

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

GOOGLE LLC

Petitioner

v.

DDC TECHNOLOGY, LLC,

Patent Owner

U.S. Patent No. 11,093,000

Case No.: IPR2023-00710

DECLARATION OF KURTIS P. KELLER

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I, Kurtis P. Keller, of Hillsborough, North Carolina, declare as follows:

I. INTRODUCTION AND SCOPE OF WORK

1. I have been retained by Google LLC (“Google” or “Petitioner”) in the above-captioned *Inter Partes* Review (IPR) as an independent expert in the fields of head-mounted displays and touchscreen technology.

2. I have been asked to provide my independent analysis regarding U.S. Patent No. 11,093,000 (“the ’000 patent”), which I understand is assigned to DDC Technology, LLC (“Patent Owner”). I have been asked to consider what one of ordinary skill in the art before the priority date would have understood, including scientific and technical knowledge related to the subject matter of the ’000 patent.

3. I have also been asked to provide my opinions regarding whether claims 1-6 and 8-33 of the ’000 patent (“challenged claims”) are patentable in view of various prior art. Specifically, I have been asked whether the challenged claims would be anticipated or rendered obvious to a person having ordinary skill in the art at the time of the alleged invention (“POSA”) in view of Kondo (JP3176588). I have also been asked whether claims 1-6, 8-16, and 18-33 are rendered obvious in view of Kondo and Chu (US 2013/0082963). Both Kondo and Chu were provided to me by Google LLC.

4. My analysis is directed by my education, training, and experience as a POSA at the time of the alleged invention of each claim.

5. For the purposes of my engagement, I have been asked to assume that the date of the alleged invention is July 16, 2014. However, I have not considered, nor have I been asked to consider, whether this priority date is correct with respect to any claims.

6. I am being compensated for my work in connection with this IPR at my standard hourly rate. My compensation is not in any way contingent on the substance of my opinions or the outcome of these proceedings.

II. SUMMARY OF OPINIONS

7. Based on my experience and expertise, discussed below, and my review of the references provided to me, it is my opinion that all challenged claims are invalid as (1) anticipated by Kondo and (2) obvious in view of Kondo. It is also my opinion that claims 1-6, 8-16, and 18-33 are obvious in view of Kondo and Chu.

III. BACKGROUND AND QUALIFICATIONS

8. I am a Research Engineer for the Computer Science Department at the University of North Carolina at Chapel Hill where I have worked for over 25 years, primarily in the mechanical/optical design of Head-Mounted Displays and other Virtual and Augmented Reality hardware/systems. I have designed or co-designed at least twelve Head-Mounted Displays (“HMDs”), evaluated many and modified

many more, and purchased/commercial or military ones for special applications. I am currently part-time at the University of North Carolina.

9. I am one of three founders of a 3D computer-assisted medical device company, InnerOptic Technology, Inc., located in Hillsborough, NC and am the COO and mechanical engineer for the company. Our first products designed and sold were Augmented Reality Head Mounted Displays for medical research use. We currently are developing software and hardware for HMDs to assist in direct human surgery.

10. My C.V. is attached as Appendix A hereto. My educational background includes an M.S. in Integrated Manufacturing Systems Engineering from North Carolina State University and a B.S. in Mechanical Engineering, from North Carolina State University. I have been involved in designing and implementing advanced electro-mechanical systems since 1988 and Head-Mounted Displays (“HMDs”) since 1992. Most of the HMD designs were at UNC Chapel Hill’s Computer Science Department in the effort to advance the art and provide innovative hardware for the graduate students and researchers to support their research efforts in Virtual and Augmented Reality. This development also included assisting designing and building of associated custom tracker systems and custom graphic computers.

11. Head-Mounted Display development includes Narrow Field of View (medical and detail work), Wide Field of View (full immersion), and augmented reality video and optical see-through systems. Particular systems include a very wide field of view HMD unit with six tiled displays per eye, a \$1.4 million one-off design, simple two and three-per-eye tiled displays, gesture tracking HMDs, integrated tracker HMDs, and medical and surgical HMDs, including the HMD used for the very first augmented reality surgery. I have been directly involved in the conception, specifications, design, build, and manufacture of HMDs since 1992. This includes the mechanical, electrical, optical and integration aspects. I have been continuously designing or customizing HMDs and optical systems since 1992 and personally have multiple HMDs of my own at home.

12. I have been directly involved in the marketing and sales of commercial Head-Mounted Displays.

13. I have been an expert witness on ten different patents previously, including writing expert declarations and being deposed for testimony.

14. I am an inventor on at least twelve issued U.S. patents. Most of them deal with integration of computer-assisted augmented reality surgery displays, content and other 3D-tracked display modalities, some with Head-Mounted Displays.

- 9,792,715, “Methods, systems, and computer readable media for utilizing synthetic animatronics”
- 9,675,319, “Loupe Display”
- 9,659,345, “System and method of providing real-time dynamic imagery of a medical procedure site using multiple modalities”
- 9,282,947, “Imager focusing based on intraoperative data”
- 8,690,776, “Systems, methods, apparatuses, and computer-readable media for image guided surgery”
- 8,585,598, “Systems, methods, apparatuses, and computer-readable media for image guided surgery”
- 8,482,606, “System and method of providing real-time dynamic imagery of a medical procedure site using multiple modalities”
- 8,350,902, “System and method of providing real-time dynamic imagery of a medical procedure site using multiple modalities”
- 8,152,305, “Methods, systems, and computer program products for full spectrum projection”
- 7,728,868, “System and method of providing real-time dynamic imagery of a medical procedure site using multiple modalities”
- 7,385,708, “Methods and systems for laser based real-time structured light depth extraction”

- 6,503,195, “Methods and systems for real-time structured Light”

I also have several currently pending patent applications.

IV. LEGAL STANDARDS

15. In preparing my analysis, I have applied the legal standards described below, which were provided to me by counsel for the Petitioner. I have been provided with an understanding of the legal standards sufficient to conduct the analysis given in this declaration.

16. It is my understanding that assessing the validity of a U.S. patent based on a prior art analysis requires two steps. First, one must construe the terms of the patent claims to understand what meaning one of ordinary skill in the art would give the terms. Second, after the claim terms have been construed, one may then assess validity by comparing a patent claim to the “prior art.” I understand that the teaching of the prior art is viewed through the eyes of a person of ordinary skill in the art at the time the invention was made. My opinion as to what constitutes a relevant person of ordinary skill in the art is set forth below.

A. CLAIM INTERPRETATION

17. In the present proceeding, I have been advised that the claims are to be construed in the same way they would be in district court, which I understand is called the *Phillips* standard. I have been informed as follows about the standard:

Claim construction begins with the language of the claims. The words of a claim are generally given their ordinary and customary meaning, which is the meaning that the term would have to a person of ordinary skill in the art in question at the time of the invention, i.e., as of the effective filing date of the patent application. The specification is the single best guide to the meaning of a disputed term and acts as a dictionary when it expressly defines terms used in the claims or when it defines terms by implication. Although the prosecution history often lacks the clarity of the specification and thus is less useful for claim construction purposes, it is another source of intrinsic evidence that can inform the meaning of the claim language by demonstrating how the inventor understood the invention and whether the inventor limited the invention in the course of prosecution, making the claim scope narrower than it would otherwise be. Extrinsic evidence, such as expert testimony and dictionaries, may be useful regarding the field of the invention or helping determine what a person of ordinary skill in the art would understand claim terms to mean. However, extrinsic evidence in general is viewed as less reliable than intrinsic evidence.

Additionally, there is a doctrine of construing claims to preserve their validity, but it should only be applied in rare circumstances in AIA proceedings. This doctrine is of limited utility and has been limited to cases in which after applying all the available tools of claim construction, that the claim is still ambiguous.

I will use this standard in my analysis below. I note that there is no ambiguity in the term that I discuss below, and therefore, I do not believe that the doctrine of construing claims to preserve their validity is applicable here.

18. Below, I set forth what I believe to be the meaning of a claim term as well as the factual basis for that claim construction. As to the other terms that I do not address, I will simply apply the ordinary and customary meaning of those terms. In arriving at the claim construction shown below, I carefully considered the '000 patent and its prosecution history, including the prosecution history of the related patents. In the chart below, I provide a summary of the construction for one term that is relevant to the challenged claims. Following the chart, I provide my reasoning and the factual basis in support of my proposed interpretation for that term.

Claim Term	Meaning
Virtual Reality Viewer Apparatus	“A viewer of an artificial environment,” where “viewer” includes both handheld devices and headsets.

Below I provide support for the term that I have construed above.

Virtual Reality Viewer Apparatus – This term appears in all claims and is not defined in the '000 patent other than to state “[v]irtual reality viewers and headsets (collectively referred to as viewers) are becoming an increasingly popular way of viewing digital media, gaming and the like.” EX1001, 1:46-48. The patent also states that “[v]iewers can be hand-held devices that a user holds up to the users [sic] face/eyes, for example, like a user would hold a pair of binoculars.” EX1001, 1:39-41. And the patent states that “[v]iewers can also be worn on a user’s head....” EX1001, 1:55-57. So, the patent is using the term “virtual reality viewer” to include both handheld devices and headsets. Beyond describing some typical features of virtual reality viewers (see 1:46-2:32), the '000 patent does not provide any definition or place any limitations on this term. I therefore considered some definitions for the term “virtual reality”:

an artificial environment which is experienced through sensory stimuli (such as sights and sounds) provided by a computer and in which one's actions partially determine what happens in the environment. Merriam-Webster Online Dictionary, <https://www.merriam-webster.com/dictionary/virtual%20reality>.

A realistic simulation of an environment, including three-dimensional graphics, by a computer system using interactive software and hardware. EX1006, p. 4 (Random House Webster’s College Dictionary, p. 1459 (2000)).

These definitions suggest that Virtual Reality is an artificial environment. These definitions are consistent with my understanding as a POSA. To further support this analysis, I note the difference between Augmented Reality, which is when computer-generated images are superimposed on a user's real-world field of vision (see §VI(A) below), and Virtual Reality, which is an artificial environment. It should be noted that there are a variety of Virtual Reality viewer sub categories, some are not tracked, like Viewmaster, which is static, and others are tracked in order to present the image from the user's point of view, even during head movement. However, in light of the term's usage and well-known meaning to a POSA, I will use its ordinary meaning, which is "a viewer of an artificial environment" where "viewer" includes both handheld devices and headsets.

B. ANTICIPATION

19. I have been informed that to obtain a patent the claimed invention must have, as of the date of the invention, been novel over the prior art. I understand that an invention is not novel if it is anticipated by the prior art. I understand that an invention is anticipated if a single prior art reference discloses all the limitations or elements as set forth in the claim. I understand that in some cases an element or limitation, while not explicitly or expressly disclosed in a prior art reference, may still be disclosed by the prior art reference if that element or

limitation is inherent in the reference. I understand that an element or limitation is inherent if the nature of the reference is such that the element or limitation is necessarily present, or put another way, that it would have to follow from the disclosed system or method that the element or limitation must be present.

C. OBVIOUSNESS

20. I understand that prior art can render a patent claim obvious to a person of skill in the art if the differences between the subject matter set forth in the patent claim and the prior art are such that the subject matter of the claim would have been obvious to a person of ordinary skill in the art at the time the claimed invention was made. I understand that obviousness is a legal conclusion, but I am not offering a legal conclusion. I am testifying regarding the relevant facts that underlie the legal conclusion: the level of skill in the relevant art, the scope and content of the prior art, the differences between the prior art and the claims, and any secondary considerations.

21. I understand that when the claimed subject matter involves combining pre-existing elements to yield no more than one would expect from such an arrangement, the combination is obvious. I understand that, in assessing whether a claim is obvious, one must consider whether the claimed improvement is more than the predictable use of prior art elements according to their established functions. I understand that there need not be a precise teaching in the prior art

directed to the specific subject matter of a claim because one can take account of the inferences and creative steps that a person of ordinary skill in the art would employ. I understand that a person of ordinary skill is a person of ordinary creativity, not an automaton.

22. I understand that obviousness cannot be based on the hindsight combination of components from the prior art. I understand that in an obviousness analysis, neither the motivation nor the avowed purpose of the inventors controls the inquiry. Any need or problem known in the field at the time of the invention and addressed by the patent can provide a reason for combining elements. For example, I understand that it is important to consider whether there existed at the time of the invention a known problem for which there was an obvious solution encompassed by the patent's claims. I understand that known techniques can have obvious uses beyond their primary purposes, and that in many cases a person of ordinary skill can fit the teachings of multiple pieces of prior art together like pieces of a puzzle.

23. I understand that, when there is a reason to solve a problem and there are a finite number of identified, predictable solutions, a person of ordinary skill has good reason to pursue the known options within his or her technical grasp. I understand that, if this leads to the anticipated success, it is likely the product not

of innovation but of ordinary skill and common sense, which bears on whether the claim would have been obvious.

24. I understand that secondary considerations can include, for example, evidence of commercial success of the invention, evidence of a long-felt need that was solved by an invention, evidence that others copied an invention, or evidence that an invention achieved a surprising result. I understand that such evidence must have a nexus, or causal relationship to the elements of a claim, in order to be relevant.

25. I am not aware of any secondary considerations applicable to the subject matter of the '000 patent, and I have not considered nor provided any opinions related to the secondary considerations at this time. If the Patent Owner provides any evidence of secondary considerations, I will evaluate it at that time.

V. A PERSON OF ORDINARY SKILL IN THE ART

26. I understand that the teaching of the prior art is viewed through the eyes of a person of ordinary skill in the art at the time of the invention (“POSA” or “person of skill in the art”). To assess the level of ordinary skill in the art, I understand that one can consider the types of problems encountered in the art, the prior solutions to those problems found in prior art references, the speed with which innovations were made at that time, the sophistication of the technology, and the level of education of active workers in the field.

27. Based upon my knowledge and experience in this field and my review of the '000 patent and the prior art, I believe that a POSA at the time of the alleged invention was a person having a minimum of an undergraduate degree (or equivalent) in mechanical engineering or a related field, with knowledge of mechanical actuation systems, basic optical design with lenses, head-mounted displays, a basic understanding of touchscreen technology, and at least two years of experience of professional work experience in mechanical and basic optical design or engineering. At the time of the alleged invention, I was such a person and continue to be. I have also supervised and worked with many such people over my career and am therefore well aware of a POSA's knowledge, skill, and level of understanding.

VI. THE '000 PATENT

A. State of the Technology at the Time of the Alleged Invention

28. Virtual reality headsets, such as the viewer described in the '000 patent, are based on a long-established, three-dimensional viewing technology called stereoscopy. Stereoscopy uses a pair of separate, distinct images presenting a left-eye and right-eye view with the views being captured or geometrically generated at unique left and right



locations; the scene is interpreted by the viewer as a single, three-dimensional image of the scene. Stereoscopy can be traced back to the 1820s. One example of a well-known stereoscopic device is the View-Master, first produced in the 1930s. Shown on the right is a version from the 1960s.

29. Advancements in computers and computing technology led in the late 1960s to development of head-mounted displays (“HMD”) for Augmented Reality (“AR”) and Virtual Reality (“VR”) applications. AR describes superimposing or layering computer-generated images or data in a user’s “real world” field of vision—such as a heads-up display in a fighter pilot’s helmet. VR is similar, but the user only sees computer-generated images. Both AR and VR require software and multiple hardware devices or systems to be effective. This includes, for example, a tracker to determine the view orientation and position of the user, a real-time graphics processor capable of stereo display generation, and an HMD worn on the user’s head.

30. Virtual Reality headsets were originally called “Head-Mounted Displays,” HMDs, before Jarret Lanier coined the term “Virtual Reality.” HMDs were first created in 1968 by Ivan Southerland and his students; it was an ungainly device but demonstrated the concept. In the mid 1980’s and especially the early 1990’s, significant advances were made in tracking, optics, and computer graphics to allow for the HMDs to become practical. UNC Chapel Hill’s Computer Science

department was at the forefront of this advancement and much of the technology we developed there has made its way into the consumer market over time.

31. While most head-mounted displays through 2014 used integrated display screens such as in the Rift, the idea of using a mobile device display in a headset was known at least as early as 2008. For example, U.S. Patent No. 8,957,835, assigned to Apple, Inc. and filed in September 2008, discloses a

“[h]ead-mounted display systems and methods of operation that allow users to couple and decouple a portable electronic device such as a handheld

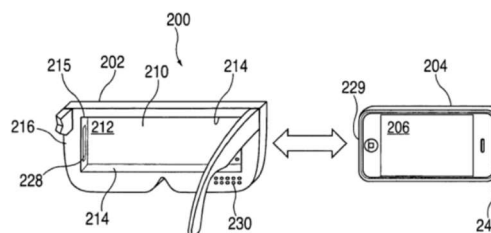


FIG. 2B

portable electronic device with a separate head-mounted device....” Although not shown in this image, the Apple patent discloses an embodiment using a left and right optical lens “so that the user is given the illusion of viewing image based content in three dimensions.” EX1005, 3:20-23, 23:34-39, Fig. 2B.

32. Prior to 2014 and still through today, there were multiple types of touchscreens that were integrated into mobile electronic devices; these include infrared, pressure, resistive, and capacitive. In order to be able to have as much consumer appeal as possible for a VR headset, one would want to accommodate as many current and legacy devices as possible. As of 2012, the filing date of Chu

(EX1004), the most common types of touchscreens used by handheld devices, like smartphones, were resistive and capacitive touchscreens. EX1004, ¶0003.

Resistive screens: These screens are made up of two layers of conductive material, typically polymer coated glass and a polymer coated plastic, and have the ability to take direct input by touch including a gloved finger or stylus. They are also resistant to water and dust. Resistive screens are now more common on legacy and lower-priced smartphones. Physical pressure is needed to make resistive screens function.

A resistive touch screen includes a glass sheet coated with a thin conductive layer and a metallic layer. The two layers are separated by a spacer. When a user makes contact with the touch screen, the two layers touch each other at the same location. The change in electric current will be identified and computed to a set of coordinates on the touch screen display. A resistive touch screen can be operated by fingers or by many types of object as long as it can provide pin point compression on the touch screen. EX1004, ¶0004.

Capacitive screens: These screens use the electrical properties of the body to create a change of charge at a location on a polymer coated touchscreen. They require a finger or conductive path to a body but are able to detect lighter touches. Their biggest advantages are that one can use multi-touch instead of a single finger-tip only and have more robust screens since the two perpendicular

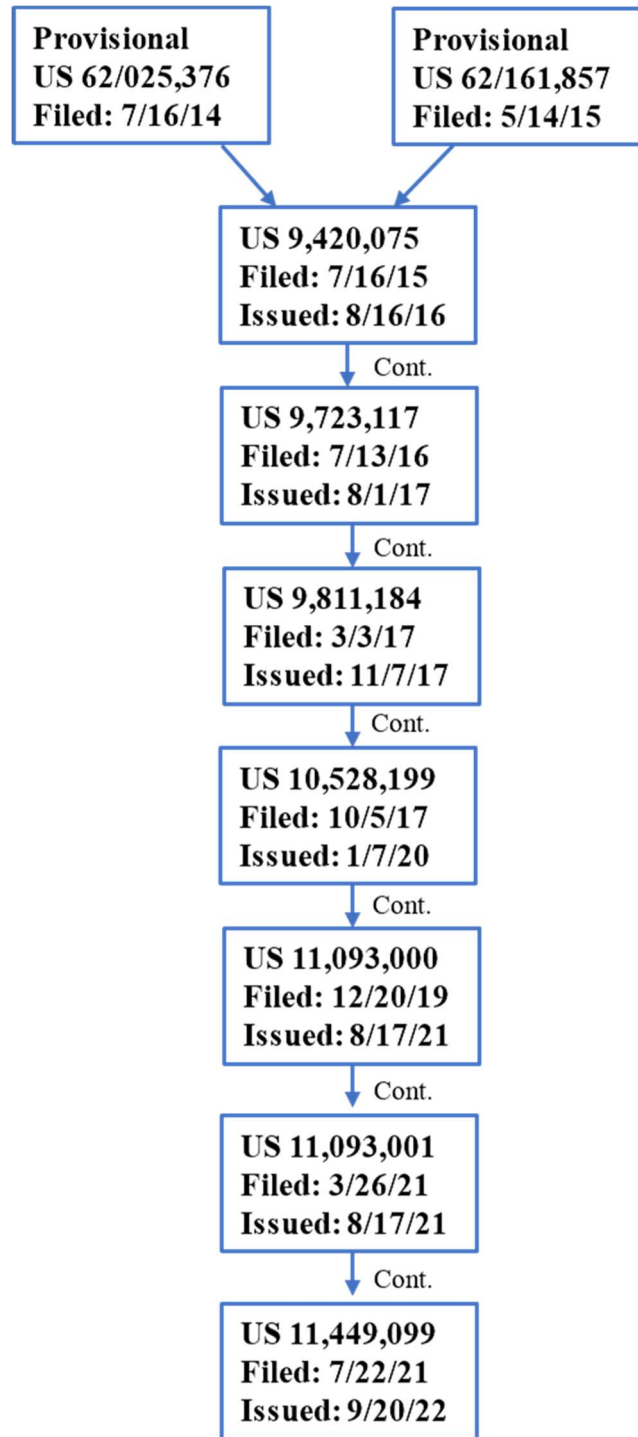
conductive layers are behind the glass screen. Capacitive screens are more costly than resistive screens.

A capacitive touch screen includes a thin conductive layer such as Indium Tin Oxide, which is visually transparent. It stores electric charge and is positioned on a glass layer of the display. When a user makes contact with the touch screen, usually with a bare finger, small quantity of electric charge is transmitted to or from the user's finger. The quantity of electric charge on the touch screen at the designated position is reduced or increased. This change in electric charge is detected and computed to a set of coordinates on the display. A finger usually works well with capacitive touch screen. A human body is a good transferor and transferee of electric charge because of the electromagnetic field around the human body at all times. A device composed of compatible materials with good conductivity of electric charge can perform the function. However, a pencil or stylus which is workable on a resistive touch screen is not workable on a capacitive touch screen. EX1004, ¶0005.

33. One well-known goal for devices that encompass a smartphone (*e.g.*, VR viewers) at the time of the '000 patent's alleged invention was to accommodate as many different types of touchscreens as possible (both current and legacy), thus appealing to a wide range of consumers.

B. The '000 Patent

34. The '000 patent is one of a family of related patents, all continuations, which I understand means that the patent specifications are all claimed to basically be the same with only the claims changing. This family stems from two provisionals, which I understand serve as priority documents but are not substantively examined. A diagram of this family follows:



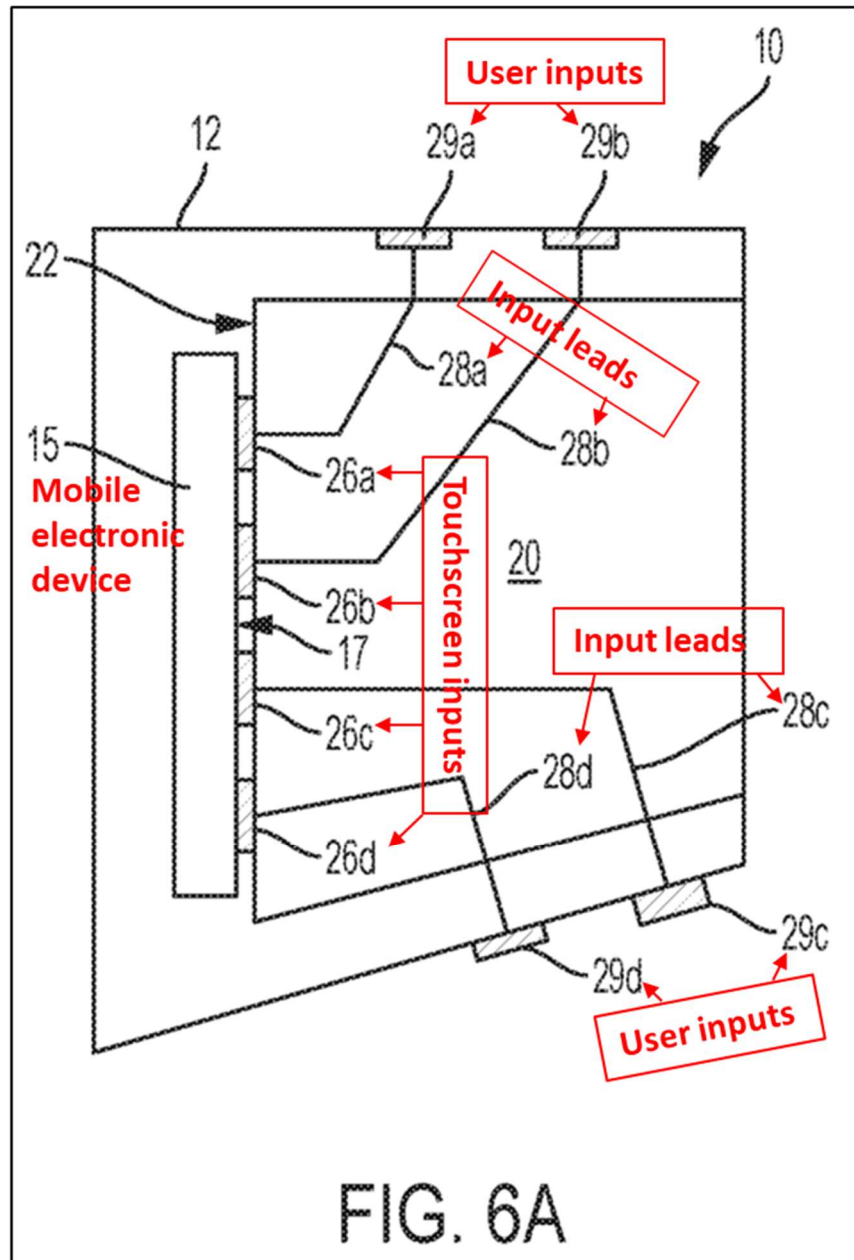
35. The '000 patent purports to invent a virtual reality viewer with “an input mechanism that can be used with [a] mobile electronic device having a touchscreen contained within the viewer.” EX1001, 2:36-39. However, the '000

patent admits that VR viewers with input devices were well-known at the time of the alleged invention. For example, in the Background of the Invention section, the patent admits that “[w]ith the widespread distribution of powerful and capable smartphone devices, many VR viewers are designed to use such smartphone devices as the visual display device, instead of having dedicated displays and electronics.” EX1001, 1:46-52.

