UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

CHEMTRONICS USA INC.,

Petitioner

v.

FLATFROG LABORATORIES AB,

Patent Owner.

U.S. Patent No. 10,775,935

Title: TOUCH DEVICE

DECLARATION OF DARRAN CAIRNS, PH.D. UNDER 37 C.F.R. § 42.100 REGARDING U.S. PATENT NO. 10,775,935

I declare that all statements made herein on 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.

Date: 10/6/2023 By:

Darran Cairns, Ph.D.

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I, Darran Cairns, do hereby declare:

1. I am making this declaration at the request of Chemtronics USA Inc., ("Chemtronics") in the matter of *Inter Partes* Review ("IPR") of U.S. Patent No. 10,775,935 ("the '935 Patent").

2. I am being compensated for my work in this matter at my standard hourly rate of $390 for such consulting services. My compensation in no way depends on the outcome of this proceeding.

I. QUALIFICATIONS

3. My qualifications generally are set forth in my curriculum vitae, which is submitted as Ex. 1040.

4. I received a Bachelor of Science degree in physics from University of Birmingham in the United Kingdom in 1995. I received a Ph.D. degree in metallurgy and materials from University of Birmingham in the United Kingdom in 1999, respectively. My Ph.D. dissertation, entitled "The Mechanical Reliability of Silica Optical Fibres" was done under the supervision Professor Stephen Kukureka, who is well known in the field of materials science.

5. I have over twenty years of experience in the field of touch sensor materials, manufacturing, and measurement in both academia and industry at Brown University, 3M Touch Systems, West Virginia University and University of

Missouri – Kansas City. I have taught these topics at Brown University, West Virginia University, and the University of Missouri – Kansas City.

6. From 1998-2001, I was a postdoctoral research associate in engineering at Brown University under the direction of Professor Gregory Crawford who is well known in the field of liquid crystal displays and sensors. My work at Brown was focused on liquid crystal materials and optical sensors.

7. From 2001-2005, I was a research specialist at 3M Touch Systems in the Optical Systems Division. I worked on a variety of technologies, including touch sensors, polymer materials and manufacturing, glass materials and manufacturing, and high performance coatings for mechanical protections of display and touch sensors.

8. From 2006 to Present, I have also been an associate professor in mechanical engineering, where my teachings include liquid crystal polymers, plastic films based electronics, and composite materials. Additionally, beginning in 2014, I founded Tailored Surfaces, a company that develops solution-based processing of smart materials for devices such as touch screens and displays. I still currently serve as CEO for Tailored Surfaces.

9. From 2019 to Present, I have also been an Associate professor at the University of Missouri – Kansas City, teaching advanced manufacturing, plastics

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manufacturing, and material engineering. Additionally, I teach about sensors and touch screens, flexible laminate electronics, and wearable devices.

10. From 2019 to Present, I have also been a teach associate professor at the University of Missouri, teaching advanced manufacturing, plastics manufacturing, and material engineering. Additionally, I teach about sensors and touch screens, flexible laminate electronics, and wearable devices.

11. I have over 13 U.S. patents, a large number of which are directed to touch sensor technologies. The vast majority of my patents are in the area of touch sensor technologies and related nanoparticles. As such, I am intimately familiar with the manufacturing of touch sensor.

12. I have also authored several technical papers that have been published in well-respected, peer-reviewed journals, such as the Journal of Applied Physics, Journal of the Society for Information Display, and Proceedings of the IEEE. As an example, I worked on a project focused on integrating touch sensing with flexible electronics. This work was published in the book Flexible Flat Panel Displays, which I edited with Professor Greg Crawford and Professor Dick Broer for Wiley.

13. Taken as a whole, my academic and practical experience have given me a substantial basis upon which to evaluate the technology that is in question in the claims of the ’935 Patent. Based on my experience and education, and the

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acceptance of my publications and professional recognition by peers in my field, I believe that I am qualified to opine as to the knowledge and level of skill of one of ordinary skill in the art at the time of the alleged invention of the ’935 Patent (which I further describe below) and what such a person would have understood at that time, and the state of the art during that time.

II. RELEVANT LEGAL STANDARDS

14. I have been asked to provide my opinion as to whether the claims of the ’935 Patent would have been obvious to a person of ordinary skill in the art (“POSA”) at the time of the alleged invention, in view of the prior art.

15. I am an engineer by training and profession. The opinions I am expressing in this declaration involve the application of my knowledge and experience to the evaluation of certain prior art with respect to the ’935 patent. My formal knowledge of patent law is no different than that of any lay person. Therefore, I have requested the attorneys from Jones Day, who represent Chemtronics, to provide me with guidance as to the applicable patent law in this matter. The paragraphs below express my understanding of how I must apply current principles related to patent validity to my analysis.

16. I have been informed that “prior art” includes patents and other printed publications in the relevant art that predate the pertinent priority date for the subject

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matter claimed by the ’935 Patent. I understand that the ’935 Patent asserts a priority date of December 7, 2016. For purposes of my analysis herein, I have assumed that to be the priority date without expressing any opinion regarding the patent’s entitlement to claim priority to that date. As such, my references to knowledge in the art herein relates to the knowledge prior to that date.

17. It is my understanding that in determining whether a patent claim is obvious in view of the prior art, the Patent Office must apply the *Phillips* standard to construe the claim by giving the claim its plain and ordinary meaning, consistent with the specification and prosecution history. For the purposes of this review, I have construed each claim term in accordance with its plain and ordinary meaning under the *Phillips* standard, unless otherwise indicated.

18. It is my understanding that a claim is unpatentable under 35 U.S.C. § 103 if the claimed subject matter as a whole would have been obvious to a person of ordinary skill in the art (“POSA”) at the time of the invention. I also understand that an obviousness analysis takes into account the scope and content of the prior art, the differences between the claimed subject matter and the prior art, and the level of ordinary skill in the art at the time of the invention.

19. In determining the scope and content of the prior art, it is my understanding that a reference is considered analogous prior art if it falls within the

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field of the inventor's endeavor. In addition, a reference is analogous prior art if it is reasonably pertinent to the particular problem with which the inventor was involved. A reference is reasonably pertinent if it logically would have commended itself to an inventor's attention in considering his problem. If a reference relates to the same problem as the claimed invention, that supports use of the reference as prior art in an obviousness analysis.

20. To assess the differences between prior art and the claimed subject matter, it is my understanding that 35 U.S.C. § 103 requires the claimed invention to be considered as a whole. This "as a whole" assessment requires showing that one of ordinary skill in the art at the time of invention, confronted by the same problems as the inventor and with no knowledge of the claimed invention, would have selected the elements from the prior art and combined them in the claimed manner.

21. It is my further understanding that the Supreme Court has recognized several rationales for combining references or modifying a reference to show obviousness of claimed subject matter. Some of these rationales include: combining prior art elements according to known methods to yield predictable results; simple substitution of one known element for another to obtain predictable results; a predictable use of prior art elements according to their established functions;

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applying a known technique to a known device (method or product) ready for improvement to yield predictable results; choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success; and some teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill in the art to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed invention.

III. MATERIALS CONSIDERED

22. In preparing this Declaration, I considered any materials cited or referenced herein, including at least the following materials:

Exhibit No.	Title
1001	U.S. Patent No. 10,775,935 to Kocovski et al.
1003	Chinese Patent No. CN203386188U to Cheng et al.
1004	Certified Translation of Chinese Patent No. CN203386188U to Cheng et al.
1005	U.S. Patent Publication No. 2019/0235701 to Han et al.
1006	PCT Application No. WO2018066761 to Han et al.
1007	Certified Translation of PCT Application No. WO2018066761 to Han et al.

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Exhibit No.	Title
1008	Korean Pub. App. No. KR2018-0037749 to Han et al.
1009	Certified Translation of Korean Pub. App. No. KR2018-0037749 to Han et al.
1010	U.S. Patent No. 9,98,3626 to Cao et al.
1011	U.S. Patent No. 9,291,845 to Shin et al.
1012	U.S. Patent Application Publication No. 2017/0123257 to Zhao et al.
1013	Prosecution History for U.S. Patent No. 10,775,935 to Kocovski et al.
1014	U.S. Application No. 13/510,155 to Kukulj et al.
1015	U.S. Application No. 15/037,823 to Ryu et al.
1016	U.S. Application No. 13/695,505 to Christiansson et al.
1017	Redacted Joint Claim Construction Brief (D.E. 110) FlatFrog v. Promethean C.A. No. 19-2246 (D. Del.)
1018	*FlatFrog Laboratories AB v. Chemtronics Co., LTD.*, Case No. 2:23-cv-00306 (E.D. TX), filed on June 26, 2023
1019	Claim Chart for US Patent No 10,775,935 (Case No. 2:23-cv-00306 (E.D. TX)
1020	*FlatFrog Laboratories AB v. Promethean Limited et al*, Case No. 1-19-cv-02246 (D. De), filed on December 10, 2019

Exhibit No.	Title
1021	*FlatFrog Laboratories AB v. Promethean Limited et al,* IPR2022-00065 (filed October 16, 2021) (Petition for Inter Partes Review of US Patent 10,775,935)
1022	*FlatFrog Laboratories AB v. Promethean Limited et al,* IPR2022-00065 Paper No. 12 (PTAB April 18, 2022) (Decision)
1023	ASTM C1048-18, Standard Specification for Heat-Strengthened and Fully Tempered Flat Glass (2018)
1024	ASTM C1048-12, Standard Specification for Heat-Strengthened and Fully Tempered Flat Glass (2012)
1025	Jonathan Barr, *The Glass Tempering Handbook* (2015)
1026	EN 12150-1:2015, Glass in Building – Thermally toughened soda lime silicate safety glass
1027	US Patent Application No. 12/893,381 to Miller et al.
1028	Chinese Published Patent Application CN104808843A to Kang
1029	Certified Translation of Chinese Published Patent Application CN104808843A to Kang
1030	U.S. Patent No. 9,207,800 to Eriksson et al.

IV. PERSON OF ORDINARY SKILL IN THE ART

23. It is my understanding that when interpreting the claims of the ’935 Patent, I must do so based on the perspective of one of ordinary skill in the art (a “POSA”) as of the relevant priority date. My understanding is that the earliest claimed priority date of the ’935 Patent is December 7, 2016.

24. In my opinion, a POSA for the ’935 patent would have been a person having at least a bachelor-of-science or comparable degree in mechanical engineering, or an equivalent discipline, and at least five years of experience designing touch sensors, provided that the educational level can offset the experience level, and vice versa. For example, a POSA includes a person with at least a master’s degree in those disciplines and at least two years of design experience in the field.

25. As described in detail above in the “Qualifications” section, my own training and experience exceeds that of one of ordinary skill in the art

V. CLAIM CONSTRUCTION

26. I understand that in the construction of claims, the Board gives claims their ordinary and customary meaning, or the meaning that the term would have to a POSA at the time of the invention. It is my understanding that a patent’s claims define the scope of the alleged invention and that a patent claim should be interpreted based on what it would mean to a POSA as of the filing date of that patent.

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27. Thus, in providing my opinion, I have applied my understanding as to what a POSA would have understood to have been the plain and ordinary meaning of the ’935 Patent’s claims at the time of invention. I have also reviewed and considered the Patent Owner’s construction of the ’935 Patent claims as informed by its allegations in co-pending litigation with Chemtronics as well as prior litigation involving the ’935 Patent. *See* Exs. 1017, 1018, 1019.

VI. TECHNOLOGY BACKGROUND AND THE ’935 PATENT

A. State Of The Art

28. Touch sensors utilizing occlusion of light have been widely used for a number of years. Such sensors typically consist of sets of optical emitters and detectors arranged around the periphery of a touch surface. When an object touches the surface it attenuates light from one or more emitters and changes the amount of light received by one or more of the detectors. By analyzing the change in light received by the detectors, it is possible to determine the location of the touch. A touch is received by a cover glass or plate, such that a light emitted from a display located beneath the cover glass can be visible to a user, while the display remains protected from the user’s touch. It was known that tuning the geometry of cover glass into a parabolic curvature resulted in reduced emitted light loss and improved touch detection accuracy performance. Further, it was also known that cover glass

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could be induced into a parabolic curvature utilizing configurations of frame elements imparting force against the cover glass during the assembly process.

B. Prior Art Background And The ’935 Patent

29. In my opinion, it was known that a plurality of light emitters and corresponding detectors could be utilized to achieve touch-sensing functionality prior to the ’935 Patent. For example, a plurality of infrared light emitters and opposing detectors could be arranged around the edges of a cover plate or display. *See* Ex. 1005 at [0040-46]. As taught by Han, as infrared light is emitted, it passes over a touch surface before being received by a detector. *Id*. When a user touches an area of the touch surface, the touch blocks specific light pathways, preventing light emitted from certain emitters from being detected by certain detectors. *Id*. at [0048-49]. A processor can then determine the coordinate of the user touch based on which light emitters’ light was blocked. *Id*.

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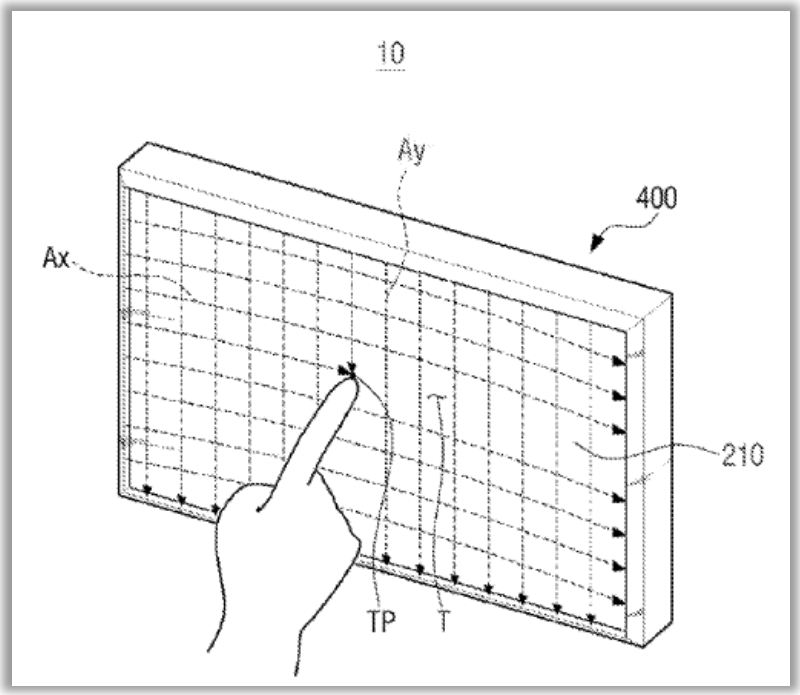

Ex. 1005 at Fig. 2.

30. In my opinion, the ’935 Patent claims the same light detection methodology. For example, the ’935 Patent teaches “emitters 30a are distributed around the periphery of touch plate 10, to propagating light across touch surface 20.” Ex. 1001 at 14:10-17. Further, “detectors 30b are distributed around the periphery of touch surface 20, to receive part of the propagating light.” *Id*.

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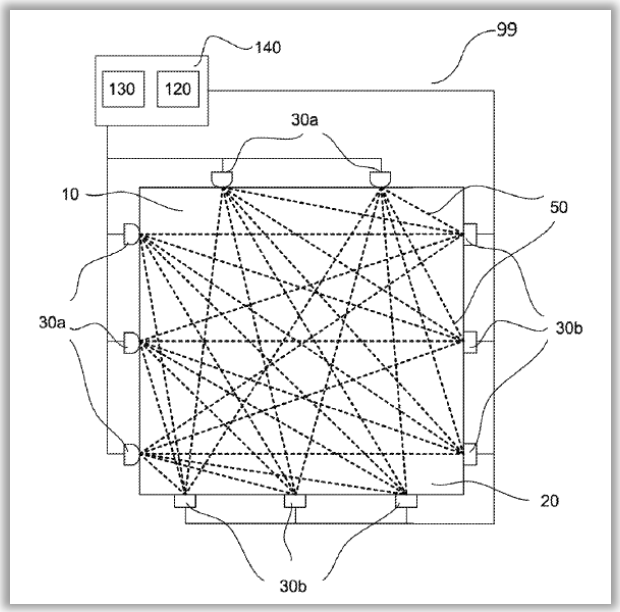
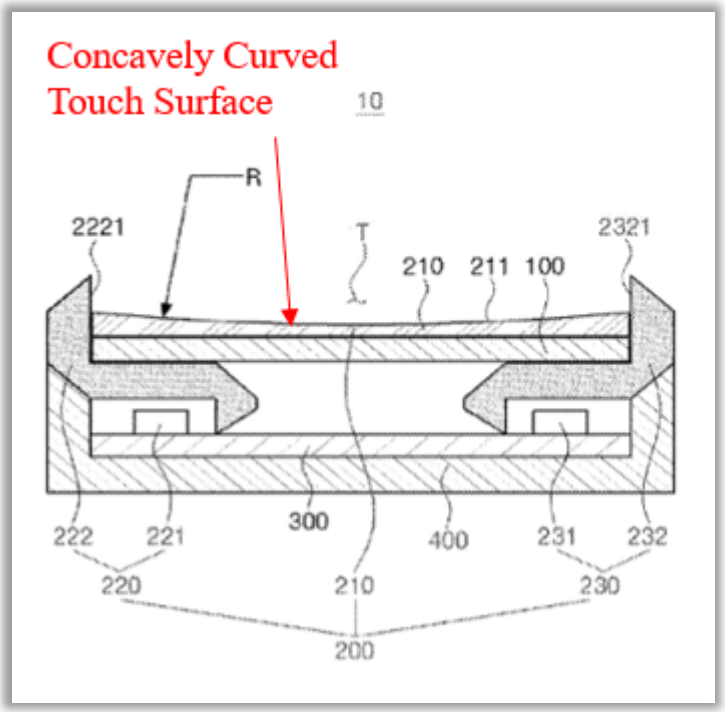


Ex. 1001 at Fig. 9.

31. The ’935 Patent goes on to explain that “the emitters 30a and detectors 30b collectively define a grid of detection lines 50 (“detection grid”) on the touch surface 20.” *Id*. at 14:24-26, Claims 1, 7.

32. It is my opinion that it was known before the ’935 Patent that if the touch surface of the cover plate is concavely curved, rather than being flat, then the amount of light transmitted from the emitters that is received at the detectors will increase, thereby improving the functionality of touch detection. For example, Han discloses that a cover plate of a touch screen display apparatus can be concavely curved according to a radius, i.e., so that the touch surface curves along a portion of

a circle, along either or both of the directions in which light moves. Ex. 1005 at Fig. 3; [0074-78], [0082-83], [0085-0088].

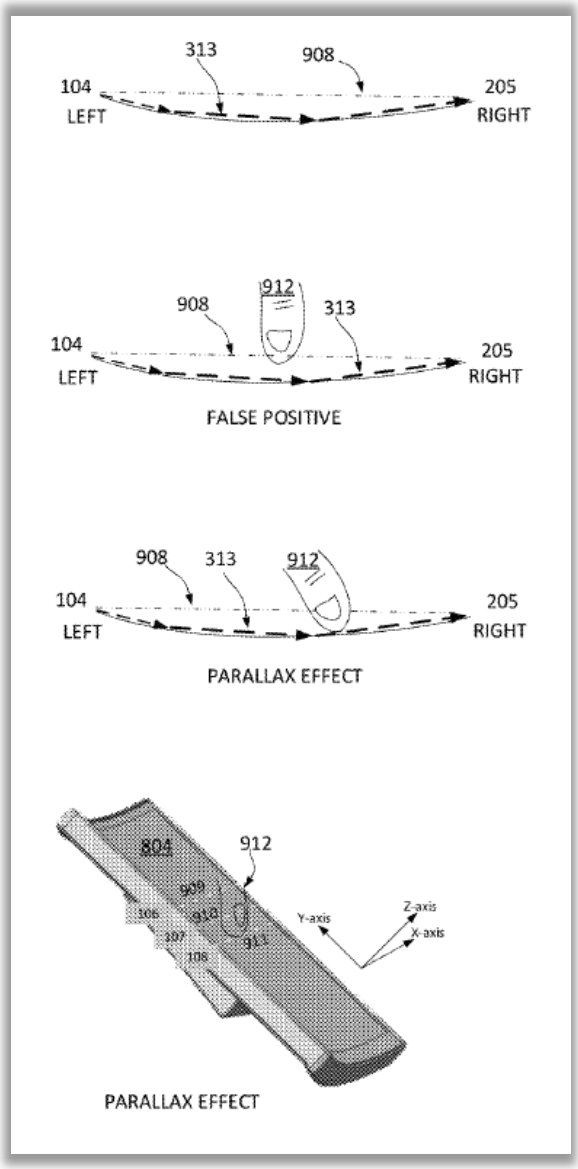


Ex. 1005 at Fig. 3.

33. Han teaches that this configuration can increase the light efficiency of a touch detector and, correspondingly, the accuracy of touch recognition. *Id*. at [0082-0086], [0091-0095], Fig. 5. As I explain in detail below, Han teaches that a parabolic curvature is one advantageous shape of a touch surface.

34. Further, additional references pre-dating the '935 Patent expressly teach parabolically curved touch surfaces. For example, references inlcuding Miller, Kang, Christiansson, and Eriksson teach that touch surfaces of touch devices may

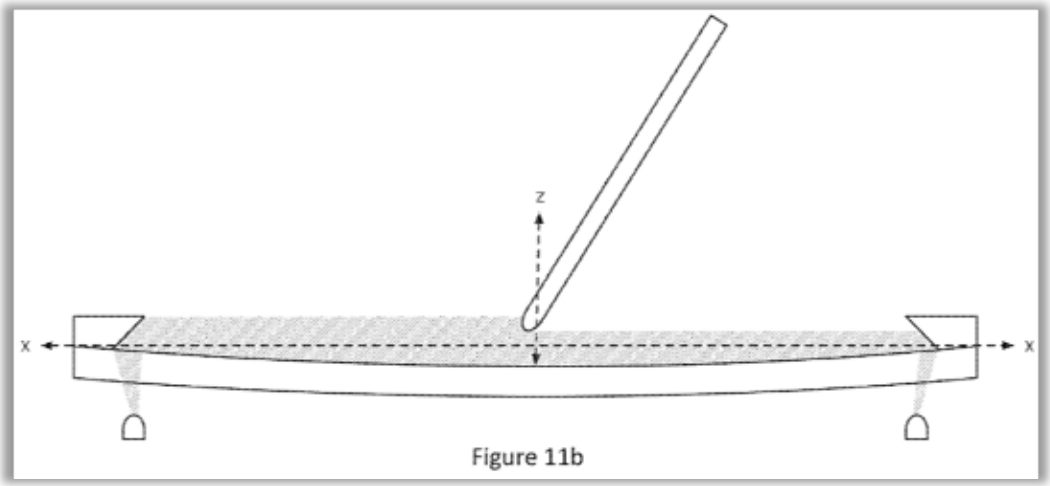
be curved or parabolic in shape. *See* Ex. 1027 at [0047], [0049], Fig. 9; Ex. 1029 at [0028], [0040]; Ex. 1016 at [0071]; Ex. 1030 at 3:6-46, Figs. 29-31.



Ex. 1030 at Fig. 31.

35. It is my opinion that the ’935 Patent claims the same parabolic, concave curvature in the cover plate of a touch sensing method and apparatus. According to

the ’935 Patent, a plate having a parabolic curvature increases the amount of light transmitted from the emitters that is received at the detectors (rather than being “lost” above or below the detectors), resulting in a “signal boost” that improves touch recognition. *See id*., Figs. 13a-17b; 17:48-18:44. In one embodiment, the ’935 Patent teaches that the touch plate 10 could be curved in two axes, rather than one. *Id.* at 16:63-17:47 & Figs. 12a-12b.



Ex. 1001 at Fig. 11b.

36. From my review, it is my opinion that the prior art teaches that a frame assembly can be used to control curvature of a glass plate in an optical touch sensing apparatus. Ex. 1011 at 18:47-64; Ex. 1010 at 4:13-26. For example, Shin teaches that, as an alternative to pre-curving a plate touch surface, a frame assembly can be configured to induce a curvature in the touch surface of an initially flat plate, such that, when the plate is installed in the frame assembly, the touch surface of the plate

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becomes curved. *See, e.g.*, Ex. 1011 at 18:40-64, Fig. 4. Other references, including Zhao, provide the same teaching in the context of large format displays having a cover glass. *See, e.g.*, Ex. 1012 at [0045], [0048], [0050], Figs. 1, 3. Both Shin and Zhao disclose a tapered surface being used in inducing the curvature. *See, e.g.*, Ex. 1011 at 20:53-21:55, Fig. 5; Ex. 1012 at [0051-52], Fig. 1.

37. It is my opinion that the ’935 Patent claims the same control of a touch plate curvature using a frame assembly. Just as in Shin and Zhao, the ’935 Patent discloses that a frame assembly component having a tapered edge can be used in inducing concavity. *See id.*, 13:29-42, Fig. 7.

> [S]upport block 301 is arranged to support glass plate 2. Support block 301 has a surface portion comprising a tapered edge 303 at an angle from second frame element 103A, Plate 2 is pressed against the top surface of support block 301 from pressure 201 b from first frame element 102 and sealing 204 a. Pressure 201 b causes plate 2 to follow the contour of the top surface of block 301 and plate 2 is forced into a curving plane at an angle to the plane of second frame element 103A. The resulting path of plate 2 is shown by curvature path 310.

Ex. 1001 at 13:29-42.

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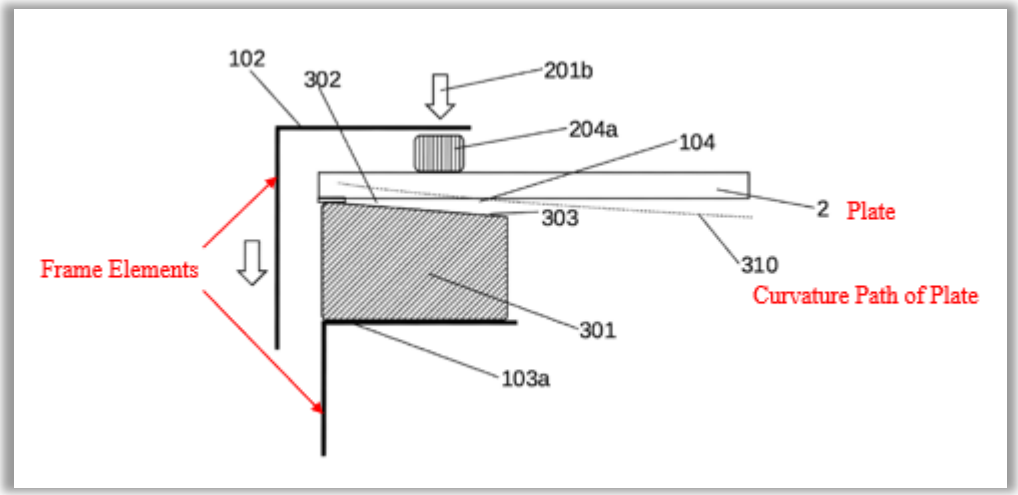

Ex. 1001 at Fig. 7.

38. The ’935 Patent claims “…configuring the frame assembly to support the plate includes inducing a parabolic curvature in the touch surface relative to a first axis and relative to a second axis perpendicular to the first axis…” and “the plate has a first curvature in the touch surface when not installed in the frame assembly, and wherein the plate has a second curvature along the width and along the length in the touch surface when the plate is installed in the frame assembly…” *Id.* at Claims 1, 7.

39. As I describe in specificity below, it is my opinion that the ’935 Patent claims known structures and methods to provide solutions to problems that were already well understood in the art.

C. Related And Priority Applications

40. From my review of the relevant related and priority applicatoins, I understand that the ’935 Patent issued from U.S. Application No. 16/706,438 (“the ’438 Application”) on September 15, 2020. The ’438 Application was filed on December 5, 2019, as a continuation of US. Application No. 16/403,283 (“the ’283 Application”). The ’283 Application was filed on May 3, 2019, as a continuation of US. Application No. 16/190,907 (“the ’907 Application”). The ’907 Application was filed on November 14, 2018, as a national stage entry from PCT Application PCT/SE2017/051233 (“the ’233 PCT”). The ’233 PCT was filed on December 7, 2017 and claimed priority to Swedish Application SE1630294, filed on December 7, 2016.

D. Prosecution History

41. I understand that during prosecution, the ’935 Patent traversed two Office Actions that each relied on US Patent Pub. No. 20120223916 (“Kukulj”), U.S. Patent Pub. No. 20160295711 (“Ryu”), and U.S. Patent Pub. No. 20130044073 (“Christiansson”). *See* Ex. 1013.

42. I understand that the Examiner issued a non-final Office Action, rejecting claims 1 – 20 based on Kukulj, Ryu, and Christiansson on January 28, 2020.

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Id. at 623. Kukulj disclosed an infrared-style touchscreen with light emission and detection means along sides of a touch input area. Ex. 1014, Abstract, Fig. 1.

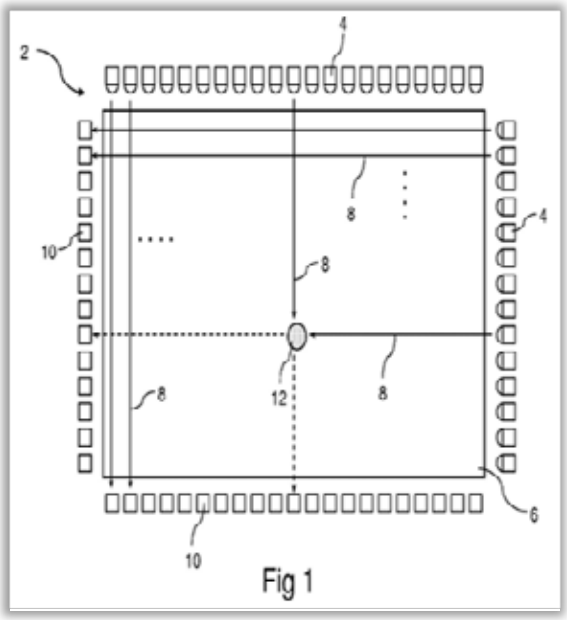
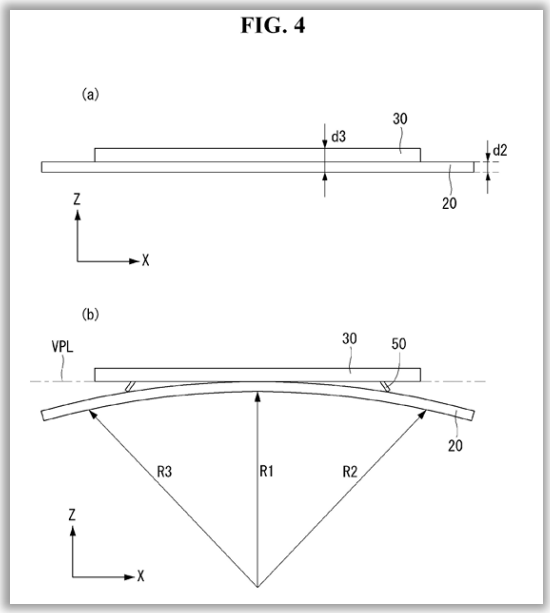
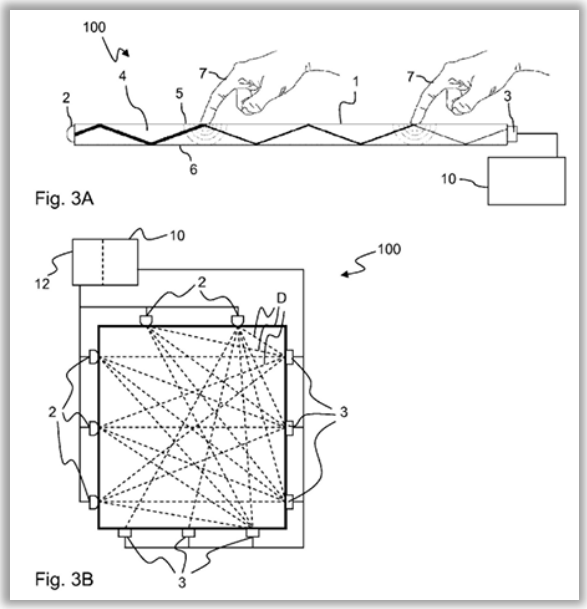


Fig 1

43. Ryu disclosed a display panel having a first and second state, wherein the display panel is straight in a first state and curved in a second state. Ex. 1015, Abstract, Fig. 4.



44. Christiansson disclosed a panel configured to conduct light signals between a plurality of incoupling and outcoupling points for the detection of touch points along the panel via internal refraction. Ex. 1016, Abstract, Figs. 3A-B.



45. I understand that the Application, in differentiating the invention of the '935 Patent, amended the independent claims to specify elements of the frame assembly, arrangements of emitters and detectors in relation to a plate having a touch surface, and inducing a curvature in the touch surface. *See* Ex. 1013 at 601.

> 1. (Currently Amended) A method for assembling a touch sensing apparatus, the touch sensing apparatus comprising a display panel, a plate including a touch surface, and a frame assembly,
> wherein the frame assembly includes:
> a first edge;
> a second edge perpendicular to the first edge; and
> a flat plane defined by the first edge and the second edge; and
> wherein the touch surface includes a center point,
>
> the method comprising:
> configuring the frame assembly to support the display panel;
> arranging a plurality of emitters adjacent to a periphery of the plate, said plurality of emitters configured to emit light to propagate over the touch surface;
> arranging a plurality of detectors arranged adjacent to the periphery of the plate, said plurality of detectors configured to receive light from the set of emitters; and
> configuring the frame assembly to support the plate;
> wherein configuring the frame assembly to support the plate includes inducing a curvature in the touch surface such that the center point moves further away from the flat plane.

Ex. 1013 at 601.

10. (Currently Amended) A touch sensing apparatus comprising:

a display panel;

a plate having a width, a length and a periphery, the plate further including a touch surface having a center point;

a flat plane defined by a first edge of the touch surface and a second edge of the touch surface perpendicular to the first edge;

one or more emitters arranged adjacent to the periphery of the plate and configured to emit light across the touch surface of the plate;

a set of detectors arranged adjacent to the periphery of the plate and configured to receive light from the set of emitters, and

a frame assembly, the frame assembly comprising [[;]] :

a first frame element configured to support the display panel; and

wherein the plate has a first curvature in the touch surface when not installed in the frame assembly, and wherein the plate has a second curvature in the touch surface greater than the first curvature when the plate is installed in the frame assembly;

wherein the frame assembly is arranged to induce the second curvature such that the center point of the touch surface causes the center point to move further away from the flat plane, and

wherein the first curvature is concave.

Ex. 1013 at 601.

46. I understand that the Examiner issued a Final Office Action on April 7, 2020, based on the same references. *Id.* at 502. In response, the Applicant further amended independent claims 1 and 10 on June 18, 2020, this time specifying a geometric "parabolic" profile of the induced curvature in the touch surface.

1. (Currently Amended) A method for assembling a touch sensing apparatus, the touch sensing apparatus comprising a display panel, a plate including a touch surface, and a frame assembly,

wherein the frame assembly includes:

a first edge; and

a second edge perpendicular to the first edge; ~~and~~

~~a flat plane defined by the first edge and the second edge; and~~

~~wherein the touch surface includes a center point,~~

the method comprising:

configuring the frame assembly to support the display panel;

arranging a plurality of emitters adjacent to a periphery of the plate, said plurality of emitters configured to emit light to propagate over the touch surface;

arranging a plurality of detectors ~~arranged~~ adjacent to the periphery of the plate, said plurality of detectors configured to receive light from the set of emitters; and

configuring the frame assembly to support the plate;

wherein configuring the frame assembly to support the plate includes inducing a parabolic curvature in the touch surface ~~such that the center point moves further away from the flat plane~~.

Ex. 1013 at 150.

10. (Currently Amended) A touch sensing apparatus comprising:

a display panel;

a plate having a width, a length and a periphery, the plate further including a touch surface having a center point;

a flat plane defined by a first edge of the touch surface and a second edge of the touch surface perpendicular to the first edge, wherein the center point is separated from the flat plane by a distance;

one or more emitters arranged adjacent to the periphery of the plate and configured to emit light across the touch surface of the plate;

a set of detectors arranged adjacent to the periphery of the plate and configured to receive light from the set of emitters, and

a frame assembly, the frame assembly comprising:

a first frame element configured to support the display panel; and

a second frame element arranged around at least a portion of the periphery of the plate, the second frame element having a first portion extending along an edge of the plate and a second portion opposed to the touch surface;

wherein the plate has a first curvature in the touch surface when not installed in the frame assembly, and wherein the plate has a second curvature in the touch surface ~~greater than the first curvature~~ when the plate is installed in the frame assembly, said second curvature is parabolic and induced to change the distance of the center point with respect the flat plane when the plate is installed in the frame assembly;

~~wherein the frame assembly is arranged to induce the second curvature such that the center point of the touch surface causes the center point to move further away from the flat plane~~, and

wherein the first curvature is concave.

Ex. 1013 at 151.

47. I understand that the Examiner issued a Notice of Allowance on July 8, 2020. *Id.* at 91.

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48. I understand that while Han was included in an IDS, it was not cited by the Examiner during prosecution. *See* Ex. 1013 at 208. I also understand that none of the Shin, Cao, Zhao, or Cheng references were considered during prosecution. *See Id.* In my opinion, Cheng, Han, Zhao, Cao, and Shin—in various obvious combinations—disclose a touch sensing apparatus and method of assembling thereof embodying each of the limitations found in claims 1– 14 of the '935 Patent.

