solenoid valve is closed, thereby ensuring better sealing of the driving cabin 131." *See also,* **Guo at [0050]**: "Since the **power mechanism can rotate in both forward and reverse directions, it allows for flexible control of the gas flow direction**, meeting the control requirements for both ascending and diving. **The linkage between the solenoid valve and the power mechanism ensures the stability and accuracy of gas flow, preventing errors and instability caused by sealing issues**."

b. Element [7b]: "wherein in response to the outlet water detection subunit detecting that at least a part of the swimming pool robot has come out of the water, the inflation and deflation subunit is controlled to start sucking air and the switch subunit is controlled to open, so that the sinking and floating control unit enters the floating working state."

675. **Guo**, in view of **Zhao**, discloses this limitation.

676. **Guo** provides a buoyancy-controlled swimming-pool cleaning robot that regulates ascent and descent through an inflation and deflation subunit (pumps) and a switch subunit (valves) configured to transfer air between a sealed driving cabin and an airbag. *See, e.g.,* **Guo at [0041]-[0050]**. When surfacing, the system draws gas from the driving cabin into the airbag to increase buoyancy, and when diving, it reverses the process to submerge. (**Guo at [0034]**.) A POSITA would understand that for the robot to achieve stable flotation at the waterline, the

control unit must activate inflation and valve operation in response to feedback indicating that the robot has begun to emerge from the water.

677. **Zhao** provides the corresponding detection mechanism. As discussed for claim 5 above, **Zhao** describes that the robot's sensors can detect when the robot reaches the water level and partially emerges from the surface. *See, e.g.*, **Zhao at 8:59-9:9**.

678. In my opinion, a POSITA would understand that this detection of a buoyancy/gravity transition—physically corresponding to part of the robot breaking the water surface—signals that the robot has begun to float. A POSITA would recognize that such a detection event provides the ideal trigger for activating Guo's inflation and valve-control system—initiating air intake and valve opening precisely when partial emergence is detected—to stabilize the robot in its floating working state.

679. The motivation to combine arises directly from established control-system design principles. **Guo** supplies the structural actuators that control buoyancy, while **Zhao** supplies a clearly defined sensor-based detection event indicating transition from submerged to surface conditions. Integrating **Zhao**'s detection logic with **Guo**'s buoyancy mechanism would enable closed-loop, event-driven control—automatically initiating air intake and valve opening in response to the detected emergence—to maintain the robot's desired position at the waterline.

680. Implementing this control relationship would have been straightforward and predictable for a POSITA. The robot's controller could use the sensor signal described by **Zhao** ("sensing that the robot has reached the water level") as the trigger to start **Guo**'s inflation/deflation pump and open the valve, causing the robot to enter and stabilize in the floating working state. Such event-driven control is standard in mechatronic and submersible systems, where sensor feedback directly triggers actuator commands to maintain desired buoyancy and stability.

681. Accordingly, **Guo** in view of **Zhao** teaches, or at minimum renders obvious, the limitation that "in response to the outlet water detection subunit detecting that at least a part of the swimming pool robot has come out of the water, the inflation and deflation subunit is controlled to start sucking air and the switch subunit is controlled to open, so that the sinking and floating control unit enters the floating working state."

8. Claim 8

a. Element [8a]: "The controllable sinking and floating swimming pool robot according to claim 5, wherein the sinking and floating control unit comprises an inflation and deflation subunit and a switch subunit,"

682. Based on exemplary disclosures for limitation [7a] above, it is my opinion that **Guo** discloses this limitation.

b. Element [8b]: "wherein in response to the proximity waterline detection subunit detecting that the

swimming pool robot has crawled to the distance less than or equal to the predetermined distance from the waterline, the inflation and deflation subunit is controlled to start sucking air,"

683. **Guo,** in view of **Zhao**, discloses this limitation.

684. **Guo** teaches a buoyancy-controlled pool-cleaning robot capable of floating, diving, and remaining suspended at any position in the water. (**Guo at Abstract; [0034]; [0055]-[0056]**.) Guo teaches a **floating and diving assembly** in which the airbag is connected to a sealed **driving cabin** that serves as an internal gas source. The inflation/deflation device 122, located inside the sealed cabin 131, draws air from the cabin into the airbag to cause the robot to float, and discharges air back into the cabin to cause it to sink.