36. The Background continues by admitting that “[t]ypically the viewers have a housing that a user looks into in order to view the video display device contained within the housing” and that “[v]iewers can be hand-held devices that a user holds up to the users [sic] face/eyes....” EX1001, 1:53-59.

37. The Background mentions that since a smartphone is enclosed within the viewer, “[o]ne challenge ... is that the touch sensitive display is concealed within the viewer housing, thereby making it difficult for a user to interact with the touch sensitive display....” EX1001, 2:5-8. Thus, the Background admits that some VR viewers use magnets as input devices and “[o]ther VR viewers utilize dedicated input devices, like video game controllers....” EX1001, 2:8-2:27.

38. The ’000 patent is directed to two embodiments of input mechanisms: one is an electrical connection, referred to in the patent as “passive,” as shown in Figure 6A:

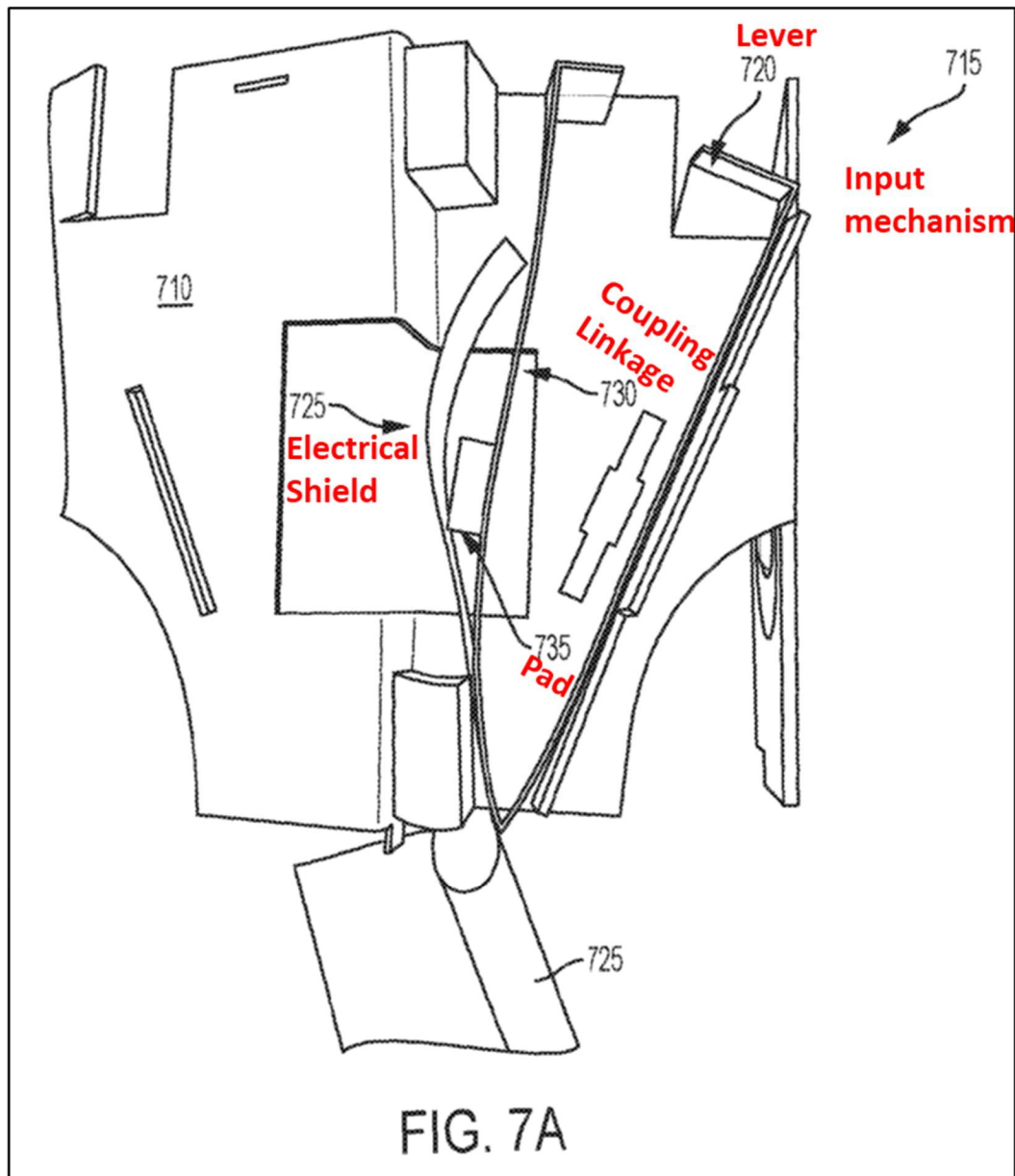


EX1001, Fig. 6A (annotations added).

39. This embodiment includes touchscreen inputs 26a–26d electrically coupled to user inputs 29a–29d via input leads 28a–28d. User inputs 29a–29d are exposed on the outer surfaces of the housing so that the user can interact with them

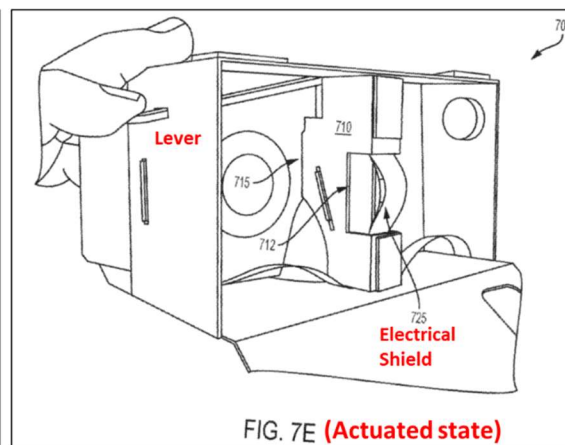
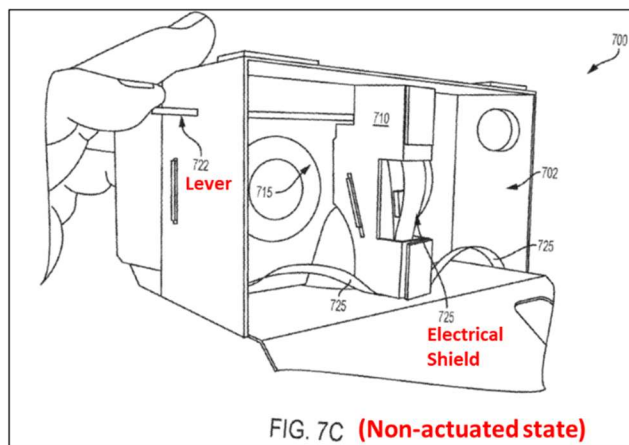
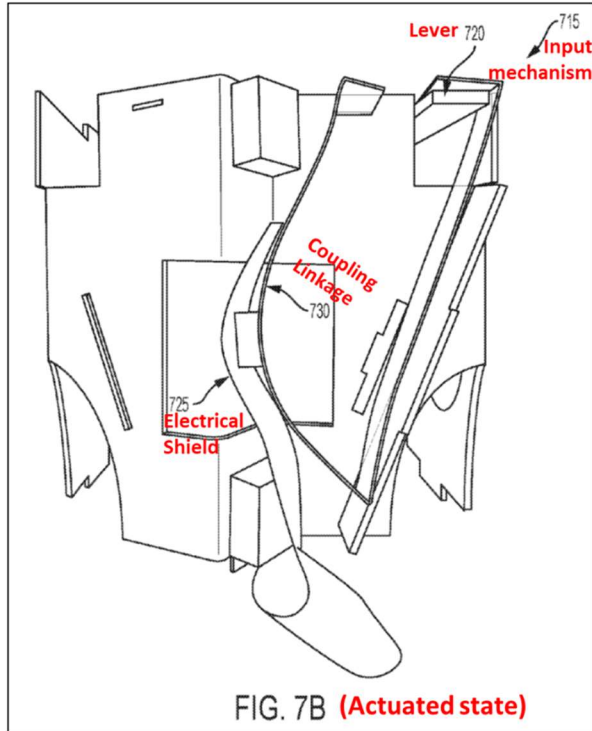
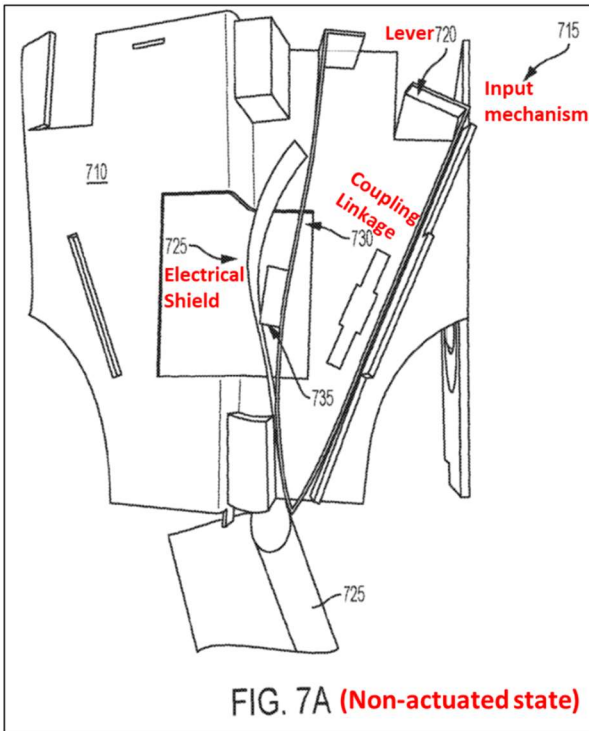
to provide input to the mobile electronic device 15. EX1001, 3:43-7:8, 5:46-63, Figs. 6A–B. In this way, the user inputs 29a-29d transfer a capacitive touch to touchscreen inputs 26a–26d.

40. The other embodiment is a mechanical embodiment, which the patent refers to as “active,” as shown in Figures 7A-F. Figure 7A is reproduced below:



EX1001, Fig. 7A (annotations added).

41. In this embodiment, the input mechanism 715 is moveable within the housing/enclosure. EX1001, 7:39–10:36, Figs. 7A–F. In particular, the viewer 700 (not shown) includes a lever 720 that is accessible from an exterior of a housing/enclosure to bring the electrical shield 725 into an actuated state where a contact event is transferred to a touchscreen and a non-actuated state where a contact event is not transferred to the touchscreen inside the housing/enclosure. A coupling linkage 730 extends between the lever 720 and the electrical shield 725. EX1001, 7:39–10:36. A pad 735 sits between the coupling linkage 730 and electrical shield 725. “[A]ctuation of the lever causes the coupling to deform and extend in a direction towards the touchscreen, which in turn moves a portion of the electrical shield towards the touchscreen.” EX1001, 8:35-38. Figures 7A and 7C below show the non-actuated state, and Figures 7B and 7E below show the actuated state.



EX1001, Figs. 7A, 7B, 7C, 7E (annotations added).

C. The '000 Patent's Prosecution History

42. In an office action dated July 22, 2020, the Examiner rejected the pending claims based on double patenting and anticipation in view of Bickerstaff.

EX1008, pps. 38-44. In response, the Patent Owner canceled all pending claims

and submitted new claims, stating that it believed the claims were patentable over Bickerstaff without explanation. EX1008, pps. 33-37. The Examiner issued a final rejection based on double patenting, and the Patent Owner filed a terminal disclaimer. EX1008, pps. 12-26. The Examiner then issued a notice of allowance, stating that the prior art did not disclose all of the claim elements:

4. The following is an examiner's statement of reasons for allowance:

In regards to claim 22, it recites, among other features, "a housing having a portion configured to receive a mobile electronic device having a touchscreen display, the housing further including two lenses;

an input device accessible from an exterior of the housing; and

a contact element located within an interior of the housing, the contact element coupled to the input device and configured to generate a detectable touch event at the touchscreen display of the mobile electronic device".

The Prior Art discloses a housing with two lenses that receives a mobile device having a touchscreen display. The Prior Art discloses a housing that receives a housing that receives a mobile device having a touchscreen display with an input device accessible from an exterior of the housing and coupled to a contact element in the interior of the housing that generates a touch on the touchscreen display of the mobile device. The Prior Art does not disclose all of the elements together or suggests a way for them to be combined.

EX1008, pps. 9-10.

43. The Patent Owner submitted comments on the reasons for allowance, stating that the Examiner's reasons for allowance should not be attributed to the Patent Owner. EX1008, pps. 1-2.

44. The Examiner did not specify what features of the claims he considered to be patentable. Therefore, this file history does not affect my below validity analysis.

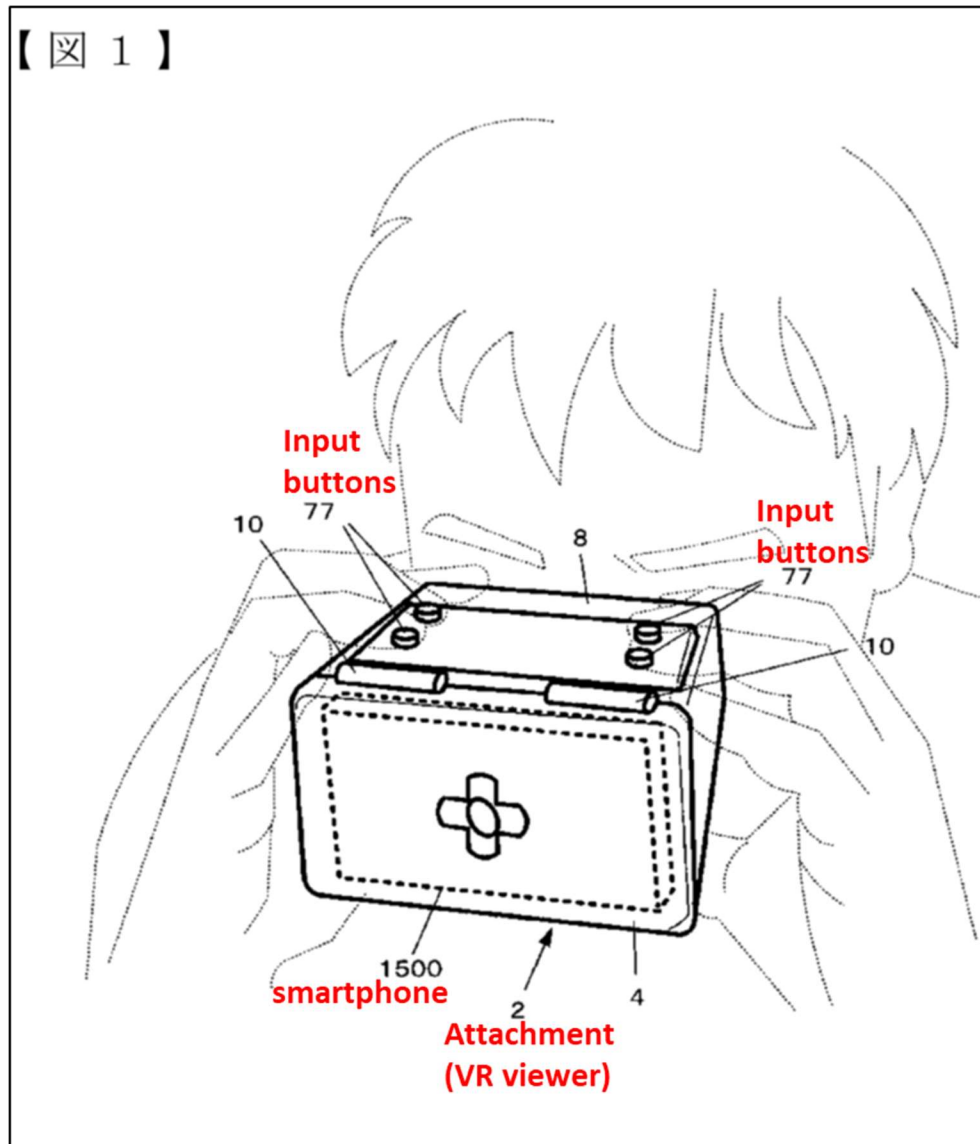
VII. PRIOR ART

A. Kondo – JP3176588

45. Kondo is a Japanese patent entitled “Remote Touch Circuit and Attachment,” issued on June 28, 2012, which provides a VR viewer so the user can enjoy “three-dimensional stereoscopic images.” EX1003, ¶0021; *see also* Fig. 3, ¶0027. Kondo refers to its VR viewer as an “attachment” using reference numeral “2.” I will therefore use “VR viewer” and “attachment” interchangeably when describing Kondo.

46. Kondo is directed to the same problem as the '000 patent, namely, “[t]o provide an attachment that achieves remote control input to a touch panel mounted on an electronic device.” EX1003, p. 2; *see also*, ¶4. Kondo's solution is to equip the VR viewer “with a remote touch circuit that enables remote operation input to the touch panel from the outside using the fingers gripping the attachment.” EX1003, p. 2. Kondo's input mechanism is electrical or passive.

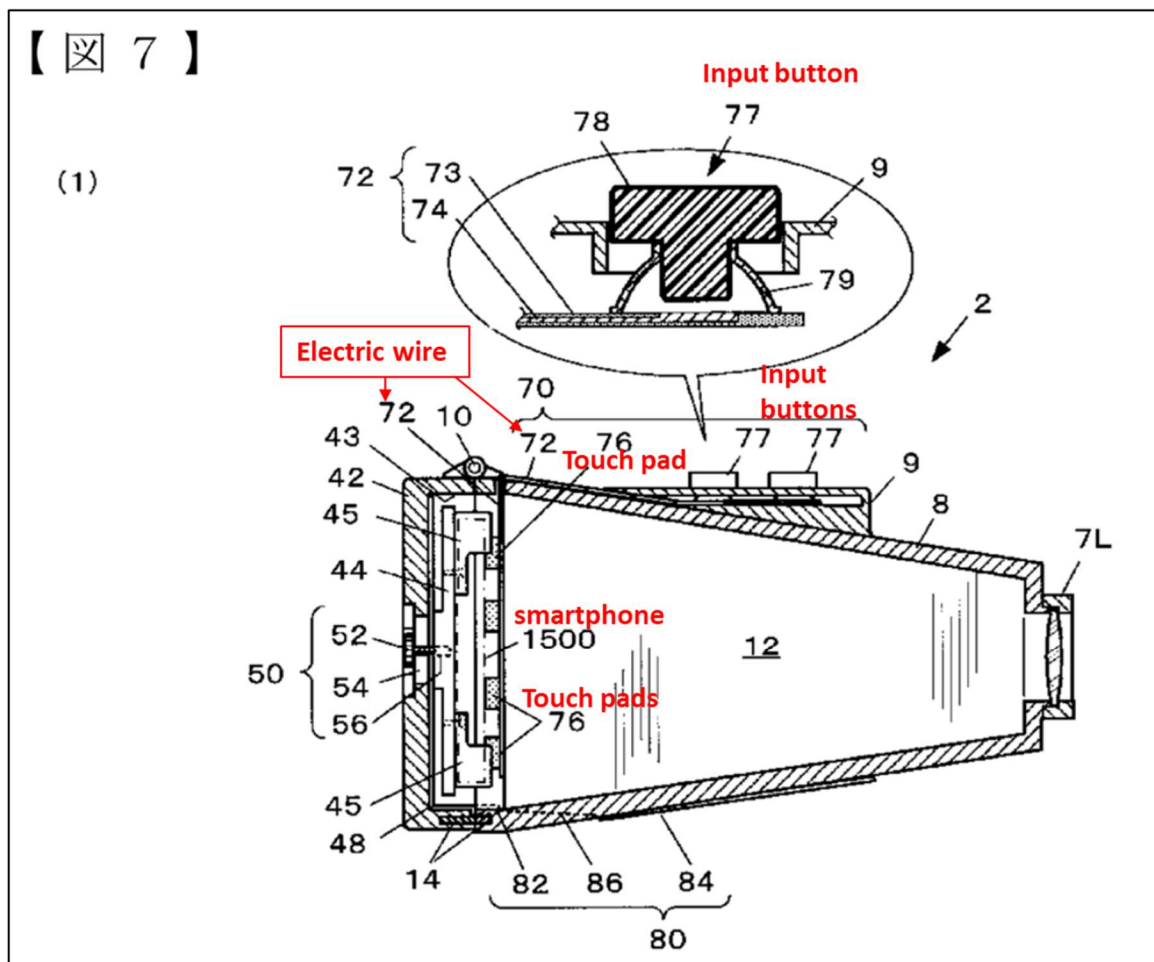
EX1003, ¶0005. Kondo's Figure 1 below shows this input mechanism (buttons 77) on a VR viewer 2 with a smartphone 1500 mounted therein. EX1003, Fig. 1; ¶0022.



EX1003, Fig. 1 (annotations added).

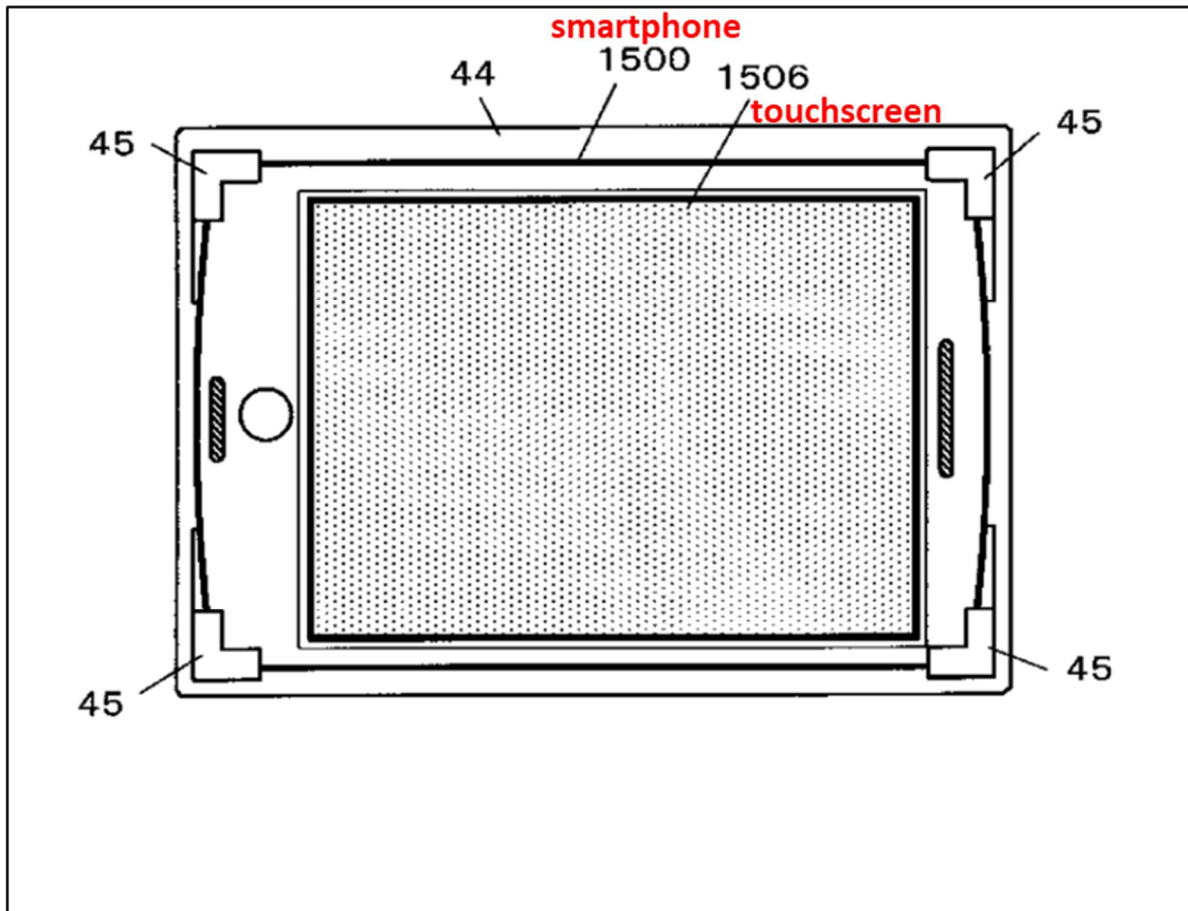
47. Kondo describes how the remote touch circuit is mounted and utilized, and the benefits of having externally available buttons 77. The basic

concept is to have one or more electrically conductive pads 76 placed over the smartphone screen and electrically in contact by wire with the external buttons 77. These external buttons are placed on the outer shell of the virtual reality viewer and can be touched by the user, which is conducted through the wire, to the conductive pad and registered by the smartphone as a “touch.” The electrical path from the external button(s) of the virtual reality viewer can provide for both capacitive and conductive types of sensing. This is shown in Fig. 7 below:



EX1003, Fig. 7 (annotations added).

48. When button 77 is depressed by a user's finger, the impedance of the user's finger is electrically connected to the smartphone 1500 (specifically, its touch panel shown as 1506 in Fig. 8, see below) via electrical wire 72 and touch pads 76. EX1003, Fig. 7; ¶¶0043-0048.