VII. BRIEF OVERVIEW OF SCOPE AND CONTENT OF ASSERTED PRIOR ART REFERENCES

A. Cheng

49. Cheng (Chinese Patent No. 203386188) is a Chinese Patent titled "Frame Structure of Infrared Touch Screen" having a publication date of January 8, 2014. Cheng claims priority to Chinese Application CN201320390996.2, filed July 2, 2013.

50. Cheng discloses an infrared touch screen device including a frame 20, a touch panel 10, a circuit board 30, and an infrared element 40. Ex. 1004 at [0013], Fig.1. The frame 20 includes a semi-closed cavity 21 in which the infrared element 40 is placed. *Id.* at [0013]. The infrared element comprises a lamp tube 41 and a pin 42. *Id.* Cheng explains that infrared receivers and transmitters may be distributed densely around a display region to form a scanning network in the

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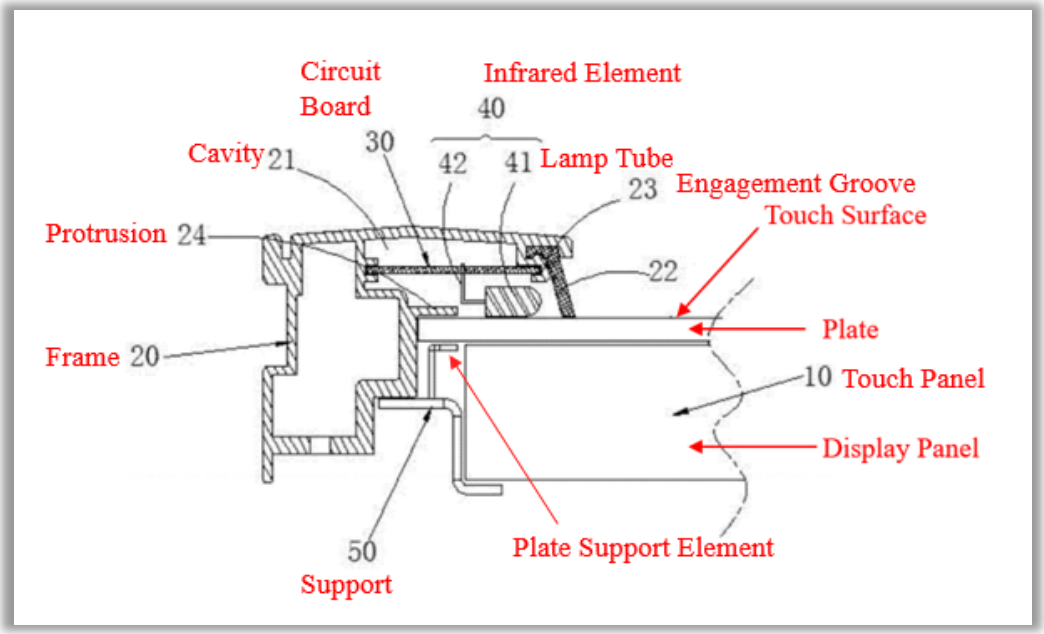
horizontal and vertical directions. Ex. 1004 at [0002]. Cheng's scanning network enables the determination of X and Y coordinates of a user touch by means of blocking or obstructing the horizontal and vertical infrared rays. *Id.*



Ex. 1004 at Fig. 1.

51. The infrared touch device in Cheng includes a display panel and plate with a touch surface. *See* Ex. 1004 at Fig. 1. Although Cheng does not explicitly label a display panel and plate with a touch surface—instead disclosing only a "touch panel 10"—Fig.1 depicts, and a POSA would understand, Cheng's touch panel 10 to comprise a display panel and plate. As depicted in Cheng's Fig.1, a plate can be seen overlaid on a display panel in a typcial touch sensing display device configuration. Further, it is my opinion that a POSA would have understood

Cheng's plate to include a touch surface, as a user would touch the surface (touch surface) of the plate to operate Cheng's touch screen device. *Id.*

52. Cheng's frame 20 includes engagement grooves 23 which clamp and fix a circuit board 30 which is connected to the infrared lamp tube 41. Ex. 1004 at [0017]. A protrusion 24 is provided in the frame 20 and placed on the upper surface of the plate of the touch panel 10. *Id.* at [0014]. A support 50 is provided below the protrusion 24 and supports the display panel of the touch panel 10. *See id.* at [0015], Fig. 1. The support 50 includes a support element which supports the lower side of the plate. *See id.* The support 50 and protrusion 24 clamp touch panel 10. *Id.*

53. Cheng teaches improving the accuracy of touch detection by configuring the frame 20 in relation to the plate of the touch panel 10. Cheng explains that touch screen devices may have lengthy distances between the infrared elements and the touch surface of a touch panel which result in the reduced accuracy of a user's touch detection. Ex. 1004 at [0003]. Cheng improves touch detection accuracy by reducing the distance between infrared elements 40 and the touch surface of the touch panel 10. *Id.* at [0010]. Cheng achieves this accuracy improvement by configuring the frame 20 to orient the lamp tubes 41 of the infrared elements 40 to lie against the plate of the touch panel 10. *Id.* at [0005-0010]. Based on Cheng's lamp tube 41 orientation with the plate, a POSA would have understood

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infrared light to be projected across, and in close in proximity with, the touch surface of the plate during operation of Cheng's device.

B. Han

54. Han (U.S. Patent Publication No. 2019/0235701) is a continuation of PCT Application No. PCT/KR2017/000004, which was filed on January 2, 2017 and which claims priority to Korean Patent Application No. 10-2016-0128325, filed on October 5, 2016. I have compared translations of the Korean Application (Ex. 1009) and the PCT Application (Ex. 1007). It is my opinion that Han's substantive disclosure in Ex. 1005 is fully supported by both the Korean application and the PCT application.

55. Han discloses an infrared touch sensitive panel that "is applicable to a large screen, . . . mainly being applied to ATM machines, kiosks, etc." Ex. 1005 at [0016]. Han's touch screen display apparatus 10 has a cover glass 210 with a front surface 211 that defines a touch area T:

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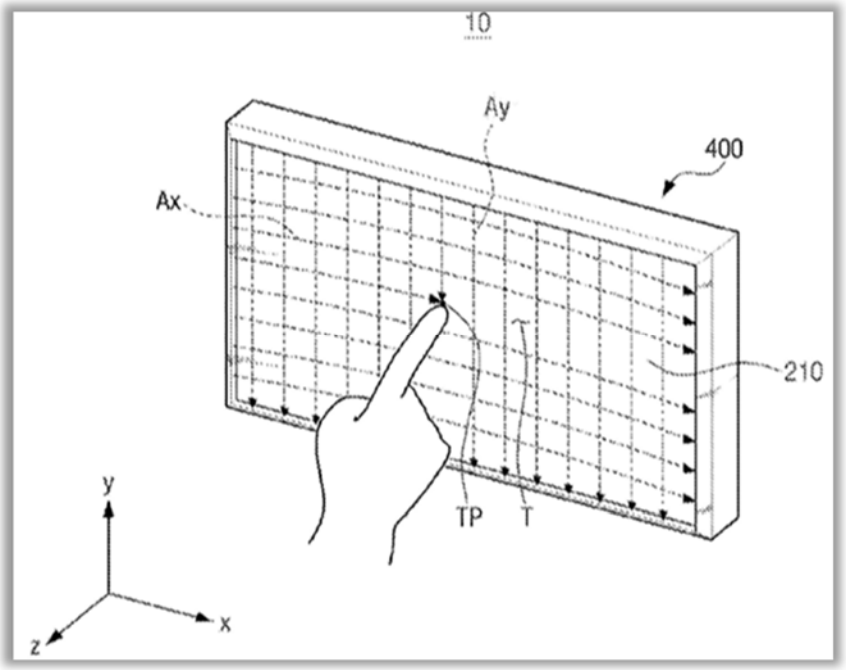
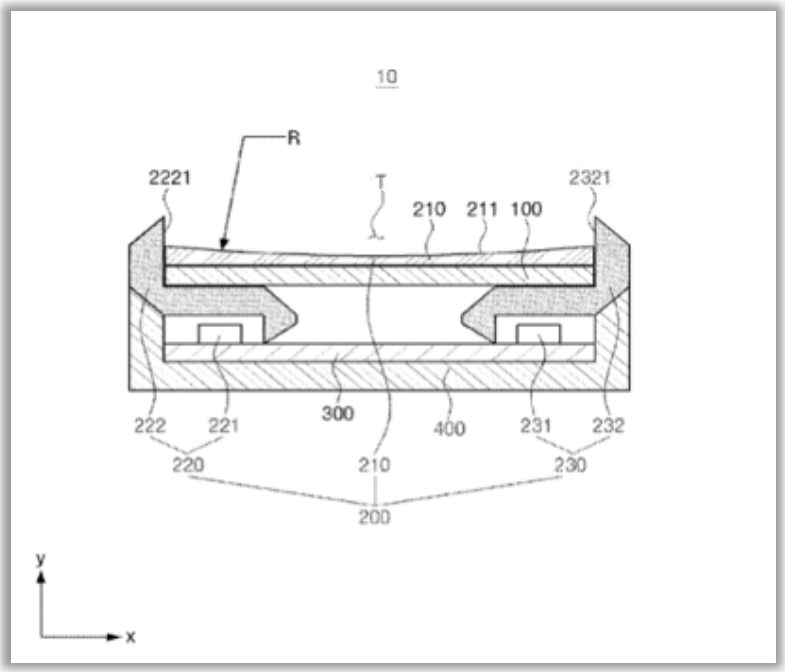


Ex. 1005 at Fig. 2.

56. Shown in Fig. 3 below, Han's cover glass 210 iscoupled to the display panel 100, which may be an LCD, and the coupled cover glass 210 and display panel 100 are surrounded by a light emissive guide member 222 and a light reception guide member 232, which together form the exterior of the touch screen display device as a rectangular structure. *Id.* at [0031-32], [0034], [0037 0042], [0057-59], [0062-63], Figs. 2-3.



Ex. 1005 at Fig. 3.

57. The Han device includes a plurality of LEDs 221 and a plurality of photo diodes 231 that are positioned near the edge of the cover glass and emit and receive light, respectively, via the guide members 222 and 232. In my opinion, a POSA woul have understood Han's LEDs 221 to be "emitters" and photo diodes 231 to be "detectors."

58. With reference to the annotated Han's annotated Fig. 3 below, (1) light is emitted from LEDs 221, (2) that light is introduced into one end of guide member 222, (3) the light is reflected through a plurality of curved parts thereof, (4) the light is then emitted from the light emitting surface 2221 to pass over the touch area T above front surface 211 of cover glass 210, (5) the light passes over the touch area

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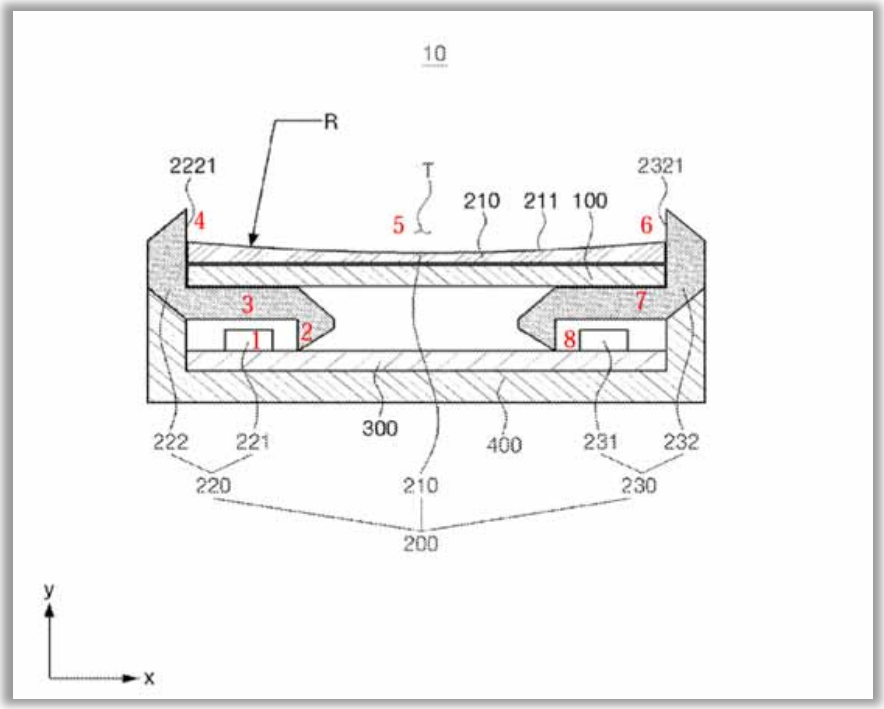
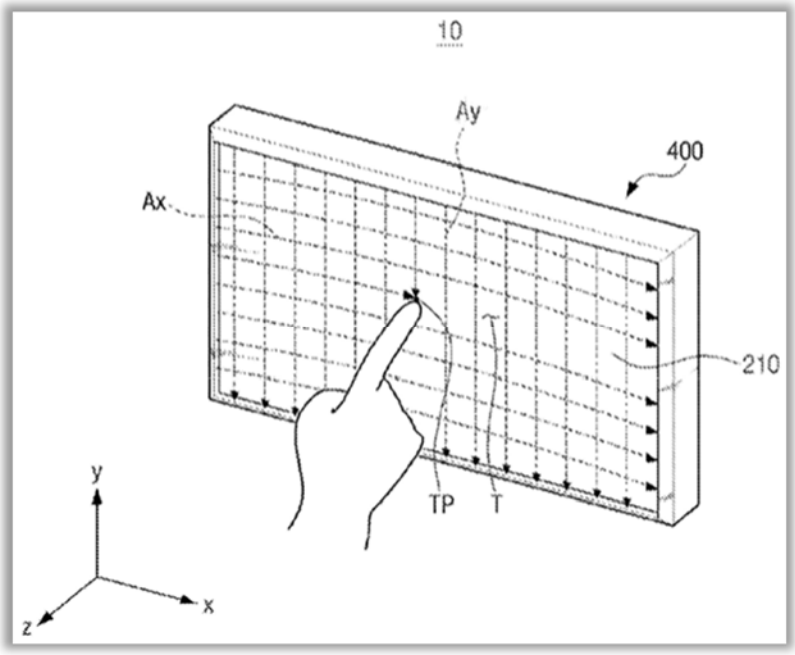
T, (6) the light becomes incident on the incidence surface 2321 of guide member 232, (7) the incident light is reflected through a plurality of curved parts of guide member 232, and (8) the light becomes incident on the photo diodes 231. *Id.* at [0067-69].



Ex. 1005 at Fig. 3.

59. When an object (such as user's finger) touches Han's touch area T, light emitted from the left edge in the direction Ax and light emitted from the upper edge in the direction Ay are blocked at the touch point TP. *Id.* at [0048-49].



Ex. 1005 at Fig. 2.

60. When the light is blocked by a touch as depecited in Han's Fig. 2 above, a controller may determine the coordinate of the touch input. *Id.* For example, a controller may determine that light emitted from specific emitters is blocked and in turn, relate the axis location of each respective blocked emitter to a coordinate of a touch input. *See id.*

61. Just as claimed by the '935 Patent, Han discloses that the front surface 211 of cover glass 210 may be concavely curved. In this regard, Han explains that its front surface 211 "may include a spherical surface or an aspherical surface, and it may also include a multiple curved surface . . . [or] an atypical curved surface."

Id. at [0078]. For example, Han discloses that front surface 211 of cover glass 210 may be curved at one or more predetermined radiuses of curvature R. *Id.* at [0088].

62. In addition, Han explains that its front surface 211 of cover glass 210 may be curved along both a first direction Ax and a second direction Ay as shown above in Fig. 2. *Id.* at [0074-77]. For example, Han explains:

> As described above, the from [sic] surface 211 of the cover glass 210 covering the display surface of the display 100 is in the form of being concavely curved toward the rear side of the display surface, and the front surface 211 ***may be curved along at least one direction between the first direction and the second direction Ax, Ay in which light moves***.
>
> For example, the front surface 211 of the cover glass 210 may be concavely curved along the first direction Ax, as illustrated in FIGS . 2 to 4.
>
> In FIGS. 2 to 4, light that moves through the touch area T along the first direction Ax, and the front surface 211 of the cover glass 210 that is concavely curved along the first direction Ax were illustrated as an example, for the convenience of explanation. ***However, the front surface of the cover glass may also be concavely curved along various directions, according to the moving direction of light***.

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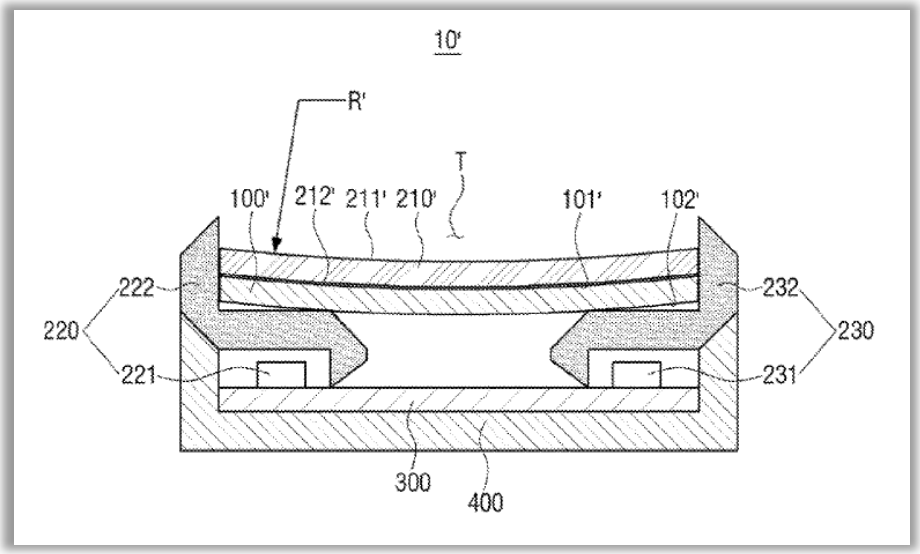
> For example , the front surface 211 of the cover glass 210 may be concavely curved along the second direction Ay that is orthogonal to the first direction Ax, ***and the front surface 211 may also be concavely curved along both of the first direction Ax and the second direction Ay***.

Ex. 1005 at [0074-77].

63. Han also explains that in some embodiments, the rear surface 212' of the cover glass 210' may be concavely curved in the same radius of curvature R' as the front surface 211'. *Id.* at [0113-14], [117].



Id. at Fig. 7.

64. Likewise, in such embodiments, the display 100 also may be curved with the same radius of curvature R' as the front and rear surfaces 211', 212' of cover glass 210'. *Id.* at [0118]. Han also makes clear that the cover glass 210' may be

curved "***along at least one direction between the first direction and the second direction Ax , Ay***." *Id.* at [114] (emphasis added). However, in other respects, the device in Fig. 7 of Han is consistent with the other embodiments described above. *Id.* at [112].

65. Han further teaches that its concave curvature of front surface 211 of cover glass 210 provides advantages over a flat cover glass 210, such as a reduced amount of light lost by reflection and an increased amount of light received at light reception guide member 232, which enhance the accuracy of touch recognition. *See id.* at [0082-83], [0085-86]. Notably, those are the same advantages described in the '935 Patent. Ex. 1001, 17:48-18:44, Figs. 13a-17b.

66. For example, Han's Fig. 5 illustrates the light efficiency relative to the radius of curvature R of the front surface 211. As shown for one embodiment, the maximum light efficiency was measured around where the radius of curvature R was 6000 mm. Ex. 1005 at [0090-95]; Fig. 5.

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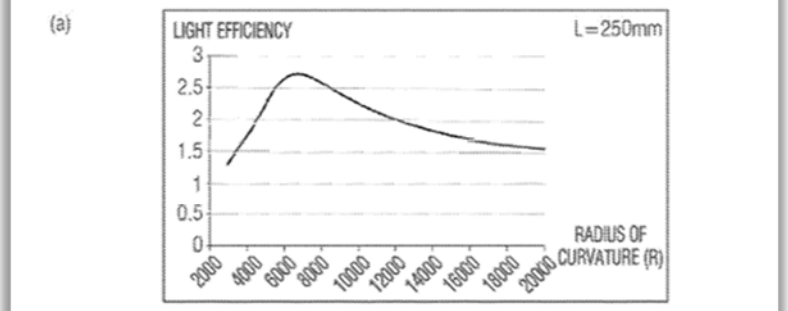
FIG. 5



RADIUS OF CURVATURE (R) (mm)	Flat	3000	4000	6000	8000	10000	12000	14000	16000	18000	20000
LIGHT EFFICIENCY	1.0	1.32	1.74	2.66	2.57	2.25	2.01	1.84	1.72	1.63	1.56

67. Han also teaches that the curvature in its cover glass is parabolic, i.e., that it is substantially similar in shape to a mathematical parabola. In particular, Han discloses an embodiment in which the radius of the circle that describes the curvature of the cover glass 210 surface 211 is approximately 6000 mm, with the circular curve extending 250 mm across the glass plate's surface. Ex. 1005 [0093], [0095]. Based on those dimensions, which provided the maximum light efficiency in Fig. 5 of Han, the curvature relative to the first-axis may be calculated and is substantially similar in shape to a mathematical parabola.

68. In particular, Han discloses an embodiment in which the radius of the circle that describes the curvature of the cover glass 210 surface 211 is approximately 6000 mm, with the circular curve extending 250 mm across the glass plate's surface. Ex. 1005 [0093], [0095]. Based on those dimensions, which

provided the maximum light efficiency in Fig. 5 of Han, the curvature relative to the first-axis may be calculated.

69. For example, it is assumed that an origin of a Cartesian coordinate system is located at the upper left edge of the curved glass surface (i.e. at the intersection of surface 211 and edge 2221 at Han, Figure 3). I used the following procedure to calculate the distance between a line extending between the edges of front surface 211 of cover glass 210 and a line extending along the curved front surface 211.

70. First, in this Cartesian coordinate system, the section of cover glass 210 shown in Figure 3 of Han defines a circular arc whose chord extends from the origin to point 0, 250mm. I calculated the sagitta, *s*, of this circular arc using the formula $s = r - \sqrt{r^2 - \left(\frac{l}{2}\right)^2}$ where r is the radius of curvature of cover glass 210 (here, 6000mm) and l is the length of the chord spanning the base of the arc (here, 250mm, based on the distance between surfaces 2221 and 2321 as disclosed in Han). The sagitta was determined to be 1.302mm. This value represents the greatest distance between the line between the surface edges of front surface 211 of cover glass 210, discussed above, and the curved line along front surface 211.

71. Next, using the value of the sagitta, the radius of curvature disclosed in Han, and half the distance between surfaces 2221 and 2321, I calculated the center

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of a circle of which the circular arc described above is a part (i.e., the origin of the coordinate system and point 0, 250mm are both points on the circle). The circle is centered at *a*=125mm, *b*=5998.698mm.

72. The formula for the bottom half of this circle can be rewritten as: $y = b - \sqrt{r^2 - (x - a)^2}$ where a is the x-axis value of the center of the circle, b is the y-axis value of the center of the circle, and r is the radius of the circle. Using this formula, I calculated the y values of the circle at fifty-one (51) x-axis locations between 0mm and 250mm (i.e., beginning at 0, continuing every 5mm, and ending at 250mm). These values correspond to the distances between the line between the surface edges of front surface 211 of cover glass 210, discussed above, and the line along the curved plane defined by front surface 211.

73. Next, using the formula for a mathematical parabola, i.e., $y = a(x - h)^2 + k$, I used a curve analysis tool provided under the name CurveExpert Professional version 2.7.3, by Hyams Development to find the parabola that best fit the values calculated above. The regression analysis determined the coefficients to be: *a*=0.0000833, *h*=125, and *k*=-1.302. Using these values in the formula for a parabola, I calculated the value of the parabola at each x- axis point. I also calculated the deviation between the calculated distance values between the lines in Han described above and the mathematical parabola values at each x-axis location.

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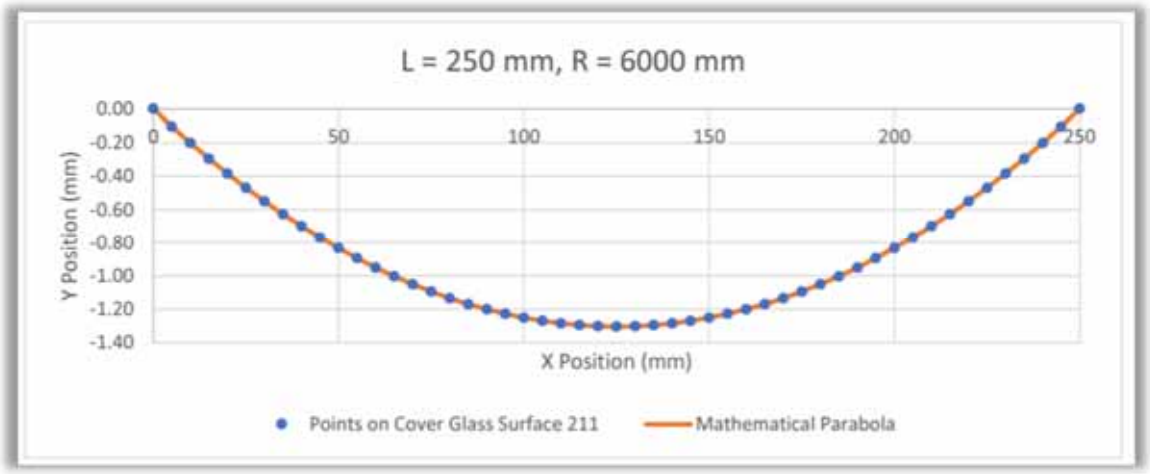
74. Based on those results, the curvature relative to the first-axis of that Han embodiment is illustrated in the plot below:



75. As shown above, the radiused data points fit almost exactly to the parabolic function.

76. Also, the deviation between the calculated distance values between the lines in Han described above and the mathematical parabola values at each x-axis location is illustrated in the plot below. The y-axis scale used in this plot is the same as that used in Fig. 18b of the ’935 Patent, which is also reproduced below following the deviation plot.

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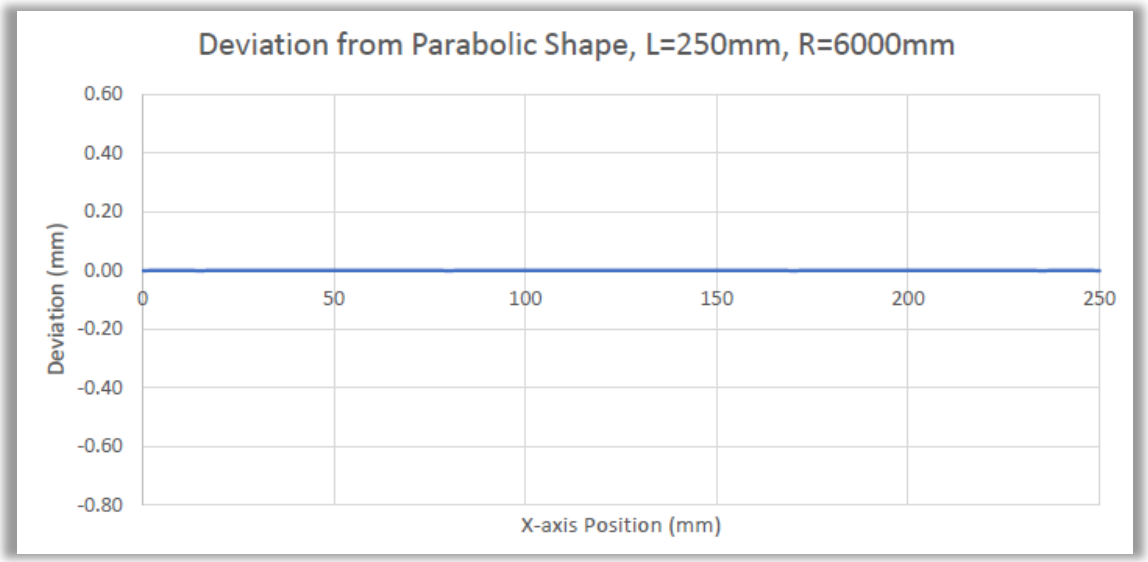

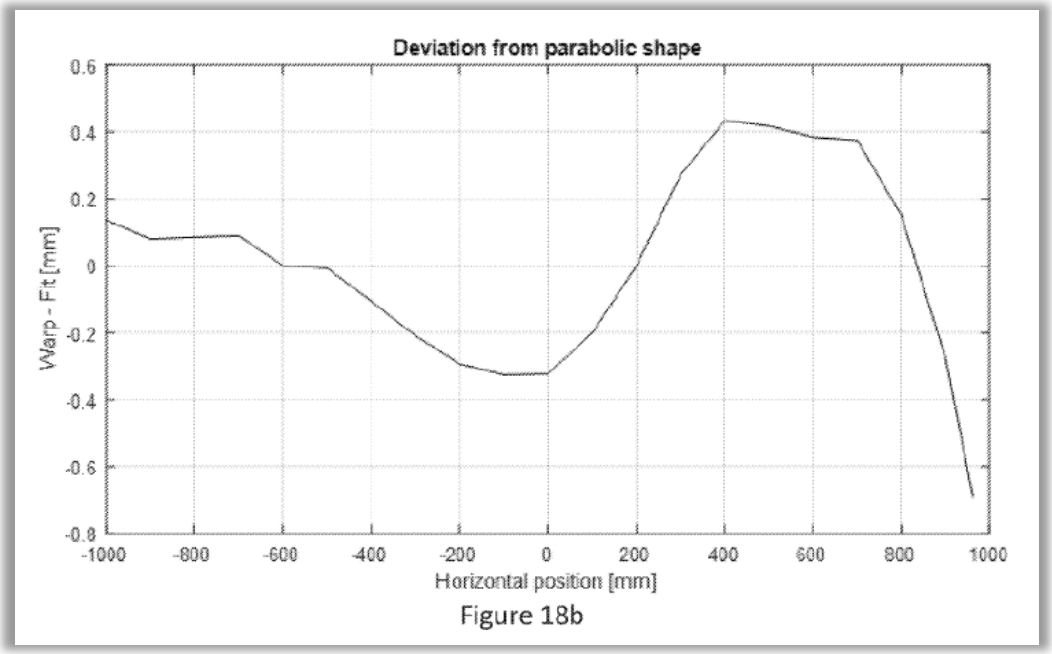

Ex. 1001 at Fig. 18b.

77. The maximum deviation occurred at the edges, and it was calculated to be 0.00003mm. As additional evidence of substantial similarity, the deviation is well within the 0.5mm "Max parabolic deviation" parameter disclosed in the '935

Patent. *See* Ex. 1001 at 18:50-19:26. Thus, Han teaches that the curvature in its cover glass may be parabolic.

78. Han explicitly discloses that such a curvature can be applied in both the Ax and Ay directions. Ex. 1005 at ¶¶ 0087-89. For example, Han explains that, in some embodiments, "the front surface 211 may also be concavely curved along both of the first direction Ax and the second direction Ay." *Id.* ¶ 77. Thus, although Han only shows curvature in one axial direction for illustrative purposes, it is my opinion that a POSA would understand from Han's disclosure how to apply Han's curvature in both axial directions. Furthermore, given that Han discloses that its parabolic curvature yielded advantageous results, it is my opinon that a POSA would have been motivated to use such parabolic curvature in both directions.

79. Further, and based on the dimensions that Han discloses, both curvatures would be parabolic, as that term is construed above, in such an embodiment having the curvature in both directions

80. As an initial matter, a POSA would appreciate that, in Han, the radius of curvature is very large compared to the length of the touch surface. As a result, the maximum depth of the curvature in a given direction will be very small, or shallow, relative to the length. As discussed above, the sagitta was calculated to be about 1.302mm in the example of a length of 250mm.

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81. Moreover, based on the disclosure of Han, it is my opinion that a POSA would have been motivated to provide curvatures along both directions that at least increase, and preferably maximize, the light efficiency, as taught by Han. Han discloses that, for a length L of 250mm between guide members 222, 232, "the light efficiency was measured to be maximum around the point wherein the radius of curvature R of the front surface 211 of the cover glass 210 is 6000 mm." Id. ¶ 0095; Fig. 5. For a length L of 150mm between guide members 222, 232, "the light efficiency was measured to be maximum around the point wherein the radius of curvature R of the front surface 211 of the cover glass 210 is 3000 mm." *Id.*

82. Accordingly, Han discloses that a rectangular device like that shown in its Fig. 2 can have a distance L of 250mm in the Ax direction and a distance L in the Ay direction of 150mm. Han further discloses that such a device has a radius curvature in both the Ax and Ay directions.

83. Han discloses that one optimal radius of curvature of front surface 211 in the Ax direction, measured at a cross-section taken along a line extending in the Ax direction and centered in the Ay direction, is 6000mm. This curvature is relative to a first axis that is parallel to a line between a first end point on a first edge of the frame assembly in Han and an opposite second end point on the first edge of the frame assembly in Han.

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84. Based on the information provided in Han, it is my opinion that a POSA would have determined that dual-curved plate may be parabolic in both directions.

85. For example, as discussed above, the curvature of front surface 211 in the Ax direction along the line centered in the Ax direction and centered in the Ay direction is parabolic, as that term is construed herein.

86. Additionally, the curvature of front surface 211 in the Ay direction along the line extending in the Ay direction and centered in the Ax direction is parabolic, as that term is construed herein. In that regard, I performed the same series of calculations to those described above in paragraphs 37-46, but using a length L of 150mm and a radius of curvature R of 3000mm (based on Fig. 5b of Han).

87. In particular, I calculated the y values of the circle at 31 locations between 0mm and 150mm (i.e., beginning at 0, continuing every 5mm, and endingat 150mm). I also used the curve analysis tool to find the parabola that best fit these values. The regression analysis determined the coefficients to be: a=0.000167, h=75, and k=-0.938. Using these values in the formula for a parabola, I calculated the value of the parabola at each x-axis point. I also calculated the deviation between the calculated distance values between the lines in Han described above and the mathematical parabola values at each x- axis location.

88. Based on those results, the curvature is illustrated by the graph below:

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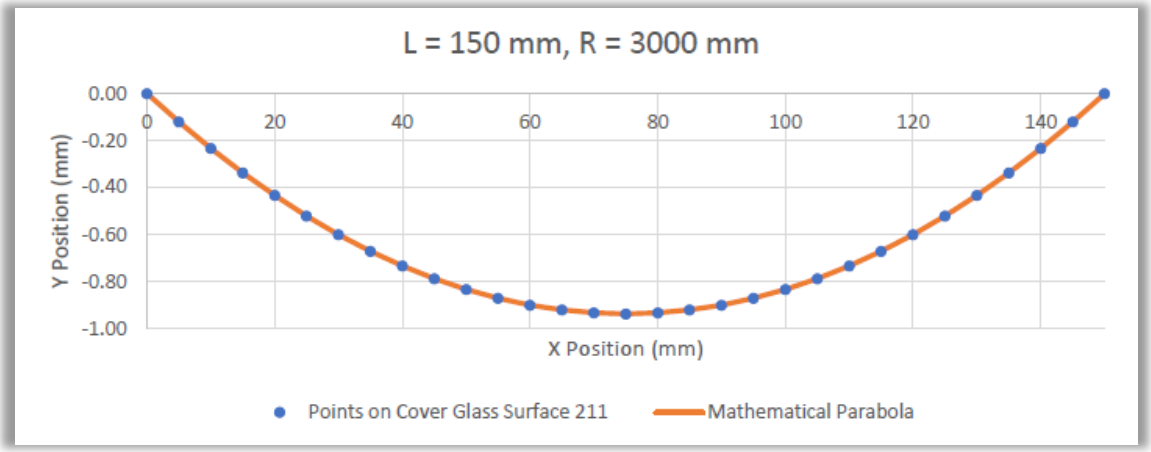
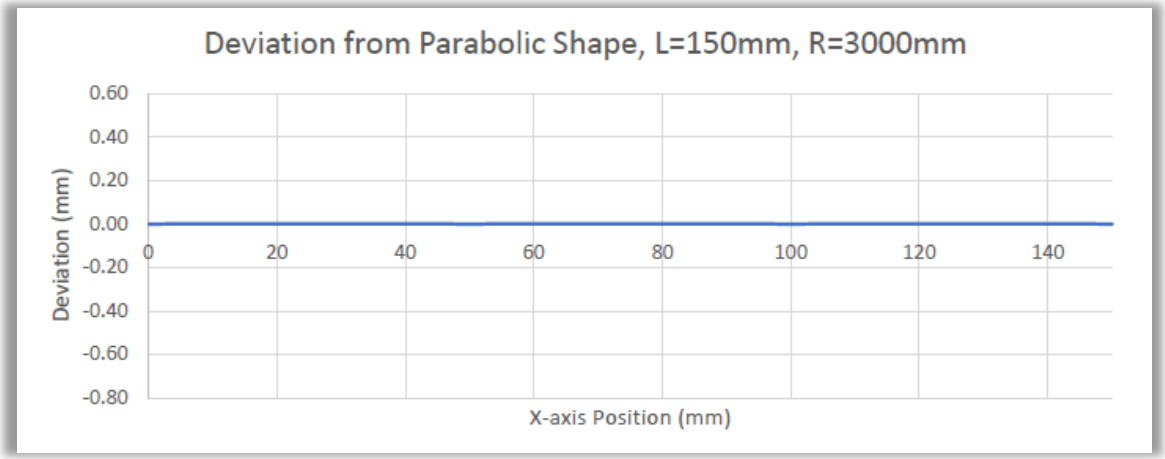


89. As shown above, the radiused data points fit almost exactly to the parabolic function in the Ay direction as well.

90. Also, the deviation between the calculated distance values between the lines in Han described above and the mathematical parabola values at each x-axis location is illustrated in the plot below. Again, the y-axis scale used in this plot is the same as that used in Fig. 18b of the ’935 Patent.