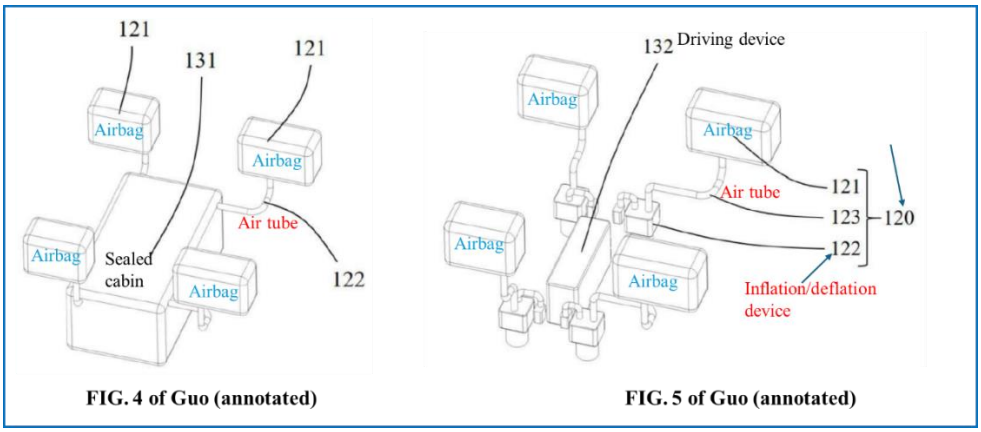


FIG. 4 of Guo (annotated)

FIG. 5 of Guo (annotated)

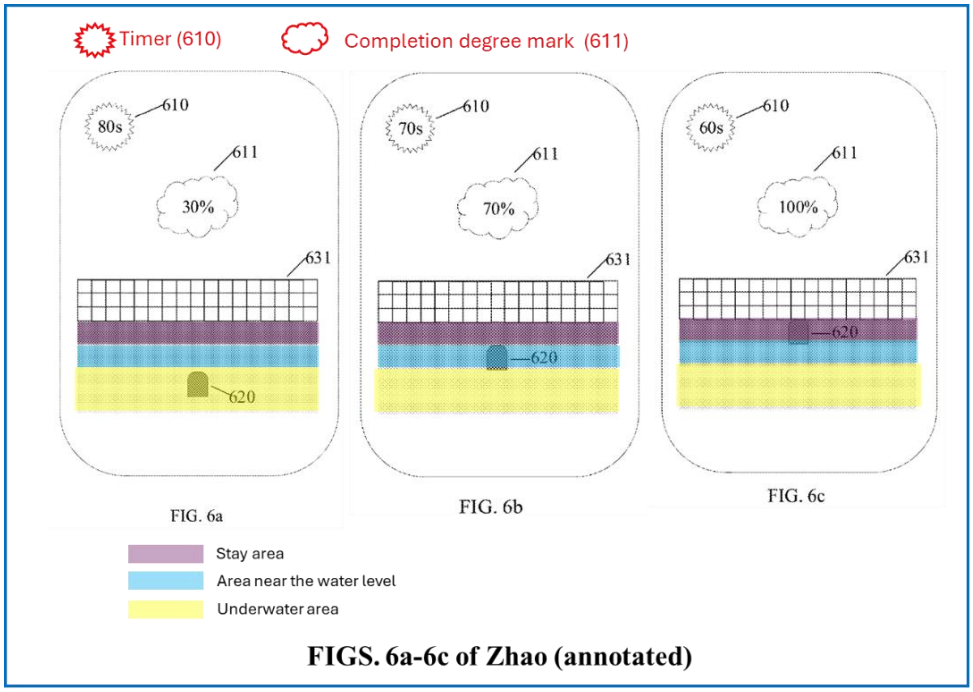
685. Operation of the driving cabin is described in greater detail in the specification. *See, e.g.*, **Guo at [0034]:** "In the swimming pool cleaning robot 100 of the present disclosure, **the airbag 121 is connected to the driving cabin 131 via the inflation/deflation device 122, and the driving cabin 131 of the swimming pool cleaning robot 100 serves as the gas source for the floating and**

diving assembly 120. When it is necessary to control the robot 100 to surface**,** the **inflation/deflation device 122 draws gas from the driving cabin 131 into the airbag 121**. When it is necessary to control the robot 100 to dive, **the inflation/deflation device 122 discharges gas from the airbag 121 into the driving cabin 131**. In this way, the robot 100 can be made to surface or dive as required. At the same time, since the driving cabin 131 also serves as the compartment for installing the driving assembly 130, there is no need to occupy additional space within the housing 110, resulting in a more compact overall layout, a smaller overall size, improved flexibility, and reduced manufacturing costs for the swimming pool cleaning robot 100."