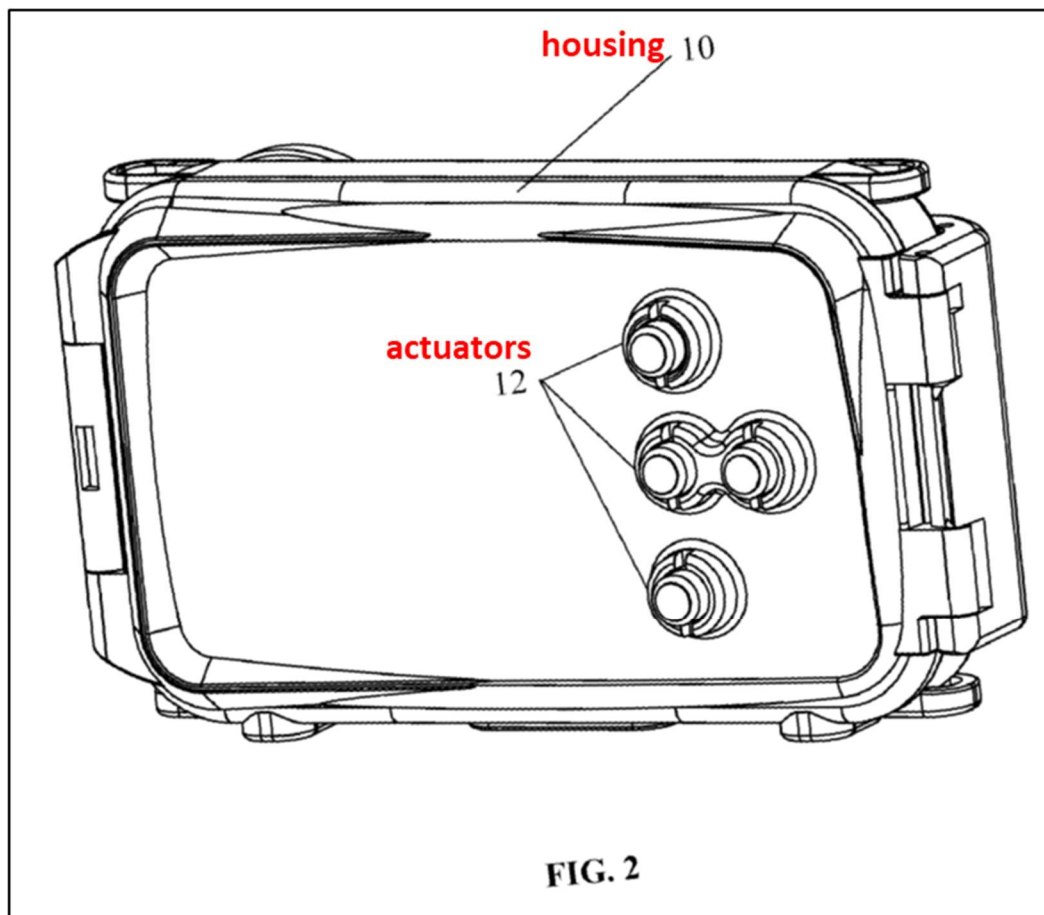
EX1003, Fig. 8(2) (annotations added).

49. Kondo discloses alternative embodiments, such as button 77 connecting to a different capacitive element other than the human body (Fig. 12, ¶0054) and using a game controller to operate the smartphone (Fig. 13, ¶0055).

Kondo also specifically contemplates alternatives to button 77, including “a cross-shaped directional input key, a joystick, and the like.” EX1003, ¶0057.

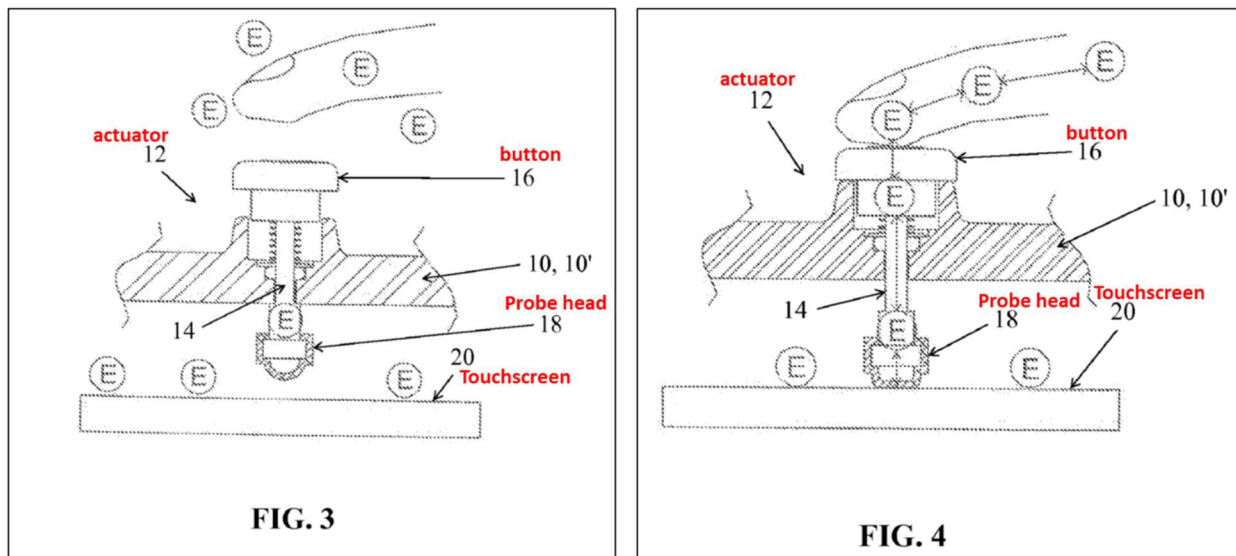
B. Chu – U.S. 2013/0082963

50. Chu is a U.S. patent publication dated April 4, 2013. It is directed to actuating a capacitive touchscreen of a smartphone held within a waterproof housing. EX1004, Abstract. Fig. 2 below shows the housing 10 enclosing a smartphone as well as the actuators 12, or input mechanisms, that are capable of actuating the touchscreen on the smartphone through physical contact:



EX1004, Fig. 2 (annotations added).

51. Figure 3 shows actuator 12 at rest, and Figure 4 shows the actuator 12 in an actuation position where probe head 18 is touching the capacitive touchscreen 20 to create a touch event. EX1004 ¶¶0040-0041.

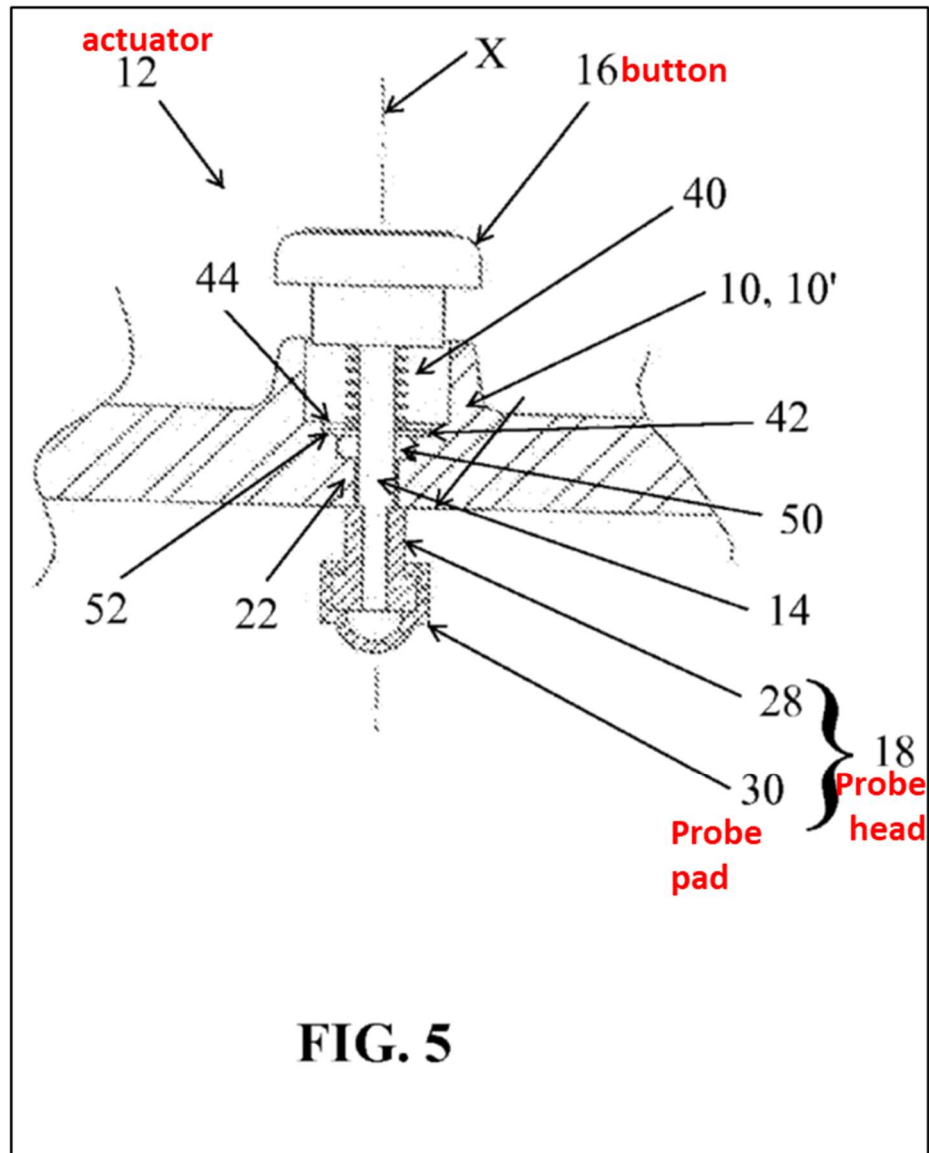


EX1004, Figs. 3, 4 (annotations added).

52. Chu explains that when the user presses down on button 16, the contact area with button 16 increases, and since button 16 is metal, the user's finger is electric charge connected. If the user continues to press down, the probe head will contact the touchscreen (see Figure 4 above) and the electric charge conductivity between the user, conductive shaft 14, and button 16 improves.

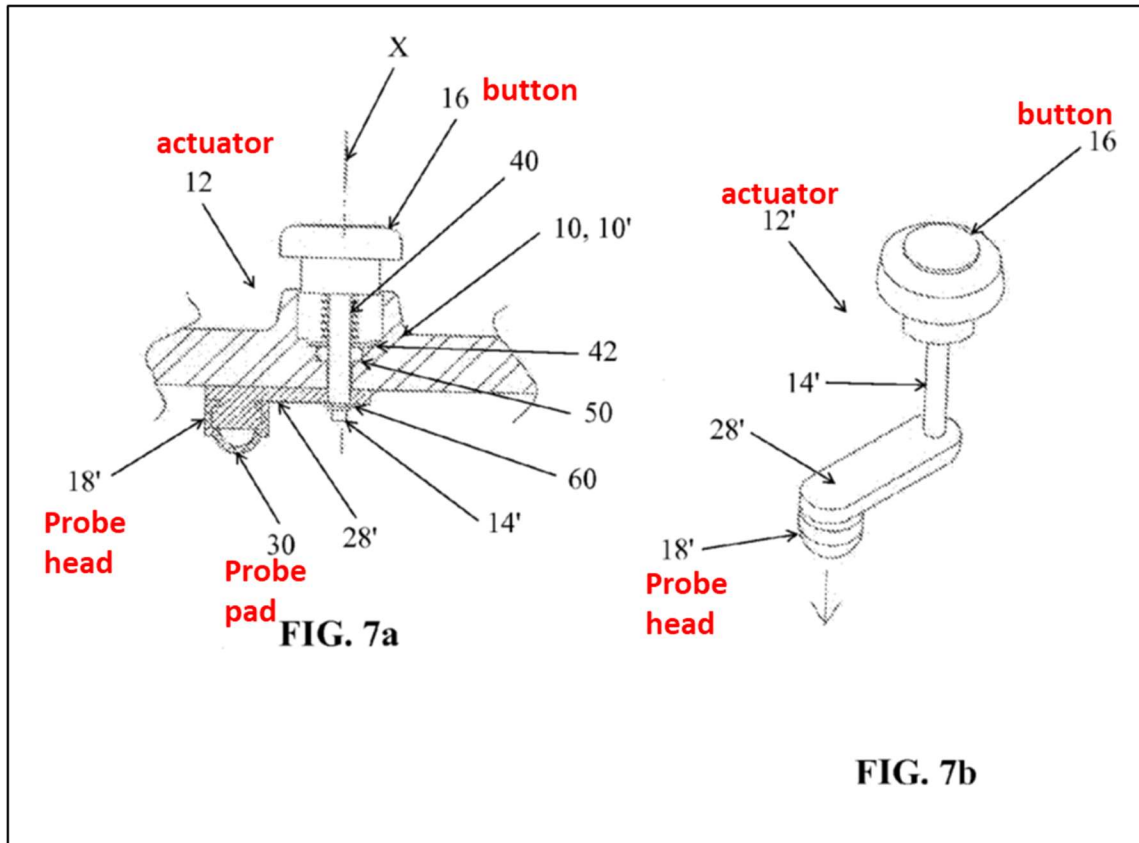
EX1004, ¶¶0054-0055.

53. Figure 5 shows a more detailed view of probe head 18, which includes probe pad 30 for direct contact with the touchscreen 20. The probe pad 30 may be made of rubber with an additive to “enhance its electric charge transfer performance.” EX1004, ¶¶0048-0049.



EX1004, Fig. 5 (annotations added).

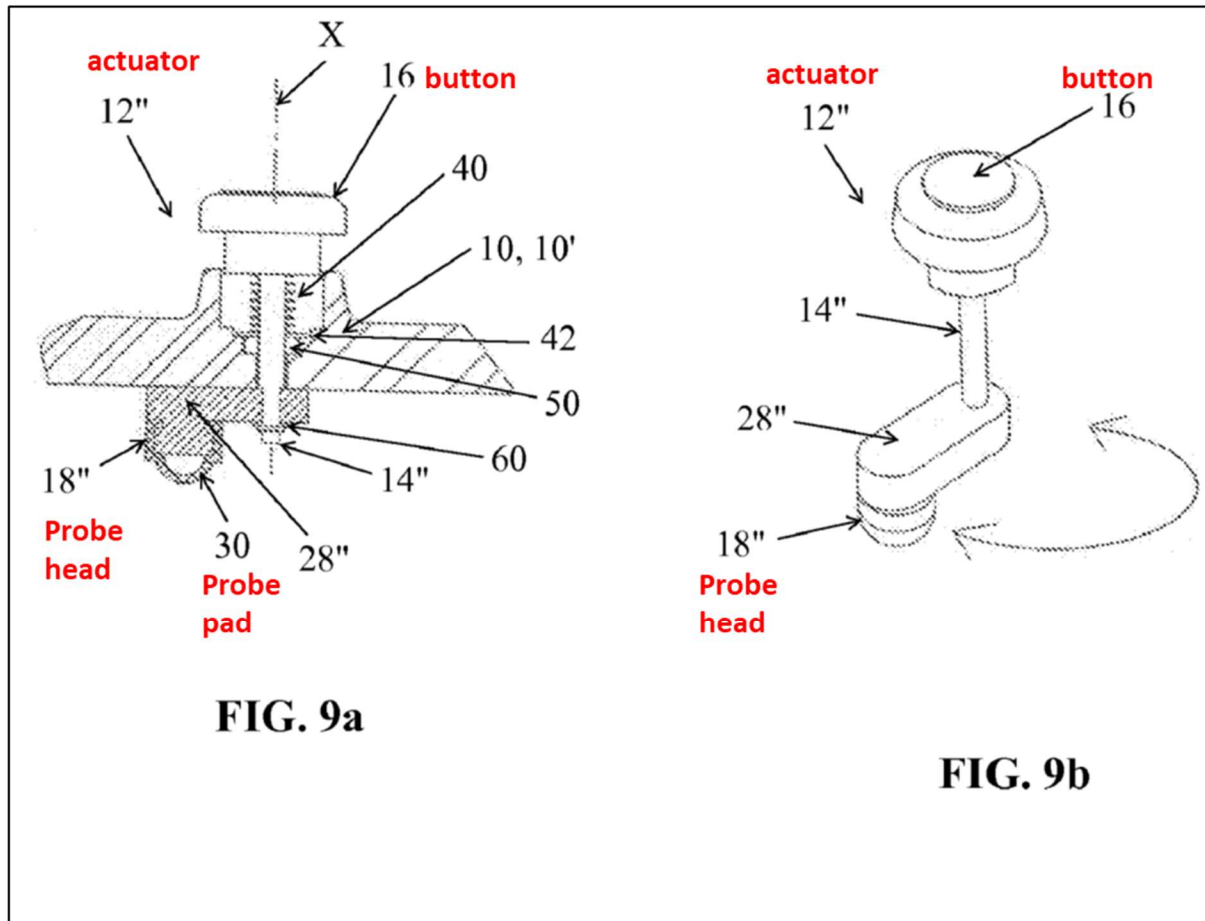
54. Figures 7a and 7b below show an alternative embodiment that operates similarly to the first embodiment in that when the user presses button 16, the probe head 18 (and probe pad 30) comes into contact with touchscreen 20 (see ¶¶0058-0059):



EX1004, Figs. 7a, 7b (annotations added).

55. Chu recognizes that in some situations, the touchscreen may require a “touch-swipe” or “touch-circle” motion where the probe head needs to move in a swiping or circular motion. Chu therefore describes another embodiment for just this situation where the user presses down on button 16 and can turn the button so

that probe head 18" touches touchscreen 20 and can move along a circular path, causing a swipe. EX1004, ¶¶0060-0062.



EX1004, Figs. 9a, 9b (annotations added).

56. A POSA would understand Chu as a conductive extension actuator from the interior to the exterior location of the device. The exterior location is accessible by the user and can be pressed by a user to create the capacitive or electrically conductive touch with the mobile device display within the housing. A POSA would understand that Chu would work not only with capacitive

touchscreens, but also with resistive touchscreens. As to resistive touchscreens, Chu's mechanical input device applies pressure to the touchscreen, thus providing a touch input for a resistive touchscreen. At ¶0004, Chu explains how such pressure will provide a touch input to a resistive screen.

C. Motivation to Combine Kondo and Chu and Reasonable Expectation of Success

57. As I mentioned above in §VI(A), the most common touchscreens on the market as of the time of the '000 patent's alleged invention were capacitive and resistive. A mechanical input mechanism, like Chu's, can work with both types of screens, whereas an electrical input mechanism, like Kondo's, can only work with capacitive screens. One goal of device designers is always to increase the usability and consumer appeal for their product where possible, allowing many different types of smartphones and touchscreens to be used. In this situation, a VR designer looking at Kondo would readily realize and be motivated to increase the usability and consumer appeal for their device by making it work with both capacitive and resistive screens and therefore would be led to Chu. Chu's input mechanism works with both types of screens.

58. Moreover, both Kondo and Chu deal with a smartphone enclosed in a housing or device and both references face a similar problem, the external activation of the touchscreen of the smartphone enclosed in that device. *See e.g.,*

EX1003, pg. 2 (“PROBLEM To provide an attachment that achieves remote control input to a touch panel mounted on an electronic device”), EX1004, ¶0009 (“Therefore, there is a need to provide a specially designed actuator mechanism for actuating a capacitive touch screen of a digital device inside a waterproof housing.”). Therefore, a POSA that is designing a VR viewer by using Kondo would look to other available input mechanisms, thus leading the POSA to Chu.

59. There are additional reasons why a POSA would combine Kondo/Chu. First, because Chu’s input mechanism is mechanical, the user can press the button using different levels of pressure, increasing not only the area in which contact is made but also the conductivity. Touchscreens can interpret this as differing inputs, based on the size of touch-screen contact, the level of pressure, and the level of conductivity. In other words, Chu provides a wider range of input at a single location on the touchscreen rather than just binary input (i.e., on or off).

60. Second, Chu’s “swipe” embodiment provides additional input to Kondo’s device. Not only can Chu provide a “touch” with different amounts of pressure and conductivity, but it also enables a whole new form of input, the swipe. A POSA would understand that having additional inputs beyond a mere binary touch, such as differing pressures, conductivity, and swipes, would allow the VR viewer to provide more functionality. The Kondo/Chu combination would

therefore allow the resulting VR viewer to be used for more applications, increasing the desirability of the device.

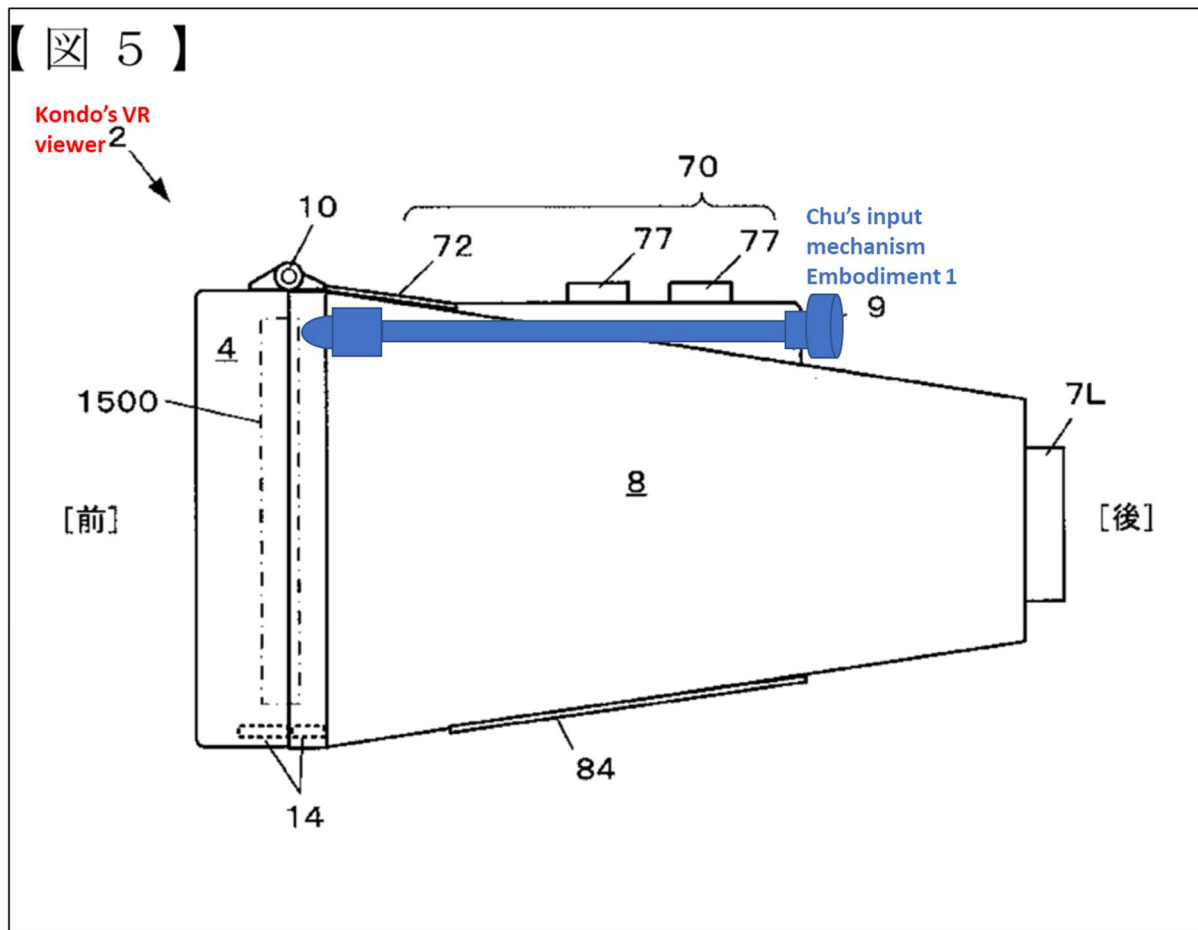
61. Third, Chu's input mechanism is not only a mechanical mechanism, but it is designed to be waterproof, and thus, adding Chu's input mechanism to Kondo has advantages.

62. In particular, this combination of Kondo and Chu would be less susceptible to damage from water and other environmental factors, like dirt and dust. Handheld devices are often subjected to such conditions if they are used outdoors or even indoors if dropped in some liquid or splashed by accident for example. Of course, this combination would also allow the resulting device to be used underwater.

63. Fourth, this combination would allow the device to be cleaned without fear of cleaning fluid reaching the inner parts of the device. This can be important if the VR viewer is being used in a sanitary environment, such as during a medical procedure or in a manufacturing facility, like a semiconductor fabrication facility. For these reasons, a POSA would be motivated to combine Kondo/Chu.

64. Both Kondo and Chu are simple mechanical devices. Thus, a POSA would have a reasonable expectation of success in combining Chu's input mechanism with Kondo. In fact, a POSA would consider the formation of this combination to be merely routine, requiring little skill.

65. The following diagram shows how a POSA could easily combine Chu's first embodiment (depicted in **blue**), found in Figs. 3-6, with Kondo's Fig. 5. Of course, inputs 77 and electrical wire 72 would be removed. To do so would require little effort and skill, and a POSA would have a reasonable expectation of success. This figure is not to scale and is only illustrative. A POSA would recognize that minor adjustments might need to be made, like elongating the stem of Chu's input device, and possibly providing supportive structure inside of Kondo's device to accommodate Chu's input device. In fact, Chu contemplates such structure as "one or more posts or guides" and shows supportive structure in its figures. EX1004, ¶0059, Figs. 3-10. All such modifications are well within the skill of a POSA, requiring little ingenuity.