91. The maximum deviation occurred at the edges, and it was calculated to be 0.00003mm. As additional evidence of substantial similarity, the deviation is well within the 0.5mm "Max parabolic deviation" parameter provided in the '935 Patent. *See* Ex. 1001 at 18:50-19:26.

92. Thus, Han teaches that in a double-curved cover glass, a parabolic curvature in the touch surface relative to a first axis and relative to a second axis perpendicular to the first axis.

93. Han does not specifically describe how the curvature in its cover glass was formed. However, as I explain below, it is my opinion that methods of using a frame assembly to induce curvature in a plate, such as cover glass 210 in Han, were well known in the art and were known to provide manufacturing efficiencies, such that a POSA would have considered such methods in assembling a parabolically curved plate according the Han device.

C. Zhao

94. Zhao (U.S. Patent Application Publication No. 2017/0123257) is a U.S. Patent Application titled "Curved-Surface Liquid Crystal Display." Zhao claims priority to Chinese Application 201510727484.4 which has a publication date of December 15, 2015.

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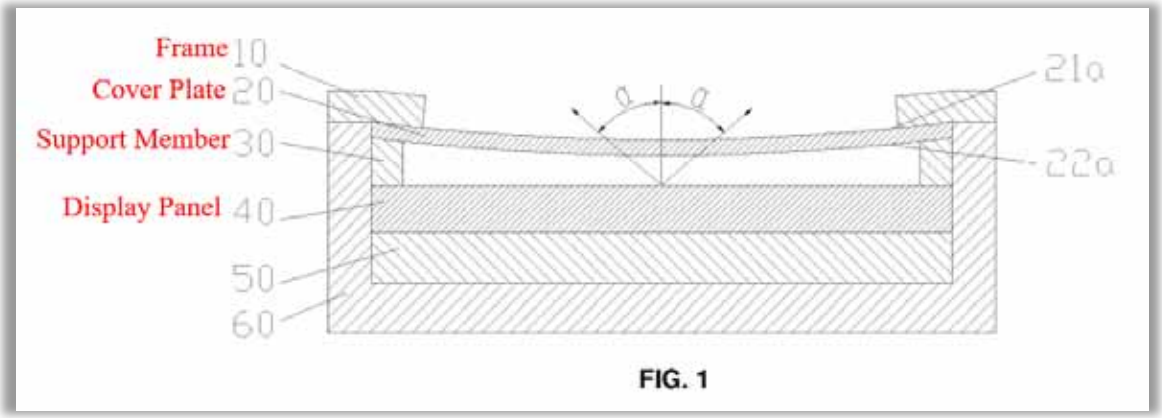
95. Zhao discloses a display device with a display (liquid crystal display panel 40) and a transparent plate (cover plate 20) having a concave curvature. Ex. 1012 at Abstract, Fig. 1. Zhao teaches inducing curvature in a plate, explaining that "[t]he cover plate 20 also may be a flat plate, and is forced to bend by squeezing the cover plate 20 in the installation process, so that its first surface 21a is concave." *Id.* at [0050].



Id. at Fig. 1.

96. As shown above, cover plate 20 is "sandwiched" between a frame 10, which is curved on two sides 12 and straight on two sides 11, and curved support members 30, which may be present on some or all sides of frame 10. *Id.* at [0045], [0051], [0053 54], Figs. 1-2.

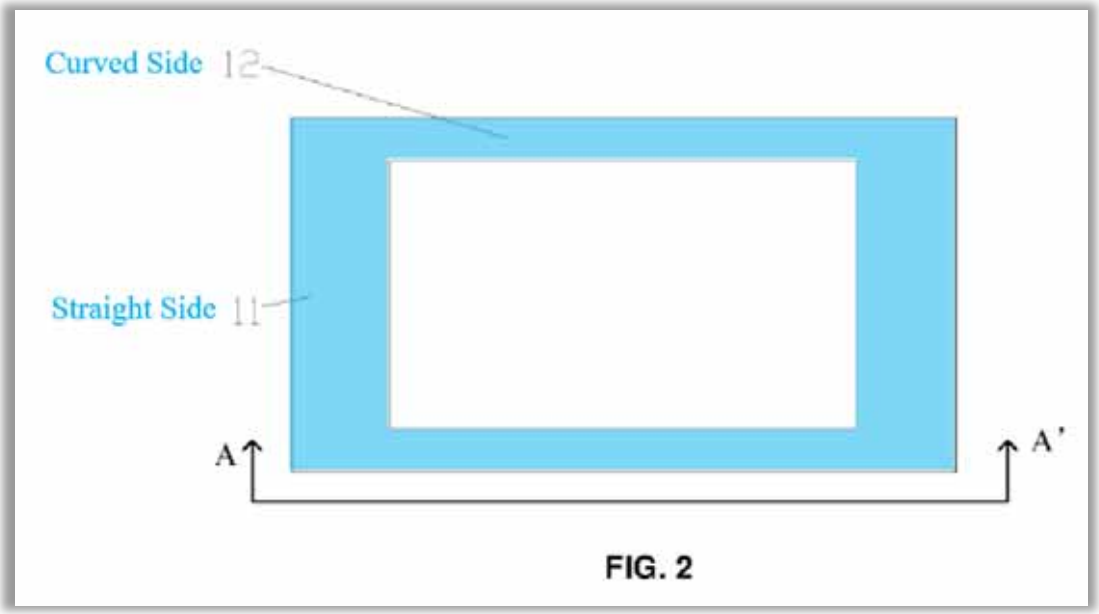


FIG. 2

Ex. 1012 at Fig. 2.

97. Zhao further explains that "the curvature radius of the two curved sides 12 of the frame 10 is the same as that of the first surface 21a [of cover plate 20], and specifically, the shape of the frame 10 mates with that of edges of the first surface where the frame is located, such that the frame 10 fits the cover plate 20 better, to prevent structure loosening." *Id*. at [0051-52].

98. Similarly, Zhao provides that the shape of the surface of each support member 30 in contact with cover plate 20 matches that of cover plate 20. Id., at [0055]. In other words, Zhao's curved support members 30 are configured to support plate 20 so that, during assembly of plate 20 and the frame 10, the same curvature of members 30 is induced in plate 20. Id. As such, Zhao discloses a frame

structure that is configured to support the plate and that, in doing so, induces a concave curvature in the touch surface

D. Shin

99. Shin (U.S. Patent No. 9,291,845) is a U.S. Patent titled "Mobile Terminal and Method for Manufacturing the Same" which issued from U.S. Patent Application 14/487,996 ("'996 Application"). The '996 application has a publication date of September 17, 2015.

100. Shin discloses an infrared touch-sensitive device configured to induce a curvature into an initially flat cover glass and display. *See* Ex. 1011 at 1:52-2:22, 3:4058, 10:45-49. Shin further teaches that configuring the frame assembly to support the plate includes inducing the parabolic curvature. *Id.* at [0050]. Although certain embodiments describe a mobile phone, Shin acknowledges that its disclosure is applicable to other mobile terminals, including "laptop computers, . . . portable computers (PCs), slate PCs, [and] tablet PCs," along with "stationary terminals, such as digital TV, desktop computers, and the like." *Id.* at 5:45-59.

101. Shin, like Han, contemplates touch sensors of various types, including "an infrared type." *Id.* 10:45-62. In particular, and as shown in Fig. 2 below, Shin describes a mobile terminal 100 having a front case 101 and a rear case 102. *Id.*at 14:4-11. A curved display unit 151 on the front side includes a window 151a

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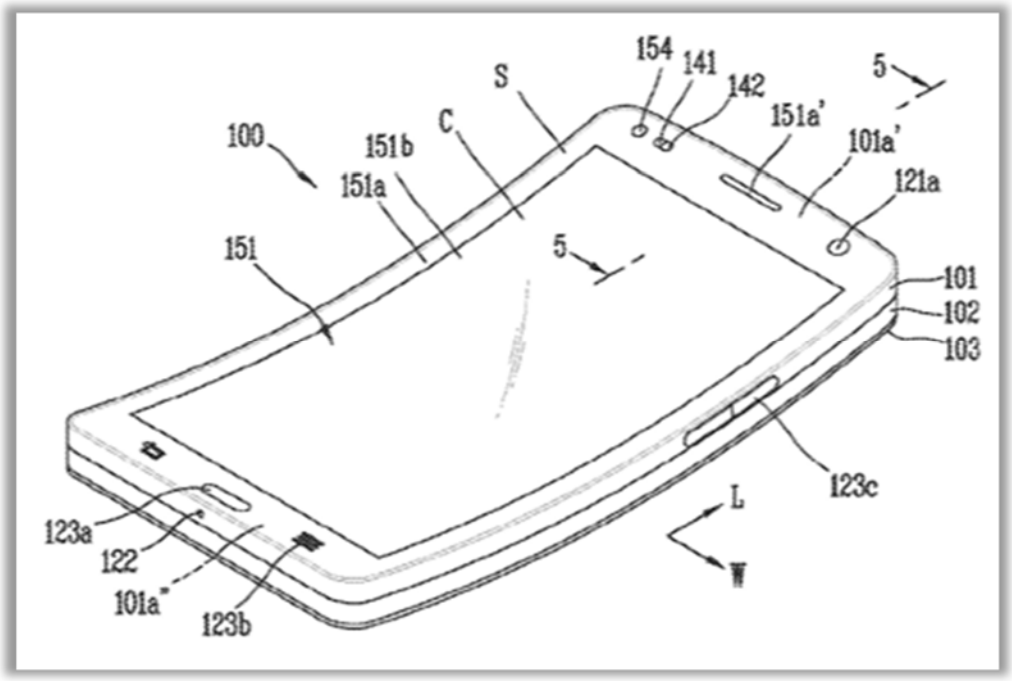
mounted to the front case 101 to form the front surface and a display 151b. *Id.* at 14:12-17, 18:5-14, 18:23-29, Figs. 2-3. As in Han, Shin's display 151b may be an LCD that is attached onto a rear surface of window 151a. *Id.* at 19:4-6, 22:9-15.



Ex. 1011 at Fig. 2.

102. As shown in Shin's Fig. 4, various alternative manners may be utilized for implementing a curved display unit in the device. *Id.* 19:33-20:18.

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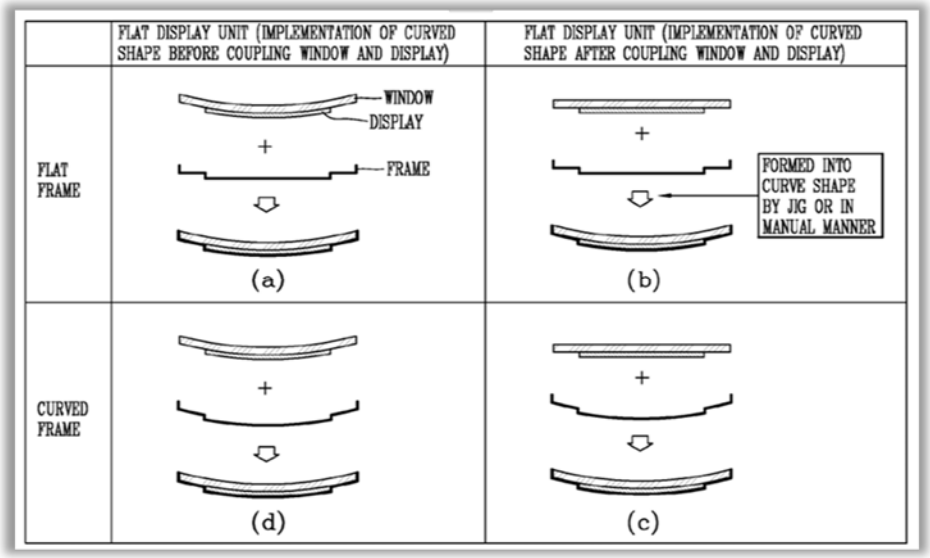

Ex. 1011 at Fig. 4.

103. For example, Fig. 4(d) shows a pre-curved display unit, including a window and a display, that is then coupled to a curved frame to yield a curved display unit in a curved frame. *Id.* at 20:9-14.

104. As another option, Fig. 4(c) shows that a flat display unit, including a flat window and a flat display, may be coupled to a curved frame so that the frame induces a curvature into the display unit when it is installed. *Id.* at 20:4-8. For example, Shin explains:

> [A] display unit in a flat shape may be coupled to a frame in a curved shape. ***By the coupling with the frame in the curved shape, the display unit*** [i.e., the window (plate) and display*]* ***may be changed into a curved shape to correspond to the shape of the frame***.

Ex. Shin-845 20:4-8 (emphasis added).

105. According to Shin, this Fig. 4(c) method of the frame inducing curvature in the display unit is advantageous because it simplifies the manufacturing process, where display curvature can be achieved via the device frame during assembly rather than manufacture of the glass. *Id.* at 18:49-64. Shin provides a detailed explanation of its method of inducing the curvature in a display using the method shown in Fig. 4(c). *Id.*at 20:32-36. In particular, such methods include the use of window mounting portions having curved, or inclined, window mounting surfaces as explained below.

106. Specifically, Shin's Fig. 5 shows that the window 151a is coupled to a window mounting portion 101a on front case 101 of a mobile terminal 100. *Id*. at 20:59-60.

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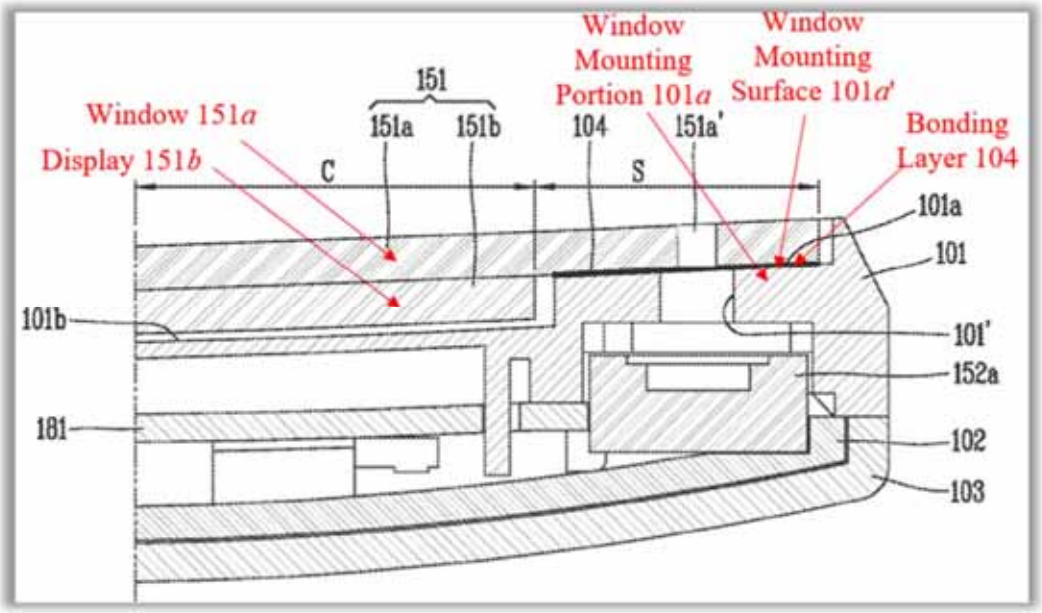

Ex. 1011 at Fig. 5.

107. Shown above, the window mounting portion 101a is formed in a curved, or inclined, shape so as to generate a bending force (or a curving force) by which window 151a is curved during installation. As Shin explains, "when the window 151a is mounted onto the mounting surface, the bending force may be applied to the window 151a such that the window 151a can be curved to correspond to the mounting surface." *Id.* at 20:66-21:6. In other words, Shin's frame assembly, including window mounting portion 101a, induces a curvature in the window 151a when it is installed.

108. As a result of that induced curvature, the window 151a "transfers the bending force to the display 151b adhered to the window 151a, and the display 151b

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is also curved." *Id.* 21:6-9; see also, *id.* 21:28-36 (explaining that "when the window 151a is coupled to the window mounting portion 101a, the window 151a may be transformed into a curved shape to correspond to the curvature of the first and second mounting surfaces 101a' and 101a," so as to have a predetermined curvature").

109. Referring to Fig. 2 of Shin below and to the annotated Fig. 5 of Shin above, Shin explains that window mounting portion 101a may include a first mounting surface 101a' and a second mounting surface 101a" on the end portions of window 151a (*id.* at 21:11-18) and that side mounting surfaces also may be present on the side edges of the window mounting portion 101a, (*id.* at 21:19-24). In some embodiments, these end and side mounting surfaces may have the same curvature. *Id.* at 21:37-42. By positioning mounting surfaces on all sides, (e.g. along both x and y directions) they collectively form a loopshaped support around the edges. *Id.* at 21:24-27, 59-60.

110. As explained above, Shin teaches that the window 151a may be transformed from a flat shape into a curved shape that corresponds with the curvature of those first and second mounting surfaces 101a' and 101a." *Id.* at 20:66-21:6. As a result of that method, the curvature of the mounting surfaces permits a predetermined curvature in the window 151a. *Id.* at 21:28-36.

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111. Shin also provides that window 151a remain coupled to mounting surfaces 101a' and 101a'' and the side mounting surfaces via bonding layers 104 (e.g., adhesive tape or optical clear adhesive) that is provided between window 151a and mounting surfaces 101a' and 101a'' (and shown in a preceding annotated figure above). *Id.* at 21:43-63.

112. Thus, Shin teaches alternative methods for generating a curved touch surface, including a method of configuring a frame assembly that includes inducing a curvature in a plate. With respect to such a method of including curvature, Shin explains that the manufacturing process is advantageously simplified.

E. Cao

113. Cao (U.S. Patent No. 9,983,626) is a U.S. Patent titled "All-in-One Smart Tablet PC and the Assembly Method Thereof" which issued from U.S. Application 14/888,331 ("'331 Application"). The '331 Application is a continuation of PCT Application PCT/CN2014/092348 which has a publication date of June 4, 2015.

114. Cao discloses an infrared "all-in-one smart tablet PC" having a frame assembly that controls glass curvature to be flat. As shown in Cao's Figs. 1, 9, and 16, the Cao device has four screen supports 100, and each screen support 100 has a

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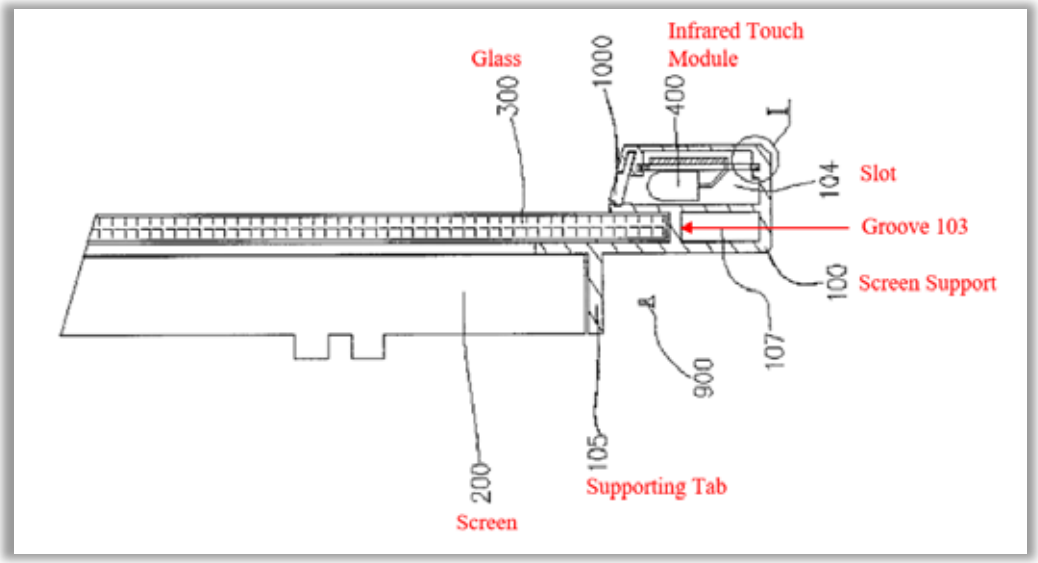
groove 103 and groove wall 112 to receive an edge of the plate (glass 300). Ex. 1010 at 4:2-14, 7:16-21.

115. In assembling the Cao device, a screen support 100 is positioned on each side of the glass 300 so that the glass 300 is fit into the grooves 103 of each screen support, and the screen supports then are joined together at each corner-by-corner cover seats 700. *Id.* at 6:53-69; 7:16-21, Figs. 14-15.



Ex. 1010 at Fig. 9.

116. Cao explains that its frame 100, as shown above, may be used to control the curvature in its plate (glass 300) to improve the fit of Cao's frame 100 and Cao's plate. For example, Cao provides that manufactured glass may have an inherent concave or convex curvature. *See* Ex. 1010 at 4:13-26. Discussed later, such curvature of stock glass is a common, well-known condition. In addition to

incoming curvuture in the plate, curvature may also be induced in Cao's plate from external forces during use (e.g., a user touching the screen). *See*, *id.* at 4:13-16. For example, Cao provides that when a glass 300 has "four rising corners," the grooves 103 of screen supports 100 force "glass 300 [to] be flat without deformation caused by external forces." *Id*. Cao explains that "[t]his will avoid the oversized gap between the glass 300 and the front frame caused by the four rising corners of the glass 300, which improves the quality and the qualified rate of the product." *Id.* at 4:16-19.

117. As shown above, the Cao device also includes a slot 104 in which an infrared touch module 400 is inserted so that it is at the peripheral border of the frame. *Id*. at 4:3-6, 6:25:28. In addition, each screen support 100 defines a supporting tab 105 that, when four screen supports are joined together, define a screen frame 106. *Id.* at 4:7:10, 5:34-36, 7:21-27, Figs. 3, 9, 14. A screen 200 is positioned into screen frame 106 and fixed by a screw 900 passing through screw holes defined in supporting tab 105 and screen back plate 203. *Id.* at 7:21-27, Fig. 9.

VIII. GROUND 1 – CLAIMS 1-14 ARE OBVIOUS UNDER CHENG IN VIEW OF HAN AND ZHAO.

118. In my opinion, Cheng in view of Han and Zhao discloses all elements of claims 1-11 and 14 of the '935 Patent. Specifically, it is my opinion that it would

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have been obvious for a POSA to combine the touch screen display device and frame elements of Cheng, with the parabolically curved touch screen elements of Han and the curvature-inducing frame elements of Zhao. A POSA would have expected to achieve a resulting touch screen display device having improved touch performance, achieved through a simplified manufacturing process.

Motivation to Combine

119. It is my opinion that A POSA would have been motived to modify the Cheng device using the teachings of Zhao to obtain the technical advantages disclosed in Han. Cheng, Han, and Zhao each relate to similar devices including a display, a covering panel, and a supporting frame assembly. *See* Ex. 1004 at Abstract, Fig. 1; Ex. 1005 at Abstract; Ex. 1012 at Abstract.

120. Cheng discloses an infrared touch device including a touch panel 10 with a plate with touch surface, a display, and a frame with a configured to have a reduced thickness. Ex. 1004 at [0001], Fig. 1. Cheng teaches utilizing infrared receivers and transmitters distributed densely around a display region to form a scanning network in both a horizontal and vertical direction. *Id.* at [0002]. Infrared light is emitted and received across a touch surface of a plate. *Id.* at [0010], Fig. 1. Cheng's frame 20 includes a protrusion 24 and plate support element for supporting a plate with a touch surface. *Id.* at Fig. 1.

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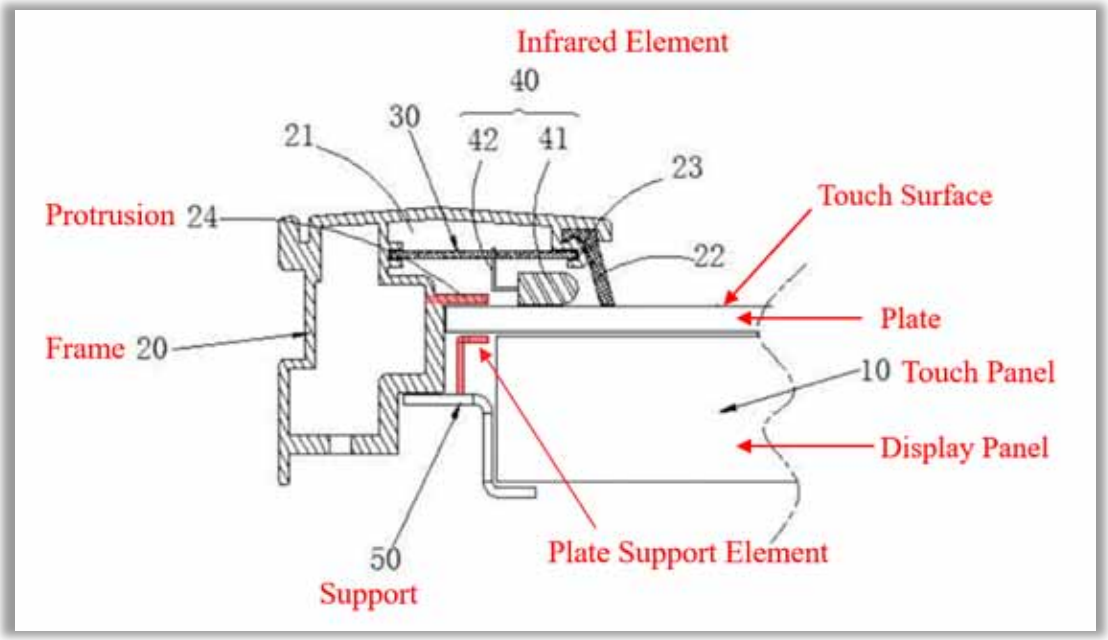
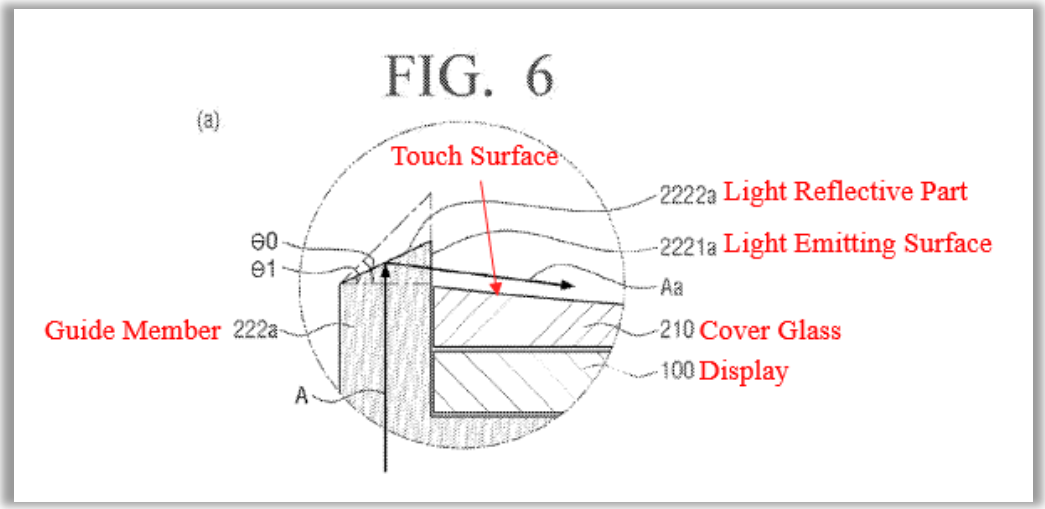


Ex. 1004 at Fig. 1.

121. Cheng's frame 20 improves touch detection accuracy by orienting the lamp tube 41 of an infrared element 40 to transmit and receive infrared light closely along the touch surface of the plate. *Id.* Cheng additionally teaches reducing material costs by reducing material requirements of the frame. *Id.* at Abstract, [0018].

122. Han, like Cheng, teaches improving touch detection accuracy in infrared touch devices. In Han, the front surface of a flat cover glass 210 (i.e. a plate) is configured to have a concave parabolic curvature. Further, Han teaches tuning the direction of emitted infrared light to travel along the surface of the curved touch surface of cover glass 210 by tilting a light reflective part 2222a of the guide member

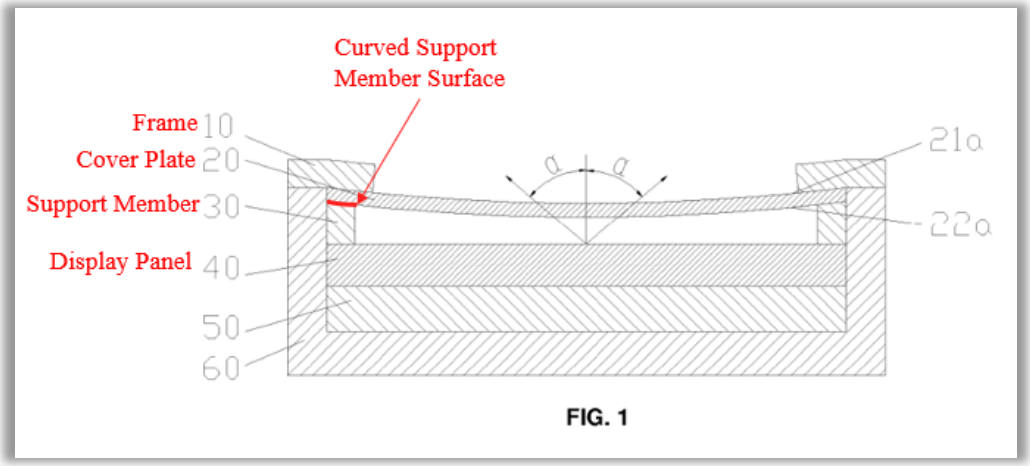
222. Ex. 1005 at [106]. For example in Han's Fig. 6, reflective part 2222a is angled to emit light Aa parallel to the angled (curved) touch surface of the cover glass 210.



Ex. 1004 at Fig. 6(a).

123. Han teaches that by utilizing a parabolic curvature of front surface 211 of cover glass 210 and tuning the travel direction of emitted light across the front surface, the amount of light lost by reflection is reduced, the amount of light received at light reception guide member 232, and corresponding detection accuracy, is increased. *Id.* at [0086]. Further, Han teaches reducing the thickness of the bezel (frame) of the infrared touch device 10 using light emission and reception guide members 222, 232. *Id.* at [0058]. Thus, in my opinion, Han discloses improvements of the same objectives (improved touch detection accuracy and frame size reduction) in the same technological field (infrared touch devices) as Cheng.

124. In my opinion, a POSA would have been motivated to modify Cheng according to Zhao's simplified manufacturing process of inducing curvature into the plate via a frame assembly to achieve Han's advantageous plate curvature. Similar to Han, Zhao discloses a device having a display 40 (Han's display 100) and a cover plate 20 (Han's cover glass 210) having a concave curvature. Like Cheng, Zhao teaches supporting the cover plate 20 with the frame 10 (Cheng's frame 20 with protrusion 24) and a support member 30 (Cheng's plate support element).



Ex. 1012 at Fig. 1.

125. Zhao teaches inducing curvature in the cover plate 20, explaining that "[t]he cover plate 20 also may be a flat plate, and is forced to bend by squeezing the cover plate 20 in the installation process, so that its first surface 21a is concave." *See* i*d.* at [0050]. Zhao explains that the shape of the surface of the support member 30 in contact with the cover plate 20 matches that of the cover plate. *Id.* at [0055].

In my opinion, a POSA would have understood inducing the curvature of the cover plate 20 to include forcing the cover plate 20 against the curved top side of the support member 30. As the cover plate 20 is bent under appliced force against the curved surface of the support member 30, its shape (curvature) would match that of the curved surface of the support member 30. *See* Ex. 1012 at [0050-55]. Zhao teaches that the curved cover panel 20 improves the optical performance of emitted light by reducing the amount of light leak. *Id.* at Abstract.

126. Thus, it is my opinion that a POSA would have been motivated to combine Cheng, Han, and Zhao to meet the claim limitations of the ’935 Patent. Starting with the increased accuracy infrared touch device of Cheng, a POSA would have expected that touch accuracy could be further increased by implementing the parabolically curved touch surface of Han into the touch surface of Cheng. In my view, Han’s teachings would have been obvious for POSA to incorporate into Cheng, as both references disclose improving touch accuracy of touch devices by tuning the travel direction of infrared light across a plate touch surface using a frame assembly. Ex. 1004 at [0010], Fig. 1; Ex. 1005 at [106]..

127. In my opinion, a POSA would have been motivated to implement Zhao’s teaching of inducing curvature in the plate via a curved support member 30 during plate installation in Cheng to achieve Han’s parabolic plate curvature.

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Cheng's frame already includes a frame support element supporting the plate, it would have been obvious for a POSA to modify Cheng's support element according to the curved support member 30 of Zhao. It is my view that a POSA would have expected such modification to achieve the same simplified curvature-inducing functionality in the modified Cheng device. Further, it is my opinion that a POSA would have appreciated Zhao's curved support member 30 to deliver a simplified manufacturing process with reduced cost. Thus, it is my opinion that a POSA combining the teachings of Han and Zhao into the device of Cheng would have expected to achieve the predictable result of a high touch accuracy (Han) infrared touch device (Cheng, Han) and manufacturing method (Cheng, Han, Zhao), meeting the limitations of the '935 Patent. In my view, such modifications would have merely embodied implementing known techniques to improve a similar device in a similar way.

1. Claim 1

(a) Preamble: "A method for assembling a touch sensing apparatus, the touch sensing apparatus comprising a display panel, a plate including a touch surface, and a frame assembly,"

128. In my opinion, Cheng discloses this element. Cheng discloses a method for assembling a touch sensing apparatus that includes a touch panel 10. *See* Ex.

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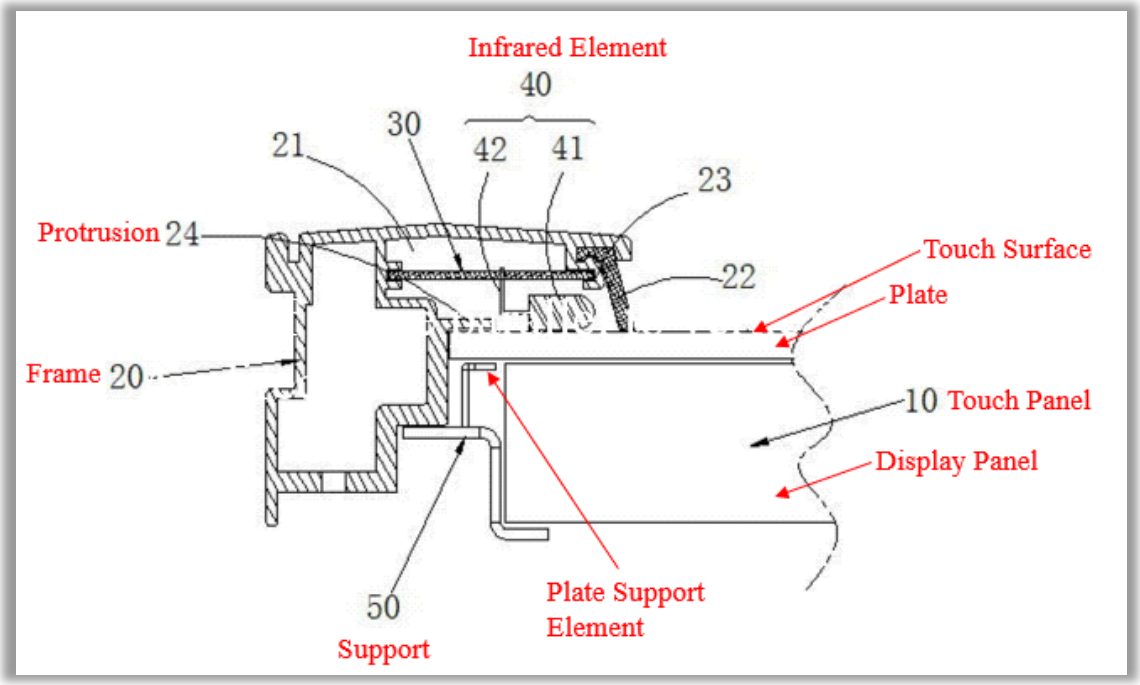
1004 at [0013]. A POSA would have understood Cheng's touch panel 10 to include a display panel and a plate including a touch surface. *See id.* at Fig. 1, [0002-3]. Cheng further discloses a frame 20 and a support 50 having a plate support element. Ex. 1004 at [0013-16].