686. Because the gas is circulated internally within the sealed structure, **Guo**'s design allows the robot to begin inflating its airbag **before any portion of the robot emerges from the water**, relying entirely on internal pressure transfer rather than external air intake. A POSITA would recognize that this internal gas-exchange architecture provides the precise mechanism needed to implement the control behavior—enabling the robot to initiate an increase in buoyancy as the robot is close to the waterline, without waiting for exposure to atmospheric air.

687. **Zhao** provides the complementary sensing logic for initiating this inflation sequence. **Zhao** discloses using a gyroscope and a counter (i.e., waterline detection unit) to detect distance and positional data so as to determine whether the

robot has reached within a **predetermined distance from the waterline**. For example, **Zhao** teaches that during wall climbing, the robot's status is displayed as being in an **underwater area, near-water-level area, or stay area at the water level**, and that a completion degree mark is calculated based on the robot's distance from the waterline.



FIGS. 6a-6c of Zhao (annotated)

688. **Zhao** further describes the operation of the robot controller with respect to the water level. *See, e.g.,* **Zhao at 8:11-23**: "FIG. 6a to FIG. 6d are schematic diagrams of an interface of a control device coupled with a pool cleaning robot, showing a visual interface of the pool cleaning robot automatically climbing to a water level, according to embodiments of the present disclosure. After the pool cleaning robot 620 receives a docking instruction, the pool cleaning

robot 620 docks and climbs up the pool wall 631. **A gyroscope and a counter built-in the pool cleaning robot 620 can record an angle and a rising height of the pool cleaning robot**. In FIG. 6a to FIG. 6d, the pool wall 631 is gridded, **the dark gray area is a stay area** for a water level, **the medium gray area is an area near the water level**, **and the light gray area is an underwater area**." *See also,* **Zhao at 8:24-42**: "**A completion degree mark 611 represents the docking completion degree calculated according to the moving speed of the pool cleaning robot 620 and a distance between the pool cleaning robot and the water level**. Timer 610 represents a remaining time for the docking instruction. For example, in FIG. 6a , the pool cleaning robot 620 is in the **underwater area**, the timer 610 shows that the remaining time for the docking instruction is 80s, and the docking completion degree is 30%; in FIG. 6b , the pool cleaning robot 620 enters the **area near the water level**, and the remaining time for the docking instruction is 70s, and the docking completion degree is 70%; in FIG. 6c , the pool cleaning robot 620 enters the **stay area for the water level**, and the remaining time for the docking instruction is 60s, the docking completion degree is 100%; in FIG. 6d , the pool cleaning robot 620 waits in the stay area for a timeout and retreats to the underwater, the remaining time for the docking command is 0s, and the docking completion degree is 100%."

689. In my opinion, a POSITA would understand that this sensor feedback provides a natural control signal for adjusting buoyancy as the robot transitions from the underwater region to the near-surface zone. A POSITA would understand that, in this transition zone, the robot's mechanical traction alone becomes less effective because the buoyant force begins to offset part of the robot's weight, reducing the normal force against the pool wall and thus decreasing grip and propulsion efficiency. To ensure the robot continues ascending smoothly and stabilizes at the waterline, the controller must compensate for reduced traction by increasing buoyancy, such as by **activating the inflation mechanism to draw air into the airbag.**

690. Integrating **Zhao**'s proximity-based detection logic into **Guo**'s buoyancy-control system would enable the main control unit to **initiate air transfer** precisely when the robot is detected to be within a short distance of the waterline. This timing allows buoyant lift to assist the final stage of the ascent, ensuring a smooth and stable approach to the surface. The motivation to combine arises from standard control-system design principles: **Zhao** provides the **sensor-based trigger condition** for starting inflation, while **Guo** provides the **closed-system structure** that allows inflation to occur immediately upon detection. A POSITA would view this integration as an obvious, functionally complementary improvement that enhances stability and efficiency during ascent, yielding a

predictable and practical implementation of the limitation: "in response to the proximity waterline detection subunit detecting that the swimming pool robot has crawled to the distance less than or equal to the predetermined distance from the waterline, the inflation and deflation subunit is controlled to start sucking air."

c. Element [8c]: "and in response to the outlet water detection subunit detecting that at least a part of the swimming pool robot has come out of the water, the switch subunit is controlled to open, so that the sinking and floating control unit enters the floating working state."