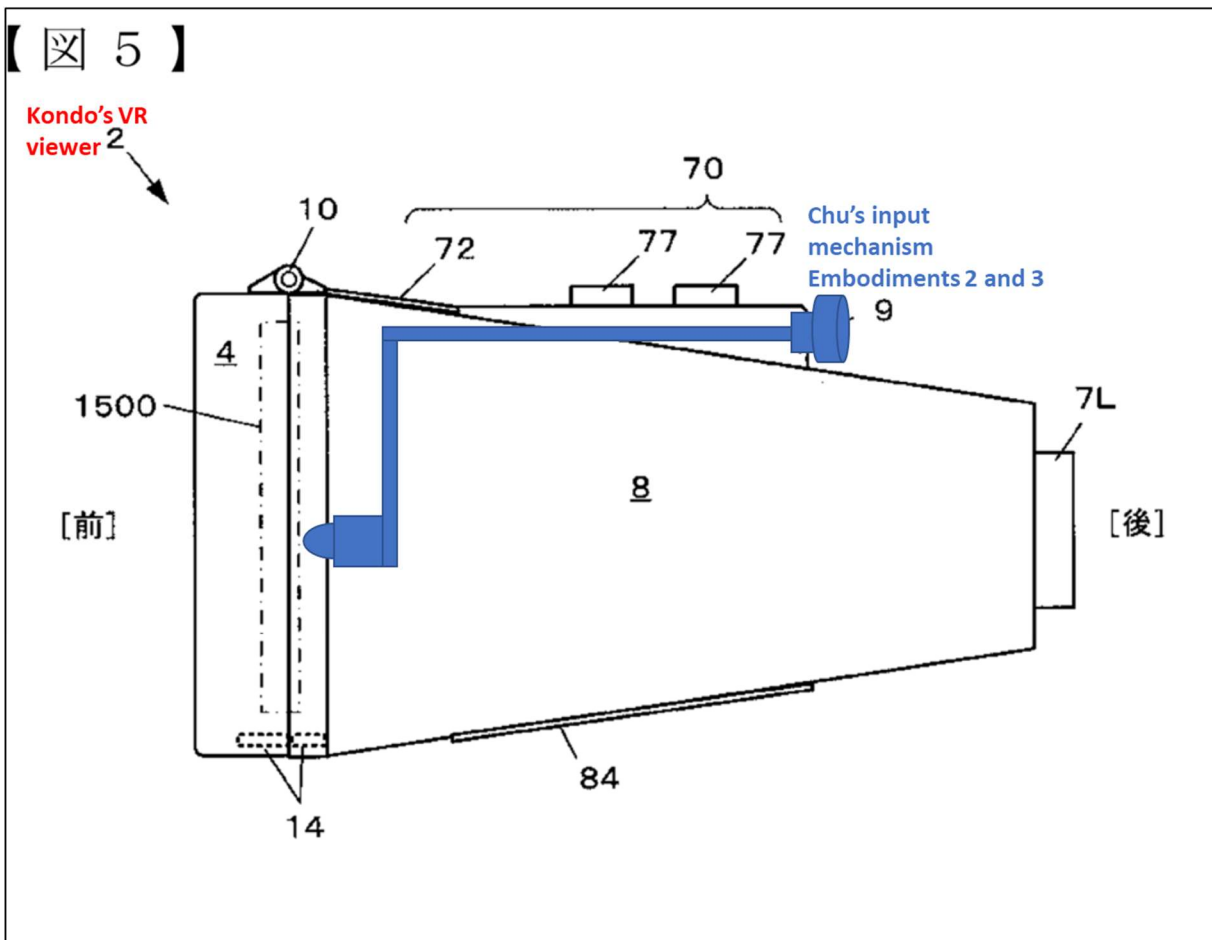


EX1003, Fig. 5 (annotated to include Chu's input device).

66. In the above diagram, Chu's input mechanism could be smaller and take a variety of sizes. Additionally, the outer shell of Kondo's device through which Chu operates could easily be extended to accommodate more input devices if desired.

67. The following diagram shows how a POSA could easily combine Chu's second embodiment, found in Figs. 7a, 7b, and 8, and third embodiment, found in Figs. 9a, 9b, and 10, in Kondo's Fig. 5. Chu's input mechanism reflecting

both the second and third embodiments is depicted in **blue**. Again, inputs 77 and electrical wire 72 would be removed. This would require little effort and skill, and a POSA would have a reasonable expectation of success.

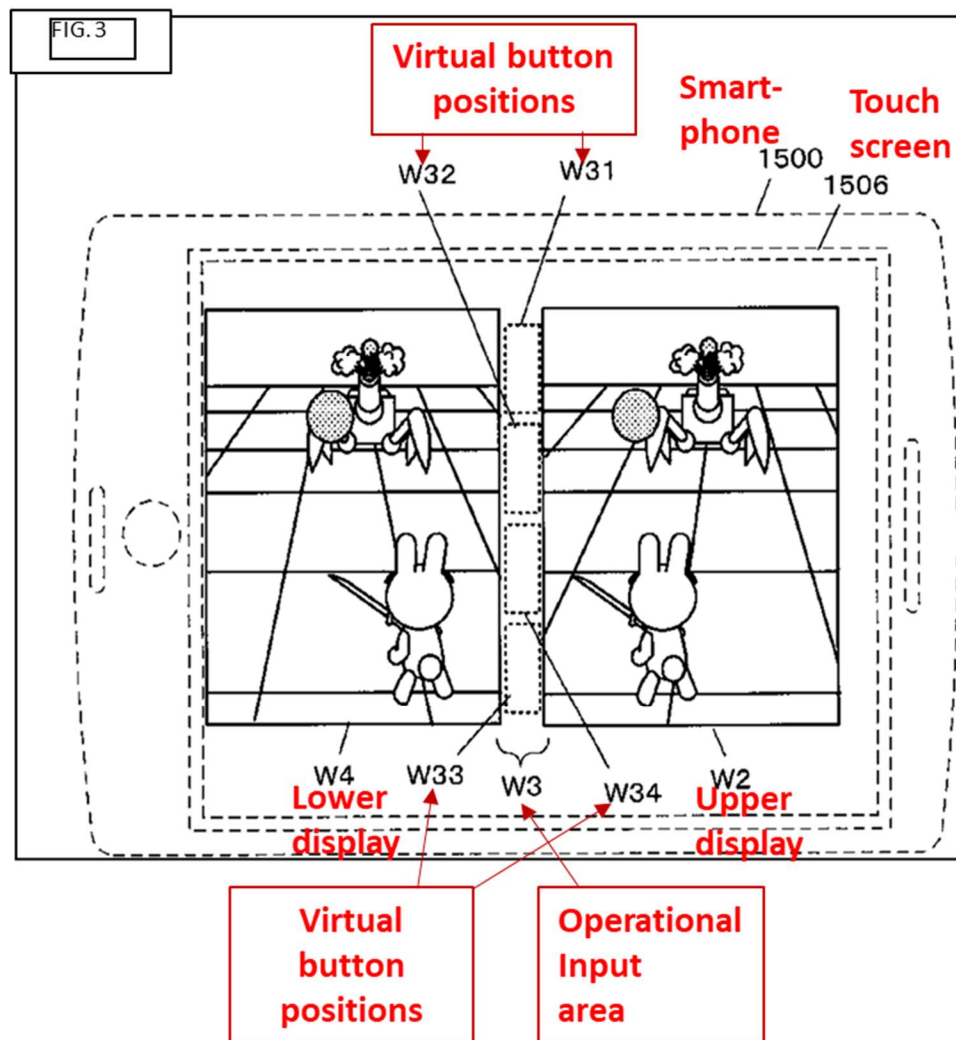


EX1003, Fig. 5 (annotated to include Chu's input device).

68. Again, minor adjustments might need to be made, including adding supportive structure. But those modifications would be well within the skill of a POSA, and as I said with respect to my discussion of Chu's first-embodiment combination, Chu contemplates such supportive structure. Additionally, Chu's

input mechanism could be smaller and take a variety of sizes. And, the outer shell of Kondo's device through which Chu operates could easily be extended to accommodate more input devices if desired.

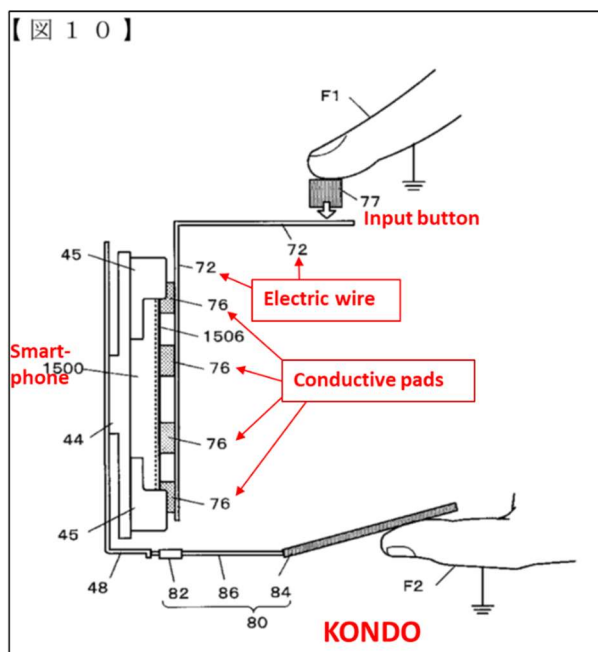
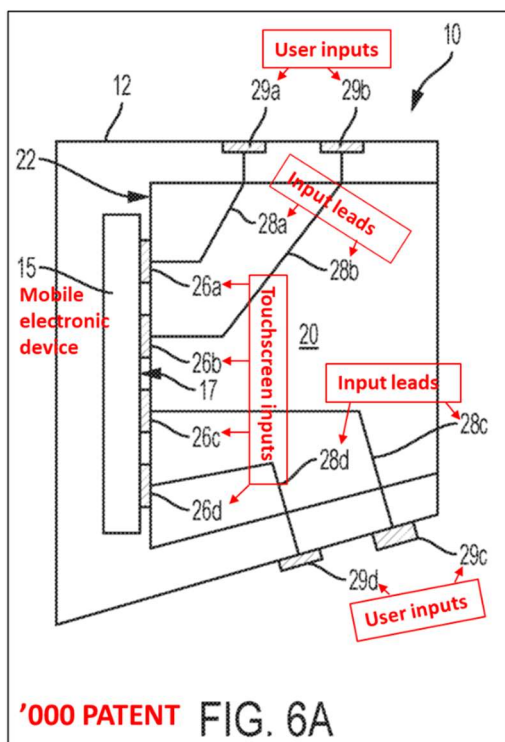
69. Both combinations shown above would contact the central region of the smartphone's touchscreen because Kondo shows that its operational input area is at the center of the touchscreen and this operational input area contains virtual button positions for operating the smartphone.



VIII. KONDO NOVELTY ANALYSIS OF CLAIMS 1-6 AND 8-33

70. In the following paragraphs, I identify specific claim elements and provide an explanation of anticipation. I note that this also demonstrates that the '000 patent is obvious, but I provide some additional thoughts on that topic in the next section.

71. I want to first observe that a quick comparison between Kondo Figure 6A and '000 patent Figure 10 demonstrates that the two are virtually identical and operate in a virtually identical way, with only minor terminology differences. I will explain how Kondo anticipates the '000 patent in the claim chart below.



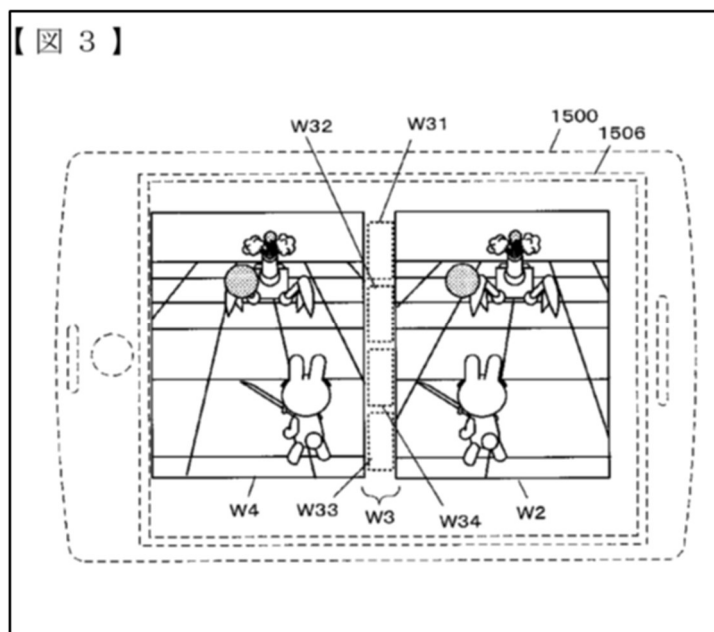
EX1001, Fig. 6A (annotations added); EX1003, Fig. 10 (annotations added).

A. Claim 1:

72. Please see my description of Kondo in §VII(A).

1. 1(a): A virtual reality viewer apparatus comprising:

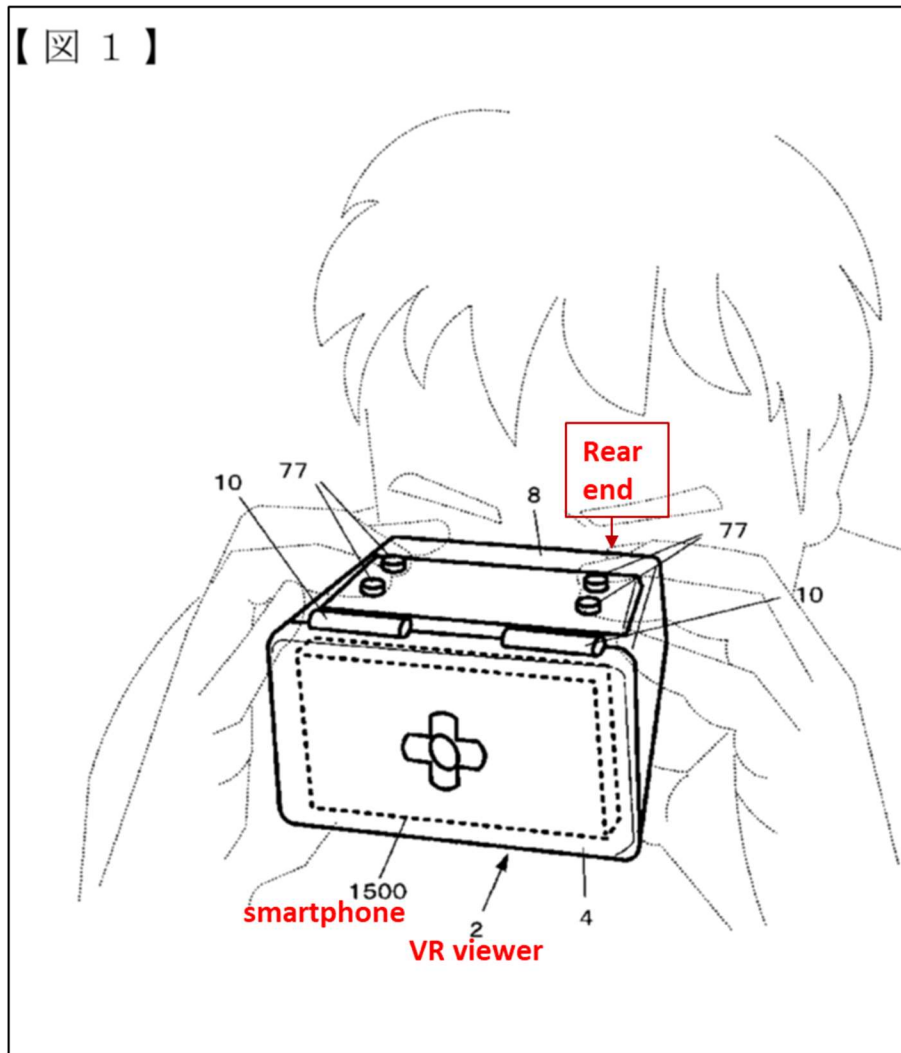
73. In my opinion, Kondo discloses a virtual reality viewer apparatus. I have defined a virtual reality viewer apparatus above to mean “a viewer of an artificial environment,” where “viewer” includes both handheld devices and headsets. See §IV(A) above. Figures 1 and 2 of Kondo below show a VR viewer 2 that encloses a smartphone 1500 with a touch-screen display 1506. As I mentioned above in §VII(A), Kondo refers to its VR viewer as an “attachment.” I will use the terms VR viewer and attachment interchangeably in my analysis of Kondo.



EX1003, Fig. 3; *see also* ¶¶0021-0024.

2. 1(b): a housing having a portion configured to receive a mobile electronic device having a touchscreen display, the housing further including two lenses;

74. See my analysis of 1(a). Kondo’s Figure 1 below shows a housing (the VR viewer’s housing) configured to receive a smartphone 1500, and a user viewing the smart phone through two lenses on a side known as the “rear end.” Figure 4(2) below shows a left and right lens on the rear end for viewing the left and right region of the touchscreen, which is on the opposite side.



EX1003, Fig. 1 (annotations added).

75. Kondo explains that the left and right eyepieces are on one side of the VR viewer and the smartphone is on the other side.

FIG. 1 is a perspective view of an attachment according to Embodiment 1, viewed obliquely from the front and above. The attachment 2 is a structural body having two substantially cylindrical bodies integrated on the left and right sides, provided with a holding part 4 that can open and close on the front end thereof, and *left and right eyepieces 7* (see

FIG. 6) on the rear end thereof. The user mounts the touch panel of the smartphone 1500 to the inside of the holding part 4 facing the eyepieces 7, then closes the holding part. ***Since left and right eye images are displayed on the touch panel of the smartphone 1500 for three-dimensional stereoscopic vision, the user can enjoy a three-dimensional stereoscopic image by abutting the eyepieces 7 to the eyes and holding the attachment 2 as if using binoculars.*** As the smartphone 1500 is stowed inside the attachment 2, it is not possible to input an operation to the touch panel as-is, however, the attachment 2 of the present Embodiment is equipped with a remote touch circuit that enables remote operation input to the touch panel from the outside using the fingers gripping the attachment. EX1003, ¶0022 (emphasis added).

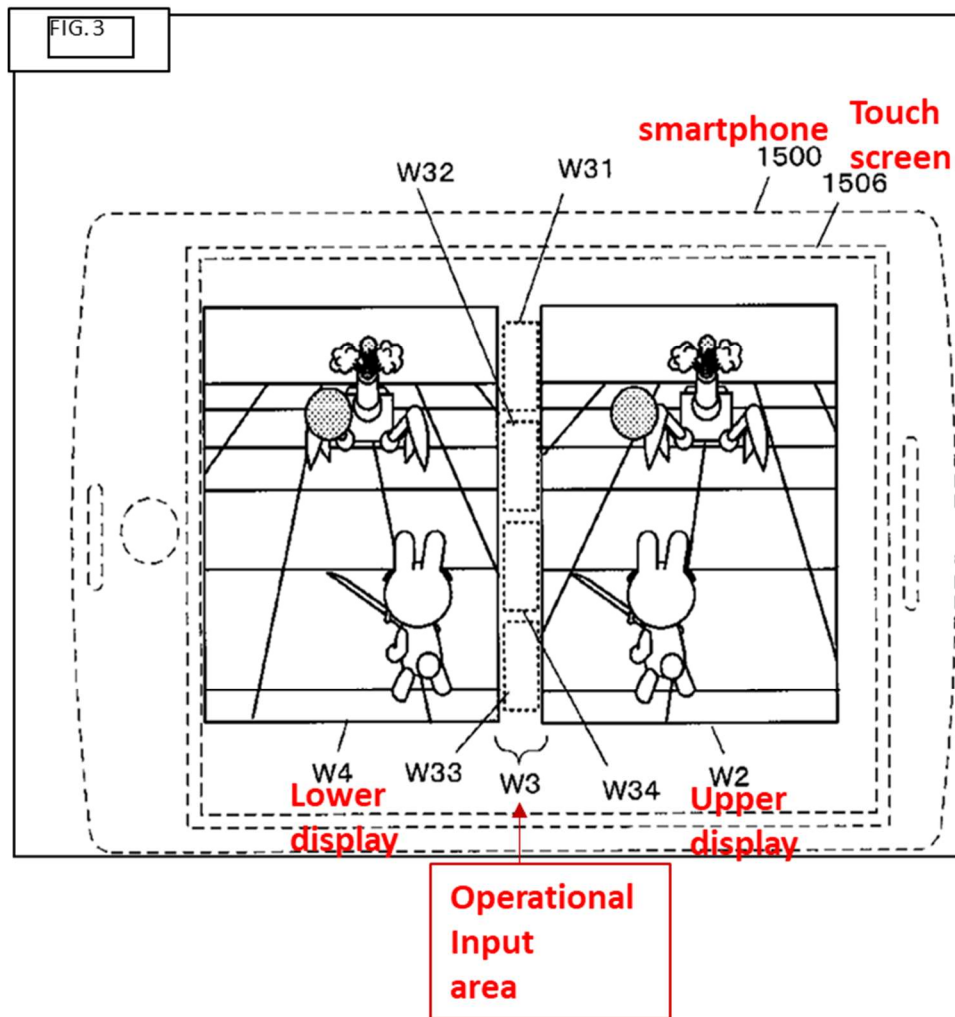
76. Figure 4(2) below shows the eyepieces spaced out horizontally and facing the same direction; note the viewpoint is from that of the smartphone, not the user.

the attachment 2 with the eyepieces placed on both eyes as if using binoculars, the user can enjoy a three-dimensional stereoscopic image.” EX1003, pg. 2.

78. Figure 4(2) also shows a partition wall 12, separating the interior to a left and right region. Thus, eyepiece 7R views a right region of the interior and eyepiece 7L views a left region of the interior.

A partition wall 12 is provided in the center side-to-side of the attachment main body 8, separating into a tubular part communicating with the right eyepiece 7R and a tubular part communicating with the left eyepiece 7L. The smartphone 1500 is supported and secured to the holding part 4 such that when the holding part 4 is closed, the operation input area W3 is positioned facing the front end part of the partition wall 12. EX1003, ¶0037 (emphasis added).

79. Figure 3 shows that, when mounted, the user will see on the touchscreen 1506 region W2 as the right side, region W4 as the left side, and region W3 is used for input.



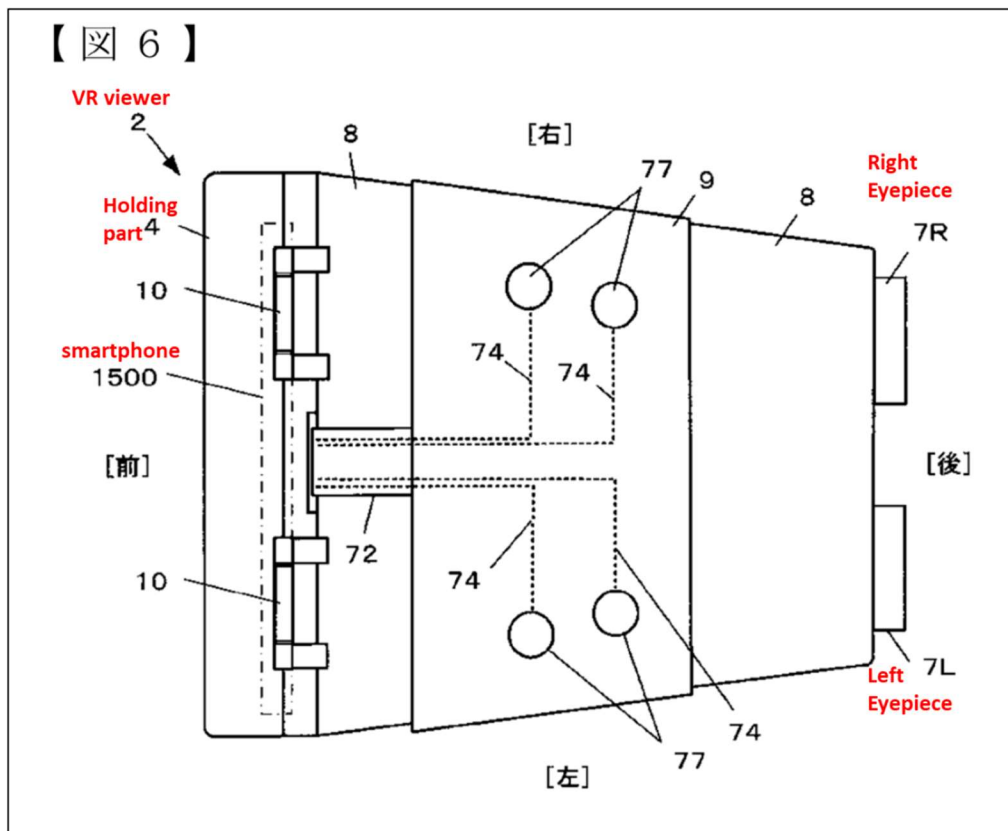
EX1003, Fig. 3 (annotations added).

80. Kondo explains that the smartphone is mounted in the VR viewer sideways using holding part 4.

FIG. 3 is a diagram illustrating an example of a display screen of a three-dimensional stereoscopic video. *The smartphone 1500 is mounted to the holding part 4 with the smartphone 1500 turned sideways.* An upper display area W2 and lower display area W4 are set on the screen of the touch panel 1506, and an operation input area W3

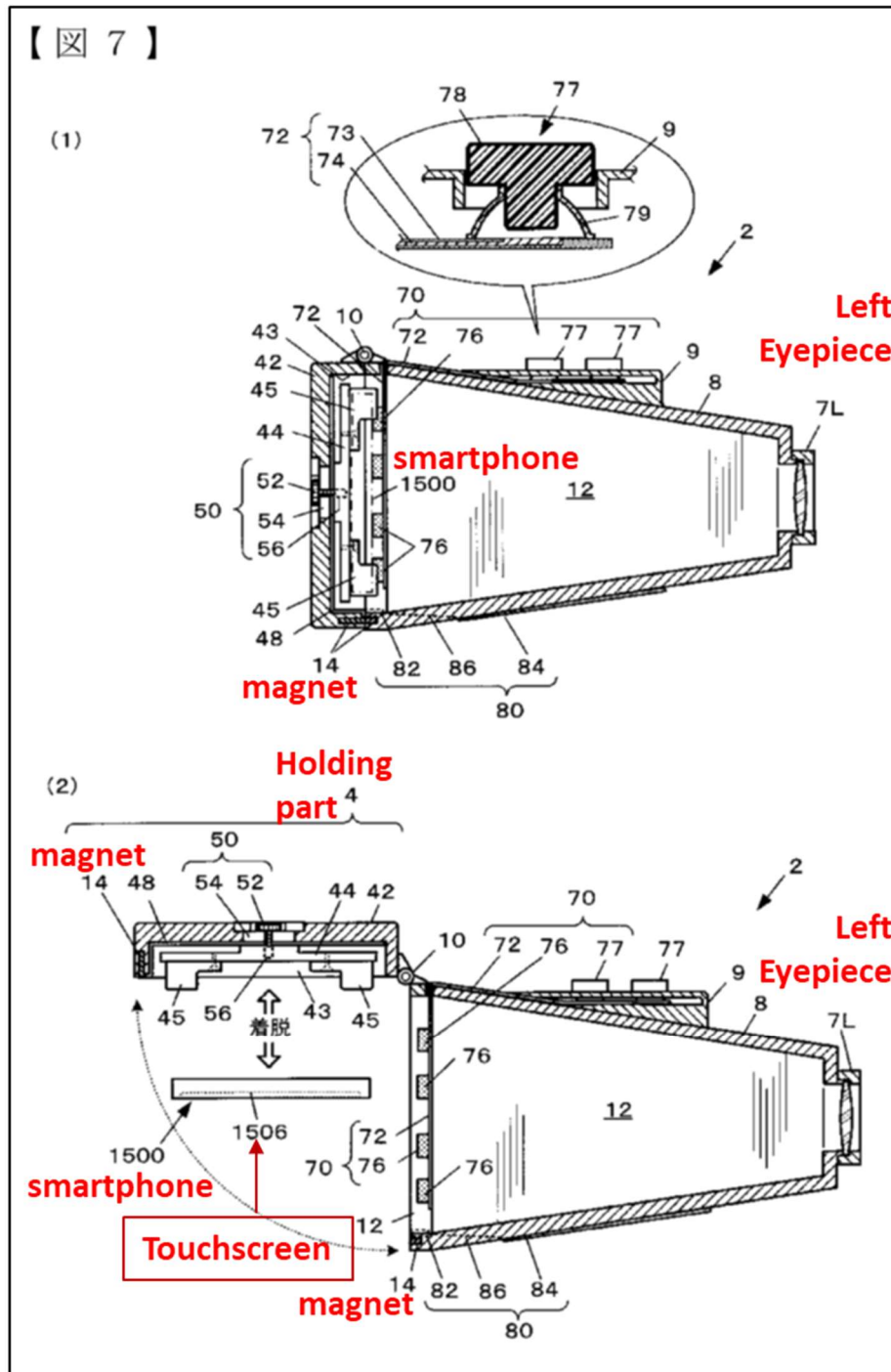
is further set between these display areas. *The upper display area W2 and lower display area W4 are on the right and left sides of the attachment 2 when the smartphone 1500 is mounted to the attachment 2. Therefore, the control board 1550 of the smartphone 1500 provides control so as to display a right eye image on the former, and a left eye image on the latter.* EX1003, ¶0027 (emphasis added).