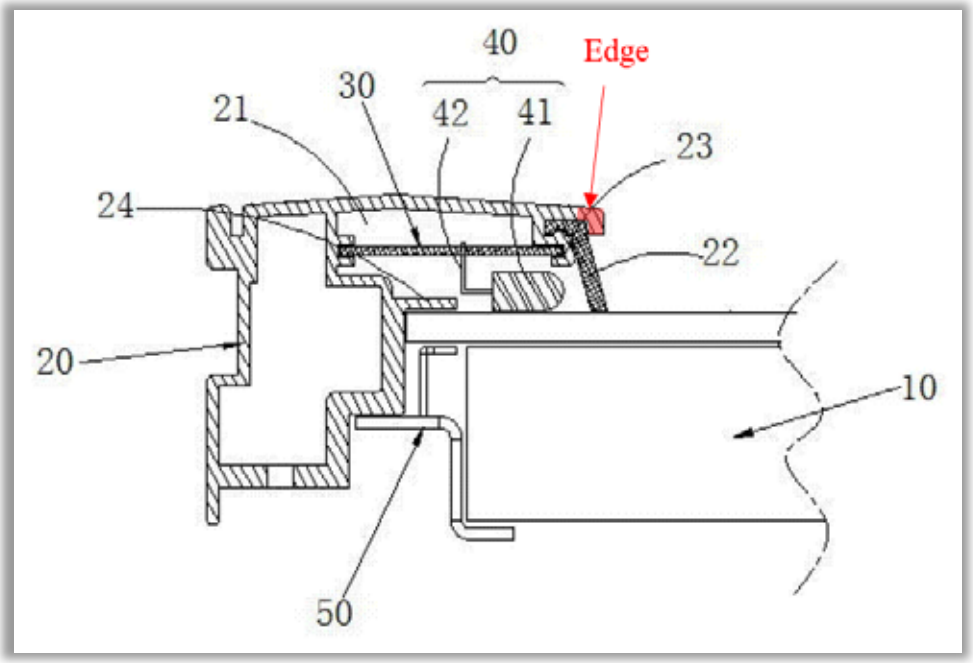


Ex. 1004 at Fig. 1.

129. Thus, it is my opinion that Cheng discloses a method for assembling a touch sensing apparatus (infrared touch screen device), the touch sensing apparatus comprising a display panel (display panel of 10), a plate including a touch surface (plate with touch surface of 10), and a frame assembly (frame 20, support 50).

(b) "wherein the frame assembly includes: a first edge extending between a first end point and an opposite second end point; and a second edge extending between the second end point and a third end point;"

130. In my opinion, Cheng and Han disclose this element. In my view, a POSA would have understood Cheng's frame 20 to disclose a frame assembly with a first and second edge.



Ex. 1004 at Fig. 1.

131. As shown above in Cheng's Fig. 1, the frame 20 includes an edge. Cheng's infrared element 40 is housed in the frame 20 so light is emitted across the plate. Cheng further discloses "a scanning network in horizontal and vertical directions, and it thus possible to determine X and Y coordinates by means of the

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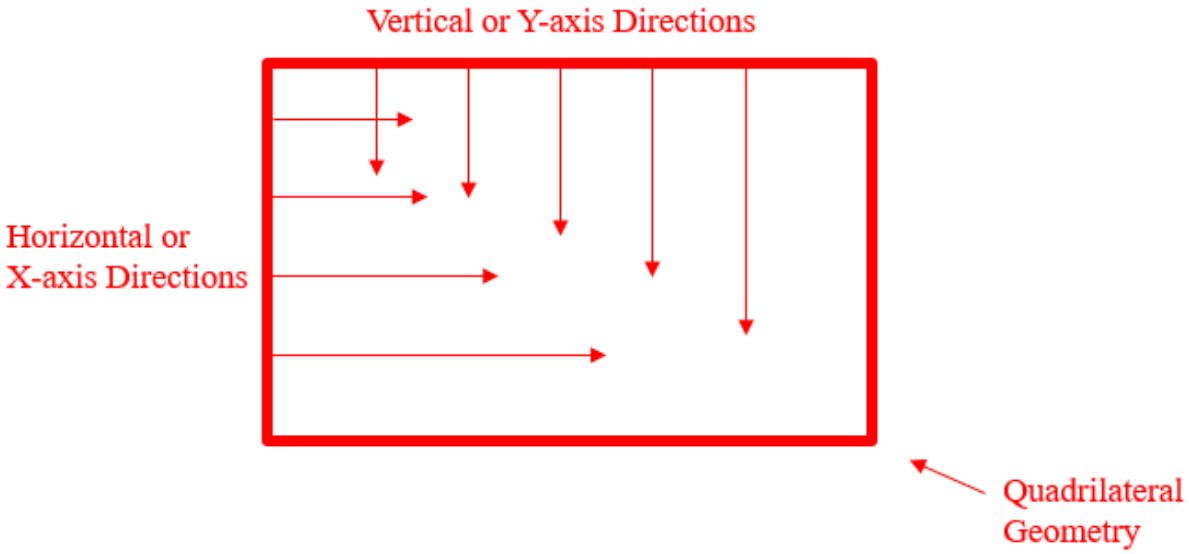
position of infrared rays in the horizontal and vertical directions." Ex. 1004 at [0002]. Horizontal and veritical (i.e. X-axis and Y-axis) are common components of a quadriateral or rectangular geometry.



132. A POSA would have therefore understood Cheng's frame 20 to disclose a frame assembly configured in the common quadrilateral geometry of infrared touch screen devices, including a first edge (frame 20 housing infrared elements to project light in a vertical direction) and second edge (frame 20 housing infrared elements to project light in a horizontal direction) as defined between endpoints. Thus, in my opinion, Cheng discloses a frame 20 with edges in both a horizontal (first edge) and vertical (second edge) direction. Cheng's first edge extends between a first end point and an opposite second end point and the second edge extends between the second end point and a third end point.

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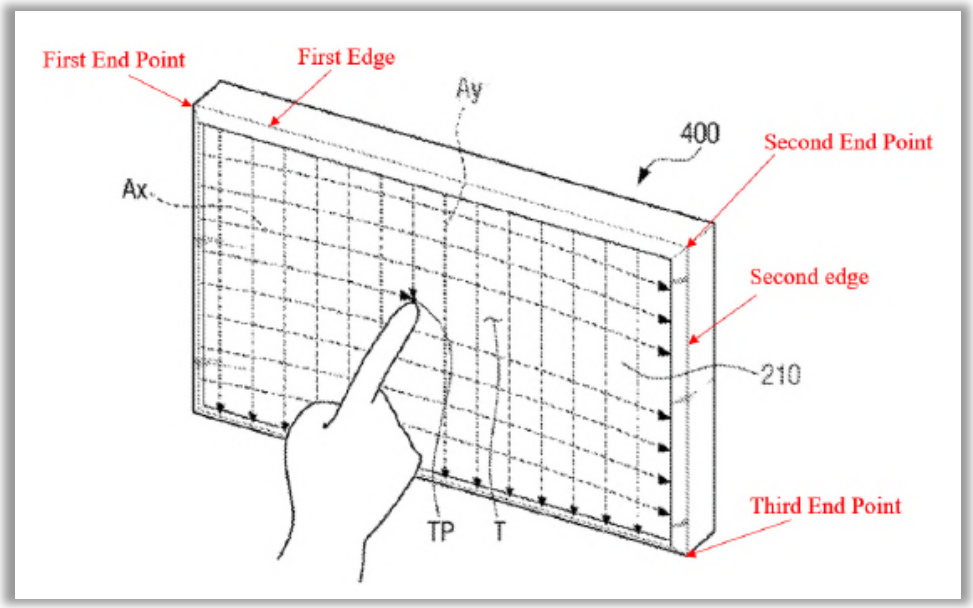
133. Further, Han's frame assembly (including rear cover 400 and guide members 222, 232) depicts a quadrilateral frame geometry including a first edge extending between a first end point and an opposite second end point, and a second edge extending between the second end point and a third end point.



Ex. 1005 at Fig. 2.

134. In modifying Cheng according to Han's Ax and Ay plate curvature to achieve improved touch performance, a POSA would have naturally also implemented Han's quadrilateral frame geometry (to the extend Cheng does not already disclose the same) that would inlcude first and second edges and depicted in Han's Fig. 2 above.

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135. Thus, in my opinion, Cheng and Han disclose wherein the frame assembly (frame 20) includes: a first edge (frame edge parallel to horizontal, Ax direction) extending between a first end point (first end point of horizontal frame edge) and an opposite second end point (second end point of horizontal frame edge); and a second edge (frame edge parallel to vertical, Ay direction) extending between the second end point (second end point of horizontal frame edge) and a third end point (endpoint of frame edge parallel to vertical, Ay direction).

(c) "the method comprising: configuring the frame assembly to support the display panel;"

136. In my opinion, Cheng discloses this element. Cheng discloses "a protrusion 24 is provided on the frame 20; the protrusion 24 is placed on an upper surface of touch panel 10" (touch surface of the plate). Ex. 1004 at [0015]. Further, Cheng explains "[a] support 50 is provided below the protrusion 24; the support 50 and the protrusion 24 together clamp the touch panel 10." *Id.* at [0016]. In my view, a POSA would have understood Cheng's frame 20 and support 50 to cooperatively function as a "frame assembly" to support the display panel. .

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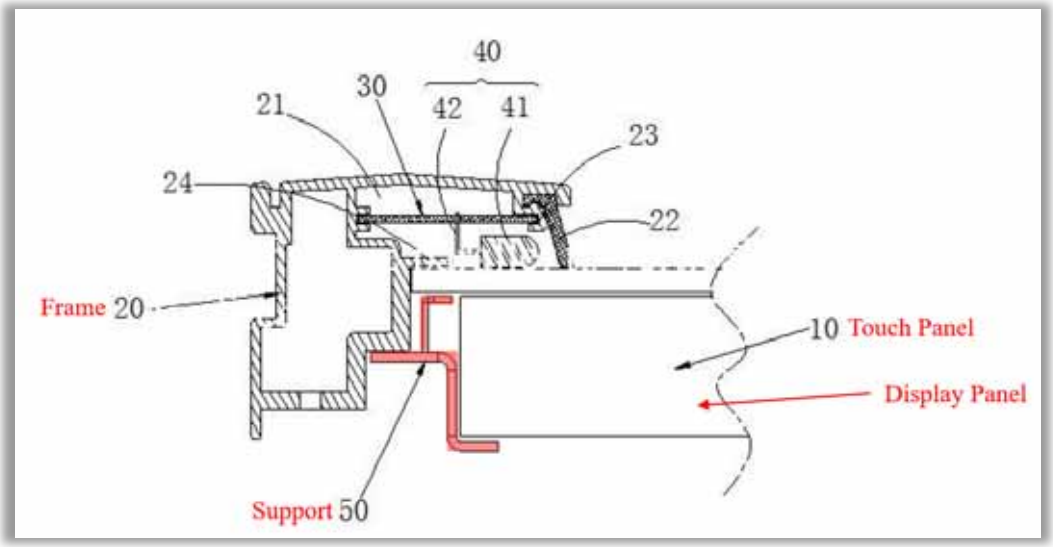


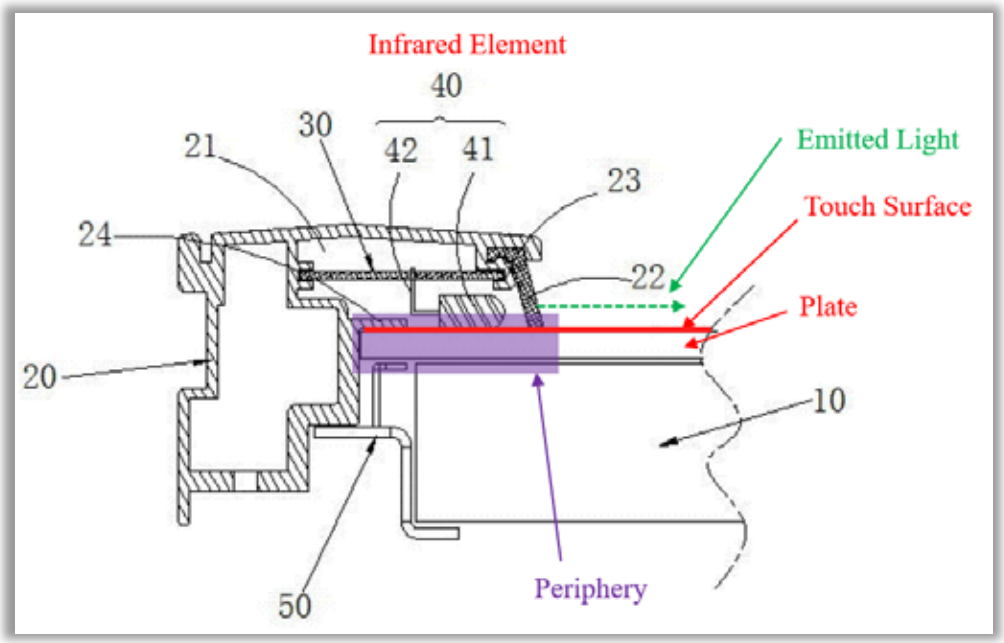
Ex. 1004 at Fig. 1.

137. Thus, in my opinion, Cheng discloses configuring the frame assembly (frame 20 and support 50) to support the display panel (display panel of touch panel 10).

(d) "arranging a plurality of emitters adjacent to a periphery of the plate, said plurality of emitters configured to emit light to propagate over the touch surface;"

138. In my opinion, Cheng discloses this element. Cheng discloses arranging "infrared receivers and **transmitters** distributed densely around a display region [to] form a scanning network in horizontal and vertical directions…" Ex. 1004 at [0002] (emphasis added). A POSA would have understood "transmitters" to be equivalent to "emitters." Cheng's infrared element 40 is arranged adjacent to

a periphery of the plate. *Id* at Fig. 1. To achieve touch sensing functionality, a POSA would have understood Cheng's lamp tube 41 of infrared element 40 to transmit (emit) light to propagate over the touch surface of the plate.



Ex. 1004 at Fig. 1.

139. Thus, in my opinion, Cheng discloses arranging a plurality of emitters (infrared element 40 including lamp tubes 41) adjacent to a periphery of the plate (plate of touch panel 10), said plurality of emitters configured to emit light to propagate over the touch surface (surface of plate).

(e) "arranging a plurality of detectors arranged adjacent to the periphery of the plate, said plurality of detectors configured to receive light from the set of emitters; and"

140. In my opinion, Cheng discloses this element. As I discussed above, Cheng discloses "infrared **receivers** and transmitters distributed densely around a display region [to] form a scanning network in horizontal and vertical directions…" Ex. 1004 at [0002] (emphasis added). A POSA would have understood "recievers" to be equivalent to "detectors." Cheng's infrared element 40 is arranged adjacent to the plate periphery. *Id.* at Fig. 1. To achieve touch sensing functionality, a POSA would have understood Cheng's infrared element 40 to also disclose a corresponding infrared element 40 with a receiver (detector) to receive light from lamp tube 41. For example, for a light ray to be obstructed by a user touch, the light ray is first emitted. Similarly, for an obstructed light ray to be registered as being obstructed (i.e. touch detection), a detector previously detecting the emitted light ray ceases to detect the light ray. Thus, a POSA would have understood a touch detecting device having a light emitter to also disclsose, necessarily, a light detector.

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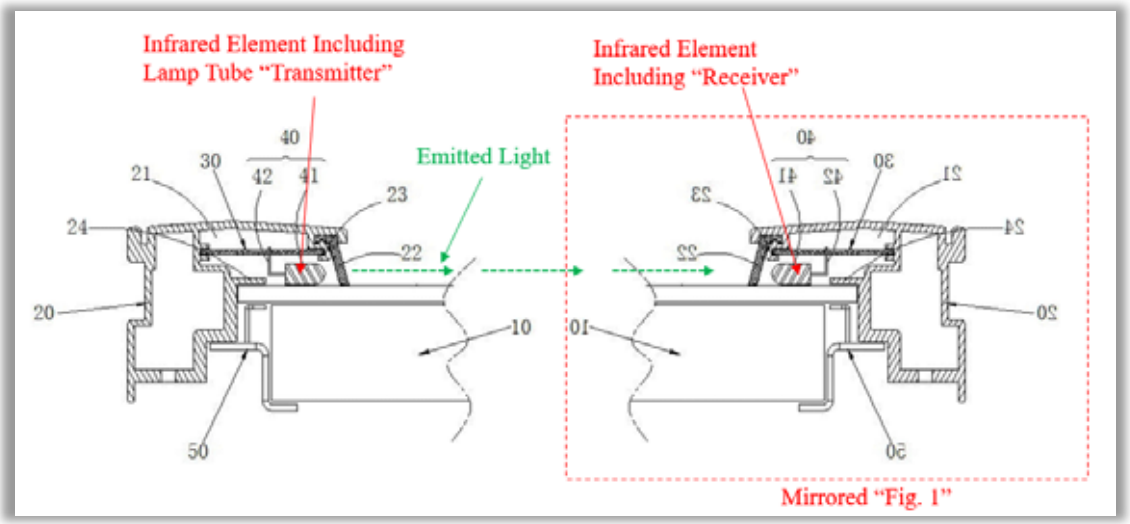
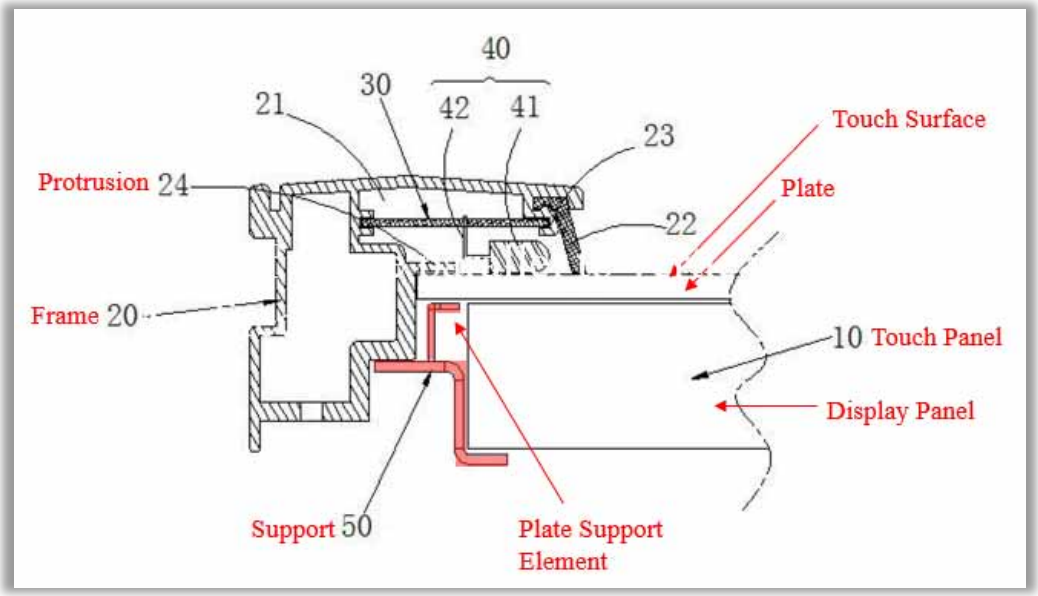


Ex. 1004 at Fig. 1.

141. Thus, in my opinion, Cheng discloses arranging a plurality of detectors (infrared element 40 including a receiver) arranged adjacent to the periphery of the plate (plate of touch panel 10), said plurality of detectors configured to receive light from the set of emitters (infrared elements with emitter (transmitter) lamp tube 41).

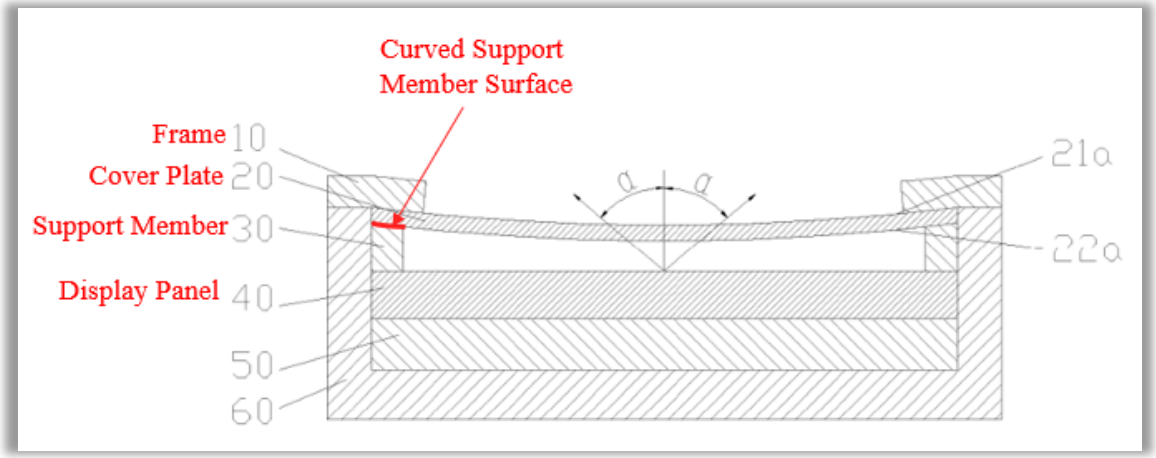
(f) "configuring the frame assembly to support the plate; wherein configuring the frame assembly to support the plate includes inducing a parabolic curvature in the touch surface relative to a first axis and relative to a second axis perpendicular to the first axis, said first axis is parallel to a line between the first end point and the second end point and said second axis is parallel to a line between the second end point and the third end point."

142. In my opinion, Cheng in view of Han and Zhao discloses this element. Cheng's frame assembly comprises frame 20 and support 50. Ex. 1004 at Fig. 1. Depicted in Cheng's Fig. 1, the support 50 includes a plate support element that supports the plate.



Ex. 1004 at Fig. 1.

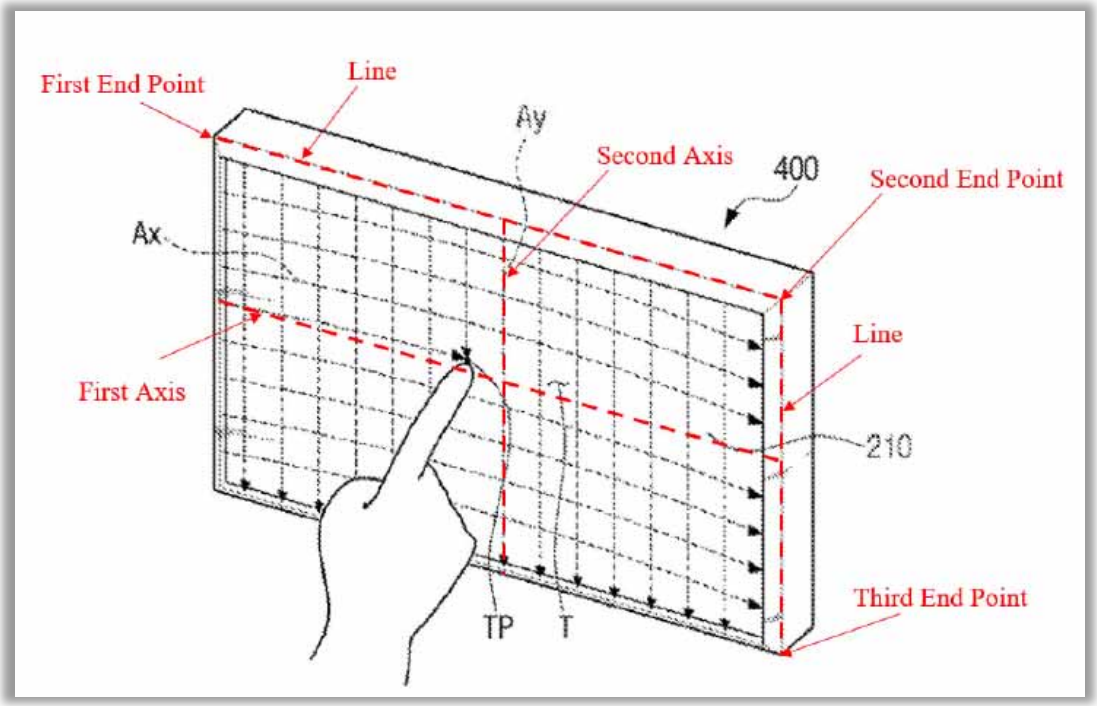
143. As I discussed above, it would have been obvious to a POSA to modify Cheng's plate to incorporate Han's parabolic touch screen curvature along Ax and Ay directions to improve touch detection accuracy. To reach Han's touch screen curvature, it would have been obvious to a POSA to modify Cheng's frame protrusions 24 and plate support elements of supports 50 according to Zhao's curved mounting surfaces 30.



Ex. 1012 at Fig. 1.

144. Like in Zhao, the modified plate support elements of Cheng would induce curvature into the plate in a simplified manufacturing step, and the modified protrusions 24 of Cheng would secure the curved touch surface side of the curved plate.. *See* Ex. 1012 at [0050-52]. According to Han's teachings, Cheng's modified plate would be parabolically curved along a first axis (Ax) and a second axis (Ay) perpendicular to the first to achieve improve touch detection accuracy. Further

according to Han, the first axis would be parallel to a line between the first and second endpoints and the second axis would be parallel to a line between the second and third endpoints. *Id.*



Ex. 1005 at Fig. 2.

145. In one example of the modified Cheng device, each side of an initially flat panel is inserted onto respective modified curved plate support element of supports 50 according to Zhao. Like in Zhao, the modified curved plate support elements would apply a bending force to the periphery of the plate, inducing a curvature into the plate, which would include curving the touch surface of the plate. The plate support elements parallel to the plate's Ax axis would induce curvature

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along the plate's Ay axis, and the plate support elements parallel to the plate's Ay axis would induce curvature along the plate's Ax axis, according to the accuracy improving plate curvature of Han. *Id.*

146. Thus, in my opinion, Cheng in view of Han and Zhao discloses configuring the frame assembly (Cheng frame 20 and support element 50) to support the plate (plate of Cheng's touch panel 10); wherein configuring the frame assembly to support the plate includes inducing a parabolic curvature (Han's parabolic curvature) in the touch surface (surface of Cheng's plate) relative to a first axis (Ax) and relative to a second axis (Ay) perpendicular to the first axis, said first axis is parallel to a line between the first end point (first endpoint of Cheng's frame 20) and the second end point (second endpoint of Cheng's frame 20) and said second axis is parallel to a line between the second end point (second end point of Cheng's frame 20) and the third end point (third end point of Cheng's frame 20). *Id.*

2. Claim 2: "The method of claim 1, wherein the first edge is curved and the second edge is curved."

147. In my opinion, Cheng in view of Zhao discloses this element. The modified Cheng device has a curved first edge and a curved second edge. As I discussed above, the modified Cheng device has curved plate support elements and a curved protrusions 24 connected to the frame 20. Cheng's frame 20 includes semi-

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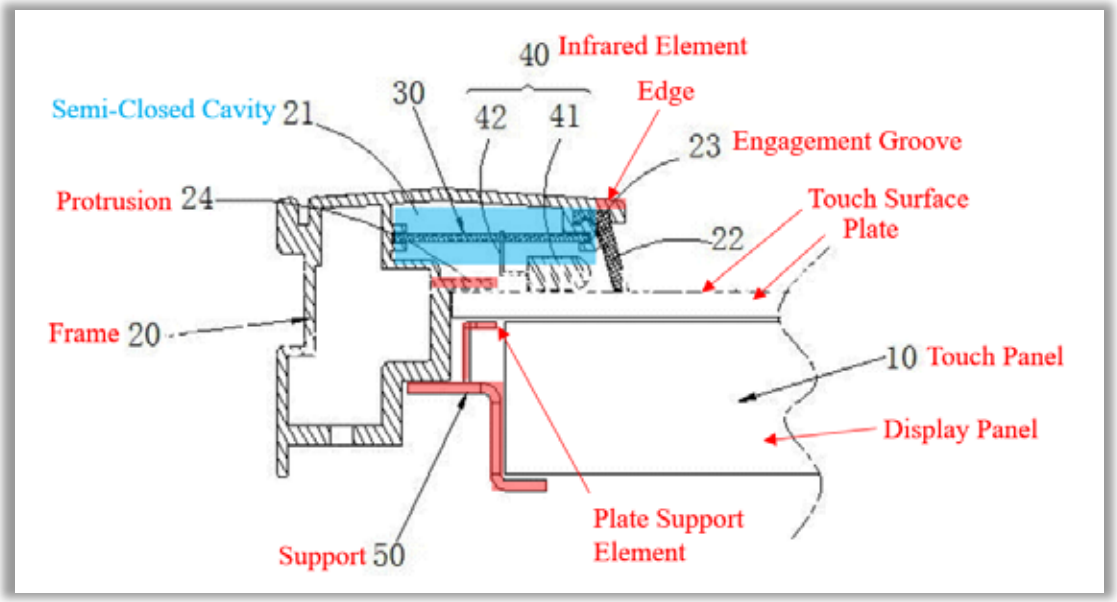
enclosed cavity 21 and engagement groove 23 for supporting the circuit board 30 and infrared element 40. Ex. 1004 at [0013-17].

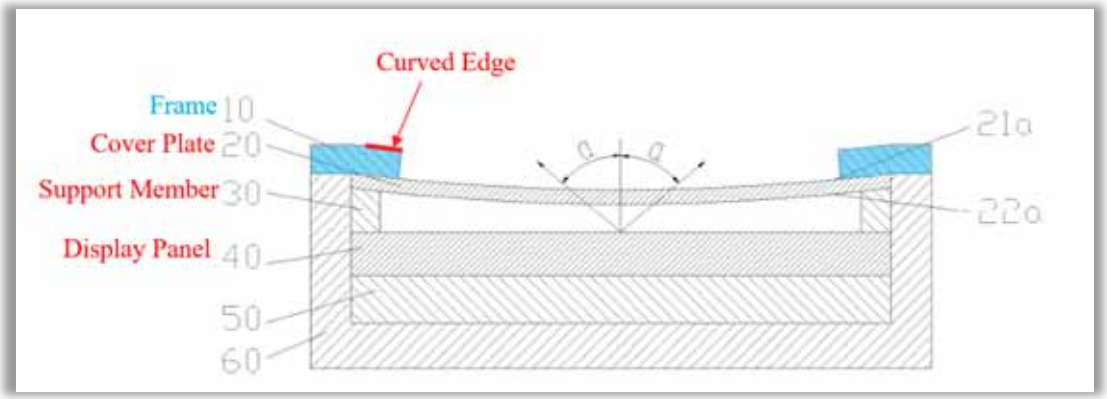


Ex. 1004 at Fig. 1.

148. Cheng teaches that "the lamp tube 41 [of infrared element 40] extends out of the semi-closed cavity 21 and lies against a surface of the touch panel 10." *Id.* at [0013], [0018]. With this lamp tube 41-to-surface-of-panel configuration, Cheng explains that "this reduces the distance from the center of the lamp tube 41 to the touch panel 10, and avoids the phenomenon whereby a touch object triggers a touch operation when it has not yet touched the touch panel…" *Id.* In the modified Cheng device, wherein the protrusion 24 and plate support element are curved according to Zhao, Cheng's modified semi-closed cavity 21 and engagement groove 23 would also be curved as such curvture would be required to maintain Cheng's lamp tube

41-to-surface-of-(curved) panel configuration. As a result, the respective first and second edges of Cheng's frame 20 which form the exterior of the semi-closed cavity 21 and are connected to engagment groove 23 would thus also be curved. *Id.* In this configuration, a POSA would have expected Cheng's lamp tube 41 to remain in contact with the curved touch surface of the plate and provide the same touch detection performance via light emission in close proximity to the surface of the plate disclosed in the unmodified Cheng device.

149. It is also my opinion that curved first and second edges in the modified Cheng device would have been obvious based on Zhao's curved frame 10.



Ex. 1012 at Fig. 1.

150. Zhao discloses an embodiment having a frame with "curved sides." Ex. 1012 at [0051-52]. The radius of curvature of the curved frame 10 is "the same as that of the first surface 21a [surface of curved cover plate 20], and specifically, the shape of the frame 10 mates with that of the edges of the first surface where the

frame is located, such that frame 10 fits the cover plate 20 better, to prevent structure loosening." *Id.*

151. In my view, A POSA would have been motivated to implement Zhao's curved frame 10 into Cheng's frame 20 with protrusion 24. A POSA would have expected such a modification to the Cheng device to achieve Zhao's structural loosening prevention performance. *See* Ex. 1012 at [0052]. In my opinion, a POSA would have valued such structural stability, especially for a device with a curved touch surface. As a result, the curved frame 20 of the modified Cheng device would also have a curved first and second edge. *Id.*

152. Thus, it is my opinion that Cheng in view Zhao discloses wherein the first edge (first edge of Cheng's curved frame 20) is curved, and the second edge (second edge of Cheng's curved frame 20) is curved.

3. "Claim 3: The method of claim 1, wherein the plate has a first curvature when not configured in the frame assembly, and wherein the plate has a second curvature greater than the first curvature after the plate is configured in the frame assembly."

153. In my opinion, Cheng in view of Han and Zhao discloses this element. In an embodiment of the modified Cheng device, the plate has an initial, pre-installed

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curvature according to the well-known material property of pre-installed stock tempered glass. *See* Exs. 1023, 1025, 1026; *see also* Ex. 1001 at 2:5-9

154. Stock glass, such as that referenced in the '935 Patent (Ex. 1001 at 18:50-67) will almost always possess some level of geometric curvature, sometimes referred to as bow or warp. This is particularly true for tempered glass having large area dimensions and produced at commerical scales. Tempered glass curvuture is typcially the result of thermal and mechanical forces imparted on the glass during the manufacturing processes. *See* Ex. 1025 at 37-38; Ex. 1026 at 10. Such curvature is well-known in the art, and is commonly used as a material quality criterion and design consideration for applications utilizing tempered glass. *See* Ex. 1023 at 2-6; Ex. 1025 at 36-38; Ex. 1001 at 2:5-17, 18:50-67. As one example, ASTM C1048-18[1] (Ex. 1023) establishes certain acceptable bow dimension ranges for heat (thermally) tempered glass.

[1] I have compared ASTM C1048-18, the standard published in 2018, with ASTM C1048-12 (Ex. 1024), the same standard published in 2012. I have determined that the two standards are substantively equivalent in their teachings of tempered glass bow.

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TABLE 2 Overall Bow, Maximum

Nominal Thickness Desig., mm (in.)	Edge Dimension, cm (in.) 0–50 (0–20)	>50–90 (>20–35)	>90–120 (>35–47)	>120–150 (>47–59)	>150–180 (>59–71)	>180–210 (>71–83)	>210–240 (>83–94)	>240–270 (>94–106)	>270–300 (>106–118)	>300–330 (>118–130)	>330–370 (>130–146)	>370–400 (>146–158)
	Maximum Bow, mm (in.)											
3 (⅛)	3.0 (0.12)	4.0 (0.16)	5.0 (0.20)	7.0 (0.28)	9.0 (0.35)	12.0 (0.47)	14.0 (0.55)	17.0 (0.67)	19.0 (0.75)	...	...	...
3 (⅛) Alternate Method[A]	2.0 (0.08)	2.0 (0.08)	2.0 (0.08)	3.0 (0.12)	5.0 (0.20)	6.0 (0.24)	7.0 (0.28)	8.0 (0.31)	10.0 (0.39)	...	...	...
4 (5/32)	3.0 (0.12)	4.0 (0.16)	5.0 (0.20)	7.0 (0.28)	9.0 (0.35)	12.0 (0.47)	14.0 (0.55)	17.0 (0.67)	19.0 (0.75)	...	...	...
5 (3/16)	3.0 (0.12)	4.0 (0.16)	5.0 (0.20)	7.0 (0.28)	9.0 (0.35)	12.0 (0.47)	14.0 (0.55)	17.0 (0.67)	19.0 (0.75)	...	...	...
6 (¼)	2.0 (0.08)	3.0 (0.12)	4.0 (0.16)	5.0 (0.20)	7.0 (0.28)	9.0 (0.35)	12.0 (0.47)	14.0 (0.55)	17.0 (0.67)	19.0 (0.75)	21.0 (0.83)	24.0 (0.94)
8 (5/16)	2.0 (0.08)	2.0 (0.08)	3.0 (0.12)	4.0 (0.16)	5.0 (0.20)	6.0 (0.24)	8.0 (0.31)	10.0 (0.39)	13.0 (0.51)	15.0 (0.59)	18.0 (0.71)	20.0 (0.79)
10 (⅜)	2.0 (0.08)	2.0 (0.08)	2.0 (0.08)	4.0 (0.16)	5.0 (0.20)	6.0 (0.24)	7.0 (0.28)	9.0 (0.35)	12.0 (0.47)	14.0 (0.55)	17.0 (0.67)	19.0 (0.75)
12–22 (½ –⅞)	1.0 (0.04)	2.0 (0.08)	2.0 (0.08)	2.0 (0.08)	4.0 (0.16)	5.0 (0.20)	5.0 (0.20)	7.0 (0.28)	10.0 (0.39)	12.0 (0.47)	14.0 (0.55)	17.0 (0.67)

[A] Values apply to 3 mm (⅛ in.) thickness only when the alternative checking procedure in 10.7.2 is used.

Ex. 1023 at 6.