691. Based on exemplary disclosures for limitation [7b] above, it is my opinion that **Guo** in view of **Zhao** discloses this limitation.

9. Claim 10: "The controllable sinking and floating swimming pool robot according to claim 1, wherein the main control unit is further capable of controlling the sinking and floating control unit to enter a sinking working state based on the operational requirement information of the swimming pool robot to realize a sinking of the swimming pool robot."

692. **Guo**, in view of **Zhao**, discloses this claim limitation.

693. **Zhao** explains that the main controller of the pool-cleaning robot directs it to submerge after a predetermined period at the water surface, in response to a timing or control condition. *See, e.g.,* **Zhao at 6:25-32**: "Maintaining dynamic balance at the water level can include **sensing that the pool cleaning robot reaches the water level through sensors**, the pool cleaning robot staying and timing; when the pool cleaning robot stays for more than a predetermined time

period, the timing is stopped and the pool cleaning robot moves to underwater, but the present disclosure is not limited thereto."

694. Similarly, **Zhao** explains that after the robot has reached the water level and started timing, if the user does not retrieve it within a predetermined time, "*the automatic docking procedure ends, and the pool cleaning robot retreats to continue cleaning work.*" **Zhao at 8:59-9:9**.

695. In my opinion, a POSITA would understand that this "predetermined time" or "timing" represents **clock information**, which is one form of the "operational requirement information" described in claim 3 of the '196 Patent. Based on this timing condition, the robot's main control logic directs the buoyancy system to terminate the floating phase and initiate sinking.

696. While **Zhao** clearly discloses the control behavior for submerging, it does not specify the underlying hardware configuration that enables buoyancy reduction.

697. **Guo** provides an explicit embodiment of a floating and diving assembly 120 (i.e., sinking and floating control unit) - an airbag 121 connected to an inflation/deflation device 122 - that performs the floating and **sinking** functions. Guo explains that to submerge the robot, the air valve (switch subunit) and the air pump (inflation/deflation subunit) are active to discharges gas from the airbag back into the sealed driving cabin, thereby reducing buoyancy and causing the robot to

sink. *See, e.g.,* **Guo at [0042]**: "In this embodiment, the inflation/deflation device 122 comprises **a first air pump, a first air valve, a second air pump, and a second air valve**. The airbag 121 is connected in sequence to the first air pump and the first air valve via one air tube 123, and to the second air pump and the second air valve via another air tube 123. When it is necessary to control the swimming pool cleaning robot 100 to ascend, the first air pump and first air valve are activated to draw gas from the driving cabin 131 into the airbag 121. **When it is necessary to control the swimming pool cleaning robot 100 to descend, the second air pump and second air valve are activated to discharge gas from the airbag 121 into the driving cabin 131.**"

698. In my opinion, a POSITA would recognize that **Zhao**'s **timing-based control signal** provides the necessary operational trigger, and **Guo**'s **airbag and pump/valve-based subsystem** provides the structure for executing that command. Combining **Zhao**'s control logic with **Guo**'s pneumatic architecture would allow the controller to automatically activate the deflation mechanism (opening the valve and operating the pump) once the timing interval expires, thereby transitioning the system into the sinking working state.

10. Claim 11: "The controllable sinking and floating swimming pool robot according to claim 10, wherein the sinking and floating control unit comprises an inflation and deflation subunit, a switch subunit and an airbag subunit connected to the inflation and deflation subunit, controlling the sinking and floating control unit to enter the sinking

working state comprises controlling the switch subunit to open and controlling the inflation and deflation subunit to discharge air in the airbag subunit."

699. **Guo** discloses this claim limitation. As discussed for claim 7 above, **Guo** discloses that the sinking and floating control unit comprises an inflation and deflation subunit, a switch subunit, and an airbag subunit connected to the inflation and deflation subunit.