81. Figure 6 below is a top view of VR viewer 2 and also shows the right eyepiece and the left eyepiece.



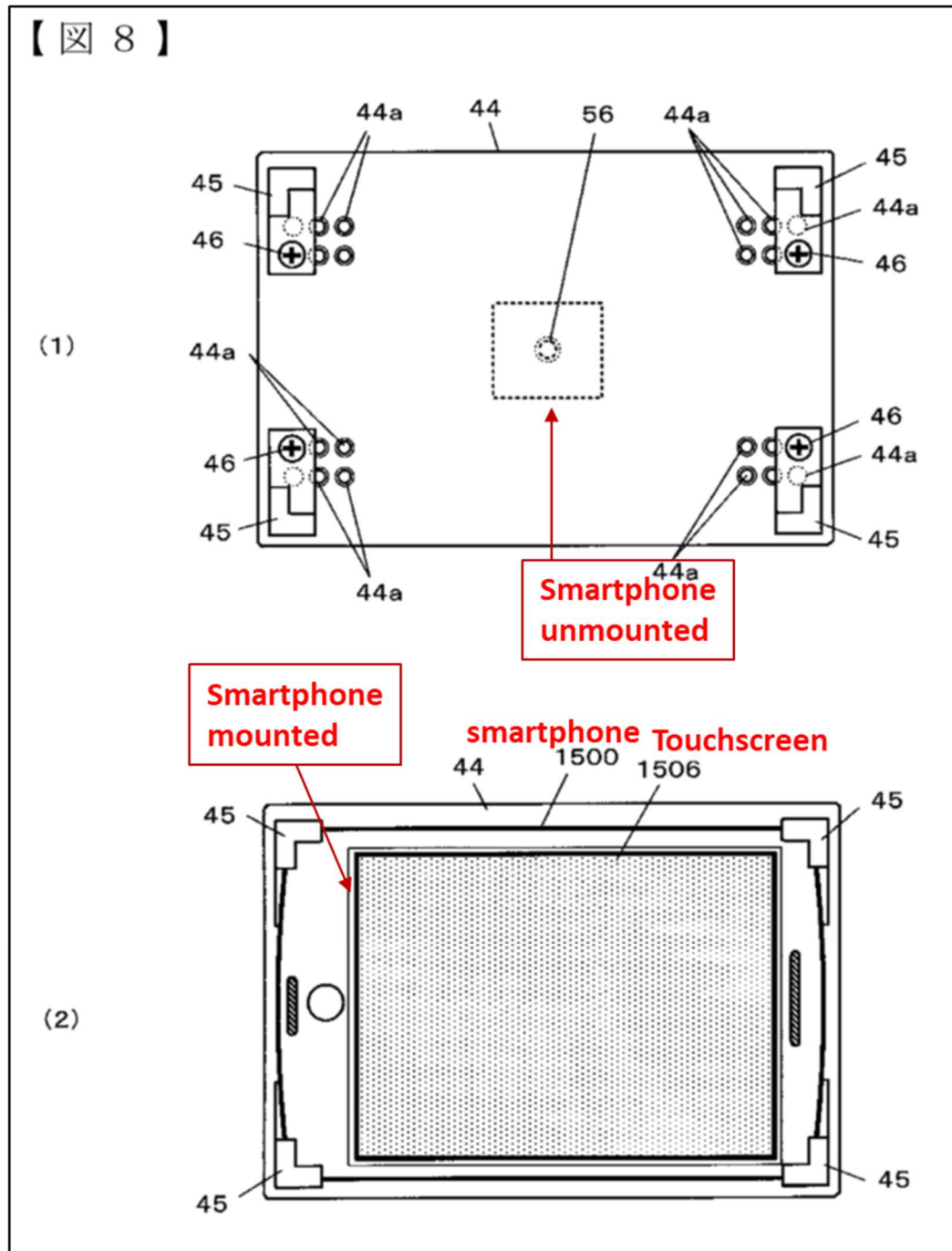
EX1003, Fig. 6 (annotations added).

82. Kondo Figure 7 below shows how the holding part 4 receives the smartphone. It uses a pair of magnets 14 embedded in the mating surfaces of the lower end of the holding part 4 and the lower end of the VR viewer's main body 8, and when the holding part 4 is closed, the magnets attract each other to keep the holding part 4 closed. Kondo Figure 7 below also shows the left eyepiece. Only the left eyepiece is shown because this figure is a side view. Additionally, this figure shows that the smartphone is directly in the user's field of view when looking through the rear end. EX1003, ¶0030, Fig. 7; *see also* ¶¶0022.



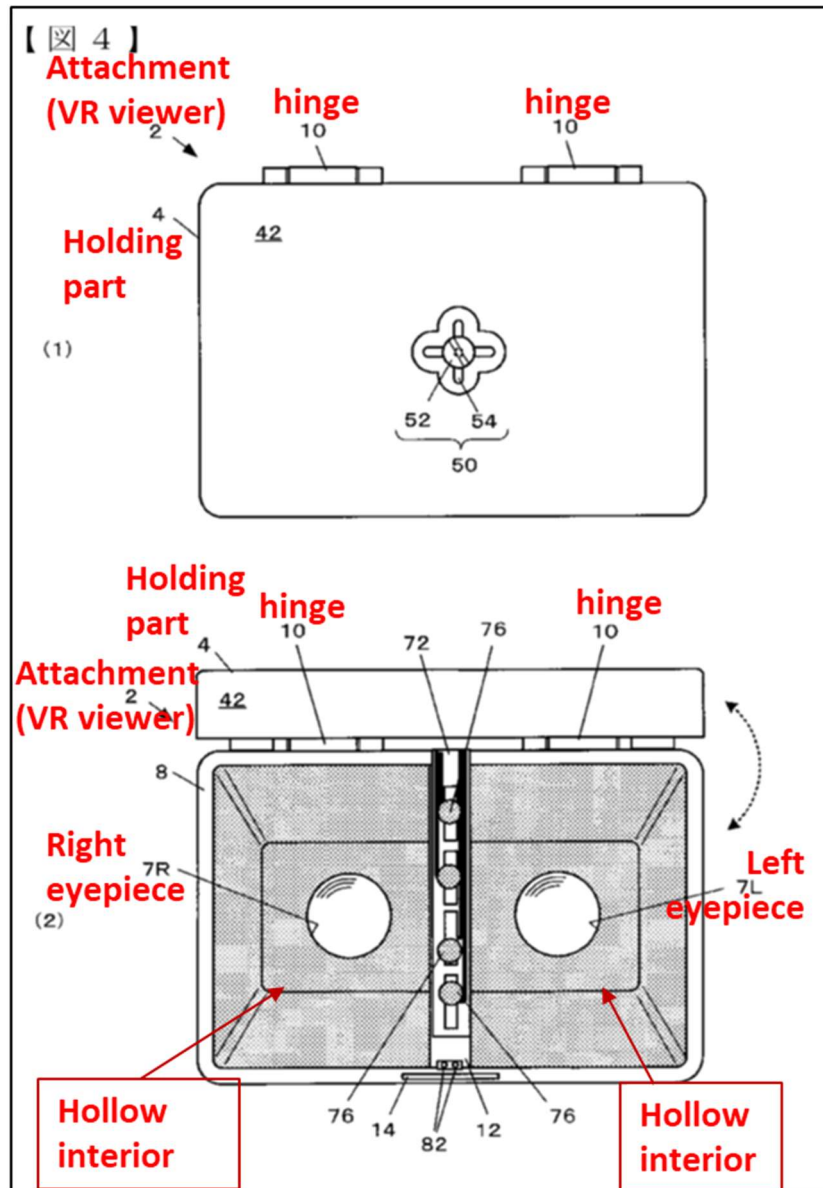
EX1003, Fig. 7 (annotations added); see also ¶¶0030-0032.

83. In Figure 8 below, Kondo shows both when the mobile phone is mounted and when it is not. When it is mounted, the mobile phone is centered in a horizontal direction.



EX1003, Fig. 8; see also ¶¶0033, 0034.

84. As illustrated in Kondo Figure 4 below (as well as Figures 5-7), the VR viewer 2 has a hinge 10 on the upper front end of a hollow attachment main body 8, and the hinge supports the holding part 4 so as to swing freely. The holding part 4 is opened to mount and dismount the smartphone 1500 to the VR viewer 2, and the holding part 4 is closed for use as a stereoscope. Figure 4 also shows that the smartphone is held in a centered, horizontal position, and is directly in the user's field of view. EX1003, ¶¶0030; *see also* ¶¶0022.



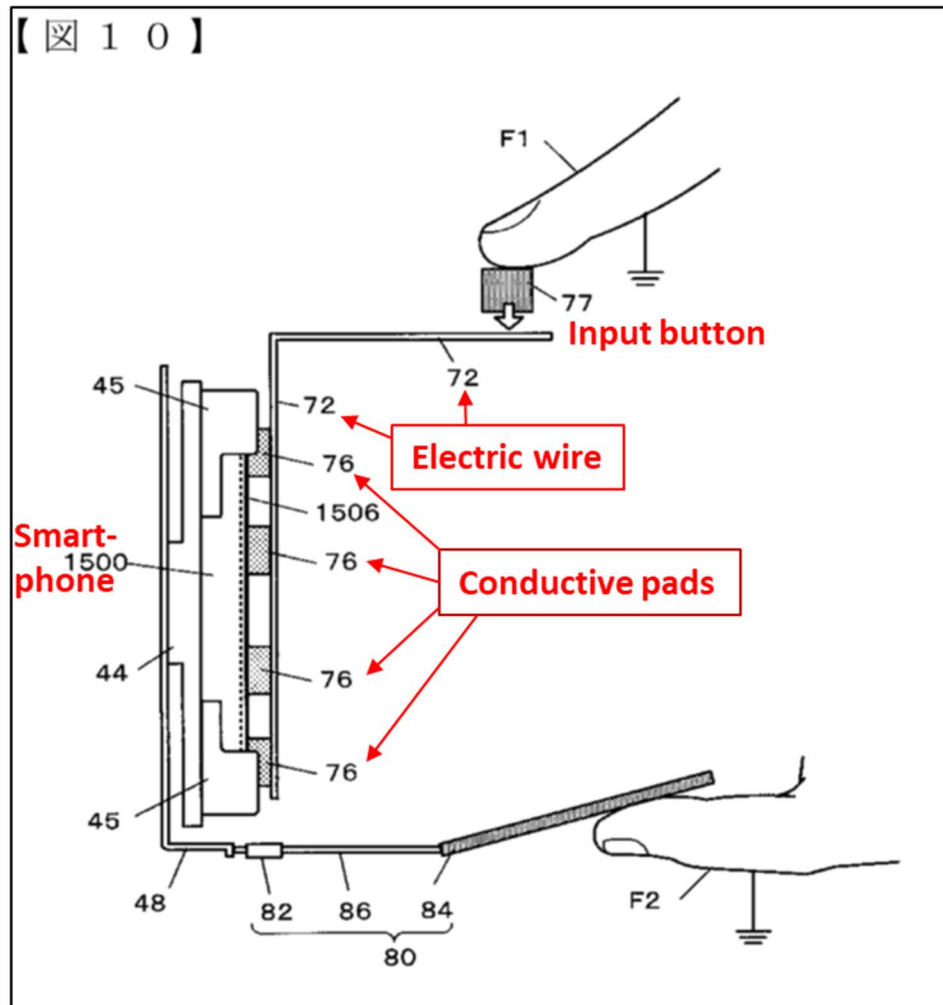
EX1003, Fig. 4 (annotations added).

3. 1(c): an input device accessible from an exterior of the housing; and

85. Kondo discloses an input device on the exterior of the housing (button 77):

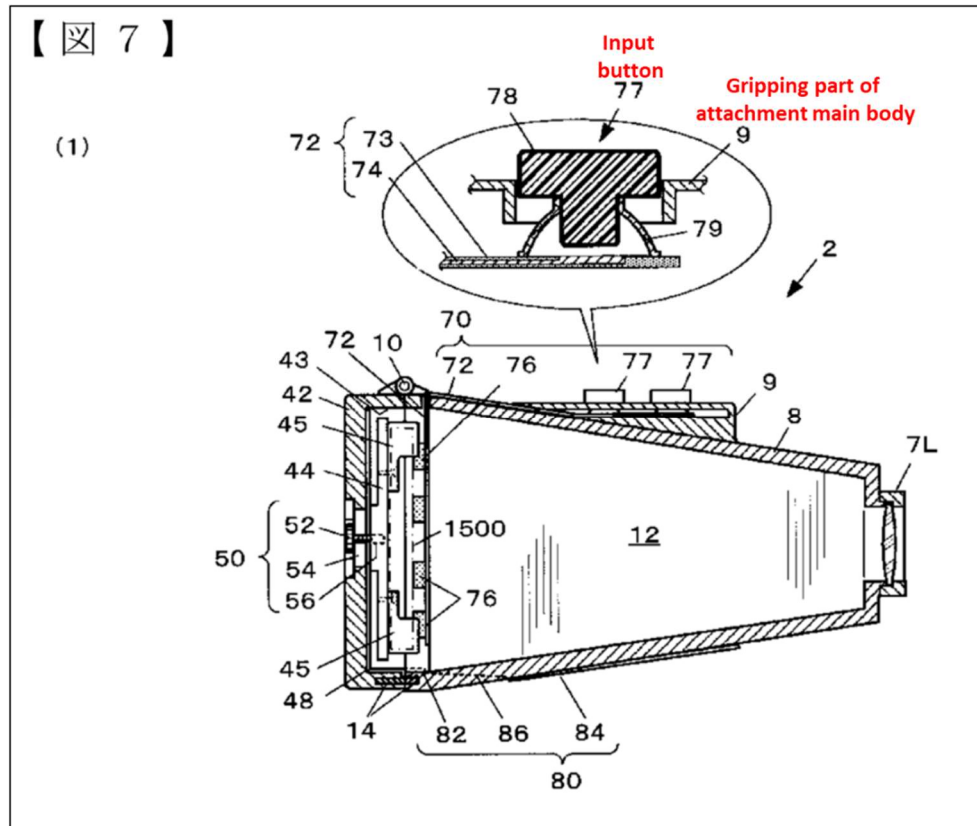
PROBLEM

To provide an attachment that achieves remote control input to a touch panel mounted on an electronic device. EX1003, pg. 2.



EX1003, Fig. 10 (annotations added).

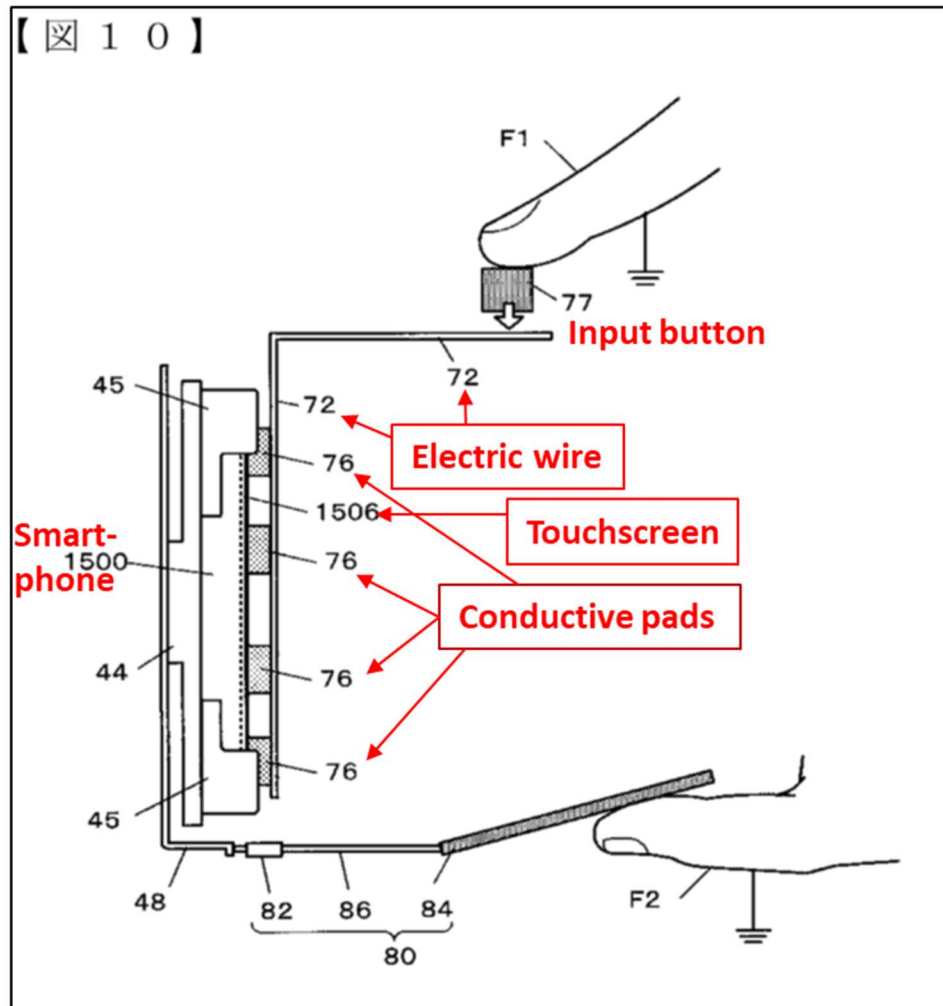
86. In Figure 10 above, Kondo shows the user actuating (by depressing) input button 77, which then provides input to mobile phone 1500 via electric wire 72 and conductive pads 76. Figure 7 below shows that button 77 is accessible



EX1003, Fig. 7 (annotations added); *see also*, ¶¶0042, 0043, 0047, 0048, 0049, 0052.

- 4. 1(d): a contact element located within an interior of the housing, the contact element coupled to the input device and configured to generate a detectable touch event at the touchscreen display of the mobile electronic device.**

87. See my analysis for claim 1(c). Kondo discloses an input mechanism 77 on the exterior of the housing (button 77):

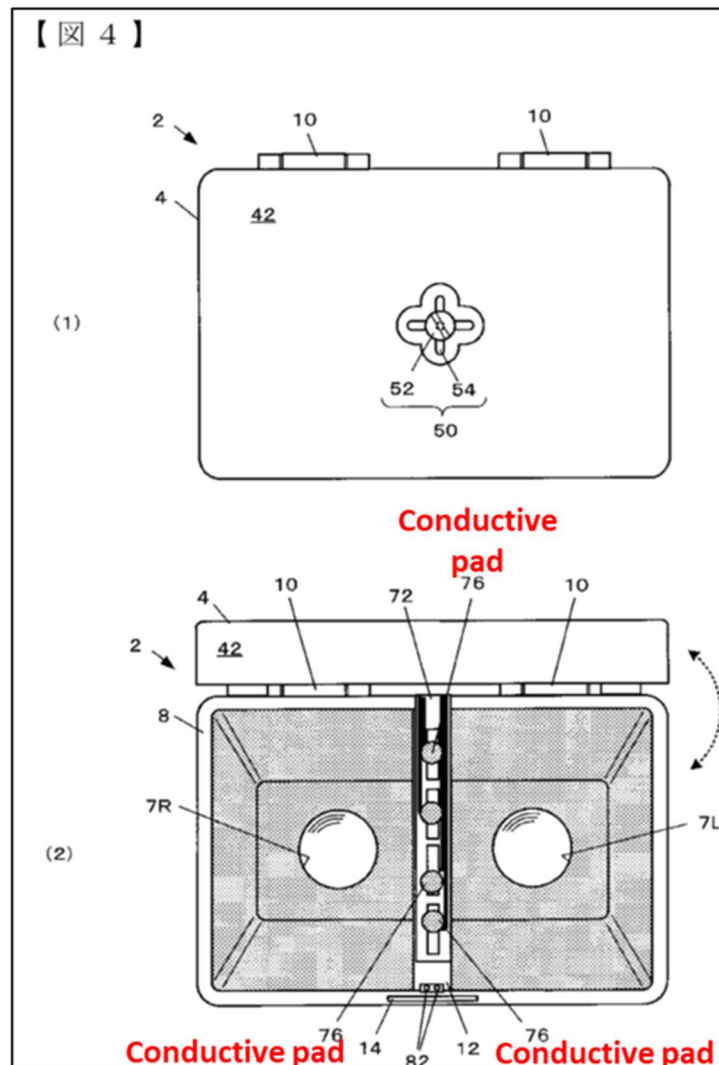


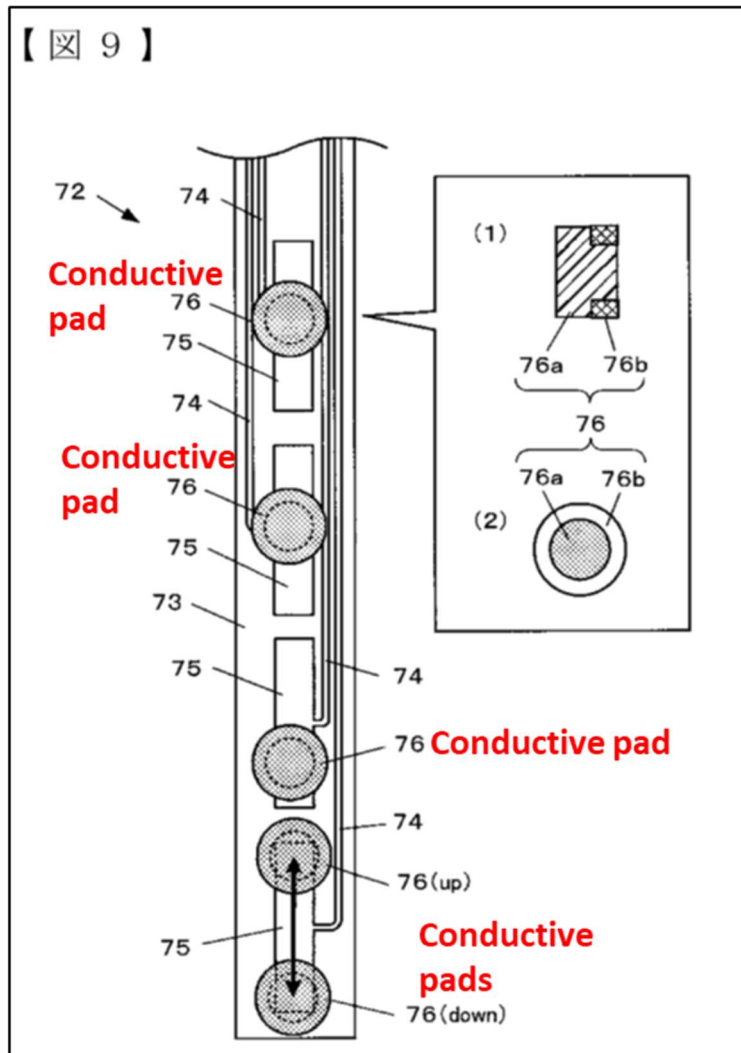
EX1003, Fig. 10 (annotations added); *see also* ¶¶0042, 0043, 0047, 0048, 0049, 0052.

88. In Figure 10 above, Kondo discloses the user depressing input button 77, which then provides input to the touchscreen 1506 of the mobile phone 1500 via electric wire 72 and conductive pads 76. The conductive pads 76 constitute the claimed “contact element.” As shown, the conductive pads 76 are in the interior of the housing, coupled to the input device (button 77) via electric wire 72, and in

physical contact with the touchscreen of the smartphone 1500 when the smartphone is mounted or received.