155. Further, EN 12150-1:2015 also provides overall bow tolerances for toughened (tempered) glass. Ex. 1026 at 18, 19.

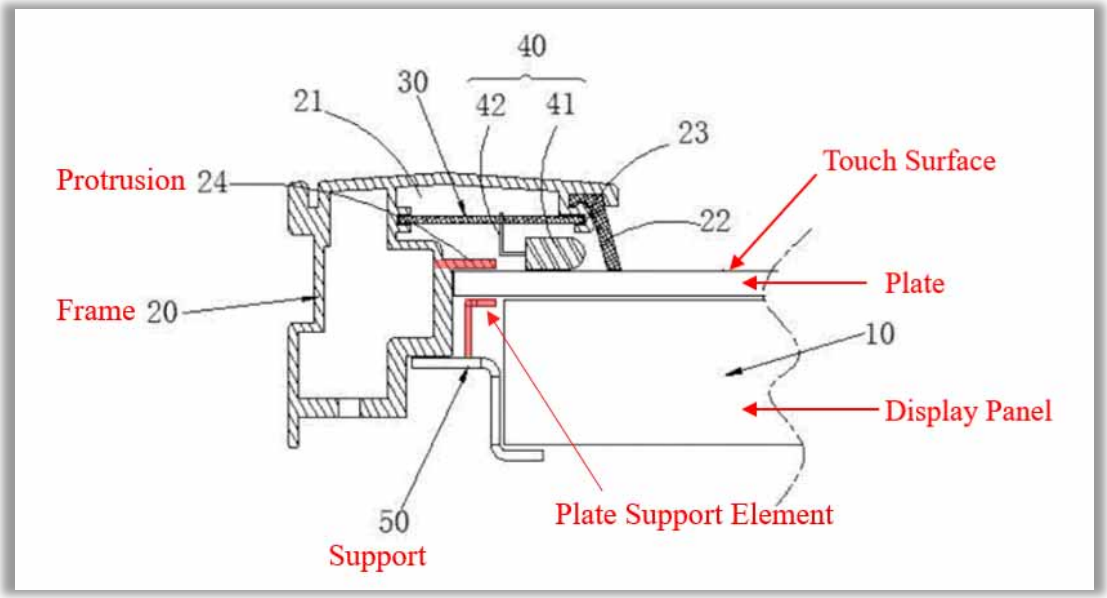
Table 6 — Maximum allowable values of overall bow and wave distortion for toughened glass manufactured by air cushion process

Glass Type	Maximum allowable value for distortion	
	Overall bow mm/m	Wave mm
Float glass in accordance with EN 572–1 and EN 572–2 and coated float glass in accordance with EN 1096-1	3,0	0,3
Others[a]	4,0	0,5
[a] For enamelled glass which is not covered over the whole surface the manufacturer should be consulted.		
NOTE For other glass types it is advised to consult the manufacturer.		

Ex. 1026 at Table 6.

156. Notabely, EN 12150-1:2015 explains that "[b]y the very nature of the toughening [tempering] process, it is not possible to obtain a product as flat as annealed glass [conventionl, non-tempered glass]." Ex. 1026 at 11.

157. Refering back to the modified Cheng device, each side of the plate is inserted onto Cheng's modified curved plate support elements of each support 50 and enclosed by curved protrusions 24.



Ex. 1004 at Fig. 1.

158. As the plate is assembled onto and between the curved plate support elements and protrusions 24, they apply a bending force to the panel. Like in Zhao, the bending force induces Cheng's modified plate to curve according to the corresponding curvature of Cheng's modified plate support elements and protrusions 24.

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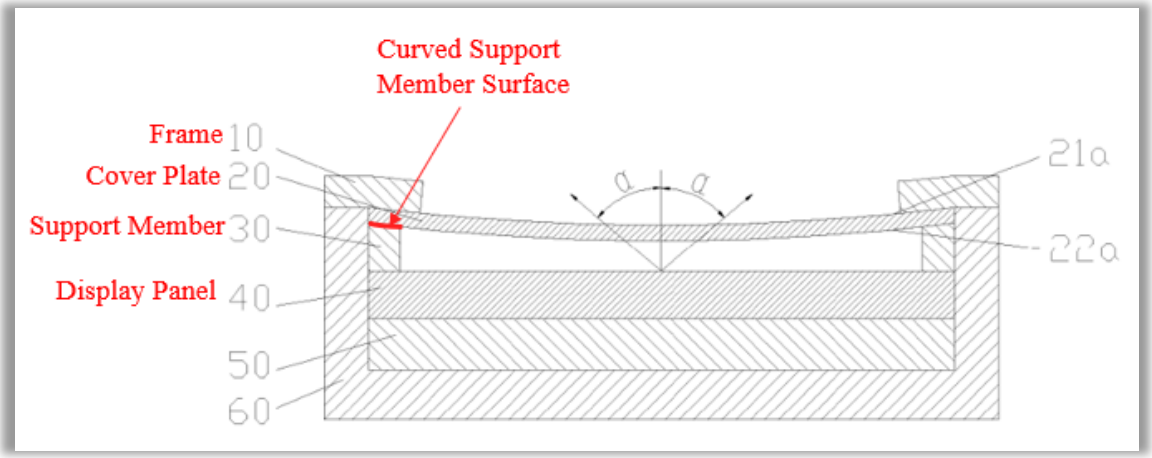

Ex. 1012 at Fig. 1.

159. The induced (second) curvature in Cheng's modified plate is greater than the first curvature based on the curvature of the modified plate support elements and protrusions 24 along both the Ax and Ay directions. As I discussed above in section VII.B, Han discloses a parabolic curvature to obtain a maximum light efficiency. Ex. 1005 at Fig. 5. I have plotted the Ax and Ay curvatures for Han's cover glass 210 with a length (Ax) dimension of 250 mm and a width (Ay) dimension of 150 mm. *See* Section VII.B. According to Han's parabolic curvature, the optimized curvature (i.e. the curvature that would be the target, post-installation curvature for the modified Cheng plate) has a curvature depth (sagitta) in the Ax direction of 1.302225 mm.

160. With reference to ASTM C1048-18 Table 2, the **maximum** bow for a tempered glass plate with an edge dimension (i.e. length or width) between 0-50 cm

(0-500 mm, which would encompass Han's cover glass length of 250 mm) is 3 mm. Ex. 1023 at 6. In other words, a POSA would have understood a typical range of bow in stock tempered glass to comprise 0 *up to* 3 mm. This range would include a bow measurement *less than* Han's disclosed optimal bow depth (sagitta) of 1.302225 mm, say for example 1 mm, as 1 mm is in the range of 0 – 3 mm.

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TABLE 2 Overall Bow, Maximum

Nominal Thickness Desig., mm (in.)	Edge Dimension, cm (in.) 0–50 (0–20)	>50–90 (>20–35)	>90–120 (>35–47)	>120–150 (>47–59)	>150–180 (>59–71)	>180–210 (>71–83)	>210–240 (>83–94)	>240–270 (>94–106)	>270–300 (>106–118)	>300–330 (>118–130)	>330–370 (>130–146)	>370–400 (>146–158)
	Maximum Bow, mm (in.)											
3 (⅛)	3.0 (0.12)	4.0 (0.16)	5.0 (0.20)	7.0 (0.28)	9.0 (0.35)	12.0 (0.47)	14.0 (0.55)	17.0 (0.67)	19.0 (0.75)	...	...	...
3 (⅛) Alternate Method[A]	2.0 (0.08)	2.0 (0.08)	2.0 (0.08)	3.0 (0.12)	5.0 (0.20)	6.0 (0.24)	7.0 (0.28)	8.0 (0.31)	10.0 (0.39)	...	...	...
4 (5/32)	3.0 (0.12)	4.0 (0.16)	5.0 (0.20)	7.0 (0.28)	9.0 (0.35)	12.0 (0.47)	14.0 (0.55)	17.0 (0.67)	19.0 (0.75)	...	...	...
5 (3/16)	3.0 (0.12)	4.0 (0.16)	5.0 (0.20)	7.0 (0.28)	9.0 (0.35)	12.0 (0.47)	14.0 (0.55)	17.0 (0.67)	19.0 (0.75)	...	...	...
6 (¼)	2.0 (0.08)	3.0 (0.12)	4.0 (0.16)	5.0 (0.20)	7.0 (0.28)	9.0 (0.35)	12.0 (0.47)	14.0 (0.55)	17.0 (0.67)	19.0 (0.75)	21.0 (0.83)	24.0 (0.94)
8 (5/16)	2.0 (0.08)	2.0 (0.08)	3.0 (0.12)	4.0 (0.16)	5.0 (0.20)	6.0 (0.24)	8.0 (0.31)	10.0 (0.39)	13.0 (0.51)	15.0 (0.59)	18.0 (0.71)	20.0 (0.79)
10 (⅜)	2.0 (0.08)	2.0 (0.08)	2.0 (0.08)	4.0 (0.16)	5.0 (0.20)	6.0 (0.24)	7.0 (0.28)	9.0 (0.35)	12.0 (0.47)	14.0 (0.55)	17.0 (0.67)	19.0 (0.75)
12–22 (½ –⅞)	1.0 (0.04)	2.0 (0.08)	2.0 (0.08)	2.0 (0.08)	4.0 (0.16)	5.0 (0.20)	5.0 (0.20)	7.0 (0.28)	10.0 (0.39)	12.0 (0.47)	14.0 (0.55)	17.0 (0.67)

[A] Values apply to 3 mm (⅛ in.) thickness only when the alternative checking procedure in 10.7.2 is used.

161. To reach Han's optimal glass cover plate curvature with a sagitta depth of 1.302225 mm, a POSA would understand that an incoming plate with a curvature depth of less than 1.302225 mm (satisfying at least the 0 – 3 mm bow range per ASTM C1048-18) would need to be induced into a second, greater curvature in order to achieve Han's optimal curvature. Further, a POSA would have been motivated to selectively choose an incoming glass curvature of between 0 and less than Han's

1.30225 mm, (for example 1 mm) as this would result in a minimzed strain induced in the glass during inducement from a pre-installed first curvature to a post-installed second greater curvature. In brief, the plate's first curvature would be less than its second curvature.

162. Thus, in my opinion, Cheng in view of Han and Zhao discloses wherein the plate (Cheng's plate of touch panel 10) has a first curvature (stock material curvature of pre-installed panel) when not configured in the frame assembly (Cheng's plate support elements and protrusions 24), and wherein the plate has a second curvature (induced by Cheng's modified curved plate support elements and protrusions 24 according to Zhao) greater than the first curvature after the plate is configured in the frame assembly.

4. Claim 4: "The touch sensing apparatus of claim 3, wherein the first curvature and second curvature are defined along an edge of the plate."

163. In my opinion, Cheng in view of Han and Zhao discloses this element. In the modified Cheng device, the first and second curvatures are defined along an edge of the plate. In my view, a POSA would have understood pre-installed plate curvature (bow) to be defined along an edge of the plate. As taught by Zhao, support member 30 and frame 10 are curved along the full length of contact with Zhao's

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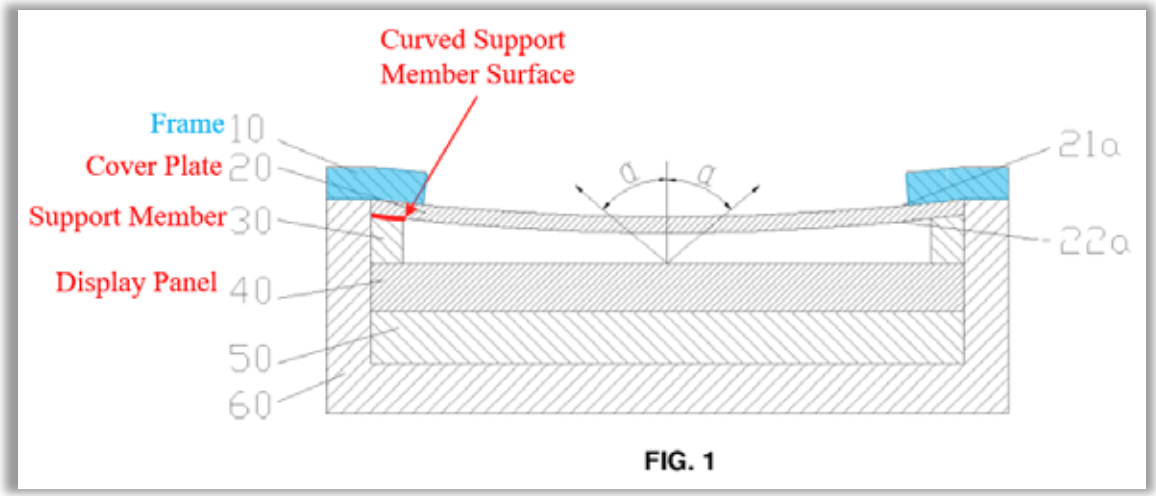
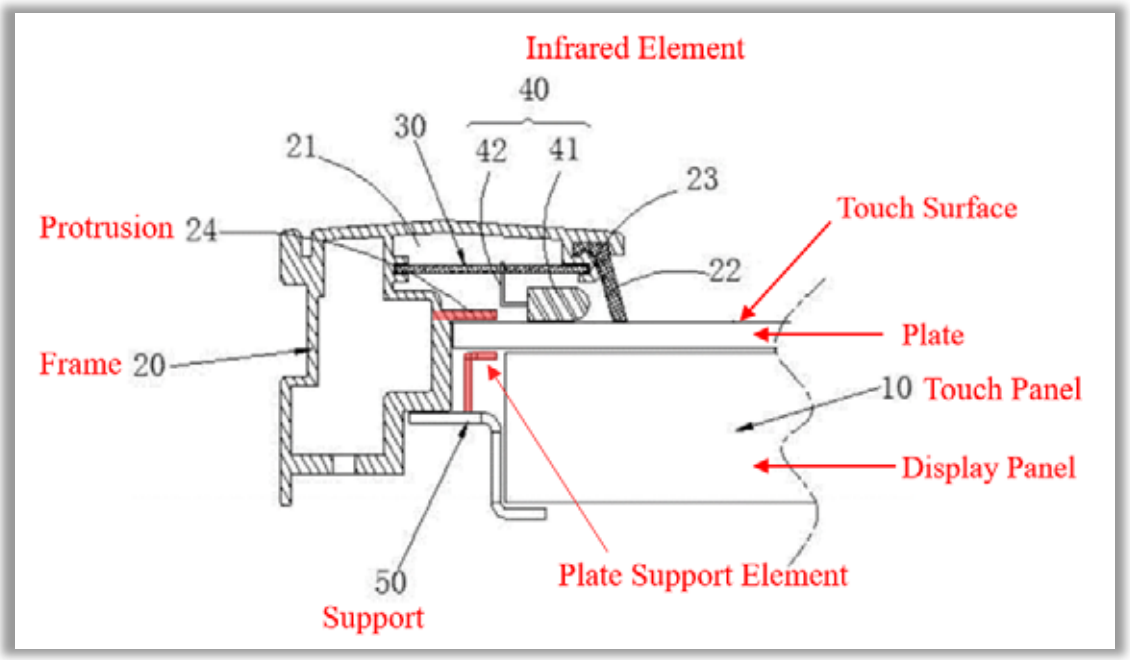
curved cover plate 20, up to and including the cover plate 20's edge. *See* Ex. 1012 at [0055], Fig. 1.



Ex. 1012 at Fig. 1.

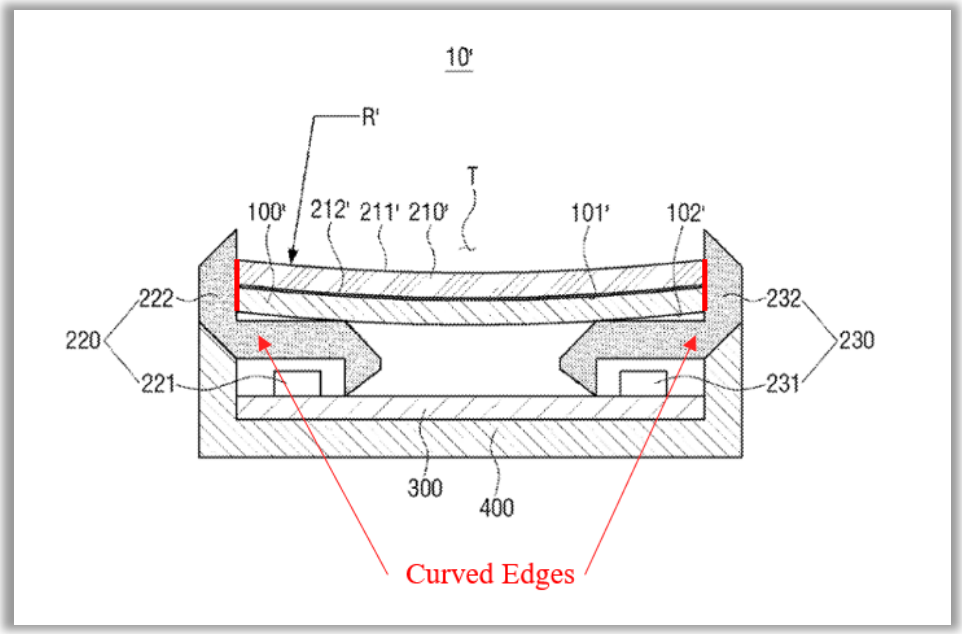
164. During installation of Zhao's cover plate 20, the curved support member 30 and frame 10 induce curvature up to the edge of cover plate 20. *Id.* Specifically, Zhao teaches that "the curvature radius of the two curved sides 12 of the frame 10 is the same as that of the first surface 21a [top of the cover plate 20], and specifically, the shape of the frame 10 mates with that of ***edges*** of the first surface where the frame is located, such that the frame 10 fits the cover plate 20 better, to prevent loosening." Ex. 1012 at [0052] (emphasis added). Zhao further teaches that "the shape of the surface of the support member 30 in contact with the cover plate 20 matches with that of the cover plate." *Id.* at [0055].

165. In the modified Cheng device according to Zhao, Cheng's curved plate support elements and protrusions 24 would also induce curvature up to the edges of the plate during installation, as each would also contact the plate up to its respective edges.



Ex. 1004 at Fig. 1.

166. Further, as I have discussed previously, Han teaches front cover class parabolic curvature along both an Ax and Ay direction. Ex. 1005 at [0077], [0085-86]. Han's glass curvature extends up to and including the edges of its front cover glass 210 to improve touch accuracy. *Id.* at Fig. 7.



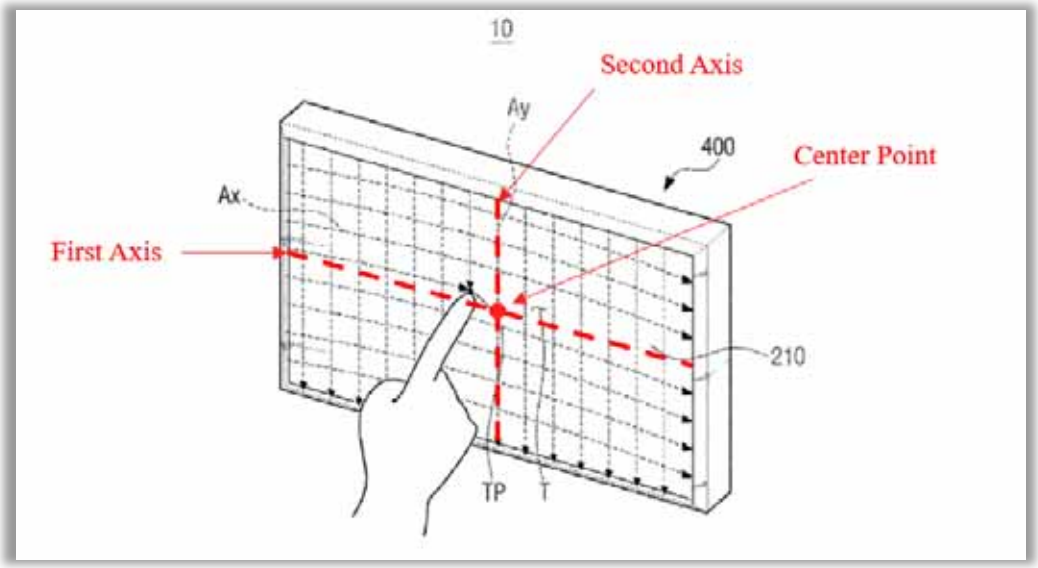
Ex. 1005 at Fig. 7.

167. In my view, a POSA would have expected to reach the same accuracy improving plate curvature of Han in the modified Cheng device by implementing Zhao's curved frame 10 and curved support member 30 teachings into the modified Cheng's protrusion 24 and plate support elements along both the horizontal (Ax) and vertical directions (Ay).

168. Thus, it is my opinion that Cheng in view of Han and Zhao discloses wherein the first curvature and second curvature are defined along an edge of the plate (Modified Cheng's curved plate up to its edges along both Ax and Ay directions).

5. Claim 5: "The touch sensing apparatus of claim 3, wherein the first curvature and second curvature are measured along an axis passing through a center point of the plate."

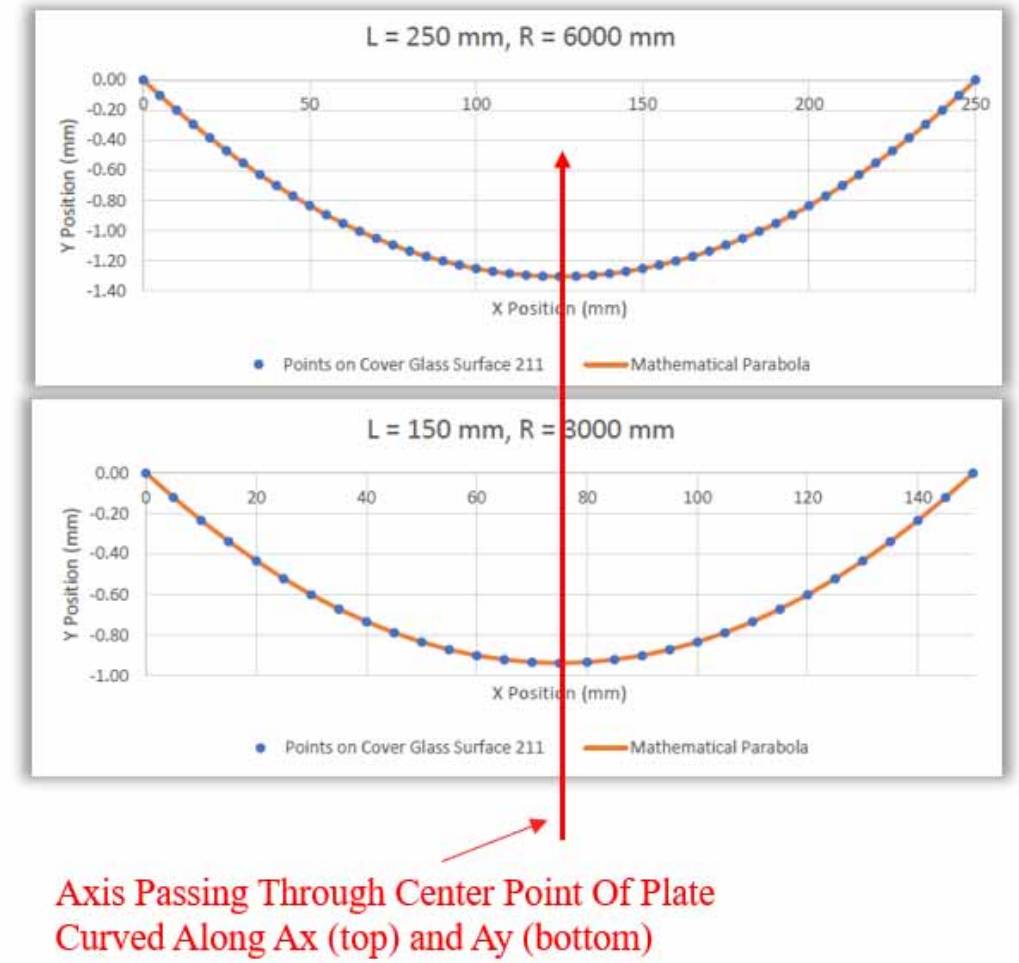
169. In my opinion, Cheng in view of Han and Zhao discloses this element. As I discussed above, Han teaches a parabolically curved plate (cover glass 210), with curvature relative to both a first (Ax) and second (Ay) axis. Ex. 1005 at [0085-87].

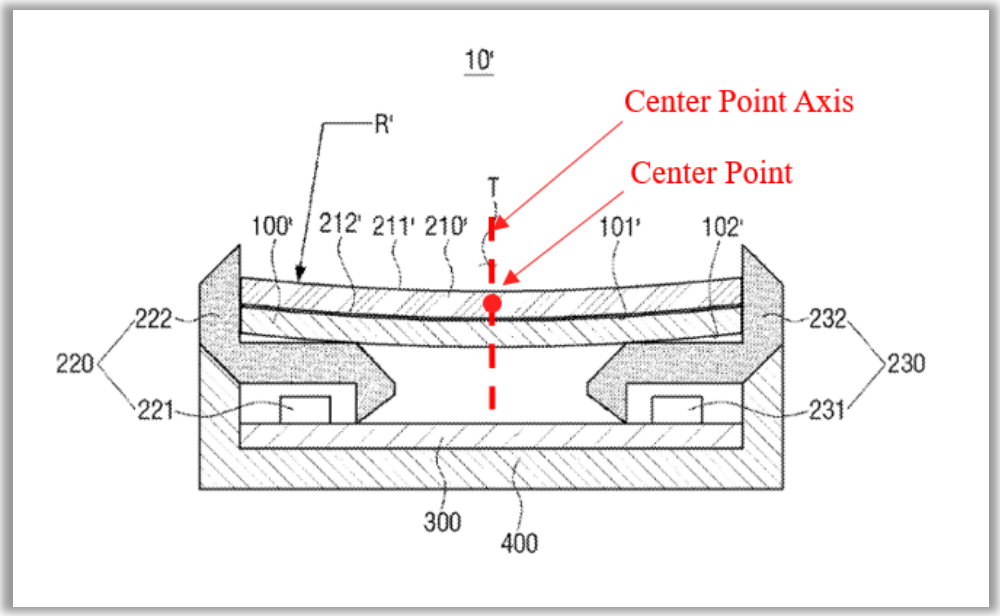


Ex. 1005 at Fig. 9.

170. Han further teaches a parabolic curvature as measured along an axis passing through a center point of the plate (cover glass 210).

See Ex. 1005 at Figs. 7, 9. For example, I have superimposed a "central axis" on plots depicting Han's parabolically curved cover glass 210, below.





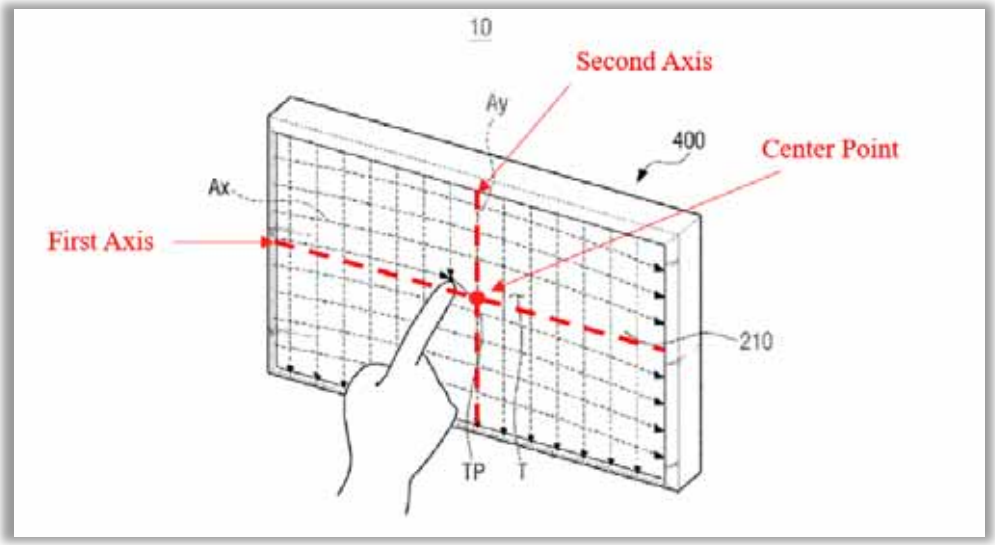
Ex. 1005 at Fig. 7.

171. In order to achieve Han's improved touch detection, it is my opinion that a POSA would have been motivated to modify Cheng's plate to have the same parabolic curvature as Han's, also as measured along an axis passing through a center point of modified Cheng's plate.

172. Thus, in my opinion, Cheng in view of Han discloses wherein the first curvature and second curvature are measured along an axis (axis passing through center point of modified Cheng's plate) passing through a center point of the plate (center point of modified Cheng's plate).

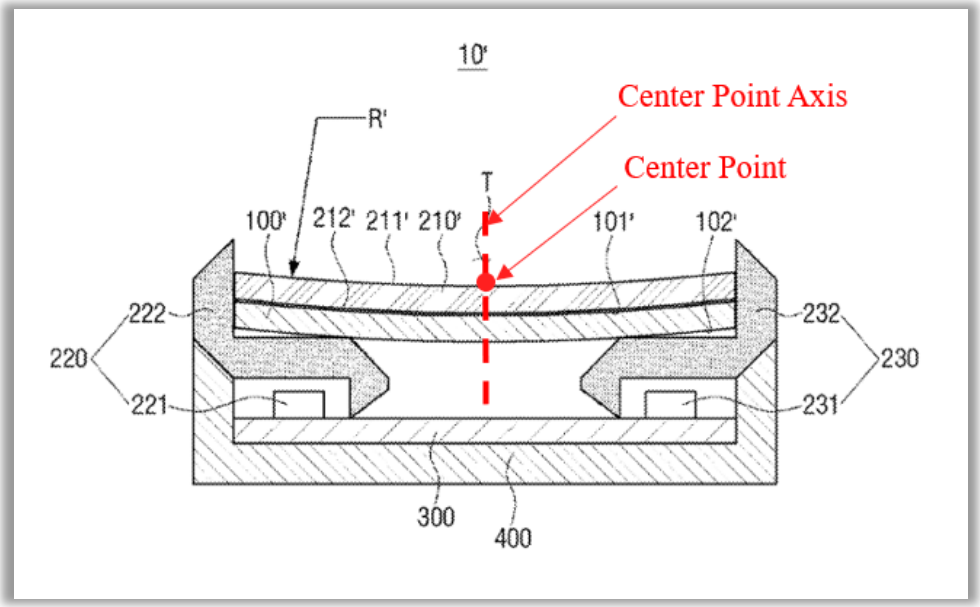
6. Claim 6: "The touch sensing apparatus of claim 3, wherein the first curvature and second curvature are measured along a line passing through a point on the touch surface."

173. In my opinion, Cheng in view of Han and Zhao discloses this element. Han teaches a parabolically curved plate (cover glass 210), with curvature relative to both a first (Ax) and second (Ay) axis. Ex. 1005 at [0074-77].



Ex. 1005 at Fig. 9.

174. Han further teaches a parabolic curvature as measured along an axis passing through a point on the touch surface (surface 211).



Ex. 1005 at Fig. 7.

175. In order to achieve Han's improved touch detection, it is my view that a POSA would have been motivated to modify Cheng's plate to have the same parabolic curvature as Han's, also as measured along an axis passing through a point on the surface of modified Cheng's plate.

176. Thus, in my opinion, Cheng in view of Han discloses wherein the first curvature and second curvature are measured along a line (axis passing through point on surface of modified Cheng's plate) passing through a point on the touch surface (point on surface of modified Cheng's plate).

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7. Claim 7

(a) Preamble: "A touch sensing apparatus comprising:"

177. In my opinion, Cheng and Han discloses this element. Both Cheng and Han disclose a touch sensing apparatus. Ex. 1004 at [0001]; Ex. 1005 at Abstract.

178. Thus, in my opinion, Cheng and Han disclose a touch sensing apparatus (apparatuses of Cheng, Han).

(b) "a display panel;"

179. In my opinion, Cheng, Han, and Zhao disclose this element. Each of Cheng, Han, and Zhao disclose a display panel. Ex. 1004 at [0013], Fig. 1; Ex. 1005 at Abstract; Ex. 1012 at Abstract.

180. Thus, in my opinion, Cheng, Han, and Zhao disclose a display panel (display panel of touch panel 10; display 2, display panel 40).

(c) "a plate having a width, a length and a periphery, the plate further including a touch surface;"

181. In my opinion, Cheng discloses this element. As I discussed above, Cheng discloses a touch panel 10 having a plate. Ex. 1004 at Fig. 1. A POSA would have understood Cheng's plate to include a width and a length, at least comprising a quadrilateral geometry according to Cheng's "horizontal" and "vertical" directions

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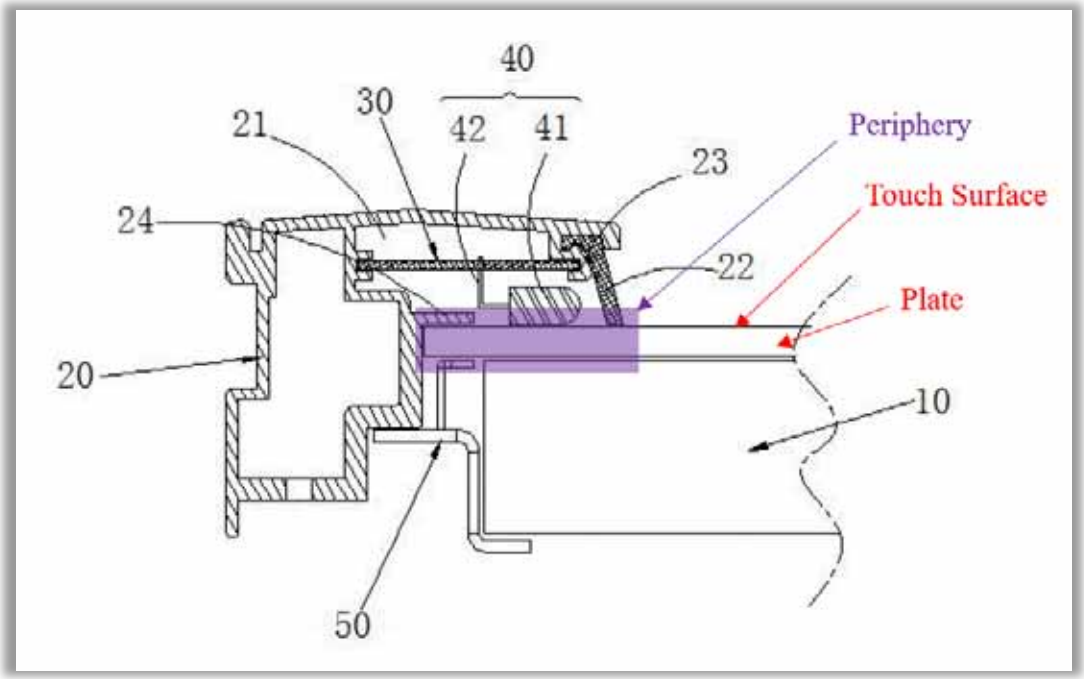
and as common in infrared touch sensing devices. Ex. 1004 at [0002]. Cheng's plate further includes a periphery and a touch surface. Ex. 1004 at Fig. 1.



Ex. 1004 at Fig. 1.

182. Thus, in my opinion, Cheng discloses a plate (plate) having a width (width of plate), a length (length of plate) and a periphery (periphery of plate), the plate further including a touch surface (touch surface of plate).

(d) "one or more emitters arranged adjacent to the periphery of the plate and configured to emit light across the touch surface of the plate;"

183. In my opinion, Cheng discloses this element. Cheng discloses "infrared receivers and **transmitters** [emitters] distributed densely around a display region

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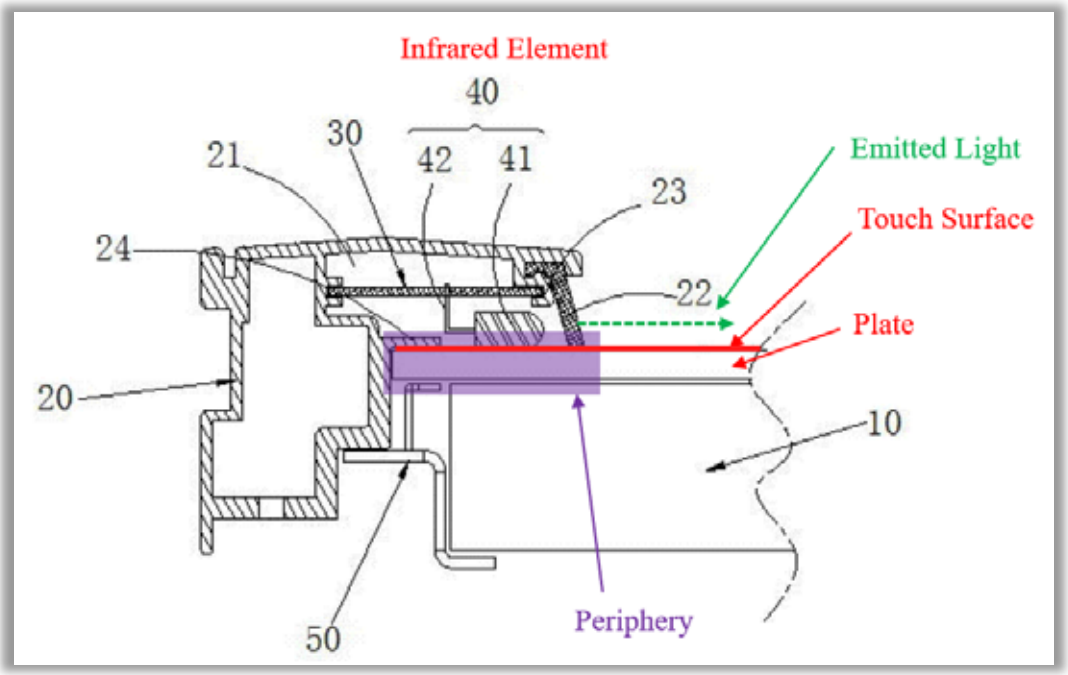
form[ing] a scanning network in horizontal and vertical directions. Ex. 1004 at [0002] (emphasis added). As seen in Cheng's Fig. 1 below, Cheng's emitters, including lamp tube 41 of infrared element 40, are arranged adjacent to the periphery of the plate and are configured to emit light across the touch surface of the plate. *Id.* at [0018], Fig. 1.