700. **Guo** further discloses that entering the sinking working state requires opening a valve (switch subunit) and actuating a pump (inflation and deflation subunit) to discharge air from the airbag. Specifically, Guo teaches a second pump and a second valve that operate together to expel air from the airbag into the drive cabin. *See, e.g.,* **Guo at [0042]**: "In this embodiment, the inflation/deflation device 122 comprises a first air pump, a first air valve, **a second air pump, and a second air valve**. The airbag 121 is connected in sequence to the first air pump and the first air valve via one air tube 123, and to the second air pump and the second air valve via another air tube 123. When it is necessary to control the swimming pool cleaning robot 100 to ascend, the first air pump and first air valve are activated to draw gas from the driving cabin 131 into the airbag 121. **When it is necessary to control the swimming pool cleaning robot 100 to descend, the second air pump and second air valve are activated to discharge gas from the airbag 121 into the driving cabin 131.**"

11. Claim 12: "The controllable sinking and floating swimming pool robot according to claim 7, wherein the inflation and deflation subunit comprises an air pump assembly, and the switch subunit comprises an electromagnetic valve assembly or a two-position three-way valve assembly."

701. **Guo** discloses this claim limitation. **Guo** discloses specific types of components that constitute the inflation/deflation device 122 (inflation and deflation subunit), including a power mechanism being one of a **peristaltic pump**, a **gear pump** or a **Roots blower** (i.e., an air pump assembly) and an **electromagnetic valve** (i.e., switch subunit). *See, e.g.,* **Guo at [0048]**: "In this embodiment, the inflation/deflation device 122 comprises a power mechanism, which may be a **peristaltic pump, a gear pump, or a Roots blower**. The airbag 121 is connected to the power mechanism, which is capable of rotating in both forward and reverse directions. When it is necessary to control the swimming pool cleaning robot 100 to ascend, the power mechanism rotates forward, causing gas from the driving cabin 131 to be injected into the airbag 121. When it is necessary to control the swimming pool cleaning robot 100 to dive, the power mechanism rotates in reverse, causing the gas in the airbag 121 to be discharged into the driving cabin 131." *See also,* **Guo at [0049]**: "To further enhance the sealing performance of the driving cabin 131, in this embodiment, the **inflation/deflation device 122 further comprises a solenoid valve connected to the power mechanism**. **When the power mechanism is operating, the solenoid valve is**

open; when the power mechanism is not operating, the solenoid valve is closed, thereby ensuring better sealing of the driving cabin 131."

12. Claim 13: "The controllable sinking and floating swimming pool robot according to claim 7, wherein in response to the outlet water detection subunit detecting that at least a part of the swimming pool robot enters underwater again and/or the posture detection unit detecting that the posture of the swimming pool robot meets a second predetermined condition, the inflation and deflation subunit and the switch subunit are controlled to be closed."

702. The '196 Patent provides that a "second predetermined condition" could be "changing from a state parallel to the side wall of the swimming pool to a state parallel to the bottom surface of the swimming pool." ('196 Patent, at 9:43-46.)

703. **Guo**, in view of **Zhao** and **Owen**, discloses this claim limitation.

704. **Guo** teaches a buoyancy-controlled swimming-pool cleaning robot that uses an airbag 121 and inflation/deflation device 122 located within a sealed driving cabin to regulate ascent and descent by transferring air between the airbag and the cabin. (**Guo at [0031]-[0034], [0041]-[0042]**.) When surfacing, the pumps and valves are activated to move gas into the airbag, and when descending, they discharge gas back into the cabin. Guo also notes that the airbag is made of flexible material and includes a protective cover to prevent damage from excessive pressure. (**Guo at [0037]**.)

705. In my opinion, a POSITA would recognize that, once the robot has reached the floating working state (i.e., buoyancy exceeds gravity and the robot is floating on the water surface), continued inflation would be unnecessary and potentially harmful. It would therefore be obvious to stop the inflation/deflation device after a predetermined time or condition to prevent overinflation.