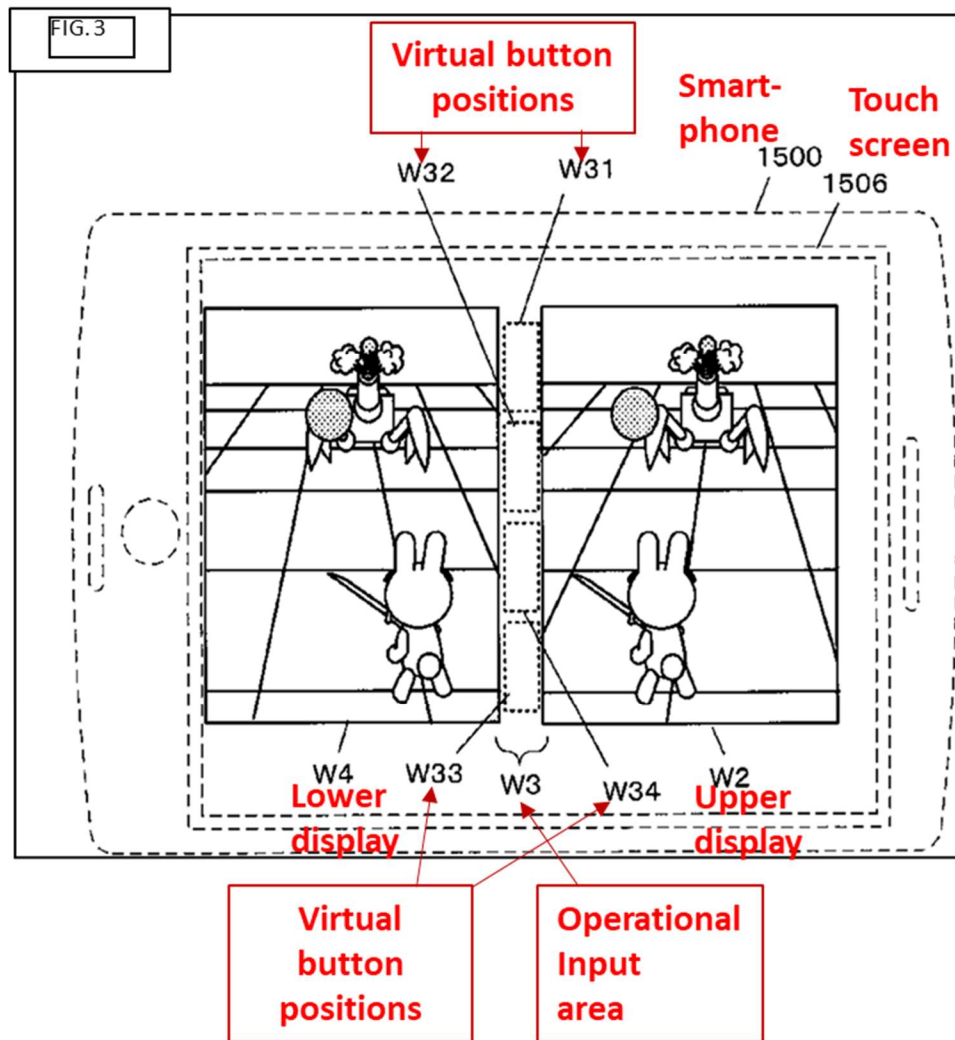
89. Kondo discloses that the conductive pads 76 are activated by pressing button 77 on the exterior of the housing and discloses that they physically contact the central region of the smartphone's touchscreen. Figure 4 below shows that the conductive pads contact the central region of the smartphone, and Figure 9 below shows the conductive pads in more detail.





EX1003, Figs. 4, 9 (annotations added).

90. Kondo's Figure 3 below shows operational input area W3 centered on the touchscreen that the conductive pads physically contact:



EX1003, Fig. 3 (annotations added); *see also* ¶¶0027-0028.

91. Kondo explains that when holding part 4 is closed (shown in Figures 5-7, *see claim 1(c)*), the conductive pads 76 (shown in Figures 4 and 9 above) physically contact (as shown in Figure 3 above (*see also* Figure 10 above)) with the operational input area W3 and, specifically, virtual button positions W31-W34, which are at the center of the touchscreen. The following quote also shows that the conductive pad is made of conductive material because it has a conductive core. A

POSA would understand that labeling the “conductive” pad so means that it is made of conductive material. Moreover, the input device would not work if the conductive pads did not conduct electricity.

The blown-up portion of FIG. 9 is a diagram illustrating a (1) vertical cross-sectional view and (2) bottom view (attachment surface side) of the conductive pad 76. *When the holding part 4 is closed, the conductive pad 76 comes into contact with the virtual button positions W31 to W34 set on the touch panel 1506 of the smartphone 1500 held by the holding part 4.* The conductive pad 76 of the present Embodiment is a disk-shaped pad, and *includes a conductive core section 76a* exposed on both end surfaces and adhesive section 76b provided on the outer periphery of the end portion of the side in contact with the widened section 75. The adhesive section 76b is an elastic resin that can be removed and re-adhered to the flexible sheet 73 and the conductive lines 74. In other words, the attachment position of the conductive pads 76 relative to the widened section 73 [sic] of the conductive lines 74 can be changed, and this functions as the position adjusting mechanism for adjusting the position at which the conductive pad 76 contacts the touch panel 1506 (adjustable in the range of 76 (up) and 76 (down) as seen in FIG. 9). EX1003, ¶0041 (emphasis added).

FIG. 10 is a circuit diagram of the remote touch circuit 70 according to the present Embodiment.

When the holding part 4 is closed, the main body of the smartphone 1500 is electrically conductively connected and grounded to the human

body that is the user through the device holding plate 44, holding side ground circuit 48, and attachment main body side ground circuit 80. On the other hand, *when the holding part 4 is closed, the conductive pad 76 projecting from the front side of the partition wall 12 comes into contact with the touch panel 1506*. EX1003, ¶0047 (emphasis added).

92. The conductive pad conducts electricity to generate a detectable touch event on the touchscreen.

When the user presses the button part 77 with a finger F1, *the touch panel 1506 is electrical conductively connected to the finger of the user through the conductive pad 75 [sic 76], electrical wire part 72, and button part 77. That is to say, that substantially, the impedance (capacitor or the like capacitance) of the finger (human body) of the user is electrically connected to the touch panel 1506*. Therefore, the touch panel 1506 can detect a current value corresponding to this impedance and *recognize that a touch operation has been performed at the virtual button positions W31 to W34*. EX1003, ¶0048 (emphasis added); *see also* cl. 1, ¶¶0005, 0009.

B. Claim 2: The apparatus of claim 1, wherein the contact element is configured to generate the detectable touch event at the touchscreen display while the mobile electronic device is located within the interior of the housing.

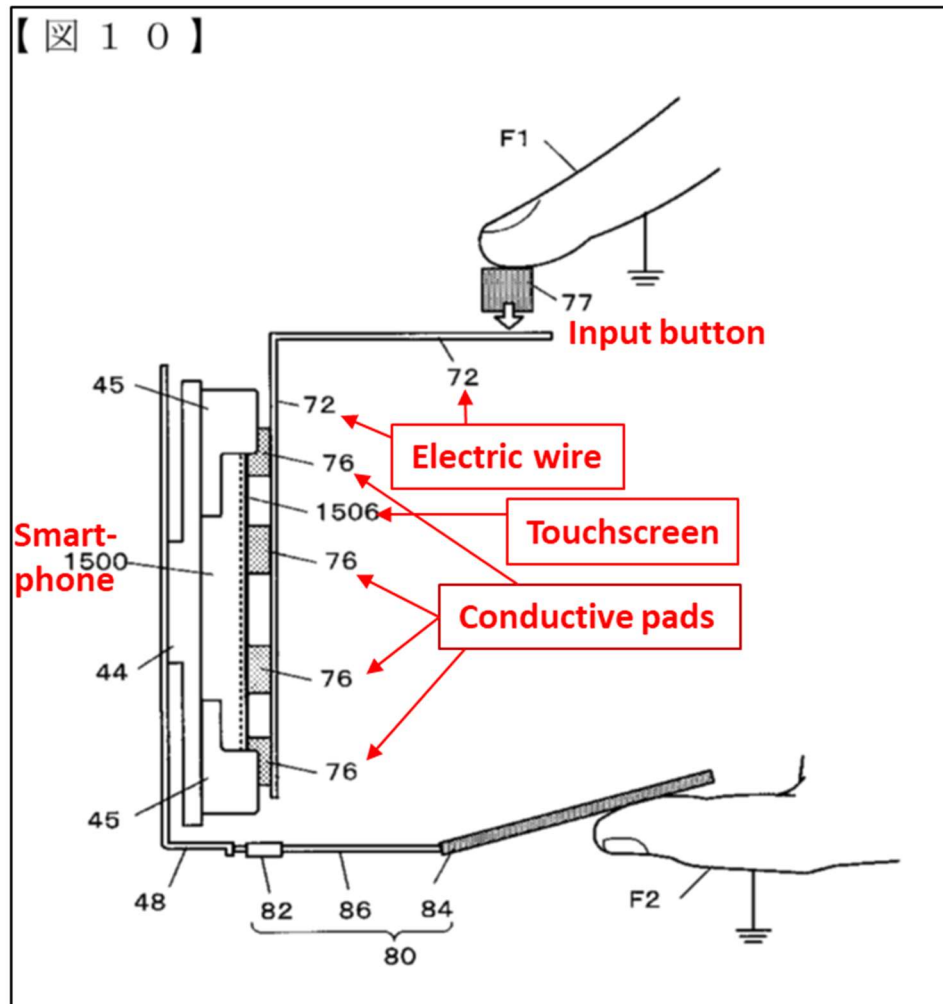
93. See my analysis of claim 1(d). Kondo discloses that the smartphone is in the housing when a touch event is generated. See EX1003, Figs. 1, 3, 4-10.

C. Claim 3: The apparatus of claim 1, wherein the input device comprises a tactile user input device.

94. Please see my analysis of claim 1.

95. The '000 patent mentions tactile user inputs as follows: “the disclosed systems and methods facilitate receiving tactile user inputs (e.g., user touches, button depressions, etc.) on the exterior of the housing....” EX1001, 3:33-38. The term “tactile user inputs” therefore includes buttons, and Kondo discloses buttons on the exterior for the user.

96. Kondo’s Figure 10 shows the user depressing button 77 to cause a touch event. Note the downward arrow for direction of motion of input button 77.

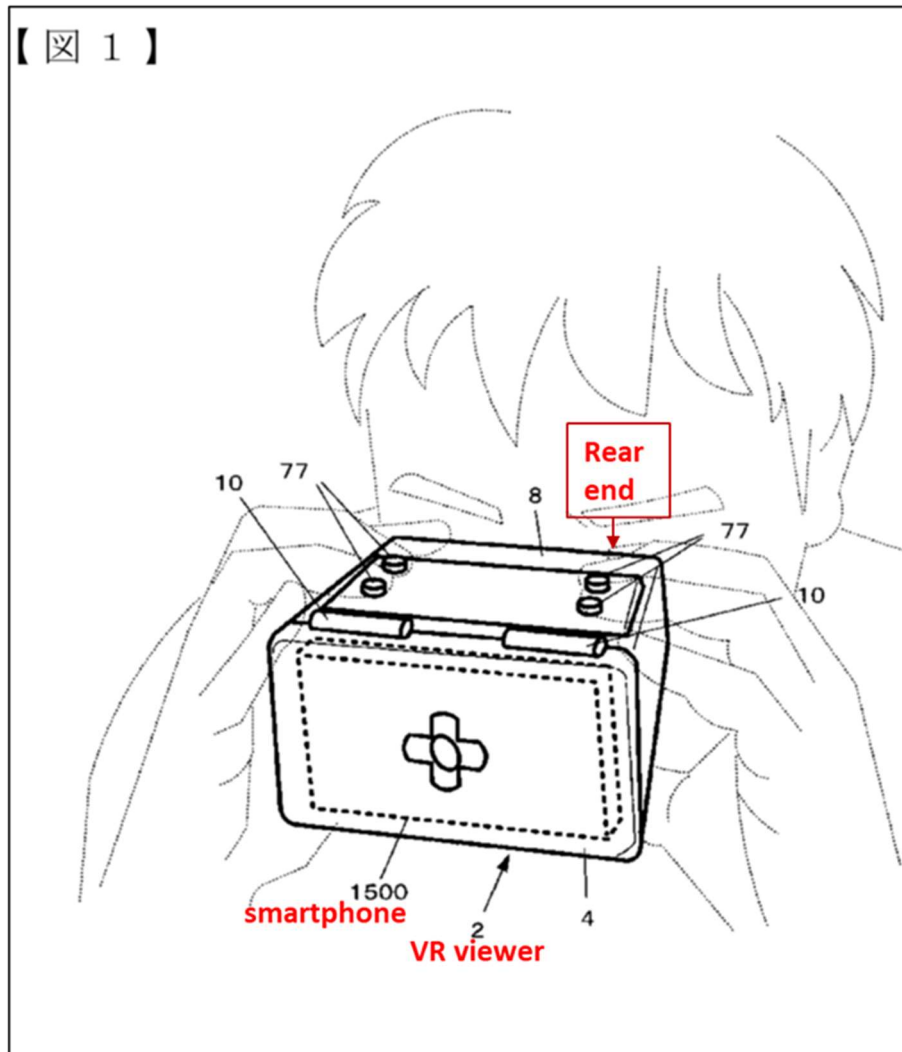


EX1003, Fig. 10 (annotations added); *see also* Figs. 1, 5-7, ¶¶0042, 0043, 0047, 0048, 0049, 0052.

D. Claim 4: The apparatus of claim 1, wherein the housing has a top surface, a bottom surface, a front surface, a back surface, and two side surfaces.

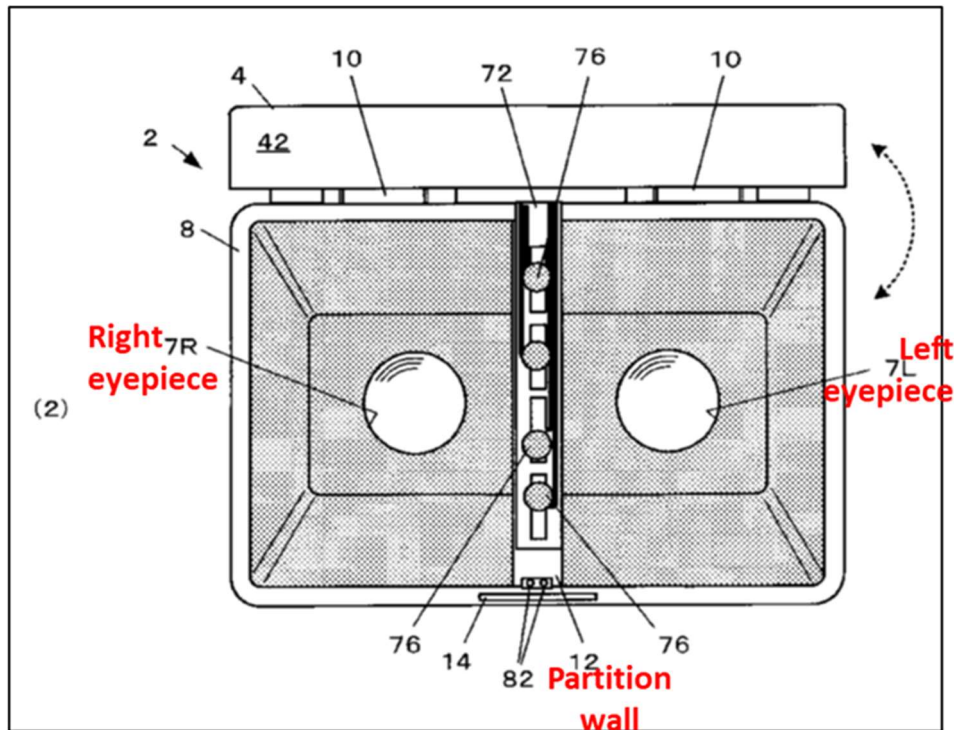
97. See my analysis of claim 1.

98. Kondo's Figure 1 shows the VR viewer with all the claimed surfaces. The "rear end" is the claimed back surface and has two lenses for viewing the smartphone 1500.



EX1003, Fig. 1 (annotations added); *see also* ¶0022.

99. Figure 4(2) below shows the VR viewer with all claimed sides as well as the claimed lenses on the rear end.



EX1003, Fig. 4(2) (annotations added); *see also* Figs. 5-11, ¶0037.

E. Claim 5: The apparatus of claim 4, wherein the back surface supports the two lenses.

100. See my analysis of claims 1 and 4.

F. Claim 6: The apparatus of claim 4, wherein the apparatus is configured to receive one or more user interactions during use of the apparatus.

101. Please see my analysis of claims 1 and 4 for a description of the user depressing Kondo's button 77 to cause a touch event.

G. Claim 8: The apparatus of claim 4, wherein the input device is located at an exterior of the housing.

102. See my analysis of claims 1 and 4 for a description of Kondo's button 77 being located on the exterior of the VR viewer.

H. Claim 9: The apparatus of claim 4, wherein the input device is user accessible for interaction therewith.

103. See my analysis of claims 1, 4, and 6.

I. Claim 10: The apparatus of claim 4, wherein the input device is configured to detect a user action.

104. See my analysis of claims 1, 4, and 6. See EX1003, ¶¶0043, 0047, 0048.

J. Claim 11: The apparatus of claim 4, wherein the input device is configured to relay a signal based on a user action to the mobile electronic device.

105. See my analysis of claims 1, 4, 6, and 10. See EX1003, ¶¶0043, 0047, 0048.

K. Claim 12: The apparatus of claim 4, wherein the input device is configured to sense a user interaction and transmit a signal based on the sensed user interaction to the touchscreen display via the touch screen input device and via a conductive lead that couples the input device and the touchscreen display.

106. See my analysis of claims 1, 4, 6, 10, and 11 for how Kondo's input device operates and generates a touch event. The claimed conductive lead is the electrical wire 72. See EX1003, Figs. 4-7, 10; ¶¶0043, 0047, 0048

L. Claim 13: The apparatus of claim 4, wherein the input device includes a conductive material.

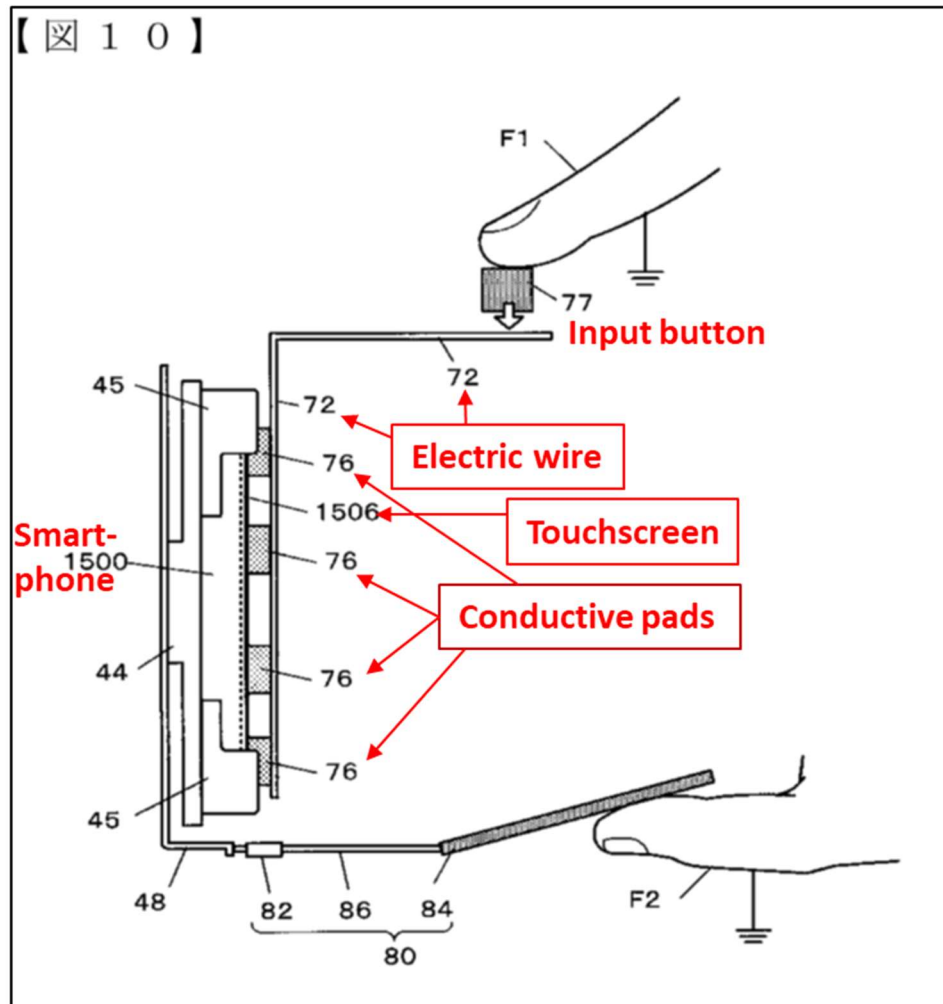
107. See my analysis of claims 1 and 4. See EX1003, ¶0043 ("The button part 77 includes a button body 78 made of a conductive material....").

M. Claim 14: The apparatus of claim 4, wherein a contact element configured to contact the touchscreen display includes a conductive material.

108. Please see my analysis of claim 1 for a discussion of the claimed "contact element" which is Kondo's conductive pads 76 and how these conductive pads contain a conductive core. See EX1003, Figs. 3, 4, 9, 10; ¶¶0041-0052

N. Claim 15: The apparatus of claim 4, wherein a conductive lead extends through at least a portion of the housing.

109. See my analysis of claims 1, 4, 6, 10, and 11. The claimed conductive lead is the electrical wire 72, which extends through the VR viewer, as can be seen in Kondo's Figure 10.



EX1003, Fig. 10 (annotations added); *see also* Figs. 4-7; ¶¶0042, 0043, 0047, 0048, 0049, 0052.

O. Claim 16: The apparatus of claim 1, wherein the contact element is coupled via a conductive lead to the input device.

110. See my analysis of claims 1, 4, 6, 10, 11, and 15. The claimed contact element are the conductive pads 76, the conductive lead is electric wire 72, and the input device is input button 77.

P. Claim 17: The apparatus of claim 1, wherein the input device comprises a passive input device.

111. See my analysis of claims 1 and 15 for a description of how a user depressing button 77 causes a touch event to occur on the touchscreen through an electrical connection with the user's finger. The '000 patent refers to its electrical embodiment as "passive." See EX1001, 5:16-6:41. So, a POSA would understand the term "passive input device" to refer to an input device that electrically connects the externally available input mechanism to the touchscreen and can generate a touch event without internal movement of the input mechanism. That is how Kondo's input device works. See EX1003, Figs. 4-7, 10; ¶¶0042, 0043, 0047, 0048, 0049, 0052.

Q. Claim 18: The apparatus of claim 1, wherein the input device is configured to receive a user input at the exterior of the housing and provide the received user input, via the contact element, to the touchscreen display.

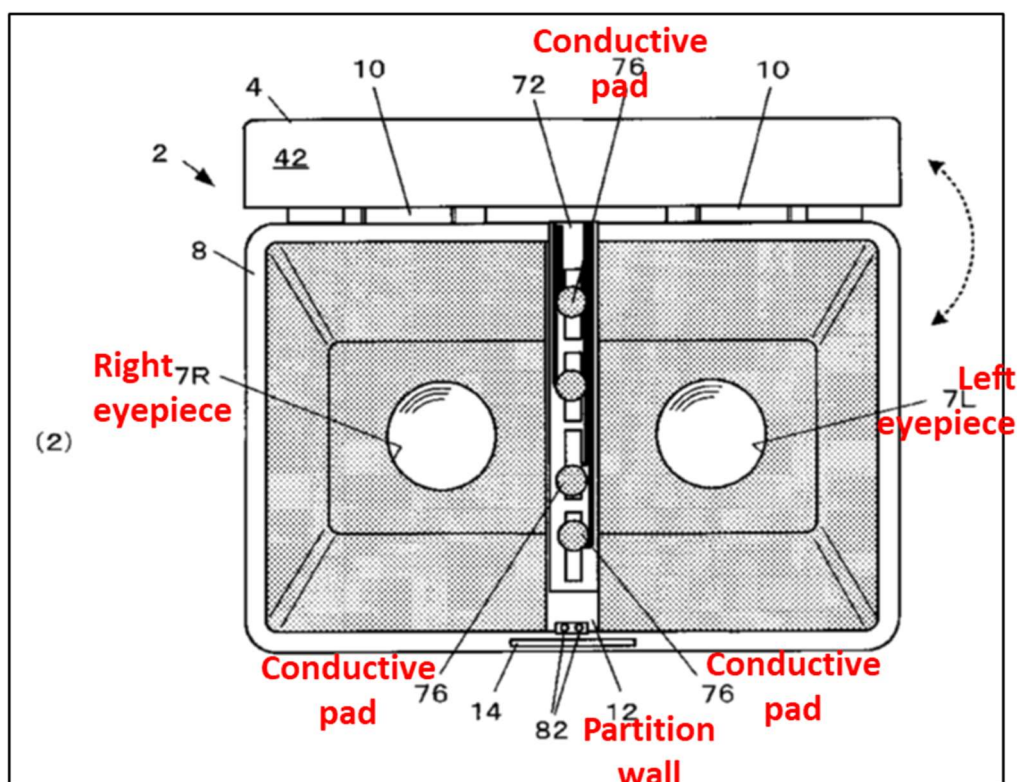
112. Please see my analysis of claims 1, 3, 8-12, 15, and 16.

R. Claim 19: The apparatus of claim 18, wherein the touch event, based on the user input, is provided to the touchscreen display at a position located within a central portion of the touchscreen display.

113. Please see my analysis of claim 1 for an explanation of how Kondo's conductive pads 76 contact virtual button positions W31-W34, which are in the center of the touchscreen. EX1003, Figs. 3, 4, 9; ¶¶0041, 0047, 0048.