Ex. 1004 at Fig. 1.

184. Thus, in my opinion, Cheng discloses one or more emitters (lamp tube 41 of infrared element 40) arranged adjacent to the periphery of the plate (plate) and configured to emit light across the touch surface (touch surface of plate) of the plate.

(e) "a set of detectors arranged adjacent to the periphery of the plate and configured to receive light from the set of emitters, and"

185. In my opinion, Cheng in view of Han discloses this element. Cheng discloses "infrared **receivers** and transmitters distributed densely around a display region form[ing] a scanning network in horizontal and vertical directions." Ex. 1004 at [0002] (emphasis added). The '935 Patent confirms it is well known in the prior art to arrange a plurality of emitters and detectors around the periphery of the plate in order to enable touch-sensing functionality. *See, e.g.,* Ex. 1001 at 1:26-46, 15:62-16:3. As I discussed above for Claim 1, while Cheng identifies a lamp tube 41 in the infrared element 41, a POSA would have understood Cheng's infrared element to also disclose an infrared receiver (detector) in place of lamp tube 41 to detect emitted light and enable touch sensing functionality.

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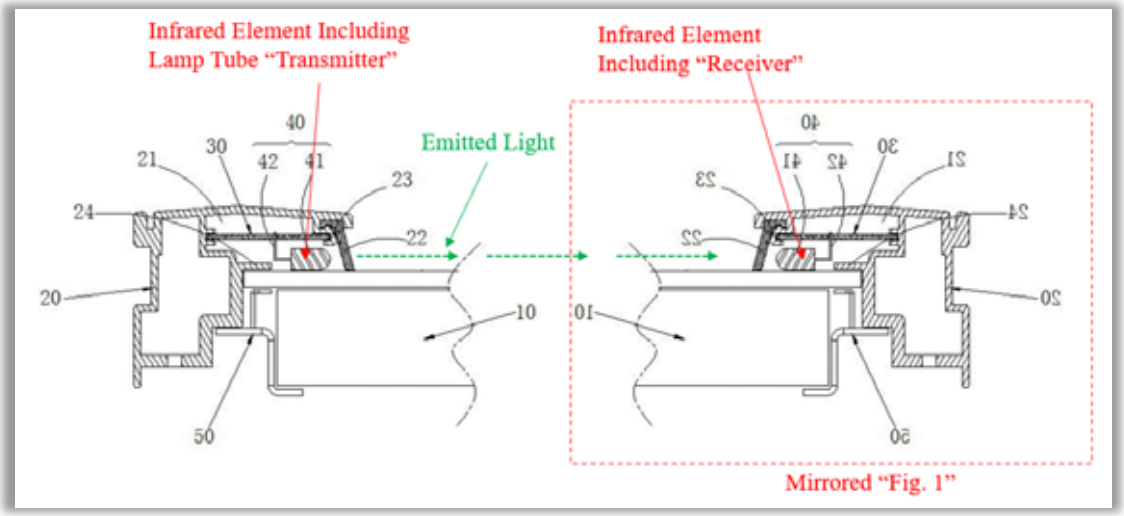
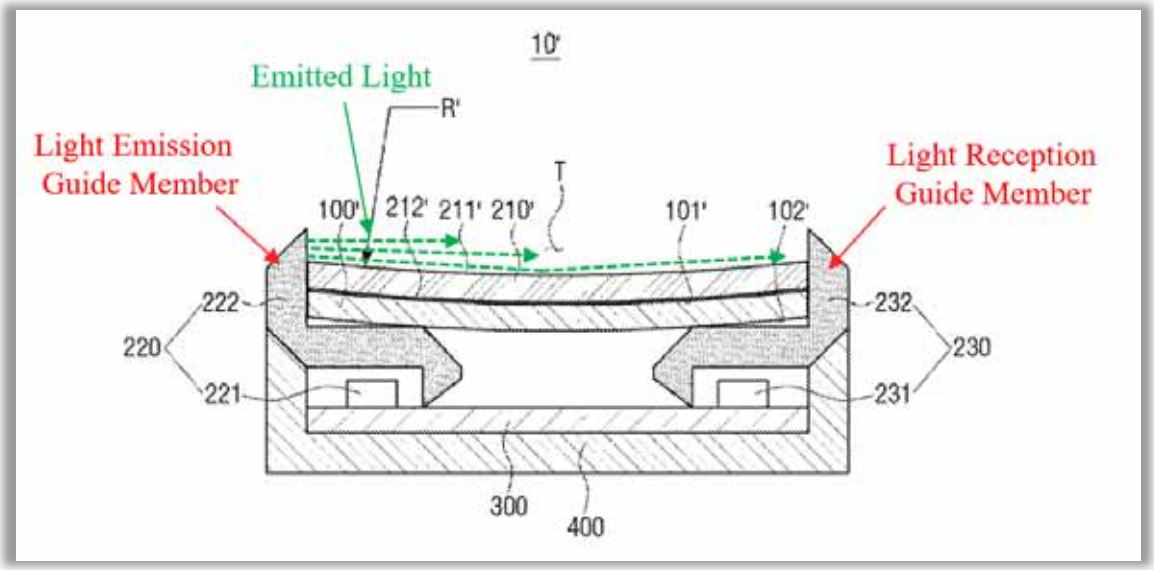


Ex. 1004 at Fig. 1.

186. Further, Han teaches that light "irradiated from the light emitting surface 2221 of the light emission guide member 222 [] passes through the touch area T to the incident surface 2321 of the light reception guide member 232. Ex. 1005, [0087].



Ex. 1005 at Fig. 7.

187. Similar to Claim 1 above, in modifying Cheng to achieve Han's improved touch detection accuracy plate curvature, a POSA would have continued to implement detectors adjacent to the periphery of the (curved) plate and configured to receive light from the set of emitters.

188. Thus, in my opinion, Cheng in view of Han discloses a set of detectors (Cheng's detector of infrared element 40, Han's light reception guide member 232) arranged adjacent to the periphery of the plate (Cheng's plate, Han's cover glass 210') and configured to receive light from the set of emitters (Cheng's emitter of infrared touch module 400, Han's light emission guide member 222).

(f) "a frame assembly, the frame assembly comprising: a first frame element configured to support the display panel; and"

189. In my opinion, Cheng discloses this element. Cheng discloses a frame 20 with protrusion 24 and a support 50. Ex. 1004 at [0007-8]. "[T]he support and the protrusion together clamp the touch panel." *Id.* at [0008]. Similar to Claim 1, a POSA would have understood the frame 20 with protrusion 24 and the support 50 to comprise a frame assembly. As depicted in Fig. 1 of Cheng, the support 50 supports the display panel of the touch panel 10. *Id.* at Fig. 1.

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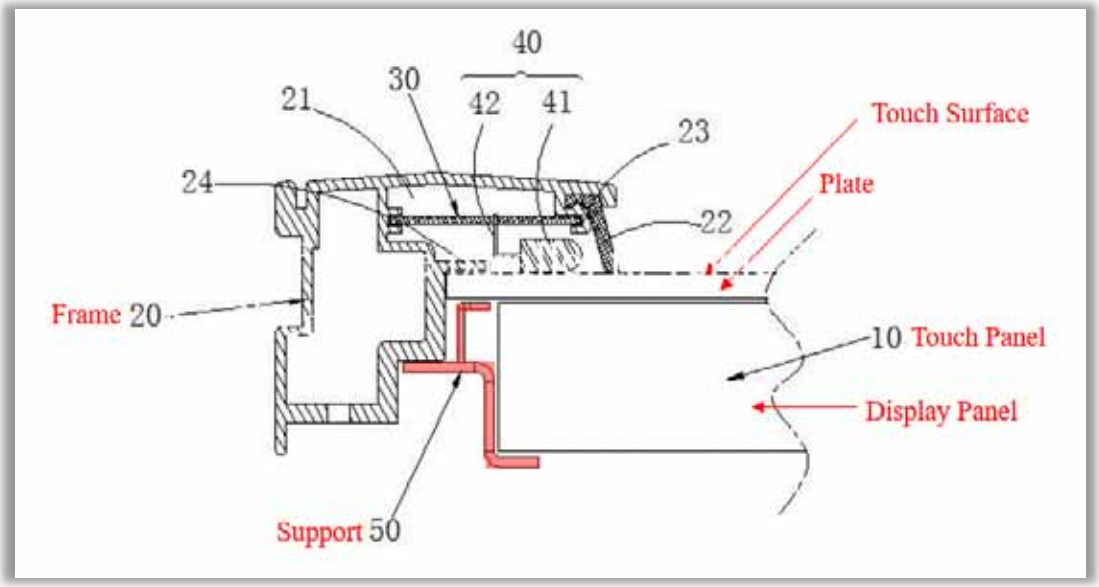


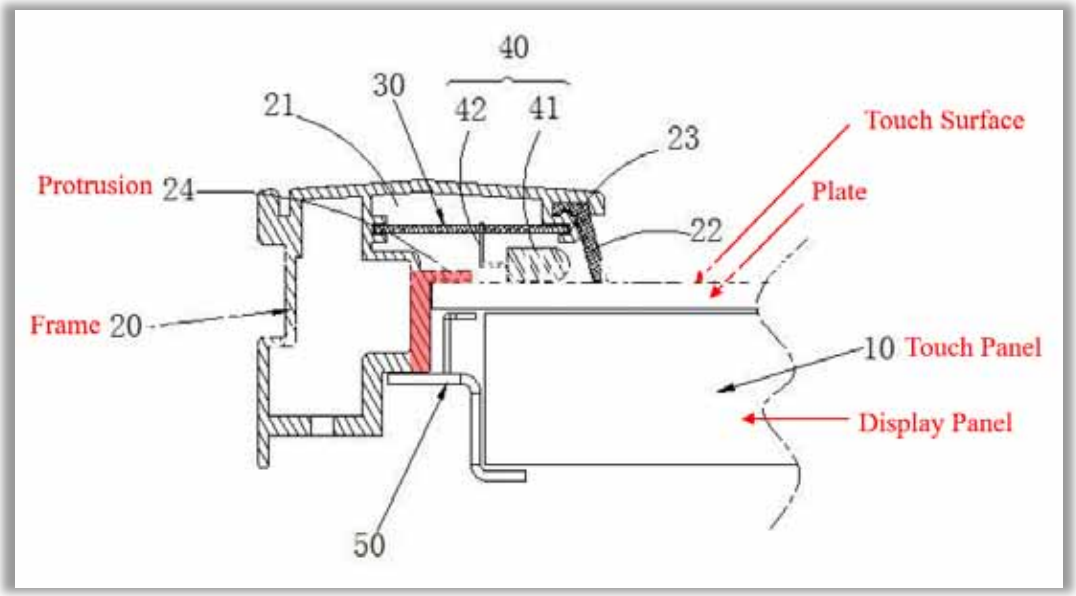
Ex. 1004 at Fig. 1.

190. Thus, it is my opinion that Cheng discloses a frame assembly (frame 20, support 50), the frame assembly comprising: a first frame element (support 50) configured to support the display panel (display panel of touch panel 10).

(g) "a second frame element arranged around at least a portion of the periphery of the plate, the second frame element having a first portion extending along an edge of the plate and a second portion opposed to the touch surface;"

191. In my opinion, Cheng discloses this element. Cheng's frame 20 is arranged around a portion of the periphery of the plate and extends along an edge of the plate. Ex. 1004 at Fig. 1. The frame 20 further includes a protrusion 24 that "is placed on an upper surface [touch surface] of the touch panel." *Id.* at [0007].

Depicted in Fig. 1 below, Cheng's protrusion 24 is placed on the touch surface of the plate. *Id.* at Fig. 1. From my understanding of Patent Owner's construction of "opposed" depicted in the co-pending litigation, Cheng's protrusion 24 is opposed to the touch surface of the plate. *See* Ex. 1019 at 203.

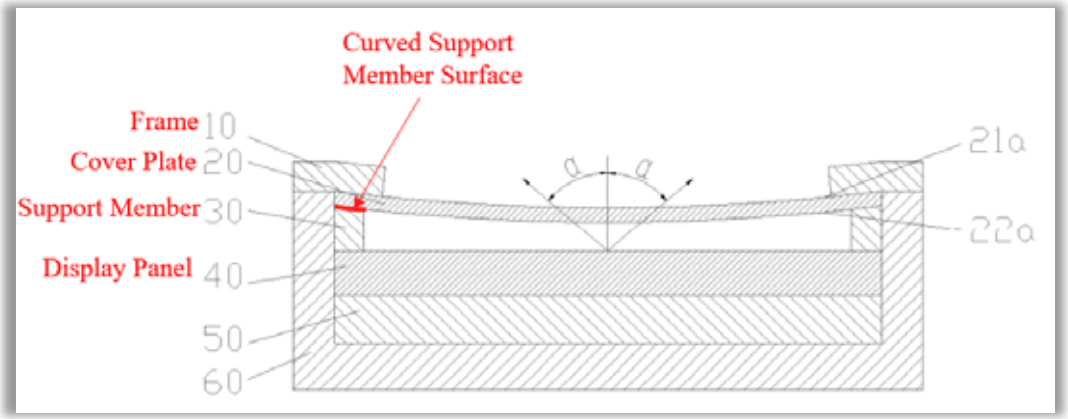


Ex. 1004 at Fig. 1.

192. Thus, in my opinion, Cheng discloses a second frame element (frame 20) arranged around at least a portion of the periphery of the plate (plate of touch panel 10), the second frame element having a first portion (vertical portion of frame 20 along plate) extending along an edge of the plate and a second portion (protrusion 24) opposed to the touch surface.

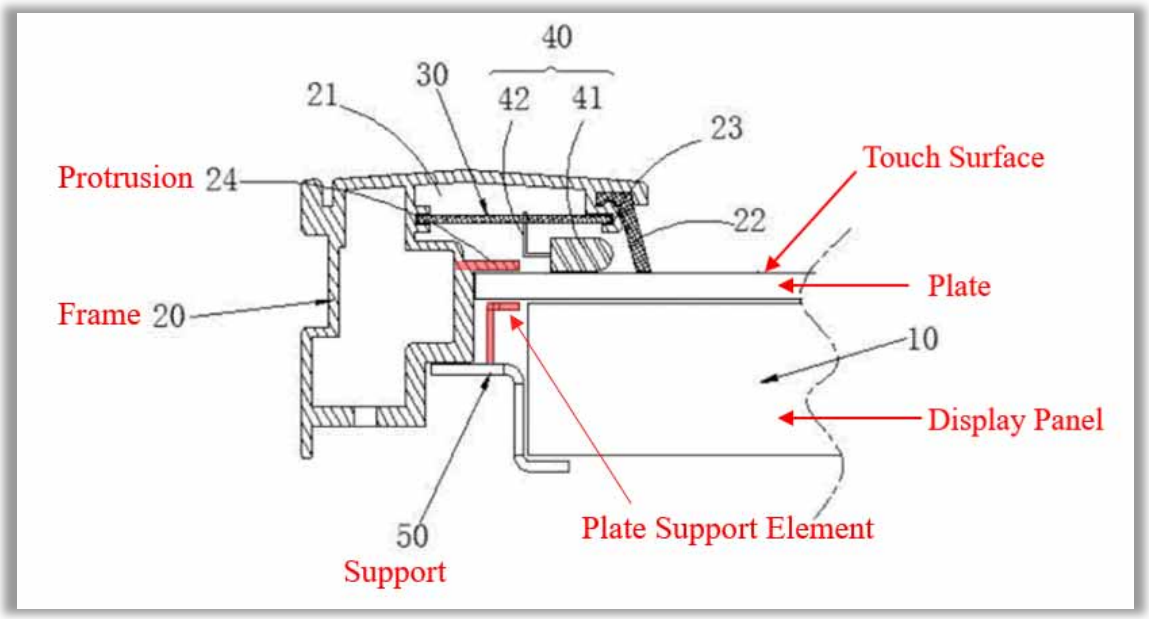
(h) "wherein the plate has a first curvature in the touch surface when not installed in the frame assembly, and wherein the plate has a second curvature along the width and along the length in the touch surface when the plate is installed in the frame assembly, said second curvature is parabolic; and"

193. In my opinion, Cheng in view of Han and Zhao discloses this element. As I explained above in an embodiment of the modified Cheng device, the pre-installed plate has an initial curvature according to the well-known material property of pre-installed stock tempered glass. *See* Ex. 1001 at 2:5-9; Ex. 1023; Ex. 1025; Ex. 1026. As the plate is assembled into Cheng's modified curved plate support elements and protrusions 24 according to Zhao's simplified configuration for inducing plate curvature, a bending force is applied to Cheng's plate. *See* Ex. 1012 at [0050].



Ex. 1012 at Fig. 1.

194. Cheng's resulting modified plate is curved into a second curvature greater than the first curvature based on the slope of the plate support elements along both the Ax and Ay directions (according to Han).



Ex. 1004 at Fig. 1.

195. According to Han's touch detection accuracy improving plate curvature, the induced second curvature of Cheng's modified plate would be parabolic and would comprise a first axis component along the length of the plate (Ax) and a second axis component along the width plate (Ay).

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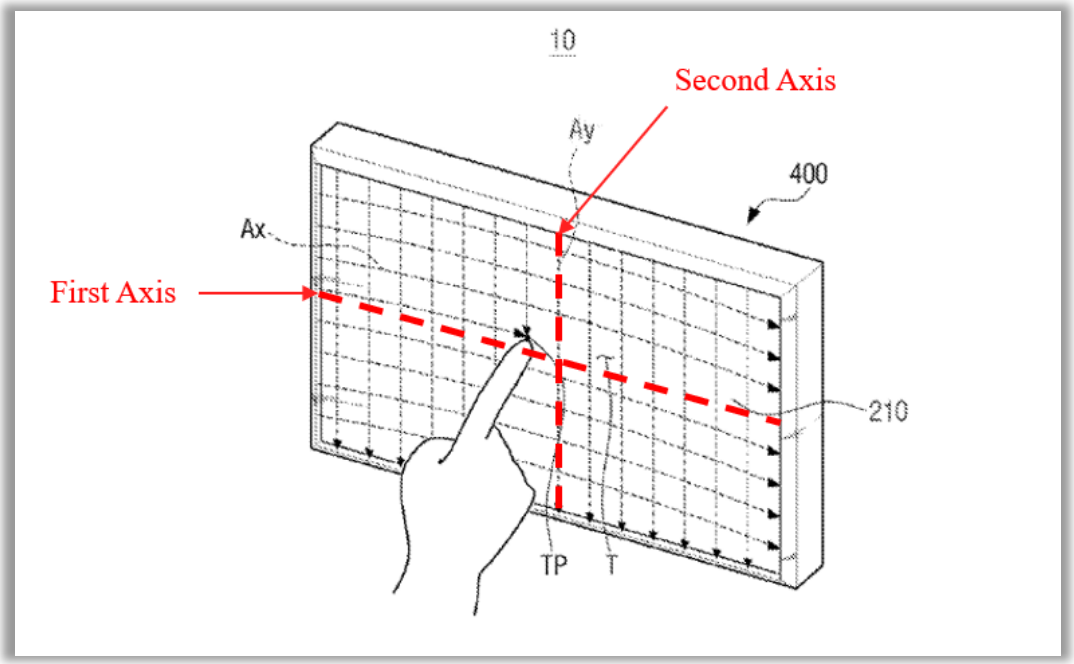

Ex. 1005 at Fig. 2.

196. Thus, in my opinion, Cheng in view of Han and Zhao discloses wherein the plate has a first curvature (stock material curvature of Cheng's pre-installed plate) in the touch surface when not installed in the frame assembly, and wherein the plate has a second curvature (induced post-assembly curvature of Cheng's modified plate) along the width and along the length in the touch surface when the plate is installed in the frame assembly, said second curvature is parabolic (post-installed parabolic curvature of Cheng's modified plate according to Han).

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(i) "wherein the first curvature is concave."

197. In my opinion, Cheng in view of Han and Zhao discloses this element. A POSA would have understood the pre-installed plate to have an initial curvature according to the well-known material property of pre-installed stock tempered glass. *See* Exs. 1023, 1025, 1026. *See also*, Ex. 1001 at 2:5-9. In my view, a POSA would have further understood this pre-installed curvature to be categorized as "bow" or "warpage" in which the edges and/or corners of the stock glass curve away from a center point of the glass, equating to a concave (or convex depending on observation orientation) curvature. *See* Ex. 1023; Ex. 1025; Ex. 1026. Where the edges and/or corners of pre-installed glass curve upwards and away from a center point relative to a staged Cheng's frame 20, a POSA would have understood the first curvature of the plate to be concave.

198. Thus, in my opinion, Cheng discloses wherein the first curvature is concave (pre-installed plate having a natural concave bow).

8. Claim 8: "The touch sensing apparatus of claim 7, further comprising a processing element configured to determine, based on output signals of the set of detectors, a position of an object proximate to the touch surface."

199. In my opinion, Cheng in view of Han discloses this element. Cheng discloses a circuit board 30 in connection with infrared element 40. Ex. 1004 at

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[0013]. Han further discloses a controller integrated circuit ("IC") that "performs the role of identifying the location where a signal was generated according to occurrence of contact or change of electrical capacity, and transmitting the information on the location to a controller IC" Ex. 1005 at [0012]. The IC "modif[ies] an analog signal transmitted from a touch detecting unit into a digital signal and chang[es] the signal to a form of a coordinate which can be displayed on the screen…" *Id.* at [0013]. Further, in my opinion, a POSA would have understood Han's IC to embody a typical element performing typical functions to enable touch sensing functionality in infrared touch devices, including the infrared touch device of Cheng.

200. In my opinion, a POSA would have understood Cheng to include a processing element—embodied in Cheng's circuit board 30 or otherwise—for determining a touch location relative to the touch surface of plate based on output signals of the infrared element 40 (having detectors) as this would embody a typical configuration to enable optical touch sensing functionality. Han's teaching of the same confirms as much. Ex. 1005 at [0012-13].

201. Thus, in my opinion, Cheng in view of Han discloses a processing element (Cheng's circuit board 30; Han's integrated circuit IC) configured to determine, based on output signals of the set of detectors (Cheng's infrared element

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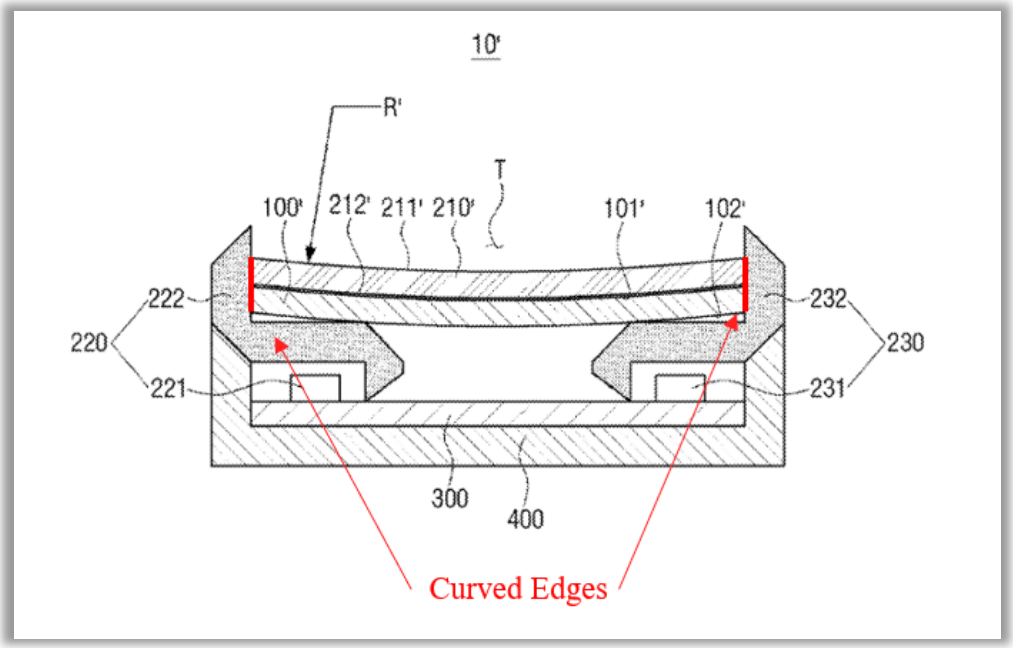
40 with detector; Han's photo diodes 231 and light reception guide members 231), a position of an object (a touch at Cheng's or Han's respective touch surfaces) proximate to the touch surface (surface of Cheng's plate; Han's front surface 211).

9. Claim 9: "The touch sensing apparatus of claim 7, wherein the first curvature and second curvature are measured along an edge of the plate."

202. In my opinion, Cheng in view of Han and Zhao discloses this element.



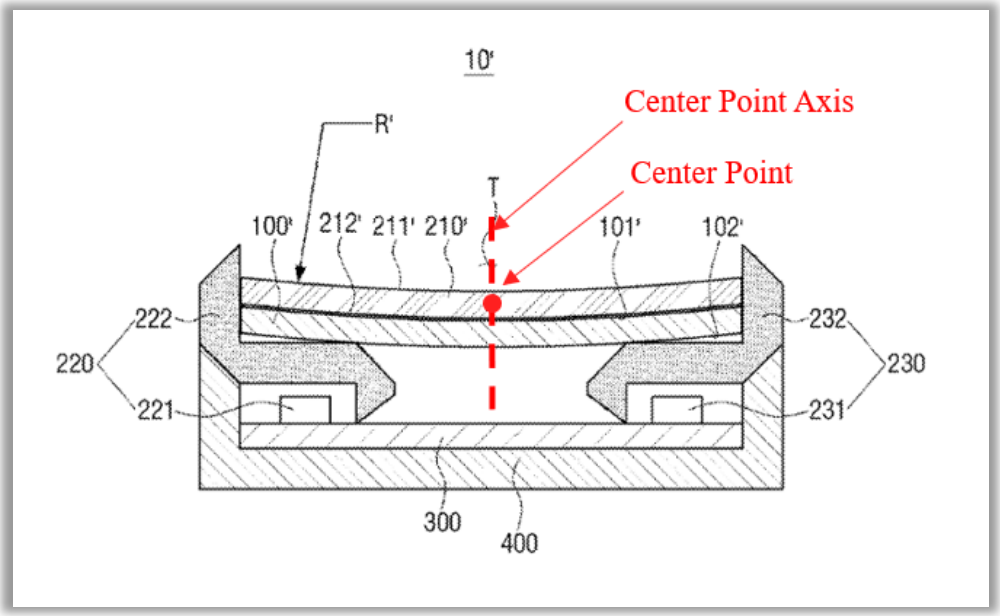
Ex. 1005 at Fig. 7.

203. For at least the same reasons and rationale I have laid out above for Claim 4, it is my opinion that Cheng in view of Han and Zhao discloses the first curvature and second curvature are measured along an edge (edges of Cheng's

modified plate curved along Ax and Ay directions according to Han) of the plate (Cheng's plate of touch panel 10).

10. Claim 10: "The touch sensing apparatus of claim 7, wherein the first curvature and second curvature are measured along an axis passing through a center point of the plate."

204. In my opinion, Cheng in view of Han discloses this element.



Ex. 1005 at Fig. 7.

205. For at least the same reasons and rationale I have laid out in Claim 5 above, it is my opinion that Cheng in view of Han discloses the first curvature and second curvature are measured along an axis (center point axis passing through

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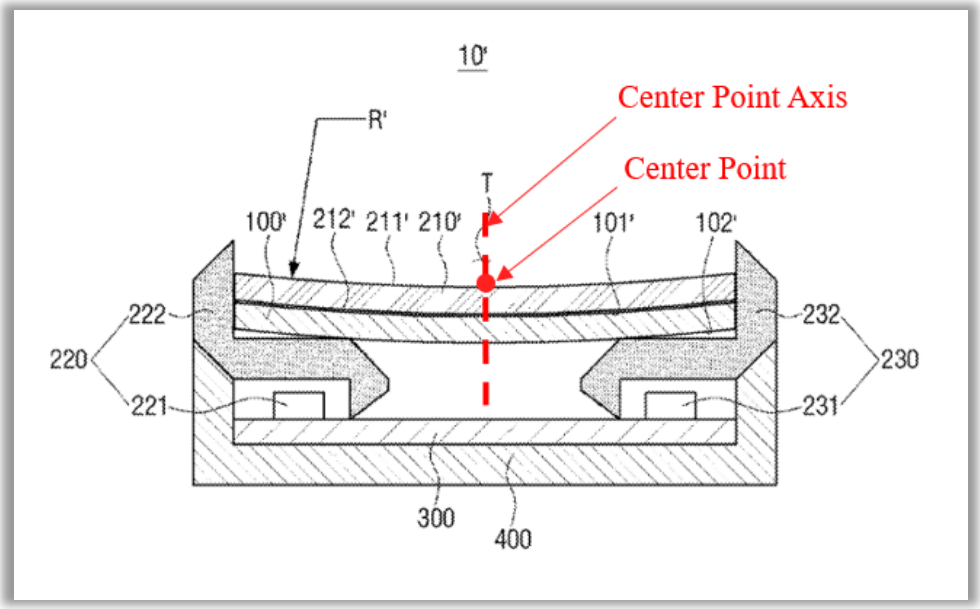
Cheng's modified plate) passing through a center point (center point of Cheng's modified plate) of the plate.

11. Claim 11: "The touch sensing apparatus of claim 7, wherein the first curvature and second curvature are measured along a line passing through a point on the touch surface."

206. In my opinion, Cheng in view of Han and Zhao discloses this element.



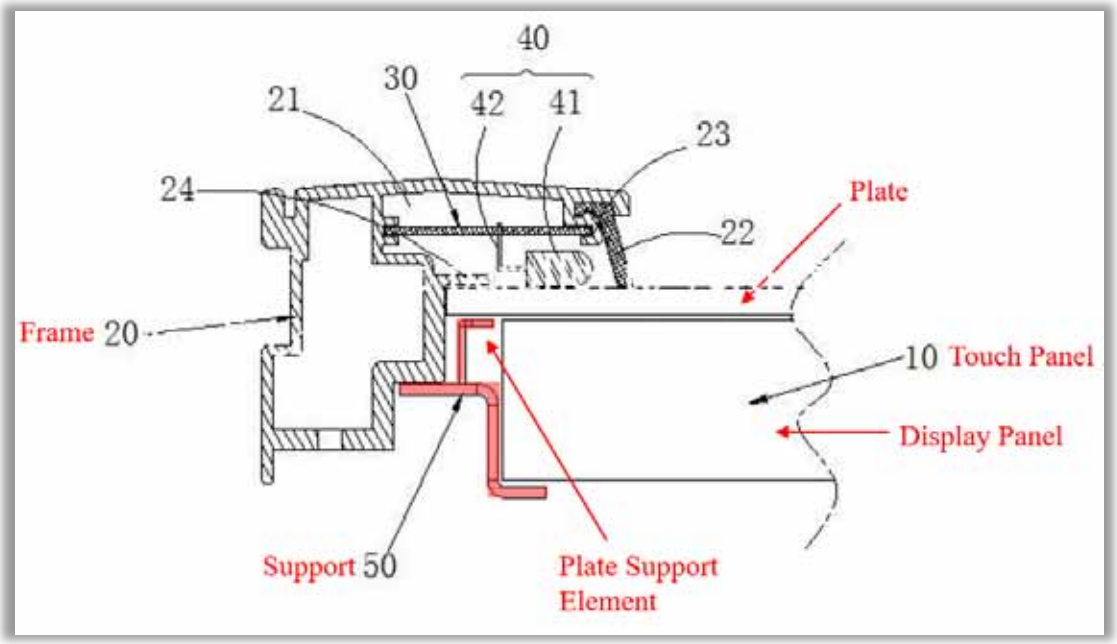
Ex. 1005 at Fig. 7.

207. For at least the same reasons and rationale I have laid out in Claim 6 above, it is my opinion that Cheng in view of Han discloses the first curvature and second curvature (Cheng's modified pre-installed curvature and curved plate in Ax and Ay direction) are measured along a line passing through a point (axis passing

through center point of Cheng's modified plate) on the touch surface (surface of Cheng's modified plate).

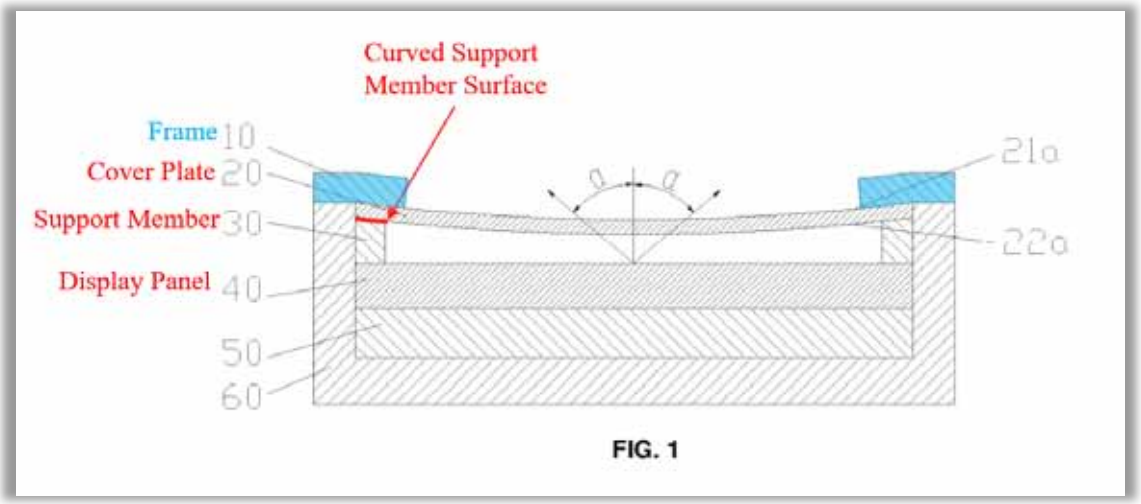
12. Claim 12: "The touch sensing apparatus of claim 7, further comprising a gasket, wherein the plate is supported by the gasket proximate to an edge of the plate."

208. It is my opinion that Cheng in view of Zhao discloses this element. As I discussed above, Cheng's support 50 includes a plate support element. Ex. 1004 at Fig. 1. As depicted in Cheng's Fig. 1 below, the plate support element supports the plate proximate to an edge of the plate.



Ex. 1004 at Fig. 1.

209. In the modified Cheng device according to Zhao, the surface of Cheng's modified plate support element in contact with the plate is curved, like in Zhao, to induce curvature into the plate with a simplified process by applying a bending force near the edge of the plate during installation.



Ex. 1012 at Fig. 1.

210. In my opinion, a POSA would have understood Zhao's support member 30 to have the same function as a "gasket" as described in the '935 Patent. For example, the '935 Patent explains "[t]he gasket 205 may have a varying thickness along its length, i.e. also along the length of the first frame element 202. This provides for **obtaining a desired curved shape of the perimeter of the plate** 2 when captured between the first frame element 202 and the second frame element 203." Ex. 1001 at 11:44-55 (emphasis added). Similarly, Zhao teaches the "the shape of the surface of the support member 30 [gasket] in contact with cover plate

[plate] matches with that of the cover plate" and the cover plate "is forced to bend by squeezing the cover plate 20 in the installation process." Ex. 1012 at [0050-55].

211. In my view, a POSA would have expected to achieve Zhao's curvature-inducing gasket function by modifying Cheng's plate support element according to Zhao's curved support member 30. Cheng's modified plate support element, like Zhao, would support the plate proximate to an edge of the plate.

212. Thus, it is my opinion that Cheng in view of Zhao discloses a gasket (Cheng's modified curved plate support member), wherein the plate is supported by the gasket proximate to an edge of the plate (Cheng's modified curved plate support element supporting plate proximate to the plate's edge).

13. Claim 13: "The apparatus of claim 12, wherein the gasket is configured to have varying thickness to match a curvature of the plate along the edge."

213. In my opinion, Cheng in view of Zhao discloses this element. As depicted in Zhao's Fig. 1 below, Zhao's support member 30 has a varying thickness that matches the curvature of the plate along its edge. Ex. 1012 at [0055], Fig. 1.