706. **Owen** provides an established solution for such automatic control. Owen teaches using a timer circuit, an integrated chip, or a timer switch to allow a pump to run for a set period of time and then automatically shut off. *See, e.g.,* **Owen at 3, 19-28**: "In one embodiment, a circuit board (not shown), or an integrated chip (not shown) that serves as a **timer** is mounted to such a circuit board, **is provided to control the pump**. The circuit board or chip is programmed to **allow the pump to run for a set period of time after it is activated**. For example, in one type of inflatable mattress 12, it may take 60 seconds to adequately inflate the mattress 12. In this case, **the circuit board is programmed to run the pump for at least 60 seconds before shutting it off**. The circuit board may also be programmed to include a buffer to make sure that the inflatable mattress 12 is adequately inflated. In the above example, the circuit board or chip could be programmed to operate the pump for 70 seconds to assure adequate inflation." *See also,* **Owen at 4, 7-10**: "Alternatively, instead of the circuit board, a mechanism such as a timer switch (not shown) could be used to automatically shut

off the pump. If such a timer switch is used, **the switch can be set to allow the pump to run for a set period of time once it is activated**, in the same fashion as the circuit board already described." *See also,* **Owen at 4, 20-26**: "In yet another embodiment, a combination of a circuit board and/or **an integrated circuit (IC) chip may be used as a timing circuit along with a pressure sensor to provide the timing signal that indicates when terminate pumping**. The IC chip may include a controlled switch (not shown) in electrical communication with the pressure sensor, wherein the controlled switch is triggered by signals from the pressure sensor that include threshold pressures, which indicate when the pump is done pumping and should be automatically turned off."

707. These mechanisms ensure precise control of inflation duration and protect inflatable systems from damage caused by continuous operation.

708. In my opinion, a POSITA would find **Owen**'s control logic readily adaptable to **Guo**'s airbag system to automatically close both the pump and valve after a defined interval or pressure condition. **Zhao** provides complementary control logic identifying the condition that triggers this shutoff. **Zhao** teaches that the pool cleaning robot determines its posture—specifically, whether it is located on the **side wall** or the **bottom wall** of the pool—based on gyroscope data. *See, e.g.,* **Zhao at 7:1-7**: "Before cleaning, a 3D map of the pool has been transmitted to the pool cleaning robot. **According to the data of the gyroscope of the pool**

cleaning robot, the pool cleaning robot can determine its own position, for example, the pool cleaning robot can determine that the pool cleaning robot is **located on the bottom wall of the pool**, or **on the pool wall of the pool**."

709. This posture feedback enables the controller to recognize the robot has entered floating working state by detecting that the robot transitions from a vertical climbing orientation to a horizontal cleaning orientation (i.e., second predetermined condition).

710. In my opinion, a POSITA would have been motivated to integrate these teachings into a unified control system. **Zhao**'s posture sensing provides the event trigger indicating that the robot has completed its ascent and reoriented horizontally; **Guo** provides the buoyancy-control structure (airbag, pumps, valves) that performs the actual inflation and deflation; and **Owen** provides the timing and pressure-based logic that ensures the system automatically shuts off once the second condition is met.

711. The combination would predictably yield a fully automated buoyancy-control mechanism that stops inflation when the robot transitions into its horizontal cleaning posture, preventing over-inflation and enhancing operational stability. This represents a straightforward and functionally complementary improvement using well-understood control and sensing techniques.

712. Accordingly, **Guo**, in view of **Zhao** and **Owen**, discloses, or at least renders obvious, that "in response to the outlet water detection subunit detecting that at least a part of the swimming pool robot enters underwater again and/or the posture detection unit detecting that the posture of the swimming pool robot meets a second predetermined condition, the inflation and deflation subunit and the switch subunit are controlled to be closed."

13. Claim 15

a. Element [15pre]: "A sinking and floating control method for a swimming pool robot, comprising:"

713. Based on exemplary disclosures for limitation [1pre] above, it is my opinion that **Guo** discloses a sinking and floating control method for a swimming pool robot.

b. Element [15a]: "controlling a swimming pool robot to find a side wall or a slope based on operational requirement information of the swimming pool robot, and enabling the swimming pool robot to crawl along the side wall or the slope;"

714. Based on exemplary disclosures for limitation [1d] above, it is my opinion that **Guo**, in view of **Zhao**, discloses controlling a swimming pool robot to find a side wall or a slope based on operational requirement information of the swimming pool robot, and enabling the swimming pool robot to crawl along the side wall or the slope.

c. Element [15b]: "detecting a positional relationship between the swimming pool robot and a waterline of a

liquid surface of a swimming pool where the swimming pool robot is located;"