S. **Claim 20: The apparatus of claim 19, wherein the central portion of the touchscreen display is not viewable, via the two lenses, by either eye of a user.**

114. See my analysis for claims 1 and 19. Kondo shows a partition wall 12 in Figure 4(2) with conductive pads 76:



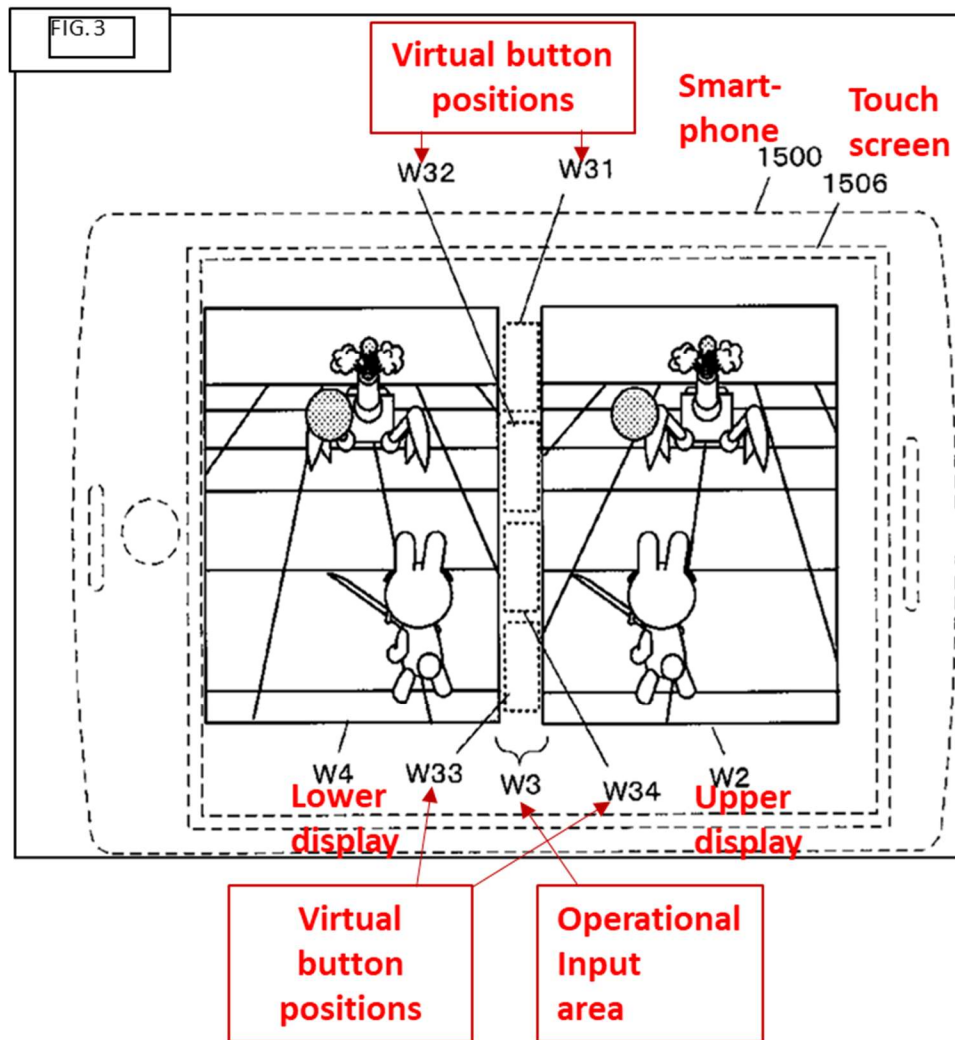
EX1003, Fig. 4(2) (annotations added).

115. Kondo explains that the partition wall 12 creates two tubular parts, one communicating with the right eyepiece and one communicating with the left:

A partition wall 12 is provided in the center side-to-side of the attachment main body 8, separating into a tubular part

communicating with the right eyepiece 7R and a tubular part communicating with the left eyepiece 7L. The smartphone 1500 is supported and secured to the holding part 4 such that when the holding part 4 is closed, the operation input area W3 is positioned facing the front end part of the partition wall 12. EX1003, ¶0037 (emphasis added).

116. A POSA would recognize that the partition wall 12 blocks the view of the center of the touchscreen, known as the operational input area, shown below in Figure 3. Kondo's Figure 3 shows that the conductive pads 76 align against the virtual button positions W31-W34 to operate the smartphone.



EX1003, Fig. 3 (annotations added); *see also* ¶¶0047-0048.

T. Claim 21: The apparatus of claim 19, wherein the contact element is configured to provide inputs to the mobile electronic device in a manner that does not disturb the field of view of the left eye or the right eye of a user.

117. Please see my analysis for claim 20 where the claimed contact element (Kondo's conductive pad 76) is on partition wall 12 facing the touchscreen, which then hides the contact element from the user's view.

U. Claim 22: The apparatus of claim 1, wherein the contact element comprises a touchscreen input device.

118. Please see my analysis of claim 1 and 21.

V. Claim 23: The apparatus of claim 22, wherein the touchscreen input device is electrically coupled to the input device.

119. Please see my analysis of claims 1 and 17.

W. Claim 24: The apparatus of claim 1, wherein the input device is configured to receive user interactions during use of the apparatus.

120. See my analysis of claims 1 and 18.

X. Claim 25: The apparatus of claim 24, wherein the input device is configured to sense the user interaction and transmit a signal based on the sensed user interaction to the touchscreen display via the touch screen input device and via a conductive lead that couples the input device and the touchscreen display.

121. See my analysis of claims 1 and 16. The claimed conductive lead is

Kondo's electric wire 72.

Y. Claim 26: The apparatus of claim 25, wherein the conductive lead runs through at least a portion of the housing.

122. See my analysis of claims 1, 4, 6, 10, 11, 15, and 25. The conductive lead is electric wire 72 and runs through the housing. See EX1003, Figs. 4-7, 10.

Z. Claim 27: The apparatus of claim 1, wherein at least a portion of the input device is exposed on an exterior surface of the housing.

123. See my analysis of claim 1. Kondo's button 77 is on the exterior of the VR viewer.

AA. Claim 28: The apparatus of claim 1, wherein the input device is positioned at the exterior of the housing.

124. See my analysis of claim 1. Kondo's button 77 is positioned at the exterior of the VR viewer.

BB. Claim 29: The apparatus of claim 1, wherein the input device is user accessible such that a user can interact with the input device.

125. See my analysis of claim 1.

CC. Claim 30: The apparatus of claim 1, wherein the input device is configured to detect a user action.

126. See my analysis of claim 1.

DD. Claim 31: The apparatus of claim 30, wherein the input device is configured to relay a signal based on the user action to the touchscreen display.

127. See my analysis of claims 1 and 11.

EE. Claim 32: The apparatus of claim 1, wherein the input device comprises a conductive material.

128. See my analysis of claims 1 and 13.

FF. Claim 33: The apparatus of claim 1, wherein the contact element comprises a conductive material.

129. See my analysis of claims 1 and 14.

IX. KONDO OBVIOUSNESS ANALYSIS OF CLAIMS 1-6 AND 8-33

130. As I have stated above, I believe that Kondo discloses every element of the challenged claims. This renders the challenged claims anticipated, but it also renders them obvious because there is no difference between the subject matter of the challenged claims and the prior art. I note that the obviousness analysis includes other considerations including secondary considerations, but as I have mentioned above in §IV(C), I am unaware of any such evidence as of this time.

131. I have demonstrated above that Kondo's eyepieces are the same as the '000 patent's lenses. Not only is the limitation "the housing further including two lenses" anticipated (*see e.g.*, §VIII(A)(2)), but it is also rendered obvious based on the '000 patent's own admissions. The '000 patent admits that VR viewers typically have lenses.

These viewers also typically include one or more optical lenses within the housing so as to facilitate a three-dimensional viewing experience despite the two-dimensional display of the smartphone. EX1001, 1:64-67 (emphasis added).

132. The '000 patent also admits that the configuration, construction, and placement of lenses in VR viewers is well-known:

The configuration, construction and placement of a lens or lenses 70 for use in virtual reality viewers are generally known and understood by those skilled in the art. EX1001, 4:24-27.

133. These admissions demonstrate that the claimed lenses were well-known and that a POSA would be motivated to use the claimed lenses to facilitate a three-dimensional viewing experience. I note that Kondo states the same motivation. EX1003, pg. 2 (“By looking into the inside of the attachment 2 with the eyepieces placed on both eyes as if using binoculars, the user can enjoy a three-dimensional stereoscopic image.”). These admissions also demonstrate that a POSA would know how to configure, construct, and place those lenses in a VR viewer and thus have a reasonable expectation of success.

X. KONDO/CHU OBVIOUSNESS ANALYSIS OF CLAIMS 1-6, 8-16, AND 18-33

134. As I demonstrated above, Kondo itself anticipates and renders obvious all limitations of the challenged claims. In fact, as shown above, Kondo is virtually identical to the '000 patent.

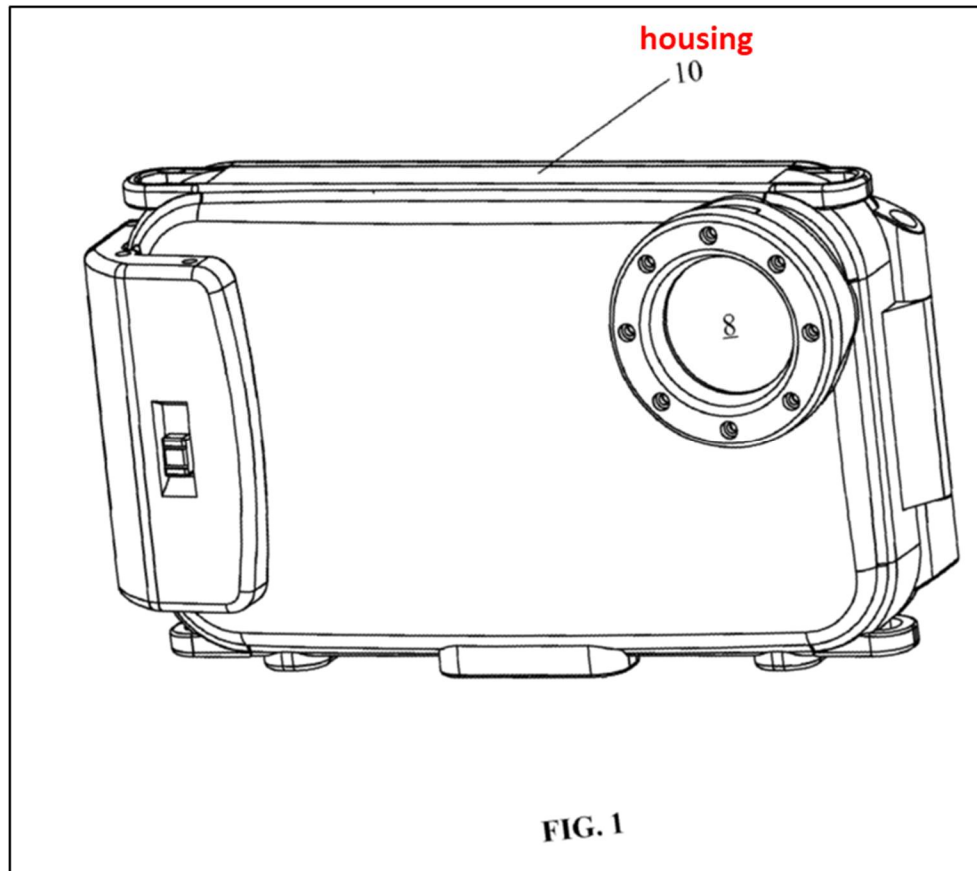
135. Nevertheless, in this section, as an alternative ground, I demonstrate how the combination of Kondo/Chu also renders the challenged claims obvious. I incorporate Chu's input device into the Kondo VR viewer, not because of any weaknesses in Kondo, but just to show that a POSA looking at Kondo would have multiple ways of considering the challenged claims invalid. Please see my analysis in §VII(C) where I explain the proposed combinations. Please note that my reference to claim elements (*e.g.*, claim 1(b)) refers to the claim elements in §VIII.

136. In the below analysis, I rely on my anticipation analysis of Kondo in §VIII. That is, I rely on Kondo's disclosures in many instances. But, for certain claims and claim elements, I explain how Chu additionally discloses those limitations, thereby rendering the '000 patent obvious when Kondo is combined with Chu.

A. Claim 1:

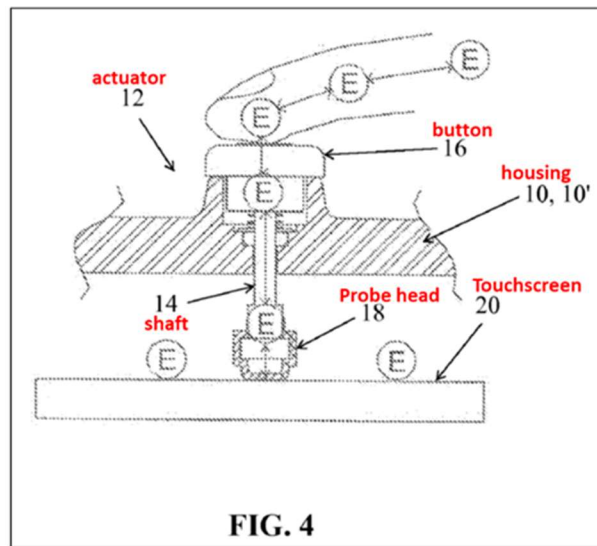
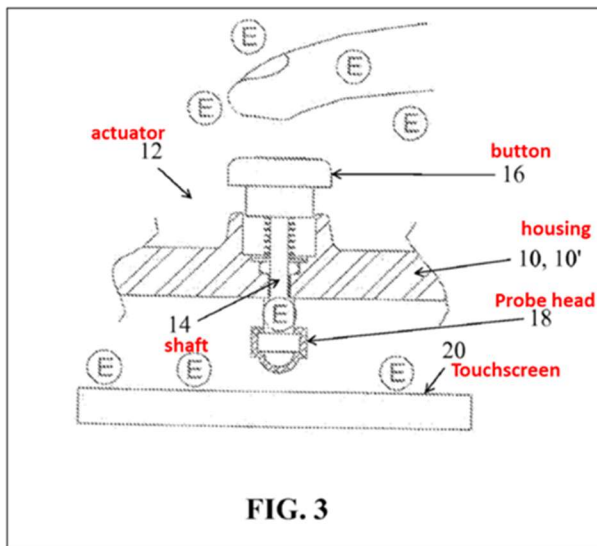
137. For claim elements 1(a) and 1(b), please see Kondo's disclosures in §§VIII(A)(1) and (2). For claim elements 1(c) and (d), Chu also discloses "an input device on the exterior of the housing" and "a contact element located within an interior of the housing, the contact element coupled to the input device and configured to generate a detectable touch event at the touchscreen display of the mobile electronic device."

138. First, Chu discloses a housing that holds a mobile phone in Figure 1 below:



EX1004, Fig. 1 (annotation added); *see also* ¶0038.

139. Chu discloses (in Figures 3 and 4 below) an input device accessible from the exterior of the housing 10 (button 16). Chu also discloses the claimed contact element (probe head 18, specifically probe pad 30, not shown below) which is in the interior of the housing, coupled to the input device (button 16), and generates a touch event on the touchscreen:



EX1004, Figs. 3, 4 (annotations added).

140. Chu explains how its input device operates as follows:

[0053] At an initial state, as illustrated in FIG. 3, the press button 16 is at its highest position when the press button 16 is released and the biasing member 40 is urging the press button 16 upwards. The biasing member 40 pushes the washer 42 downwards thereby holding the O-ring 50 inside the circular recess 52 formed on waterproof housing 10. Since the press button 16 is at its highest position, the probe head 18 being connected to the shaft 14 is also at its highest position. ***Therefore, the probe head 18 is not touching the capacitive touch screen 20 of the digital device inside the waterproof housing 10.*** The electric charge E on the capacitive touch screen 20 does not change.

EX1004, ¶0053 (emphasis added).

[0054] When a user's finger or body part starts to touch the press button 16 and begins to press downwards, the user's finger or body part gets

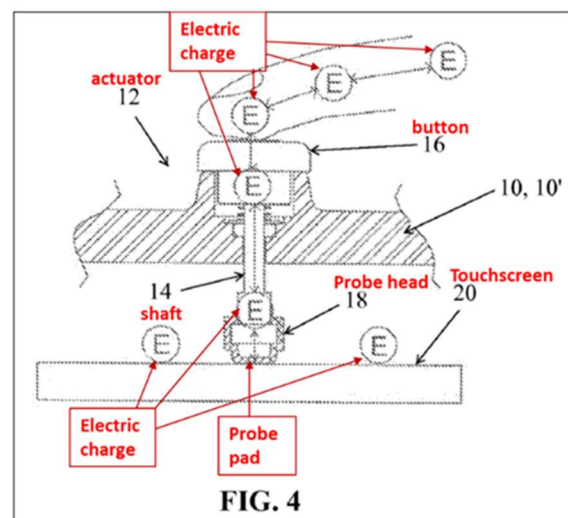
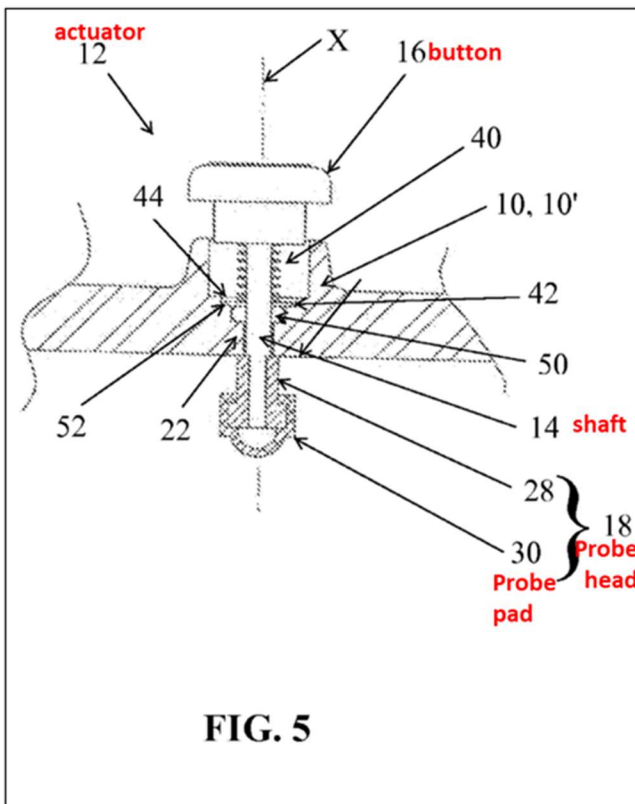
intimate with the press button 16 and the contact area with the press button 16 increases. *Since the press button 16 is metal or metalized, the user's finger or body part is electric charge connected.* EX1004, ¶0054 (emphasis added).

[0055] *When the user's finger or body part continues to press downwards, the electric charge conductivity between the press button 16 and the user's finger or body part further improves. The press button 16 together with the actuator shaft 14 starts to move downwards.* The biasing member 40 supporting the press button 16 is compressed. Since an O-ring 50 is installed on the actuator shaft 14 with a water-sealing compound, it can prevent water outside the waterproof housing 10, 10 from entering into the waterproof housing 10, 10 and damaging the digital device held therein. *The probe head 18 carried by the actuator shaft 14 starts touching the touch screen 20. When the probe pad 30 is further pressed onto the touch screen 20, the probe pad 30 starts to deform and form a larger contact area with the touch screen 20, as depicted in FIG. 4, thereby enhancing the electric charge conductivity.* Through the large flat or mushroom-shaped surface of the press button 16, the actuator shaft 14 and the probe head 18, it starts to transfer or receive electric charge to or from human body. This results in change of electric charge on the touch screen 20. The digital device can then compute a set of coordinates on the touch screen display. EX1004, ¶0055 (emphasis added).

[0056] *When the press button 16 is released, the biasing member 40 then pushes the press button 16 upwards. The actuator shaft 14 and*

the probe head 18 also move upwards thereby separating the probe head 18 from the touch screen 20 and stopping the interaction with the touch screen 20. The operation of the actuator mechanism 12 is then completed. EX1004, ¶0056 (emphasis added); *see also* ¶¶0011, 0038.

141. In Figure 5 below, Chu discloses the contact element (probe pad 30), which has a surface that is made of material capable of conducting electric charge to a touchscreen. EX1004, ¶0011. And Figure 4 below shows the probe pad's surface contacting the touchscreen 20 of the smartphone when the input device is extended to create a detectable touch event.



EX1004, Figs. 4, 5 (annotations added).

FIG. 4 shows the actuator mechanism 12 at an actuation position when the press button 16 is pushed downwards/inwards by a finger of a user, and the probe head 18 is touching the capacitive touch screen 20. At this actuation position, electric charge E can be transferred between the finger of the user and the capacitive touch screen 20 through the press button 16, the actuator shaft 14 and the probe head 18, as shown by the arrows. EX1004, ¶0041 (emphasis added).

142. The probe pad 30 is made of conductive material, such as metal or rubber with a conductive additive.

The press button, the shaft and ***the probe head may be made of a material capable of conducting electric charge.*** EX1004, ¶0011(emphasis added).

The press button, the shaft, the adaptor, and the probe head may be made of metal. EX1004, ¶0014; *see also* ¶¶0019, 0049.

The probe pad 30 may be made of soft material such as rubber. Additive may be added to the rubber in order to enhance its electric charge transfer performance. Soft material is used because it can minimize possible scratch or damage on the touchscreen 20. EX1004, ¶0049 (emphasis added).

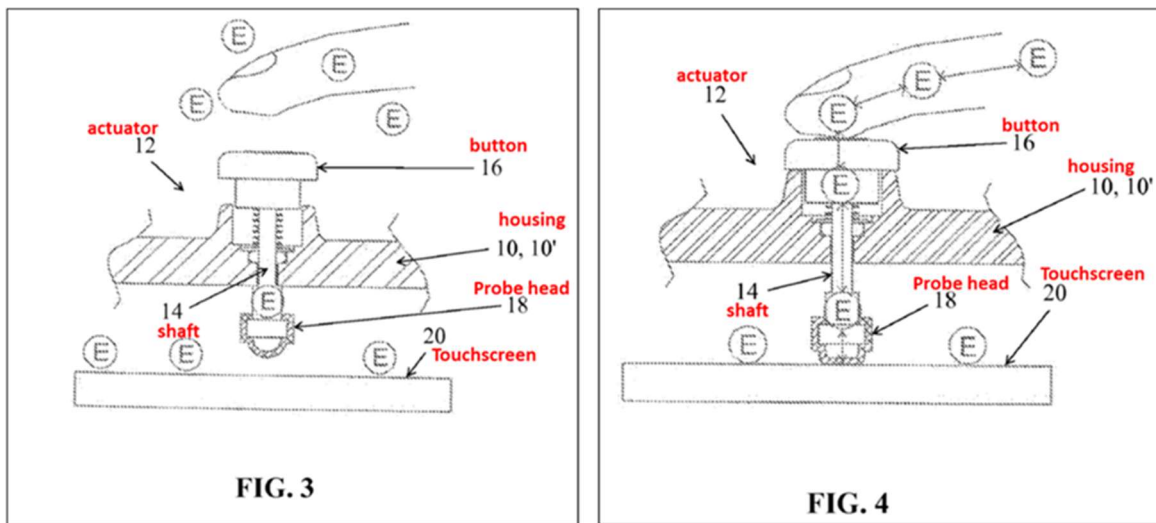
143. All three embodiments of Chu operate in this same way. See EX1004, ¶¶0053-0062.

B. Claim 2: The apparatus of claim 1, wherein the contact element is configured to generate the detectable touch event at the touchscreen display while the mobile electronic device is located within the interior of the housing.

144. See my analysis of claim 1 in this section. Chu generates a detectable touch event when the smartphone is mounted. EX1004, Fig. 4.

C. Claim 3: The apparatus of claim 1, wherein the input device comprises a tactile user input device.

145. See my analysis of claim 3 in §VIII where I discuss that the '000 patent uses the term “tactile user input device” to include buttons. Chu also includes a button 16 on the exterior for the user to cause a touch event:



EX1004, Figs. 3, 4 (annotations added); *see also* ¶¶0053-0062.

D. Claim 4: The apparatus of claim 1, wherein the housing has a top surface, a bottom surface, a front surface, a back surface, and two side surfaces.

146. See my analysis for claim 4 in §VIII.

E. Claim 5: The apparatus of claim 4, wherein the back surface supports the two lenses.

147. See my analysis of claims 1 and 4 in §VIII.

F. Claim 6: The apparatus of claim 4, wherein the apparatus is configured to receive one or more user interactions during use of the apparatus.

148. Please see my analysis of claims 1 and 4 in this section. For claim 1, I provide a description of the user depressing Chu's button 16 to cause a touch event.

G. Claim 8: The apparatus of claim 4, wherein the input device is located at an exterior of the housing.

149. See my analysis of claims 1 and 4 in this section. Chu's button 16 is located on the exterior of the VR viewer.

H. Claim 9: The apparatus of claim 4, wherein the input device is user accessible for interaction therewith.

150. See my analysis of claims 1, 4, and 6 in this section. Chu's button 16 is user accessible.

I. Claim 10: The apparatus of claim 4, wherein the input device is configured to detect a user action.

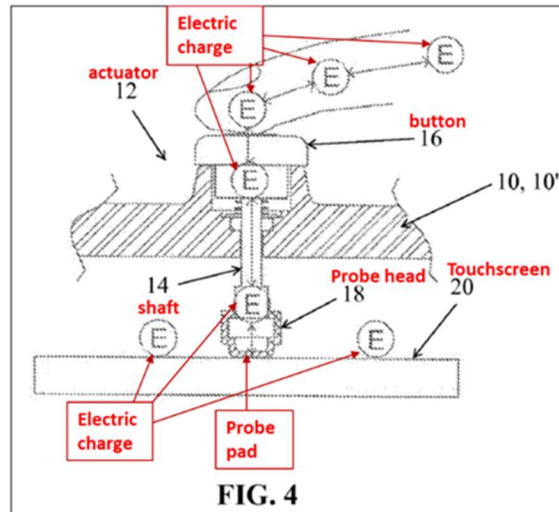
151. See my analysis of claims 1, 4, and 6 in this section.

J. Claim 11: The apparatus of claim 4, wherein the input device is configured to relay a signal based on a user action to the mobile electronic device.

152. See my analysis of claims 1, 4, 6, and 10 in this section. See EX1004, ¶¶0041-0062.

K. Claim 12: The apparatus of claim 4, wherein the input device is configured to sense a user interaction and transmit a signal based on the sensed user interaction to the touchscreen display via the touch screen input device and via a conductive lead that couples the input device and the touchscreen display.

153. See my analysis of claims 1, 4, 6, 10, and 11 in this section. The claimed conductive lead can be seen in Chu's Figure 4 as electric charge flowing through button 16, shaft 14, probe head 18, and the probe pad. Chu's shaft alone could constitute the claimed conductive lead. Alternatively, Chu's shaft combined with any combination of button 16, probe head 18, and the probe pad could also constitute the claimed conductive lead.



EX1004, Fig 4 (annotations added); *see also* ¶¶0041-0062.