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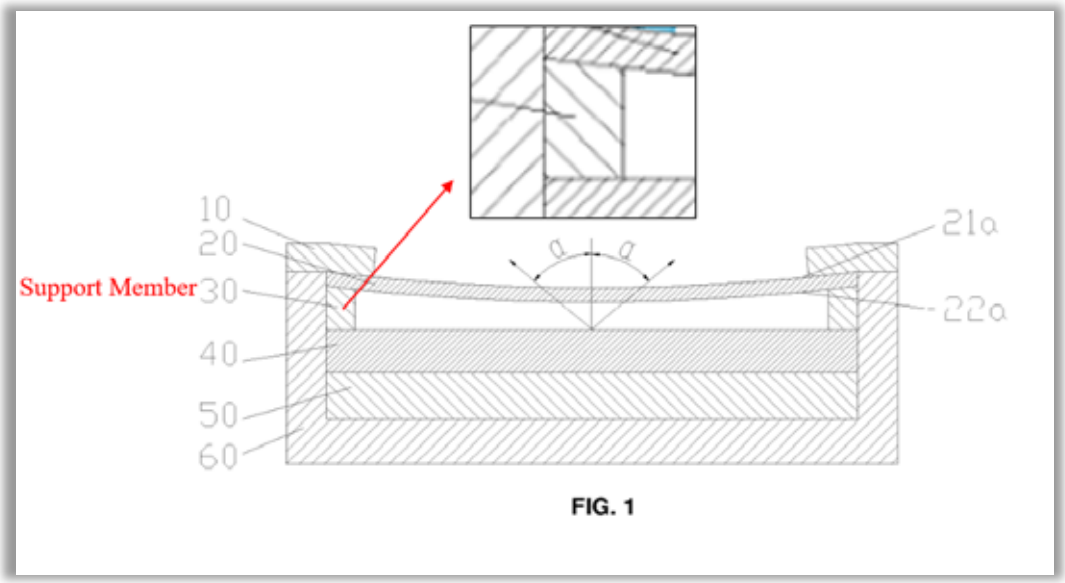

Ex. 1012 at Fig. 1, portion enlarged.

214. As Zhao states, "the shape of the surface of the support member 30 in contact with the cover plate 20 matches with that of the cover plate." *Id.* at [0055]. In other words and a seen in Zhao's Fig. 1, the thickness of the support member 30 closest to the edge of the curved cover plate 20 is greater than the thickness closest to the center of the curved cover plate 20. *See id.*, at Fig. 1. The varying thickness of Zhao's the support member 30 induces curvature in the cover plate in a simplified process during installation. *See id.*, at [0050].

215. By modifying Cheng's plate support element to have Zhao's support member 30's thickness variation in relation to the curvature of the plate, it is my view that a POSA would have expected to achieve the Zhao's simplified curvature inducing functionality in Cheng's modified plate support member.

216. Thus, it is my opinion that Cheng in view of Zhao discloses wherein the gasket is configured to have varying thickness (plate support element thicker closer to plate edge) to match a curvature (curvature of the plate) of the plate along the edge.

14. Claim 14: "The apparatus of claim 7, wherein the second frame element is curved."

217. In my opinion, Cheng in view of Zhao discloses this element. As I have discussed above, the frame 10 of Zhao is curved according to the curvature of the cover plate 20. Ex. 1012 at [0052]. A POSA would have understood Zhao's frame curvature to both "prevent structure loosening" and aid in inducing curvature in the cover plate 20 when the cover plate 20 is "squeezed" during Zhao's simplified installation process.. *See id.* at [0050-52].

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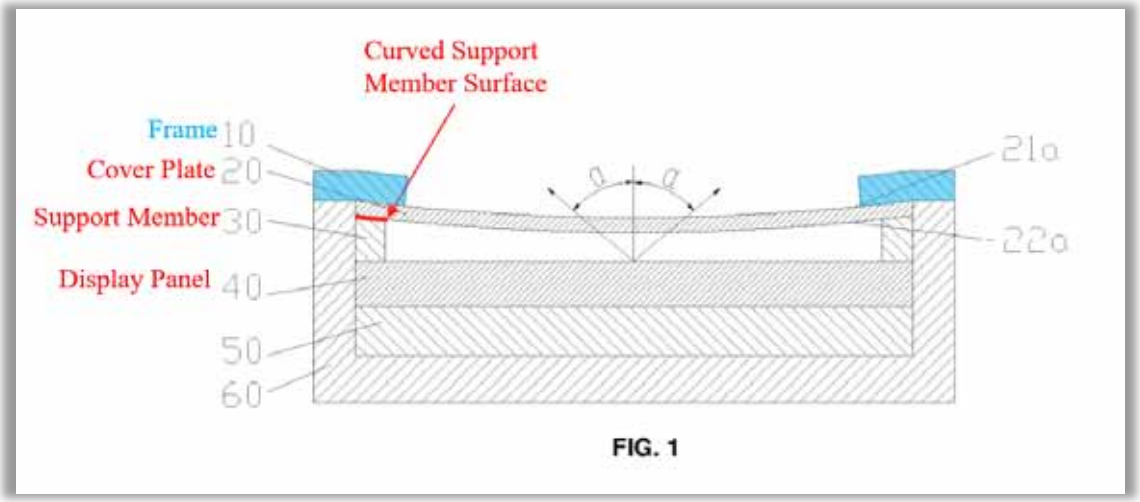
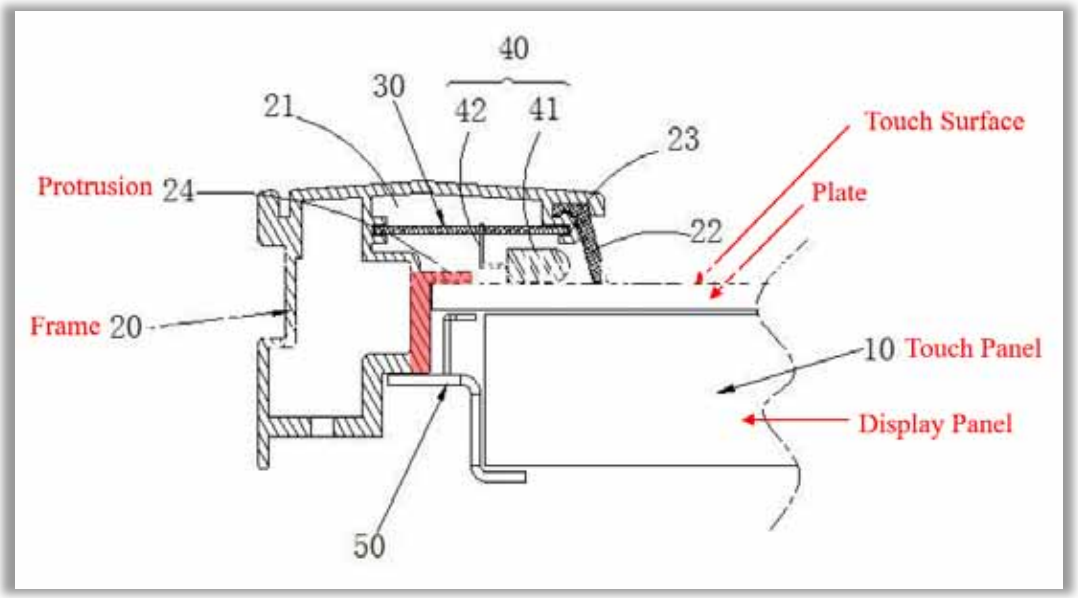


Ex. 1012 at Fig. 1.

218. In the modified Cheng device, the frame 20 with protrusion 24 would also be curved according to Zhao's frame 10. In other words, the second frame element (Cheng's modified frame 20 with protrusion 24) in the modified Cheng device is curved. *Id.* In my opinion, a POSA would have expected such curvature to achieve the same structural reinforcement and simplified plate curvature inducement function of Zhao's frame 10. In other words, the second frame element (Cheng's modified frame 20 with protrusion 24) in the modified Cheng device is curved.



Ex. 1004 at Fig. 1.

219. Thus, it is my opinion that Cheng in view of Zhao discloses wherein the second frame element is curved (curved frame 20 and protrusion 24).

IX. GROUND 2 – CLAIMS 1-11, AND 14 ARE OBVIOUS UNDER CAO IN VIEW OF HAN AND SHIN.

220. It is my opinion that Cao in view of Han and Shin discloses all elements of claims 1-11 and 14 of the ’935 Patent. Specifically, and as I detail below, it would have been obvious for a POSA to combine the touch screen display device and frame elements of Cao, with the parabolically curved touch screen elements of Han and the curvature-inducing frame elements of Shin. In my view, a POSA would have expected to achieve a resulting improved touch screen display device through a simplified manufacturing process.

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Motivation to Comine

221. In my view, a POSA would have been motivated to modify the touch device of Cao using the glass curvature inducing frame teachings of Shin to obtain the technical advantages of Han's parabolically curved touch surface. Cao, Han, and Shin each relate to similar touch-sensing devices including a display, a covering panel touch surface, and a supporting frame assembly. *See* Ex. 1005 at Abstract; Ex. 1011 at Abstract; Ex. 1010 at Abstract.

222. Cao discloses an "all-in-one smart tablet PC" having an infrared module for touch detection. Ex. 1010 at Abstract, 1:17-19. Cao's device includes a display panel (screen 200), a plate (glass 300) with a touch surface on its upper side, and a frame assembly including four screen supports 100 joined at their ends to form a rectangular shape. *Id.* at 4:1-26, 4:41-42, 5:30-34, 5:47-6:2, 7:16-21, 7:66-67, Figs. 1, 9, 13. Cao specifically discloses infrared light touch detection configurations, while leaving implementation details to the reader.

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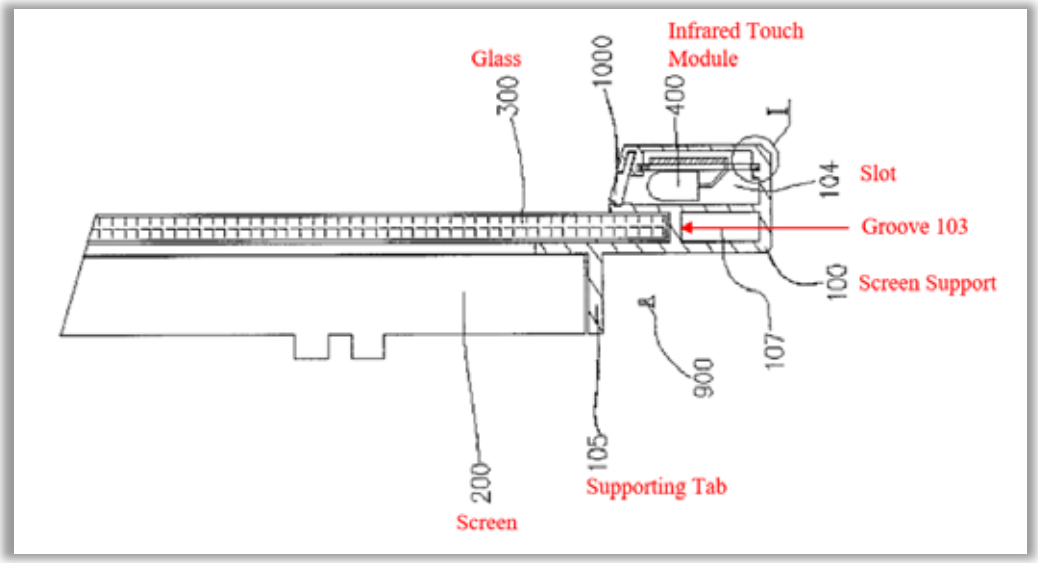

Ex. 1010 at Fig. 9.

223. For example, where Cao discloses a relatively flat touch surface resulting in an improved glass to frame fit (Cao teaching the concept of adjusting glass's incoming inherent curvature with grooves 103), Han teaches increasing the accuracy of touch detection by utilizing a multi-axis (Ax, Ay) parabolic concave curvature of a touch surface to reduce the amount of light lost by reflection and increasing the amount of light received at light reception guide member 232. *See* Ex. 1005 at [0082-83], [0084-86].

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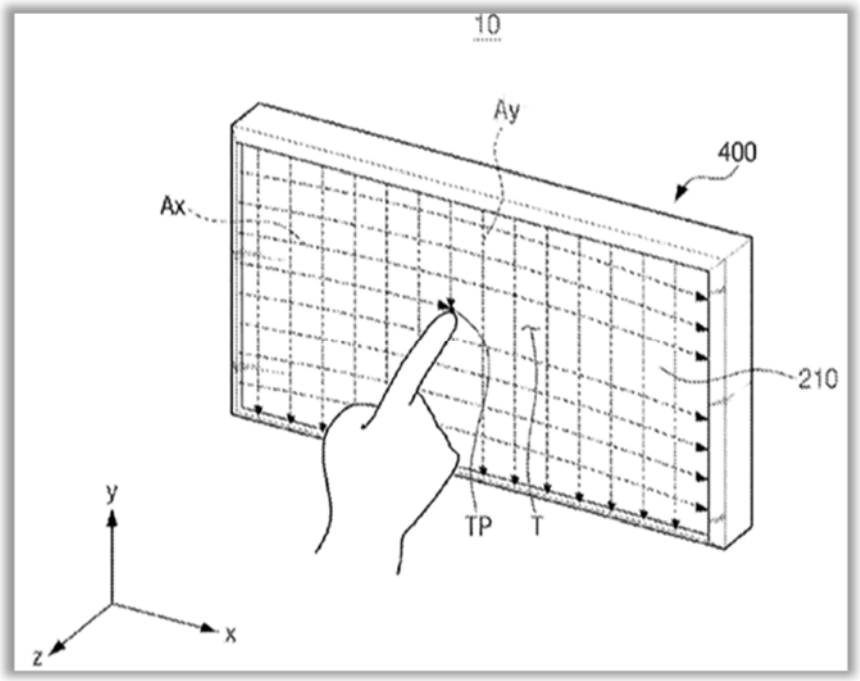
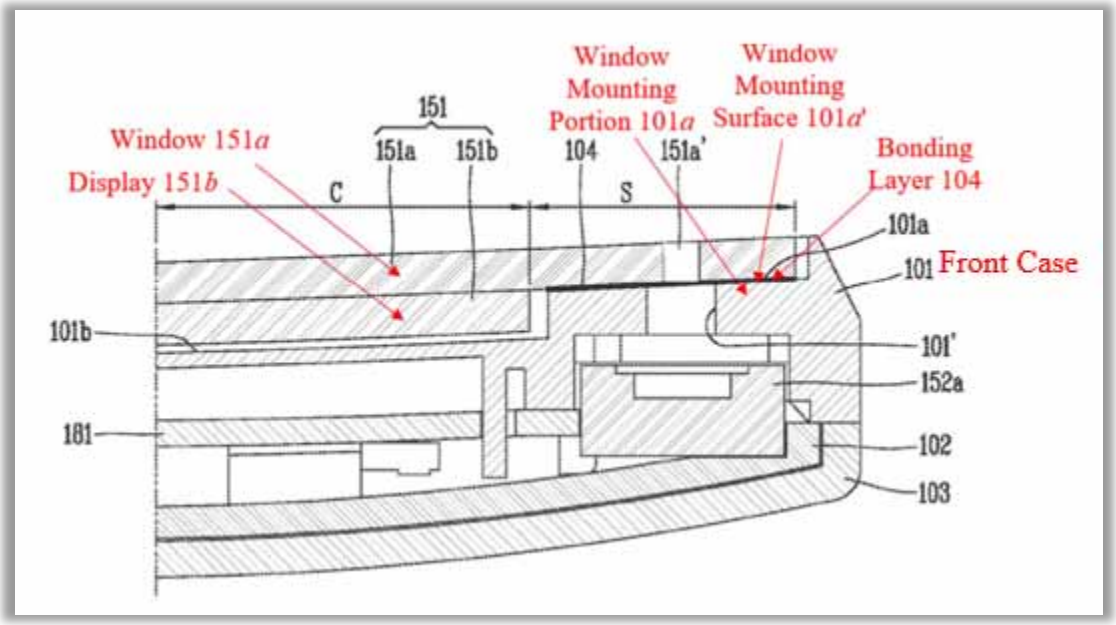


Ex. Han at Fig. 2.

224. Han teaches that its concave curvature of front surface 211 of cover glass 210 provides advantages over a flat cover glass 210, such as a reduced amount of light lost by reflection and an increased amount of light received at light reception guide member 232, which enhance the accuracy of touch recognition. *See id.* at [0082-83], [0085-86].

225. Where Cao does not explicitly disclose that its infrared touch modules 400 comprise a plurality of infrared emitters and detectors, Han provides details on how a POSA would implement such an touch module 400 using a plurality of LEDs 221 (emitters) and photo diodes 231 (detectors). *Id.* at [0040-43].

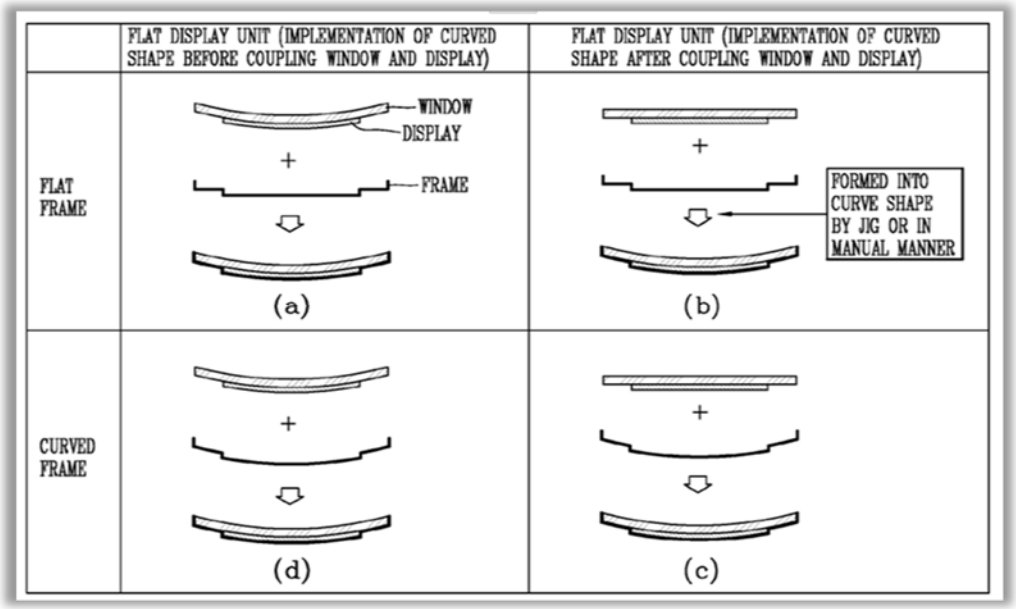
226. While Han discloses the advantages of using a curved touch surface compared to a flat surface, Han leaves certain details on implementing that touch surface curvature to the reader. In my view, Shin fills in those details. Shin discloses an infrared touch-sensitive device and method of manufacture including inducing a curvature into an initially flat cover glass and display utilizing a curved frame. *See* Ex.1011 at 1:52-2:22, 3:4058, 10:45-49.



Ex. 1011 at Fig. 5.

228. As shown above, the window mounting portion 101a of a front case 100 is formed in a curved, or inclined, shape so as to generate a bending force (or a curving force) by which window 151a is curved during installation. As Shin explains, "when the window 151a is mounted onto the mounting surface, the bending

force may be applied to the window 151a such that the window 151a can be curved to correspond to the mounting surface." *Id.* 20:66-21:6. In other words, Shin's frame assembly, including window mounting portion 101a, induces a curvature in the window 151a when it is installed.



Ex. 1011 at Fig. 4.

229. Shin teaches by utilizing the curved mounting potions 101a of the frame to induce curvature in the window 151, the process of manufacturing an infrared touch device is simplified. *Id.* at 18:57-64. For example, the amount of steps needed to create a touch device with a curved panel is reduced as the step of curving the glass panel is combined with the step of installing the glass panel into the frame.

230. In my view, a POSA would have been motivated to combine the teachings of Cao and Han for a variety of reasons. For example, Cao specifically discloses infrared light touch detection configurations, while leaving certain implementation details to the reader. To the extent Cao does not explicitly disclose that its infrared touch modules 400 comprise a plurality of infrared emitters and detectors, it is my opinion that it would have been obvious to a POSA to incorporate Han's plurality of LEDs 221 (emitters) and photo diodes 231 (detectors) into Cao's infrared touch module 400. Some type of emitter/detector arrangement would be required in Cao to provide its "all-in-one smart tablet PC" having an infrared module for touch detection. Ex. 1010 at Abstract, 1:17-19. Implementing that infrared module using "a plurality of infrared emitters and detectors" would have been an obvious design choice, as evidenced by Han. Such modification of Cao would yield the predictable result of Han's infrared touch-sensing functionality. Corroborating this, the '935 Patent acknowledges it is well known in the prior art to arrange a plurality of emitters and detectors around the periphery of the plate in order to enable touch-sensing functionality. *See, e.g.*, Ex. 1001 at 1:26-46, 15:62-16:3.

231. Additionally, it is my opinion that a POSA would have been motivated to incorporate the teachings of Han and Shin into the disclosure of Cao to provide the curved-touch-surface benefits that Han and Shin that can be realized in an

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infrared touch detection implementation, like Cao's. Starting with the infrared touch device of Cao, it is my opinion that a POSA would have expected to improve touch detection accuracy by incorporating the parabolically curved plate teachings of the infrared touch device in Han. Incorporating Han's plate curvature into Cao would have been obvious, as Cao discloses—as a baseline—affecting the curvature of the plate (four rising corners) to improve quality. *See* Ex. 1010 at 4:13-19. Thus, it is my opinion that Han's parabolic plate curvature would merely be an obvious iterative progression of Cao's plate curvature tuning; affecting curvature of the entire plate (Han), rather than just four rising corners (Cao).

232. To achieve Han's parabolic plate curvature in device of Cao, it is my view that a POSA would have been motivated to implement Shin's teaching of inducing curvature in the plate during the installation process via a curved frame mounting surface 101a'. As the frame in Cao already includes a groove 103 and groove wall 112 for supporting the plate, it would have been obvious for POSA to modify Cao by curving the groove wall 112 according to the curved frame mounting surface 101a' of Shin. A POSA would have expected such modification to achieve the same simplified curvature-inducing functionality of Shin in the modified Cao device.

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233. Thus, it is my opinion that a POSA combining the teachings of Han and Shin into the device of Cao would have expected to achieve the predictable result of high touch detection accuracy (Han) infrared touch device (Cao, Han, Shin) and manufacturing method (Cao, Han, Shin) meeting the limitations of the ’935 Patent. Such modifications would have merely embodied known techniques to improve a similar device in a similar way.

1. Claim 1

(a) Preamble: “A method for assembling a touch sensing apparatus, the touch sensing apparatus comprising a display panel, a plate including a touch surface, and a frame assembly,”

234. In my opinion, Cao discloses this element. Cao discloses a method of assembling a touch sensing apparatus including a display panel (screen 200), a plate including a touch surface (glass 300) and a frame assembly (screen support 100). *See* Ex. 1010 at Abstract.

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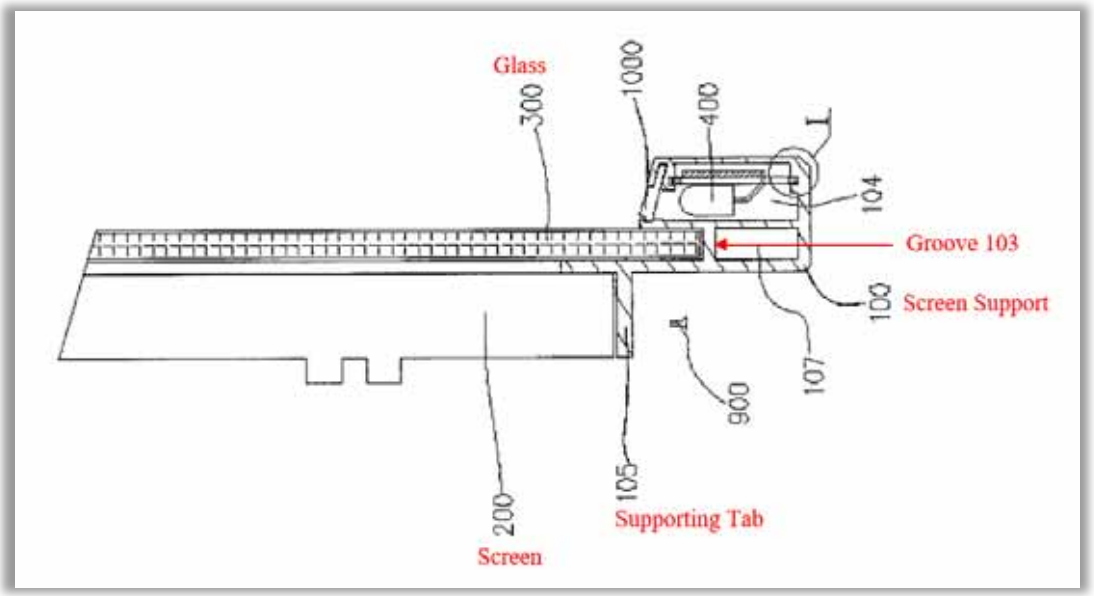
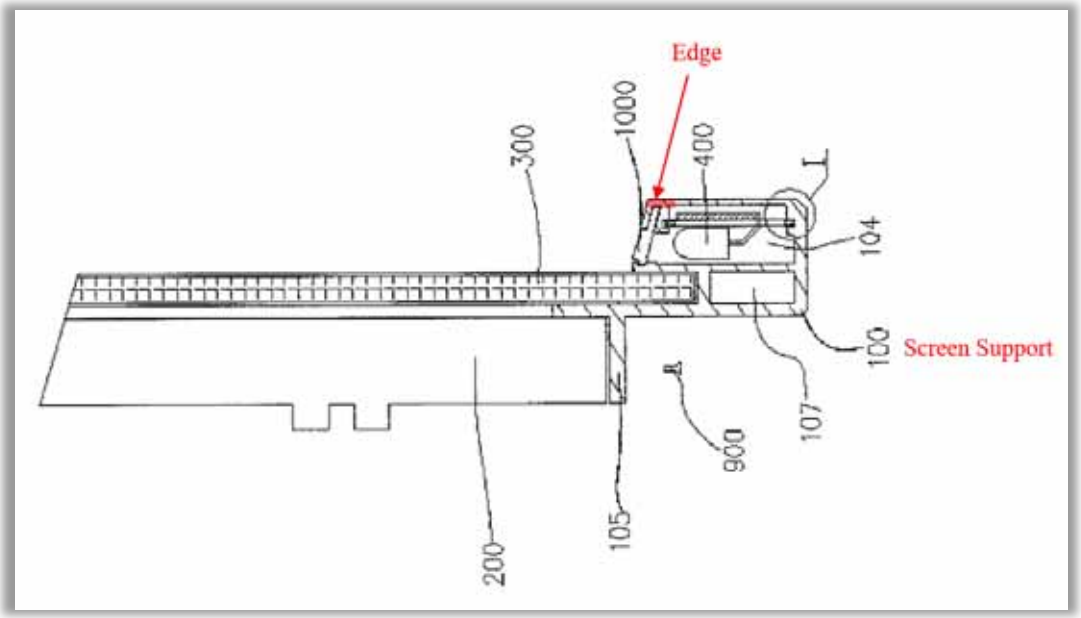


Ex. 1010 at Fig. 9.

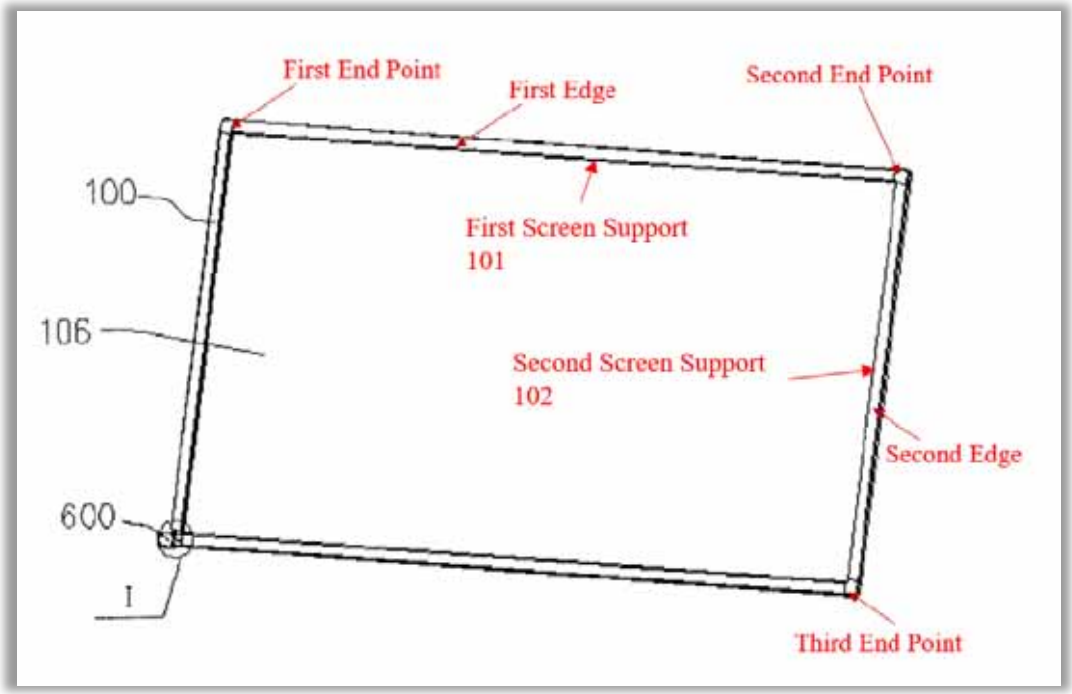
235. Thus, it is my opinion that Cao discloses a method for assembling a touch sensing apparatus, the touch sensing apparatus comprising a display panel (screen 200), a plate including a touch surface (glass 300), and a frame assembly (screen support 100).

(b) "wherein the frame assembly includes: a first edge extending between a first end point and an opposite second end point; and a second edge extending between the second end point and a third end point;"

236. In my opinion, Cao discloses this element. As depicted in Cao's Figs. 9 and 14 below, Cao's frame assembly 100 includes a first edge extending between a first end point and an opposite second end point and a second edge extending between the second end point and a third end point.



Ex. 1010 at Fig. 9.



Ex. 1010 at Fig. 14.

238. Cao explains:

> [T]he screen support 100 may include a first screen support 101 and a second screen support 102. The first screen support 101 is provided on its each end with a corner cover seat 700, the second screen support 102 is provided on its each end with a recess 107, and one end of the corner cover seat 700 is provided with a protrusion 800 matching first fitting opening 120, with the corner cover 600 mounted on the corner cover seat 700. The corner cover seat 700 is integral with the first screen support 101, which is easy to use with less components, improving the assembly efficiency.

Ex. 1010 at 4:41-58.

239. Thus, it is my opinion that Cao discloses wherein the frame assembly (screen supports 100) includes: a first edge (edge of a first screen support 100) extending between a first end point (first end of first screen support 101) and an opposite second end point (second end of first screen support 101); and a second edge (edge of a second screen support 102 joined "end-to-end" with the first support 101) extending between the second end point (first end point of second screen support 102) and a third end point (second end point of second screen support 102).

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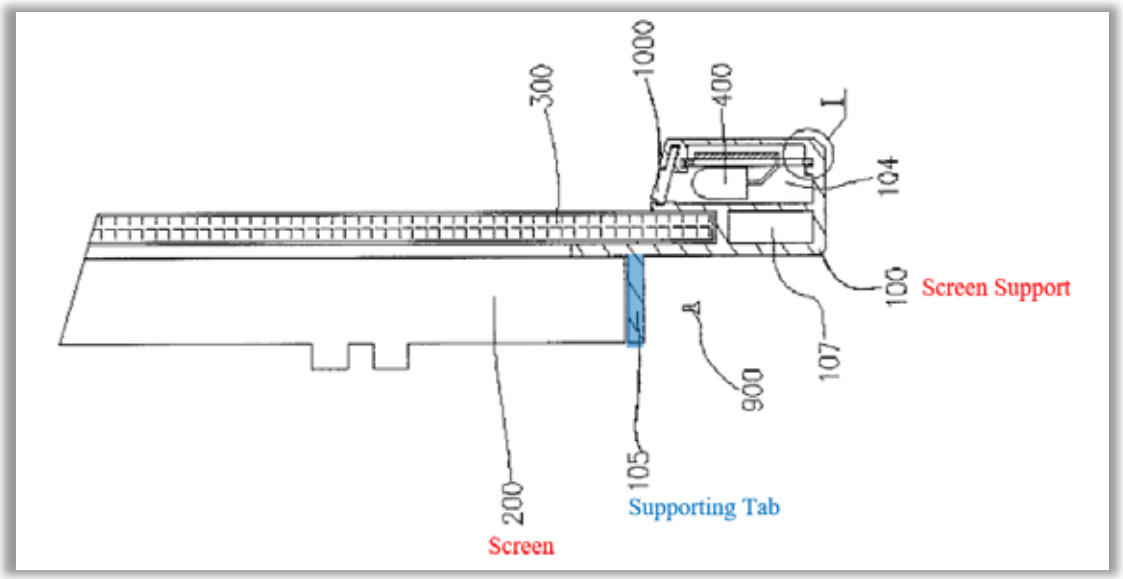
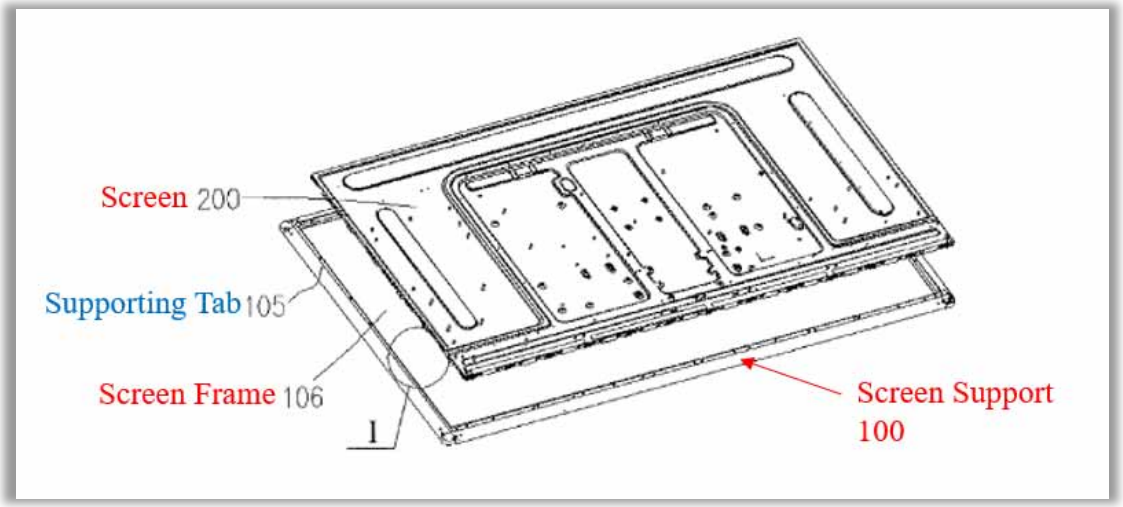
(c) "the method comprising: configuring the frame assembly to support the display panel;"

240. In my opinion, Cao discloses this element. Cao's frame assembly comprises four screen supports 100 that each include a supporting tab 105 that together form a screen frame 106. Ex. 1010 at 4:7-12. Cao explains that "[t]he screen support 100 is provided on one side with a supporting tab 105, with each supporting tab 105 of the respective screen support 100 forming a screen frame 106 by joining together end to end. As shown below in Cao's Figs. 9 and 3, the screen 200 is mounted onto the screen frame 106…" Ex. 1010 at 4:7-12.



Ex. 1010 at Fig. 9.

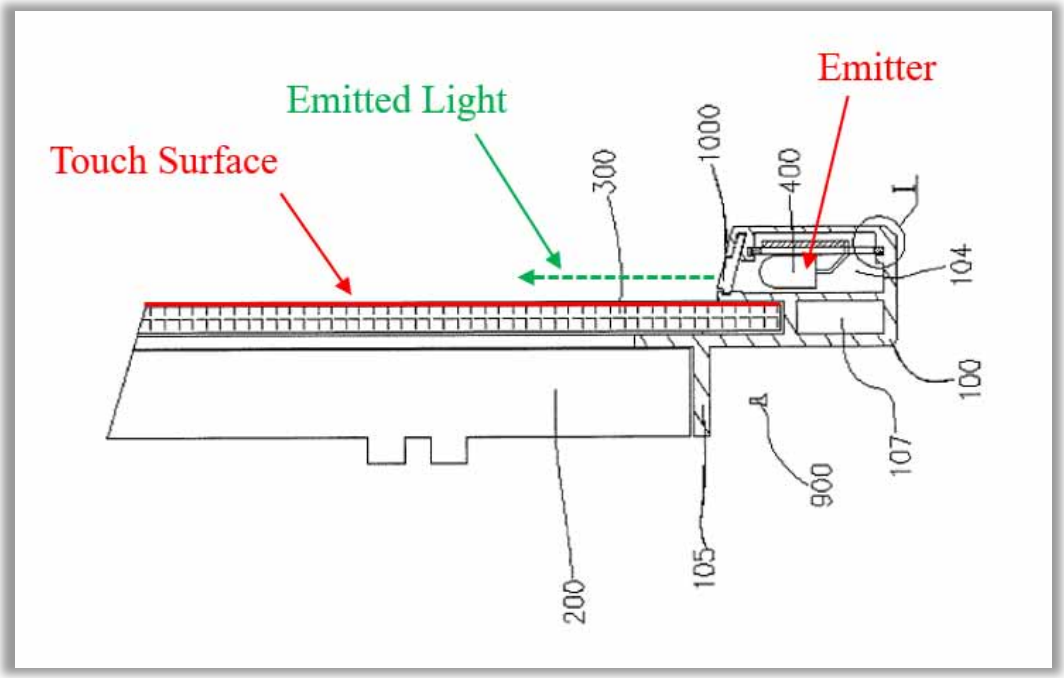


Ex. 1010 at Fig. 3.