715. Based on exemplary disclosures for limitation [1e] above, it is my opinion that **Guo**, in view of **Zhao**, discloses detecting a positional relationship between the swimming pool robot and a waterline of a liquid surface of a swimming pool where the swimming pool robot is located.

d. Element [15c]: "controlling a sinking and floating control unit to enter a floating working state based on detection results to realize a floating of the swimming pool robot; and"

716. Based on exemplary disclosures for limitation [1f] above, it is my opinion that **Guo**, in view of **Zhao**, discloses controlling a sinking and floating control unit to enter a floating working state based on detection results to realize a floating of the swimming pool robot.

e. Element [15d]: "controlling the sinking and floating control unit to stop working after the sinking and floating control unit enters the floating working state for a predetermined time."

717. Based on exemplary disclosures for limitation [1g] above, it is my opinion that **Guo**, in view of **Zhao** and **Owen**, discloses controlling the sinking and floating control unit to stop working after the sinking and floating control unit enters the floating working state for a predetermined time.

14. Claim 16: "The sinking and floating control method for the swimming pool robot according to claim 15, wherein detecting the positional relationship between the swimming pool robot and the waterline of the liquid surface of the

swimming pool where the swimming pool robot is located comprises: starting detecting the positional relationship in response to a posture of the swimming pool robot meeting a first predetermined condition."

718. Based on exemplary disclosures for claim 2, it is my opinion that **Guo**, in view of **Zhao**, discloses detecting the positional relationship between the swimming pool robot and the waterline of the liquid surface of the swimming pool where the swimming pool robot is located comprises: starting detecting the positional relationship in response to a posture of the swimming pool robot meeting a first predetermined condition.

15. Claim 17: "The sinking and floating control method for the swimming pool robot according to claim 16, wherein the operational requirement information comprises remote control command information sent by a user, clock information, operational task progress information, fault information, power information or swimming pool bottom environment information."

719. Based on exemplary disclosures for claim 3 above, it is my opinion that **Guo**, in view of **Zhao**, discloses the operational requirement information comprises remote control command information sent by a user, clock information, operational task progress information, fault information, power information or swimming pool bottom environment information.

16. Claim 18: "The sinking and floating control method for the swimming pool robot according to claim 17, wherein controlling the sinking and floating control unit to enter the floating working state based on detection results to realize the floating of the swimming pool robot comprises: controlling the sinking and floating control unit to enter the

floating working state in response to detecting that at least a part of the swimming pool robot has come out of water."

720. Based on exemplary disclosures for claim 7 above, it is my opinion that **Guo**, in view of **Zhao**, discloses controlling the sinking and floating control unit to enter the floating working state based on detection results to realize the floating of the swimming pool robot comprises: controlling the sinking and floating control unit to enter the floating working state in response to detecting that at least a part of the swimming pool robot has come out of water.

17. Claim 19: "The sinking and floating control method for the swimming pool robot according to claim 17, further comprising: controlling the sinking and floating control unit to stop working in response to detecting that at least a part of the swimming pool robot enters underwater again and/or detecting that the posture of the swimming pool robot meets a second predetermined condition."

721. Based on exemplary disclosures for claim 13 above, it is my opinion that **Guo**, in view of **Zhao** and **Owen**, discloses controlling the sinking and floating control unit to stop working in response to detecting that at least a part of the swimming pool robot enters underwater again and/or detecting that the posture of the swimming pool robot meets a second predetermined condition.

722. For the foregoing reasons, it is my opinion that all the claims of the '196 Patent are unpatentable. I have not seen any evidence of secondary considerations related to the '196 Patent, including the commercial success of products that practice the patent, the long-felt need for the patented technology, the

failure of others to solve the problem addressed by the patent, initial skepticism by others in the industry, industry recognition and praise of the patented products, and efforts by others to copy the patented technology. I reserve the right to rebut any secondary considerations related to the ’196 Patent presented by the patentee.

IX. DECLARATION

723. In signing this Declaration, I understand it will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I understand I may be subject to cross-examination in this case, and that any cross-examination will take place in the United States. If cross-examination is required of me, I will appear for cross-examination within the United States during the time allotted for cross-examination.

724. I declare that all statements made herein of my knowledge are true and that all statements made on information and belief are believed to be true; and further, that these statements were made with knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. § 1001.

725. I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct.

Executed on this 5th day of November 2025.

By: 

Dr. Noah J. Cowan