L. Claim 13: The apparatus of claim 4, wherein the input device includes a conductive material.

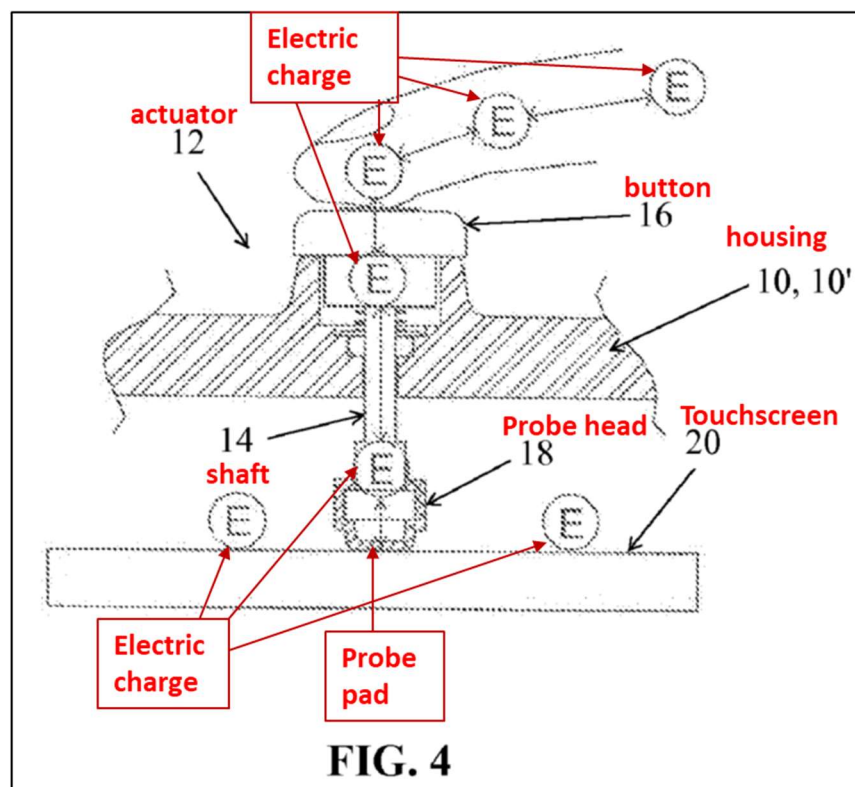
154. See my analysis above for claims 1 and 4 in this section. Chu discloses that its button 16 “may be made of metal, a metalized material or a material capable of conducting electric charge.” EX1004, ¶0043.

M. Claim 14: The apparatus of claim 4, wherein a contact element configured to contact the touchscreen display includes a conductive material.

155. Please see my analysis of claim 1 in this section for a discussion of the claimed “contact element” which is Chu’s probe pad 30. Chu’s probe pad is made of conductive material, such as metal or rubber with a conductive additive. See EX1004, ¶¶0011, 0014, 0019, 0049; *see also* Figs. 3-5; ¶¶0041-0062.

N. Claim 15: The apparatus of claim 4, wherein a conductive lead extends through at least a portion of the housing.

156. See my analysis of claims 1, 4, and 12 in this section. The claimed conductive lead can be seen in Chu's Figure 4 as electric charge flowing through button 16, shaft 14, probe head 18, and probe pad 30, which extend through housing 10. Chu's shaft alone could constitute the claimed conductive lead. Alternatively, Chu's shaft combined with any combination of button 16, probe head 18, and the probe pad could also constitute the claimed conductive lead.



EX1004, Fig 4 (annotations added); *see also* ¶¶0041-0062.

- O. Claim 16: The apparatus of claim 1, wherein the contact element is coupled via a conductive lead to the input device.**

157. See my analysis of claims 1, 12, and 15 in this section for an explanation of how Chu's probe pad (the claimed contact element) is electrically and mechanically coupled to button 16.

- P. Claim 18: The apparatus of claim 1, wherein the input device is configured to receive a user input at the exterior of the housing and provide the received user input, via the contact element, to the touchscreen display.**

158. See my analysis of claim 1 in this section. EX1004, ¶¶0041-0062.

- Q. Claim 19: The apparatus of claim 18, wherein the touch event, based on the user input, is provided to the touchscreen display at a position located within a central portion of the touchscreen display.**

159. See §VII(C) for a discussion of how the Kondo/Chu combination provides input to the central portion of the touchscreen display. See also my analysis of claim 1 in §VIII.

- R. Claim 20: The apparatus of claim 19, wherein the central portion of the touchscreen display is not viewable, via the two lenses, by either eye of a user.**

160. See my claim 20 analysis in §VIII.

S. Claim 21: The apparatus of claim 19, wherein the contact element is configured to provide inputs to the mobile electronic device in a manner that does not disturb the field of view of the left eye or the right eye of a user.

161. See my claim 21 analysis in §VIII.

T. Claim 22: The apparatus of claim 1, wherein the contact element comprises a touchscreen input device.

162. Please see my analysis of claim 1 in this section.

U. Claim 23: The apparatus of claim 22, wherein the touchscreen input device is electrically coupled to the input device.

163. Please see my analysis of claims 1, 11, 12, 15, and 17 in this section.

V. Claim 24: The apparatus of claim 1, wherein the input device is configured to receive user interactions during use of the apparatus.

164. See my analysis of claims 1 and 18 in this section.

W. Claim 25: The apparatus of claim 24, wherein the input device is configured to sense the user interaction and transmit a signal based on the sensed user interaction to the touchscreen display via the touch screen input device and via a conductive lead that couples the input device and the touchscreen display.

165. See my analysis of claims 1, 12, 15, 16, and 18 in this section.

X. Claim 26: The apparatus of claim 25, wherein the conductive lead runs through at least a portion of the housing.

166. See my analysis of claims 1, 12, 15, 16, and 18 in this section.

Y. Claim 27: The apparatus of claim 1, wherein at least a portion of the input device is exposed on an exterior surface of the housing.

167. See my analysis of claim 1. Chu's button 16 is on the exterior of the VR viewer.

Z. Claim 28: The apparatus of claim 1, wherein the input device is positioned at the exterior of the housing.

168. See my analysis of claim 1. Chu's button 16 is on the exterior of the VR viewer.

AA. Claim 29: The apparatus of claim 1, wherein the input device is user accessible such that a user can interact with the input device.

169. See my analysis of claim 1. Chu's button 16 is on the exterior of the VR viewer.

BB. Claim 30: The apparatus of claim 1, wherein the input device is configured to detect a user action.

170. See my analysis above in claim 1 for how Chu's button 16 is used.

CC. Claim 31: The apparatus of claim 30, wherein the input device is configured to relay a signal based on the user action to the touchscreen display.

171. See my analysis of claim 1 for how Chu's input device relays a signal to the touchscreen display. See EX1003, Figs. 3, 4, 5; ¶¶0040-0062.

DD. Claim 32: The apparatus of claim 1, wherein the input device comprises a conductive material.

172. See my analysis for claim 13.

EE. Claim 33: The apparatus of claim 1, wherein the contact element comprises a conductive material.

173. The claimed contact element is Chu's probe pad. See my discussion of the probe pad above for claims 1 and 14.

XI. OATH

174. I declare that all statements made herein of my own 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 the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the results of these proceedings.

175. I declare under penalty of perjury that the foregoing is true and correct.

Executed on 3/28, 2023.


Kurtis P. Keller

Appendix A

KURTIS KELLER

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<http://www.cs.unc.edu/~keller>

Research Engineer **Mechanical Design of Optical and Electrical Systems**

Medical Equipment design – FDA 510K.
Head Mount Display Design

Virtual/Augmented Reality hardware
Computer interfaces and VR trackers

Education:

1994 M.S. North Carolina State University, Integrated Manufacturing Systems Engineering,

1988 B.S. North Carolina State University, Mechanical Engineering.

Post grad & Business MBA (*27 of 33 credits – started company*): additionally:

Optical Perception, UNC

Patent Law (2 classes), NCSU, UNC

Optical Mounting, U. Arizona.

Business Law, NCSU

Professional:

2003 - Co-founder, Optical/Mechanical Eng. Director & COO, InnerOptic Technology Inc.
Hillsborough, NC (split time with UNC).

1993 - Research Engineer, Microelectronic Systems Laboratory, Department of Computer
Science, University of North Carolina Chapel Hill. (split time with InnerOptic).

2000 – 2001 3rdTech, Senior Mechanical Engineer, Chapel Hill, NC (part time).

Expert witness:

Provided expert witness testimony, declarations and depositions for multiple patents for both prosecution and defense for eight cases involving medical equipment and optical / electro-optical apparatuses and 20+ patents. Depositions were on location or video-taped with court recorder and attorneys; items included invalidity, infringement, claim construction, etc.

Expert witness for projectors and projection systems: Optical and optical electronic packaging and mounting US patents: 6,203,158; 5,297,005; 6,402,324; 6,527,392; 6,558,004; 6,644,817; 6,739,831; and 6,742,899. Seiko Epson Corporation, vs. Coretronic Corporation; Civil Action No. 3:06-cv-06946-MHP, Northern District of California, San Francisco Division; cases settled.

Expert witness for SAIC vs Microsoft. Augmented Reality Head Mounted display tracking technology, multiple patents. Case settled 2020.

Expert witness for MechSource for virtual reality Head Mounted Display (HMD) devices. Investigation, examinations, Infringement, invalidity contentions. Northern District of California. Case settled 2019.

Expert witness for Polycom vs. Fullview. Multi-camera single node camera system for virtual office conferencing. Infringement and invalidity contentions. US patents 5,760,826, 6,128,143, and 6,700,711. Case is ongoing 2022.

Continued

Expert witness for endoscopic medical computer interface / display for Karl Storz - Endoscope. Ongoing, includes declarations and depositions and scheduled in-court appearance, US patent numbers 8,069,420 and 7844,657. Northern District of California, San Francisco Division; Jury. Settled 2019.

Expert witness for Carestream dental scanner. Carestream vs, 3Shape. Dental optical scanning and tracking patent case for IPR. US Patents 10,695,151 and 11,076,146. Case completed 2022.

Expert witness for Axon Enterprises for body mounted cameras, mostly police use. Investigation, Infringement, invalidity contentions. Northern District of California. Case is appears settled.

Expert Witness for GoPro. Thermal and packaging patent issues. Investigation, infringement. Case is settled.

Expert Witness for Samsung, micro camera design, micro lens mounting, multiple patents. Invalidity, Case is settled.

Expert Witness for Polycom, shared optical nodal point teleconferencing camera, versus Fullview, Inc. Patents 6,700,711, 6,128,143. Case ongoing.

Major Projects, abbreviated:

Head Mounted Displays (HMDs). Designer and co-designer of at least 15 HMDs including optical and video see-through systems. Includes designs with LCDs, shutters, projectors and CRTs. 1993 - present UNC & InnerOptic Technology Inc.

Video See through HMD for surgery. First Augmented Reality system to be used for actual surgery in the United States, 1994. Designed AR HMD, surgical tools, calibration mechanisms, and tracker for this innovative project. Custom system design including custom video see-through Head Mounted Display and custom tracked surgical tools. Integrated with live, registered ultrasound. UNC- CS and UNC Hospitals.

HiBall Ceiling Tracker for Virtual and Augmented Reality use. PC design, layout and mechanical design of world's largest & accurate virtual / augmented reality tracker. Six, IR shared path sensors for 5 arc minute rotation accuracy, 1400 updates/sec. Co - designed multi-sensor optical tracker. Commercialized with 3rTech Inc. UNC and 3rdTech Inc.

Wide Field of View See-through Head Mounted Display. Co designer of 60 degree off-axis optical see through HMD design. Full optical mounting, weight and ergonomics. UNC.

Multi Display HMD – 6 display per eye ultra wide field of view full immersion head mount display. Full ergonomic design headset; at the time, both world record pixel count and widest field of view. Kaiser Electro Optics and UNC.

Commercial design and sales of Video see-through HMD. Co-designed, built, patented and commercial sold miniature video see-through HMD. Used from medical procedures, especially surgery. UNC and licensed and commercialized by InnerOptic Technology, Inc.

Pinlight HMD Display. Projector LCD for use as see-through HMD display. Used electronics and display of large cinema projector for source of HMD ultra-wide field of view display and control. UNC and continued at Microsoft.

Virtual Reality welding glasses. Utilized registered cameras and HMD/headset and displayed onto internal screens. Avoided direct intense UV viewing of welding radiation and automatically adjusted brightness levels. UNC.

Virtual Reality hardware and tool design for Virtual Reality golf game where synchronizing swing to “virtual” hit was the difficult issue due to lag; research influenced predictive tracking for future games. UNC-CS.

Virtual Reality safety system – Dual zone system for either XY platform movement or for out of bounds sensing at Virtual Reality stations. Used floor based proximity sensors. UNC.

Scanner System for creating 3D Virtual Reality spaces from real 3D indoor environments. Point clouds were then optimized into 3D textures for tracked HMD registration / display. UNC.

Pixel Flow 8KW Graphics super computer for Virtual Reality (commercialization with Hewlett Packard). Head Mechanical Engineer for \$30 million project. Provided all thermal design, air flow analysis, custom processor heatsink designs, backplane layout (256 bit wide, 12,000 pin, 8 layer), test board designs, co – layout main PC (44 processors, 18 layer board). Hewlett Packard & UNC.

AIM Computer assisted surgical system. Lead Engineer for commercial system that combined tracked ablation needles and ultrasound in a full 3D stereo, real-time display to assist surgeons. From conception to fully FDA approved system. InnerOptic Technology Inc.

Graphic interface review and selection including evaluations of tiled (multiple) projectors systems, flatscreens, virtual touch (3D) and touch screen and other input devices. UNC

Augmented Reality / Virtual Reality hardware – HMDs designs, trackers, interfaces, tools, integration, custom graphic supercomputer team at #1 ranked VR lab in the world, UNC - Computer Science Dept.

Virtual Monticello - Large 3D museum display (about 30 feet) of multiple 3D virtual reality windows to observe Thomas Jefferson's house in tracked stereo. New Orleans Museum of Art and UNC-CH.

Stereo Endoscope Design: Designed patent-pending micro, 5mm diameter dual path endoscope with wide IPD separation, single HD imager, and compact and economical camera interface for surgery use. InnerOptic Technology, Inc.

Projector and 3D display detailed evaluation and analysis. Performed studies on both commercial and UNC's own custom-designed DLP and LCD projectors along with 3D display empirical and user study evaluations. UNC. Also, expert witness for several projector patents.

High-speed optical cancer detection device. Design for a high-speed optical cancer detection apparatus for cancers. Optical design in the visible and IR with multiple, parallel digital cameras and computer. For cervical, prostate and throat cancers. InnerOptic Technology, Inc.

Endoscope camera head for stereo and mono endoscopes: Patent-pending design allows a single camera head to attach to both standard mono- endoscopes and miniature stereo endoscopes providing HD quality imagery. InnerOptic Technology, Inc.

Medical Device FDA and FCC approval process. Worked with team for preparing and submitting 510K of surgical, electronic medical device. Received first clearance Fall 2009. Also included detailed UL 60601-1 and 60601-2 electromagnetic design, test and safety approvals. InnerOptic Technology, Inc.

Magnetic force microscope. Lead mechanical and optical design for real-time magnetic force microscope. Includes design of microscope stages, top and lower optics including dichroic mirrors and custom optics, magnetic coils and circuit boards, optical interfaces, thermal regulation and other. From lab designs to optimized, manufacturable design. UNC.

Multiview. Designed multi-camera 180° FOV shared nodal point camera system. System has six cameras with shared, apparent virtual location by use of use of mirrors and overlapping apertures. Used for effective virtual, wide angle presence and telecollaboration. UNC.

Miniature laser projector design and build. For 3D depth extraction and imaging through an endoscope for surgery. Multiple versions of systems including deployed system and miniature handheld system; laser-based. UNC and licensed to InnerOptic Technology.

Laser projector design humanoid. Design and Implement mini laser projector for rear projection of 3D anatomical mannequins for Office of the future research and eventually incorporated into medical simulations and theatrical use. UNC, U of Florida.

Laser projector design for HMDs. Early attempts at implementing laser projectors on Head Mounted Displays for display engines. Microvision and UNC.

3D Laser range depth finder and imager. Mechanical design of scanning 3D laser scanner for room-sized scans. Commercial product used in crime scene reconstruction. As seen on TV show *CSI*. UNC and Delta Sphere, Inc.

3D laser scanner. Single laser with four planar outputs for very fast scanning of feet for custom orthotics. Multipass system for verification. NCSU, DARPA and NASA.

Dental Implant 3D guidance. Design and build 6DOF magnetic tracker system and mounts with graphic feedback for registration of dental implants across jaw. InnerOptic Technology.

Structured Light projectors, custom projectors for integrating IR projection with standard video for depth extraction. Imperceptible structured light. UNC.

3D depth extraction and imaging endoscope design and build: Real-time 3D depth extraction through an endoscope for medical use. Uses custom structured light projector and camera head to view subject in not only stereo but off-axis in True 3D, not just stereo; imaging-based. 2 patents. UNC and InnerOptic Technology.

Infrared Projectors. Designed and build multiple wideband infrared and laser-based narrowband projectors for imperceptible depth extraction for teleconference and medical use. Includes design of optics, beam splitters, mounts and thermal designs. UNC.

Stereo Projectors. Built and modified projectors with new optics for both passive polarization stereo (Sharp) or active stereo (TI micromirrors). Includes design of custom light wheels, collimators, exit optics, cooling and illuminators. UNC.

Four color IR projector. Uses four color wheel, custom filter design, custom lens, DMD microdisplay and custom source for combined IR and visible projector to allow imperceptible structured light inclusion. UNC and TI.

Frequency doubling, optical. Experiment with using laser to provide multiple wavelength from single laser source; in this case 532nm by using second harmonics. UNC.

High-speed optical cancer detection device. Design for a high-speed optical cancer detection apparatus for cancers. Optical design in the visible and IR using an array of optical filters with multiple, parallel digital cameras and computer. For cervical, prostate and throat cancers. InnerOptic Technology, Inc.

Endoscope camera head for stereo and mono endoscopes: Allows a single camera head to attach to both standard mono- endoscopes and miniature stereo endoscopes providing HD quality imagery. InnerOptic Technology, Inc.

IR camera design. Single element narrowband IR camera for tracking. Uses phosphor filter for visible image detection. Combined into a 6 camera, cross axis WFOV system. UNC.

Stereo Endoscope Design: Designed patent-pending micro, 5mm diameter dual path endoscope with wide IPD separation, single HD imager, and compact and economical camera interface for surgery use. InnerOptic Technology, Inc.

Light amplifier. Using phosphor-based imager, custom camera lens, and image intensifier tube (night vision core), used for tracked scope design for weapon system. UNC & DARPA.

Design of large aperture endoscope: Custom endoscope for very low light environments. InnerOptic.

Design Kinect depth extraction multiple unit environment. Performed laboratory-based reverse engineering of Microsoft's Kinect device by analyzing individual operational wavelengths (to 0.1nm) to allow multiple devices to run overlapping each other. With graduate students. Also built custom mounts and other optical devices for Kinects to expand number to be used. UNC.

Very Large Telescope Optical mounts. Designed & built mechanisms for SOAR telescope, 162" aperture. Co-designed ADC optical system of 12" and 4" optics, in Chile. UNC.

Very Large Telescope spectrum analyzer. Co-designed IFU multi pickup spectrum analyzer. Uses 240 optical fibers and 4 miniature X-Y motion platforms for SOAR telescope. Chile. UNC.

Patents (~6 others pending):

- 9,792,715, "Methods, systems, and computer readable media for utilizing synthetic animatronics"
- 9,675,319, "Loupe Display"
- 9,659,345, "System and method of providing real-time dynamic imagery of a medical procedure site using multiple modalities"
- 9,282,947, "Imager focusing based on intraoperative data"
- 8,690,776, "Systems, methods, apparatuses, and computer-readable media for image guided surgery"
- 8,585,598, "Systems, methods, apparatuses, and computer-readable media for image guided surgery"
- 8,482,606, "System and method of providing real-time dynamic imagery of a medical procedure site using multiple modalities"
- 8,350,902, "System and method of providing real-time dynamic imagery of a medical procedure site using multiple modalities"
- 8,152,305, "Methods, systems, and computer program products for full spectrum projection"
- 7,728,868, "System and method of providing real-time dynamic imagery of a medical procedure site using multiple modalities"
- 7,385,708, "Methods and systems for laser based real-time structured light depth extraction"
- 6,503,195, "Methods and systems for real-time structured Light"

Publications, selected:

- "Single-imager, Stereo Endoscope"; Kurtis Keller & Andrei State. SPIE Medical Imaging 2011,
- "Deployable Integral Field Units, Multislits, and Image Slicer for the Goodman Imaging Spectrograph on the SOAR Telescope"; Cecil, Gerald N.; Moffett, A. J.; Cui, Y.; Eckert, K. D.; McBride, J.; Kannappan, S.; Keller, K.; Barlow, B. N.; Dunlap, B.; Bland-Hawthorn, J.. American Astronomical Society; Bulletin of the American Astronomical Society, Vol. 42, p.403, 2010.
- "Head Mounted Displays for Medical Use"; Kurtis Keller, Andrei State, and Henry Fuchs; Invited Paper; Journal of Display Technology, IEEE and OSA, Vol. 4 Number 4, 2008
- "Thin-foil magnetic force system for high-numerical-aperture microscopy "; Fisher, J. K., L. Vicci, J. Cribb, K. Keller, B. G. Wilde, T. O'Brien, K. Desai, , R. M. Taylor II, R. Superfine; Review of Scientific Instruments; 2006.
- "Simulation-Based Design and Rapid Prototyping of a Parallax-Free, Orthoscopic Video See-Through Head-Mounted Display"; Andrei State, Kurtis P. Keller and Henry Fuchs; *Proc. International Symposium on Mixed and Augmented Reality (ISMAR)* 2005 (Vienna, Austria, Oct 5-8, 2005
- "Towards Tumor Detection through Optical Tomography in a 3D Depth Extraction Endoscope"; Kurtis Keller, Adam Wax, Caroline Green, Andrei State, and Henry Fuchs; MMVR, 2005.
- "3D Force Microscope: a nanometric optical tracking and magnetic manipulation system for the biomedical sciences"; Fisher, J. K., L. Vicci, J. R. Cummings, K. Keller, B. G. Wilde, T. O'Brien, K. Desai, C. Weigle, G. Bishop, R. M. Taylor II, R. Superfine; Review of Scientific Instruments; October 2004.
- "Monticello Through the Window"; 4th Symposium on Virtual Reality, Archaeology and Cultural Heritage 2003, Nathaniel Williams, Chad Hantak, Kom-Lim Low, John Thomas, Kurtis Keller, Lars Nyland, David Luebke and Anselmo Lastra.
- "Mixed Reality HMD Design"; VR2002, Andrei State & Kurtis Keller.

- “Surface Reconstruction of Abdominal organs using Laparoscopic Structured Light for Augmented Reality Applications”; Jeremy Ackerman, Kurtis Keller, Henry Fuchs; Electronic Imaging 2002 – Photonics West.
- “Switched Pattern Laser Projection for Real-time Depth Extraction and Visualization through Endoscopes”; Kurtis Keller, Jeremy Ackerman, and Henry Fuchs; 2002, International Symposium on Optical Science and Technology SPIE's 47th annual meeting.
- “Augmented Reality Guidance for Needle Biopsies: A Randomized, Controlled Trial in Phantoms”; MICCAI 2001”, Rosenthal, M. R., State, A., Lee, J., Hirota, G., Ackerman, J., Keller, K., Pisano, E., Jiroutek, M., Muller, K., & Fuchs, H.
- “High-Performance Wide-Area Optical Tracking: The HiBall Tracking System”; Welch, Greg, Gary Bishop, Leandra Vicci, Stephen Brumback, Kurtis Keller, and D'nardo Colucci; 2001 Presence: Teleoperators and Virtual Environments 10(1): 1-21.
- “Real-time Structured Light Depth Extraction”; Kurtis Keller and Jeremy Ackerman; Photonics West – Electronic Imaging, 2000.
- “The HiBall Tracker: High-Performance Wide-Area Tracking for Virtual and Augmented Environments”; Greg Welch, Leandra Vicci, Stephen Brumback, Kurtis Keller, and D'nardo Colucci; VRST99, 1999.
- “Real-time Anatomical 3D depth Extraction”; Jeremy Ackerman and Kurtis Keller, MMVR, 2001.
- “Augmented Reality Visualization for Laparoscopic Surgery”; Fuchs, Henry, Mark A. Livingston, Ramesh Raskar, D'nardo Colucci, Kurtis Keller, Andrei State, Jessica R. Crawford, Paul Rademacher, Samuel H. Drake, and Anthony A. Meyer; MICCAI '98, 1998.
- “Perception in HMDs, what really makes them all so terrible?”; Kurtis Keller and D'nardo Colucci; Lead conference paper; SPIE Aerosense '98, 1998.
- “Cast 3D Heatsink Design Advantages”; Kurtis Keller; IEEE ITherm '98, 1998. Transactions on Components and Packaging Technologies, IEEE press, 2000.
- “Augmented Reality Assistance for Needle Biopsies: From Early Prototypes to a Controlled User Study”; IMPSE, Andrei State, Michael Rosenthal, Joohi Lee, Gentaro Hirota, Jeremy Ackerman, Kurtis Keller, Etta D Pisano and Henry Fuchs.
- “Efficiency and Cost Tradeoffs Between Aluminum and Zinc Die Cast Heatsinks”; Kurtis Keller; InterPack (International Electronic Packaging conf.), Invited talk, 1997.
- “PXFL Cooling Issues and Solutions for a Graphics Supercomputer”, Kurtis Keller; Colloquium “PXPL at 40”, UNC Chapel Hill, 2022.
- “Video See-through HMD for Surgery Assisted by Augmented Reality”; D. Colucci, G. Hirota, K. Keller, A. State, S. Drake, R. Fish; SPIE - EI'97, 1997.
- “Low Cost, High Performance, High Volume Heatsinks”; Kurtis Keller, 1998 IEMT-Europe Symposium, Berlin, 1998.
- “Commercial Packaging Solutions for a Research Oriented Graphics Supercomputer,” Kurtis Keller and John Poulton; InterPack 1995.
- “Video See-through Design for Merging of Real and Virtual Environments”; Emily K. Edwards, Jannick P. Rolland and Kurtis Keller; VRAIS conference, 1993.