241. Thus, it is my opinion that Cao discloses a method comprising: configuring the frame assembly (screen supports 100) to support the display panel (screen 200).

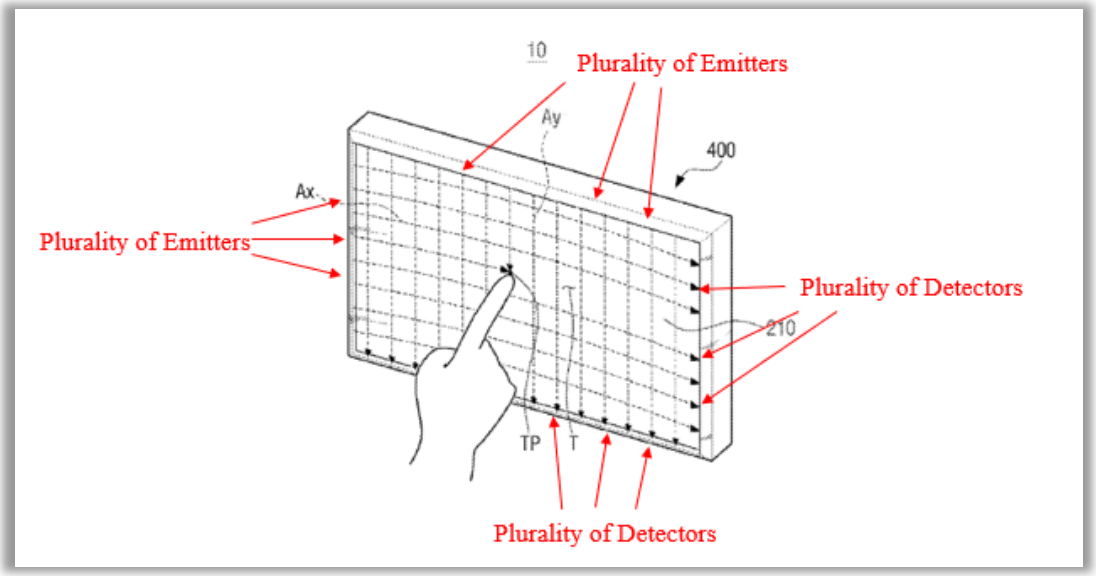
(d) "arranging a plurality of emitters adjacent to a periphery of the plate, said plurality of emitters configured to emit light to propagate over the touch surface;"

242. In my opinion, Cao in view of Han discloses this element. In Cao, the infrared touch modules 400 are arranged adjacent to, or near, the periphery of the plate 300. Ex. 1010 at Fig. 9. While Cao only describes "infrared touch modules 400," it is my view that a POSA would have understood infrared touch modules to disclose an emitter, at least based on the depiction of the infrared touch modules 400 in Cao's Fig. 9.



Ex. 1010 at Fig. 9.

243. Based on the orientation of Cao's emitter in relation to glass 300, a POSA would have understood the emitter to emit light to propagate across the (touch) surface of the glass 300. Further, while Cao does not explicitly describe a *plurality* of emitters, it is my opinion that it would have been obvious to a POSA to implement a plurality of emitters, at least based on the teachings of Han and as known generally in the prior art. Ex. 1005 at [0040]; Ex. 1001 at 1:26-46, 15:62-16:3.



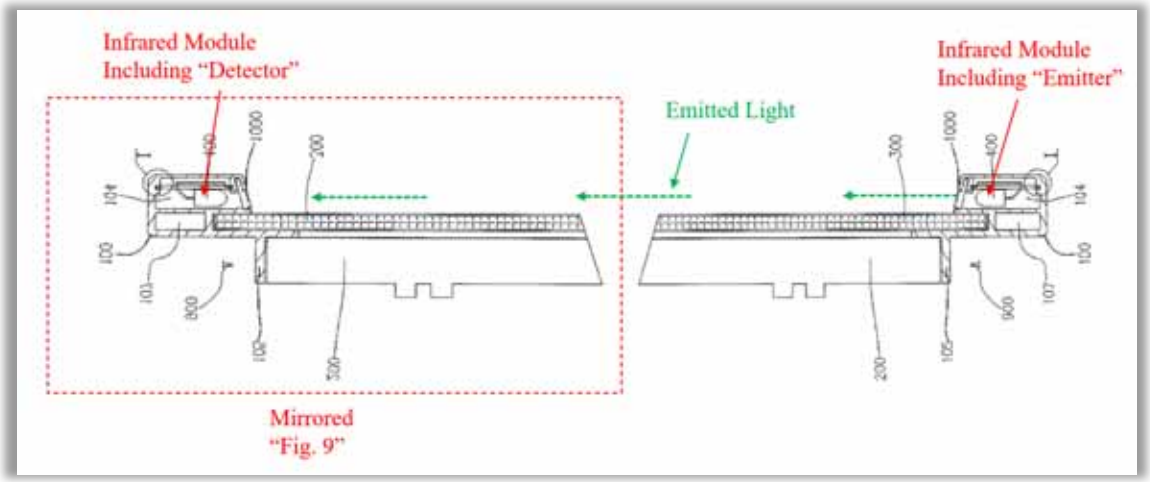
Ex. 1005 at Fig. 2.

244. It is my view that a POSA would have expected such a modification to Cao to yield the predictable touch-sensing functionality of Han and the similar devices known in the prior art.

245. Thus, in my opinion, Cao in view of Han discloses arranging a plurality of emitters (Cao's infrared touch modules 400 with emitters) adjacent to a periphery of the plate (Cao's glass 300), said plurality of emitters configured to emit light to propagate over the touch surface (top surface of Cao's glass 300).

(e) "arranging a plurality of detectors arranged adjacent to the periphery of the plate, said plurality of detectors configured to receive light from the set of emitters; and"

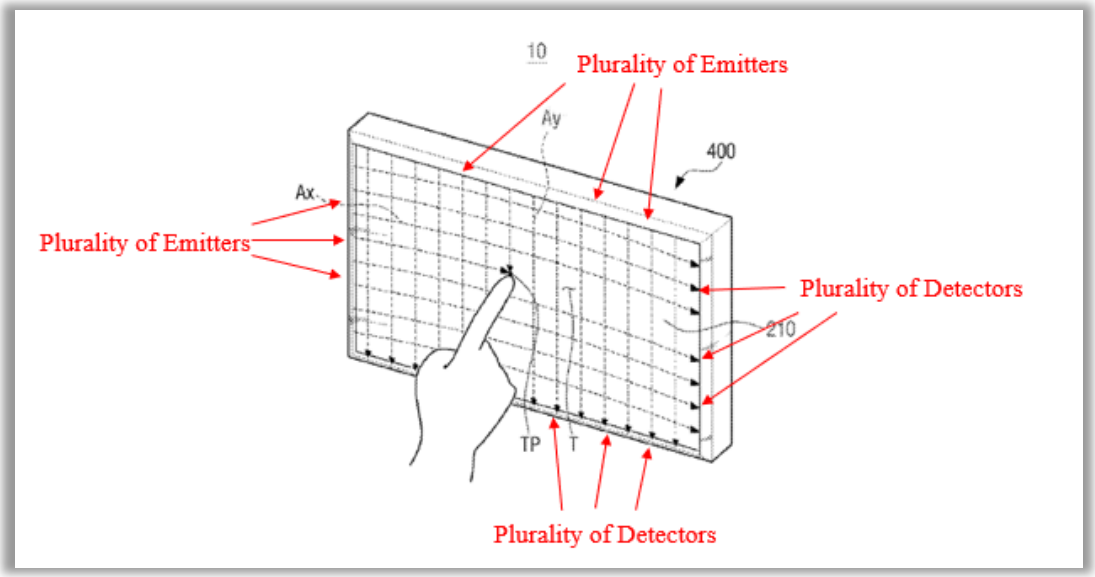
246. It is my opinion that Cao in view of Han discloses this element. While Cao only describes "infrared touch modules 400, " a POSA would have understood infrared touch modules 400 to disclose a detector. In my view, a POSA's understanding would have been supported by the fact that in optical touch sensing devices—such as Cao—infrared emitters require opposing infrared detectors to enable infrared touch sensing functionality.



Ex. 1010 at Fig. 9.

247. As I discussed above for claim 1(d), it would have been similarly obvious to a POSA to include a *plurality* of detectors according to Han. It is my view that a POSA would have expected such a modification to yield the predictable

touch-sensing functionality of Han and the similar devices known in the prior art. Ex. 1005 at [0040]; Ex. 1001 at 1:26-46, 15:62-16:3.



Ex. 1005 at Fig. 2.

248. Thus, it is my opinion that Cao in view of Han discloses arranging a plurality of detectors (infrared touch modules 400 including detectors) adjacent to the periphery of the plate, said plurality of detectors configured to receive light from the set of emitters (opposing infrared touch modules 400 including emitters).

(f) "configuring the frame assembly to support the plate; wherein configuring the frame assembly to support the plate includes inducing a parabolic curvature in the touch surface relative to a first axis and relative to a second axis perpendicular to the first axis, said first axis is parallel to a line between the first end point and the second end point and said second axis is parallel to a line between the second end point and the third end point."

249. It is my opinion that Cao in view of Han and Shin discloses this element. Cao's frame assembly with screen supports 100 include a plurality of grooves 103 which position or support the glass 300. Ex. 1010 at 4:13-16. Cao teaches that the grooves 103 of the frame assembly are used to control the curvature of the glass 300. *Id.* at 4:13-19. As I discussed above, it would have been obvious to a POSA to modify Cao's glass 300 to incorporate Han's parabolic touch screen curvature along Ax and Ay directions to improve touch detection accuracy. Towards reaching Han's touch screen curvature, it is my opinion that it would have also been obvious to a POSA to modify each of Cao's screen supports 100 and grooves 103 according to the curved mounting surfaces 101a' of Shin. In my view, a POSA would have expected to achieve a simplified manufacturing process for producing a curved plate by incorporating Shin's manufacturing process depicted in Fig. 4 and including curved mounting surface 101a' into Cao's screen supports 100 and grooves 103. Ex. 1011 at 18:57-64, Fig. 4.

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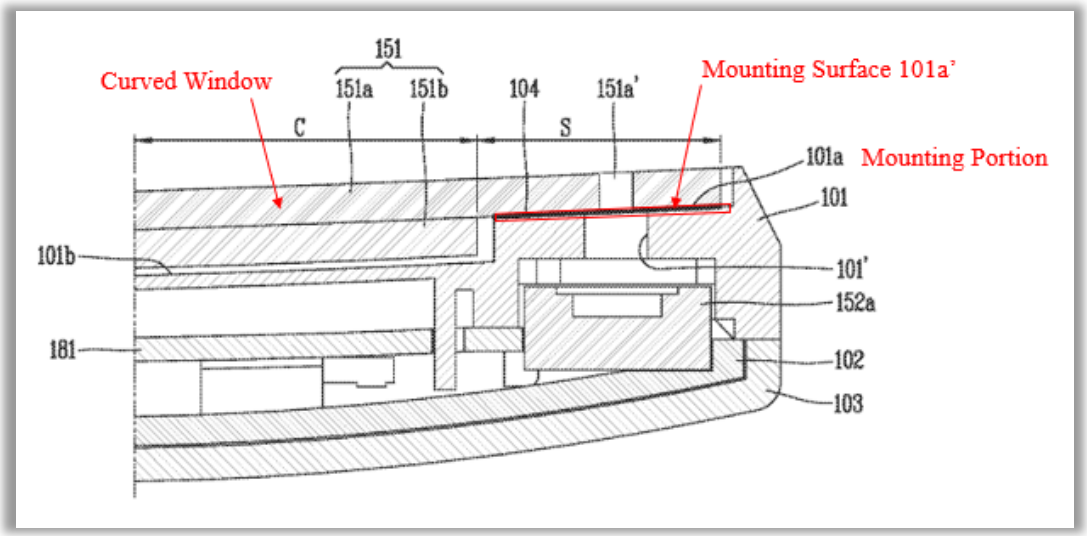
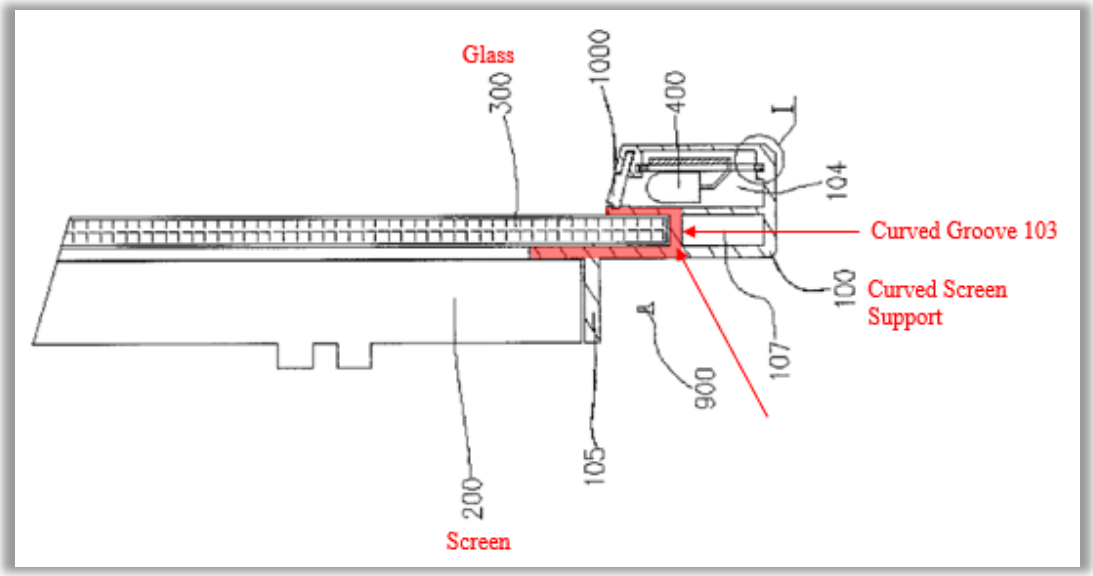


Ex. 1011 at Fig. 5.

250. In one example of the modified Cao device, each side of an initially flat glass 300 is inserted into respective Cao's modified curved grooves 103, and the screen supports 100 are coupled together using corner cover seats 700.



Ex. 1010 at Fig. 9.

251. As the glass 300 is assembled into the screen supports 100, the curved grooves 103 apply a bending force to the glass 300, which induces the glass 300 to curve according to the corresponding curvature of grooves 103 and screen support 100. Curved grooves 103 along the Ax axis would induce curvature along the Ay axis, and vice versa. As in Han, the resulting Ax and Ay glass curvatures in the modified Cao glass 300 would be parabolic and would extend from one side of the touch surface of Cao's glass 300 to an opposite side thereof along a first Ax axis and along a second Ay axis perpendicular to the first. As in Han, the first axis would be parallel with a line between the first end point and the second end point, and the second axis would be parallel to a line between the second end point and the third end point. *Id.*

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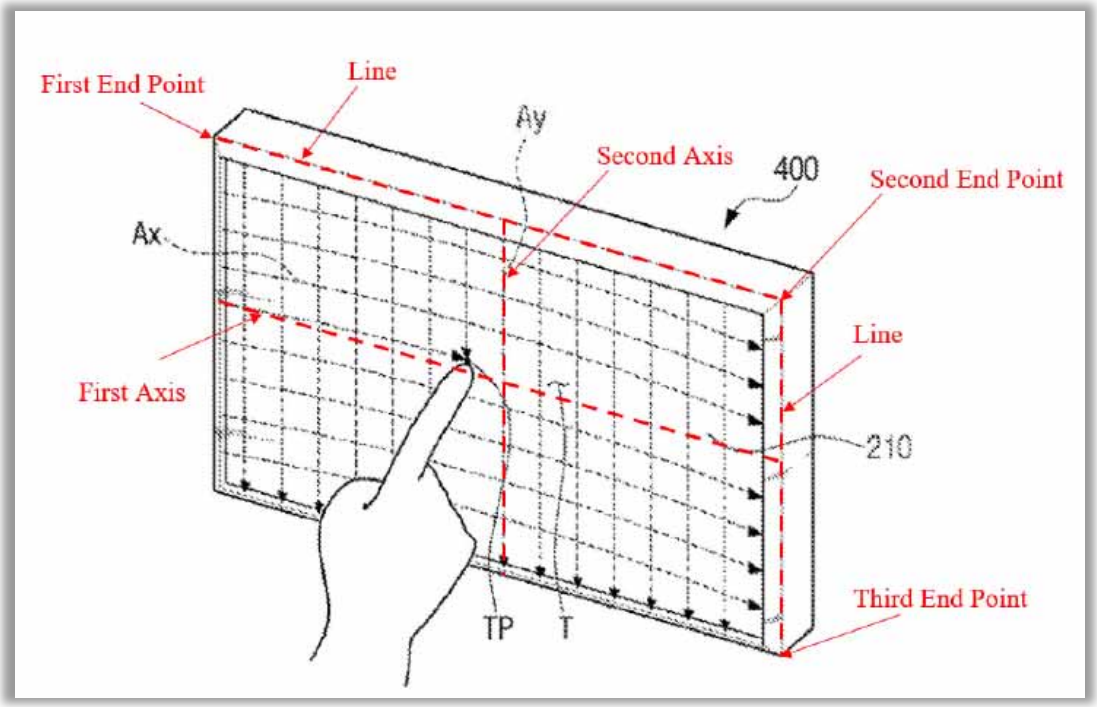


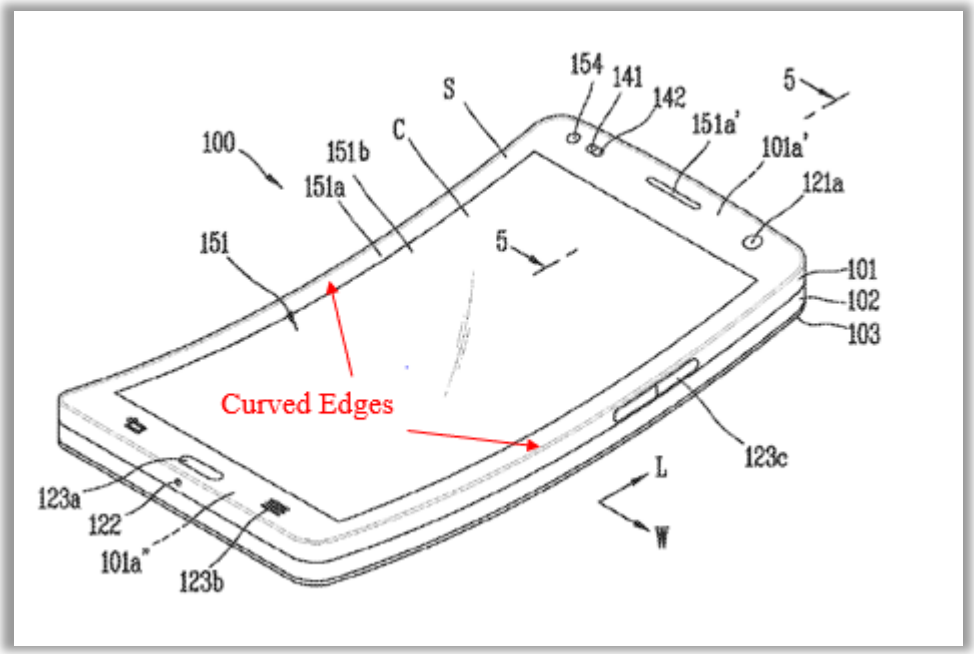
Ex. 1005 at Fig. 2.

252. Thus, it is my opinion that Cao in view of Han and Shin discloses configuring the frame assembly (modified Cao screen support 100 and groove 103) to support the plate (Cao's glass 300); wherein configuring the frame assembly to support the plate includes inducing a parabolic curvature (Han's parabolic curvature) in the touch surface (surface of Cao's glass 300) relative to a first axis (Han's Ax) and relative to a second axis (Han's Ay) perpendicular to the first axis, said first axis is parallel to a line between the first end point (first endpoint of Cao's screen support 101) and the second end point (second endpoint of Cao's screen support 101) and said second axis is parallel to a line between the second end point (second

endpoint of Cao's screen support 101) and the third end point (endpoint of second Cao's screen support 102).

2. Claim 2: "The method of claim 1, wherein the first edge is curved and the second edge is curved."

253. It is my opinion that Cao in view of Han and Shin discloses this element. In one embodiment of the modified Cao device, each of the four screen supports 100 and grooves 103 are curved in the same manner as Shin's mounting surfaces described above. Just as Shins "length" edges are curved as shown in Shin's Fig. 2 below, both the length and width edges of the modified Cao device would be curved, as each modified Cao support 100—which forms the edges—is curved along with grooved 103 to induce curvature in the plate in both an Ax and Ay direction.



Ex. 1011 at Fig. 2.

254. In my view, this embodiment of the modified Cao device would be consistent with Cao's original objective of preventing an "oversized gap between the glass 300 and the front frame cause by [curved glass 300]." *See* Ex. 1010 at 4:16-19. Curved edges of Cao's modified screen supports 100 would also help prevent a gap between the frame supports 100 and the glass 300.

255. Additionally, a POSA would have appreciated Cao's infrared modules 400 housed in Cao's modified curved screen supports 100 (having curved edges) to better project infrared light along the surface of the curved glass 300. This configuration would have been obvious based on Han's teaching of angling infrared light along the surface of Han's curved screen 210 to reduce light loss and yield improved touch recognition accuracy. *See* Ex. 1005 at [0106], Fig. 6.

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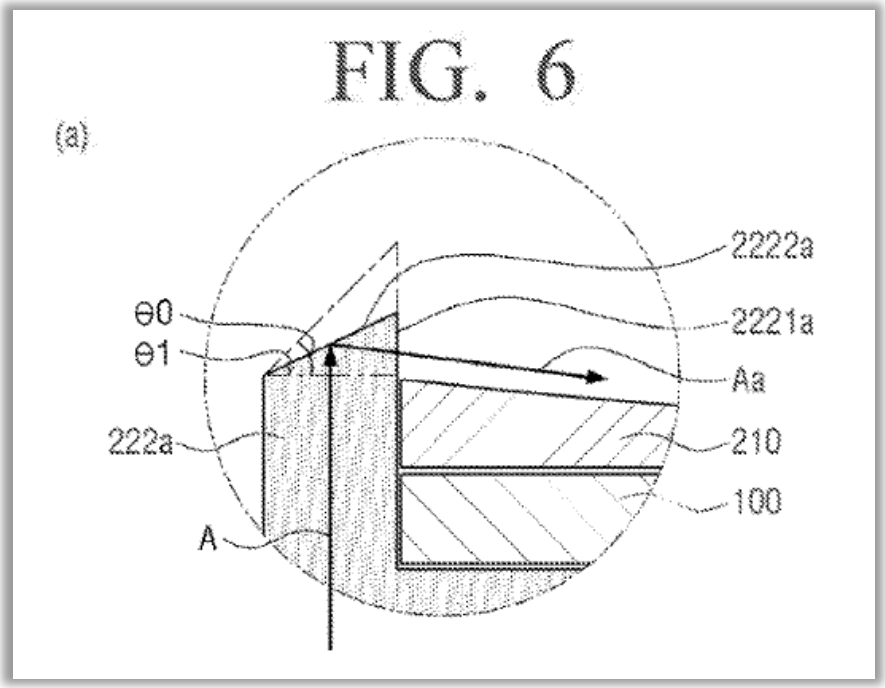

Ex. 1005 at Fig 6.

256. Thus, it is my opinion that Cao in view of Han and Shin discloses wherein the first edge (edge of Cao screen support 101) is curved, and the second edge (edge of Cao screen support 102) is curved.

3. Claim 3: "The method of claim 1, wherein the plate has a first curvature when not configured in the frame assembly, and wherein the plate has a second curvature greater than the first curvature after the plate is configured in the frame assembly."

257. It is my opinion that Cao in view of Han and Shin discloses this element. In an embodiment of the modified Cao device according to Han and Shin, Cao's

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glass 300 before installation has an initial or first curvature according to the well-known material property of pre-installed stock tempered glass. Ex. 1010 at 4:13-19; Ex. 1023; Ex. 1025; Ex. 1026; *see also* Ex. 1001 at 2:5-9. Each side of the glass 300 is then inserted into respective Cao's modified curved grooves 103 of each screen support 100, and each screen support 100 is coupled together end to end using corner cover seats 700. As the glass 300 is assembled into the curved grooves 103, the grooves 103 apply a bending force to the glass 300. The bending force induces the glass 300 to curve according to the corresponding curvature of grooves 103 of screen supports 100. As I discussed above, the induced curvature (according to Han's optimal curvature depth of 1.302225 mm) is greater than the first curvature (according at least to Ex. 1023, ASTM C1048-18, stock glass curvature depth range of 0-3 mm) based on the slope of the grooves 103 along both the Ax and Ay directions.

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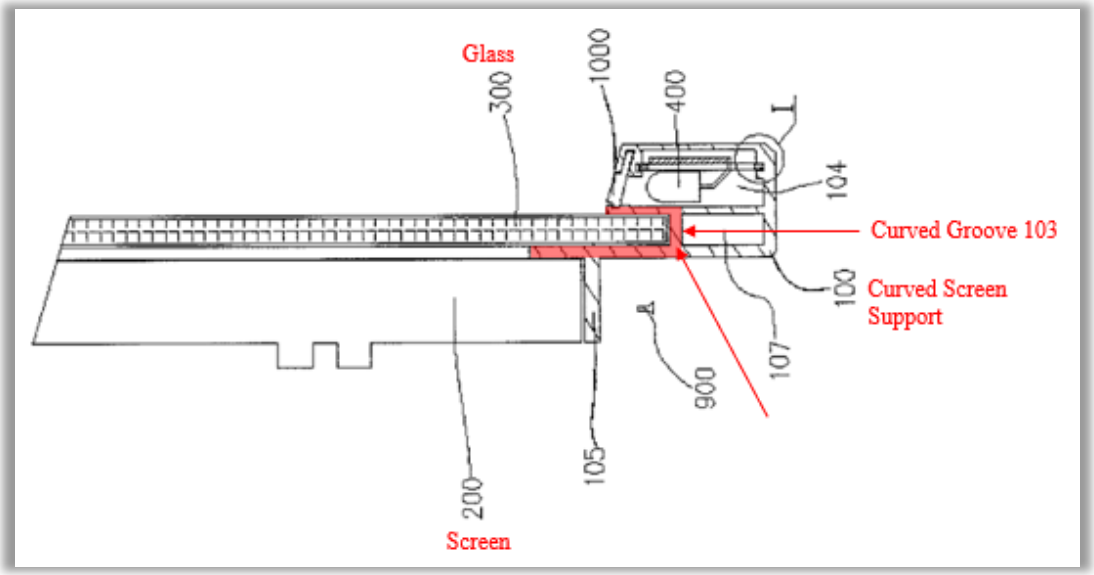


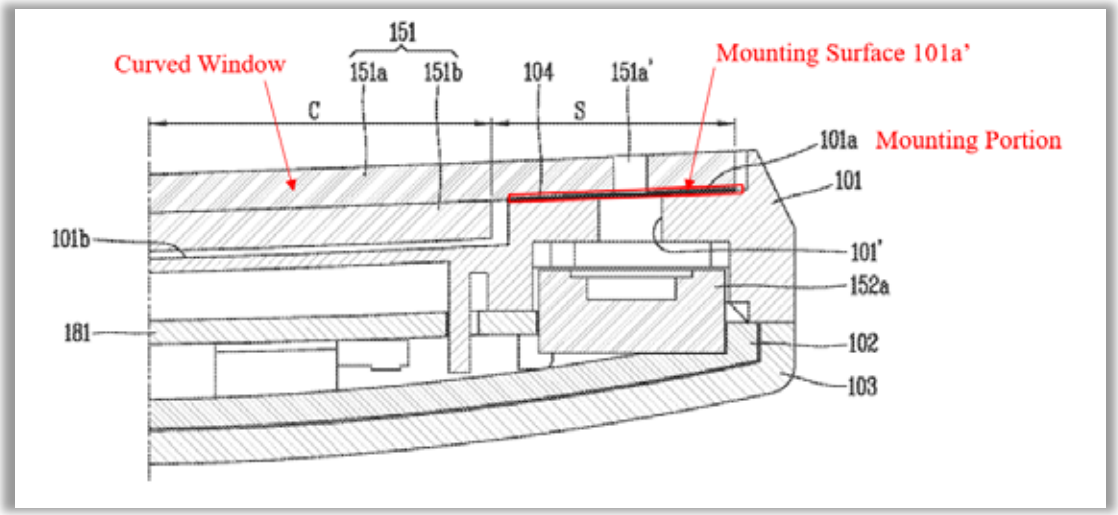
Ex. 1010 at Fig. 9.

258. Thus, in my opinion, Cao in view of Han and Shin discloses wherein the plate (glass 300) has a first curvature (stock material curvature of pre-installed glass 300) when not configured in the frame assembly (Cao's modified screen supports 100 and grooves 103), and wherein the plate has a second curvature (induced by Cao's modified screen support 100 and grooves 103) greater than the first curvature after the plate is configured in the frame assembly.

4. Claim 4: "The touch sensing apparatus of claim 3, wherein the first curvature and second curvature are defined along an edge of the plate."

259. In my opinion, Cao in view of Han and Shin discloses this element. In the modified Cao device, the first and second curvatures are defined along an edge

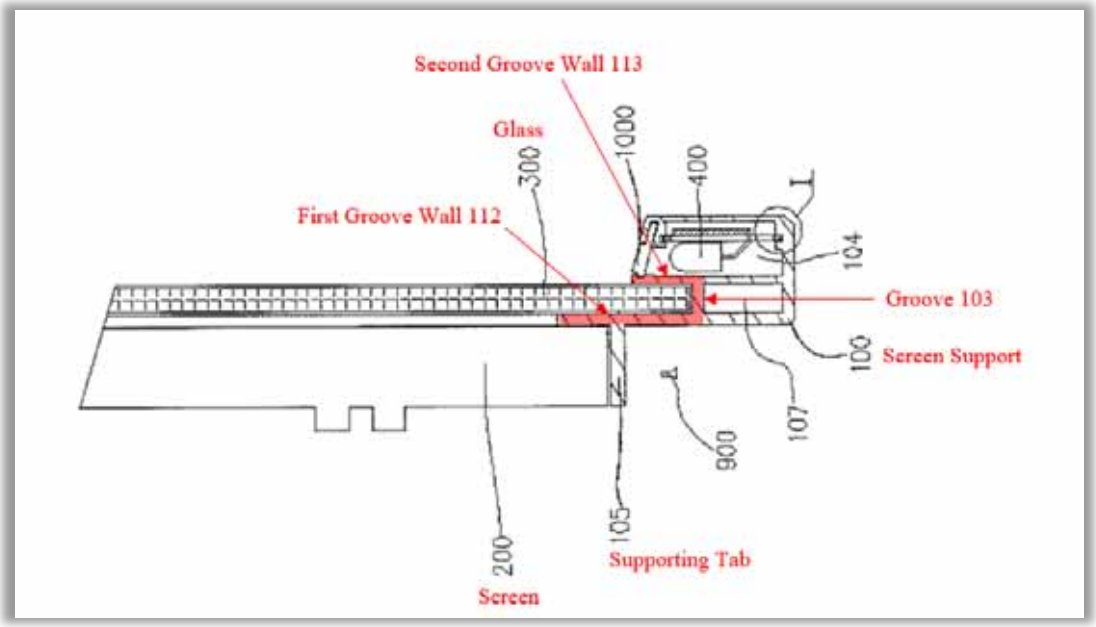
of the plate. In the modified Cao device, it is my view that a POSA would have understood pre-installed glass to have a first curvature that would be defined along the edge of the glass. Incorporating Shins' teaching, a POSA would have also expected an induced second curvature of the glass to be defined along its edge. For example, as taught by Shin, the mounting surface 101a' is curved along the full length of contact with the curved window 151a up to and including the window edge, "S" length. Ex. 1011 at Fig. 5. Thus, during installation of the window 151a in Shin, the curved mounting surface 101a' induces curvature up to the edge of window 151a. *Id.* at Fig. 5.



Ex. 1011 at Fig. 5.

260. In the modified Cao device according to Shin, Cao's modified first groove walls 112 of the curved grooves 103 would also induce curvature up to the

edges of glass 300 during installation as, like in Shin, Cao's first groove walls 112 would also contact glass 300 up to its respective edges.



Ex. 1010 at Fig. 9.

261. Han further teaches curvature along both an Ax and Ay direction, up to and including the edges of its front cover glass 210 in order to improve touch detection accuracy. *See* Ex. 1005 at [0077-89], Fig. 7. Thus, the glass 300 of the modified Cao device incorporating Han's glass curvature (curved up to glass 210 edges in both an Ax and Ay axis) would also include curvature up to its respective screen 300 edges to achieve Han's improved touch detection accuracy.

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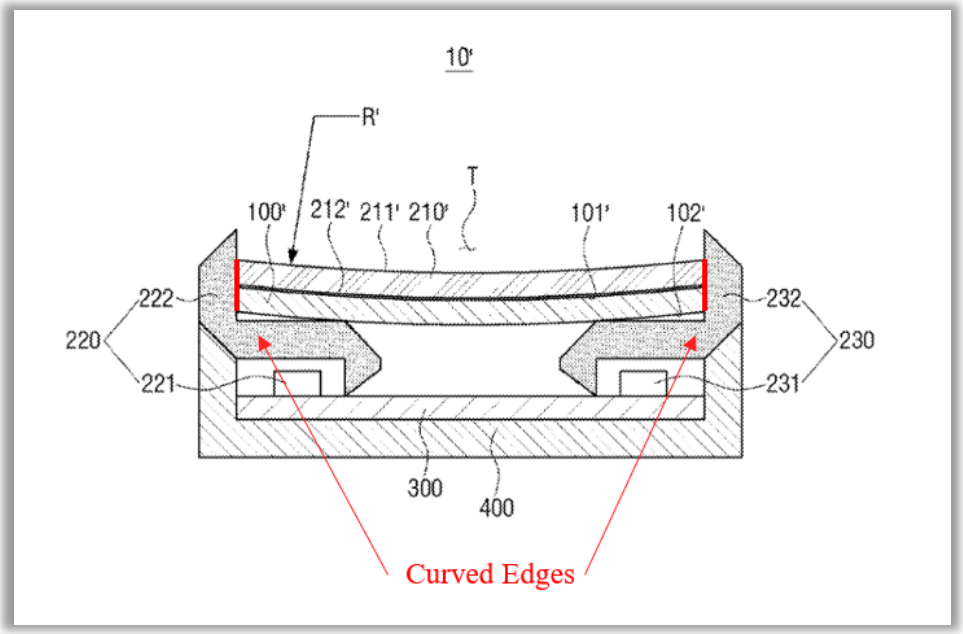
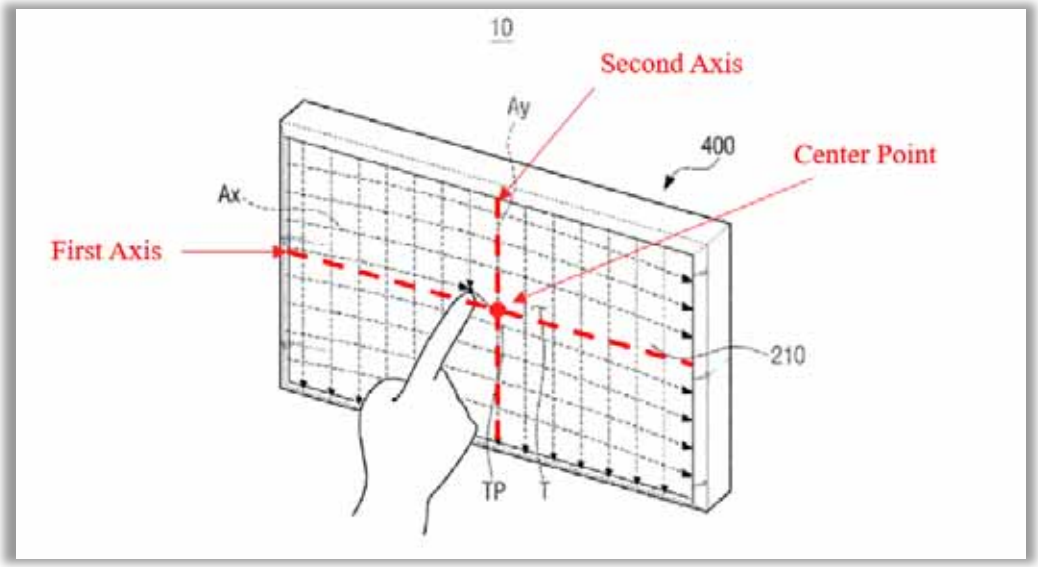


Ex. 1005 at Fig. 7.

262. Thus, it is my opinion that Cao in view of Han and Shin discloses wherein the first curvature and second curvature are defined along an edge of the plate (Cao's modified curved glass 300 up to its edges along both Ax and Ay directions).

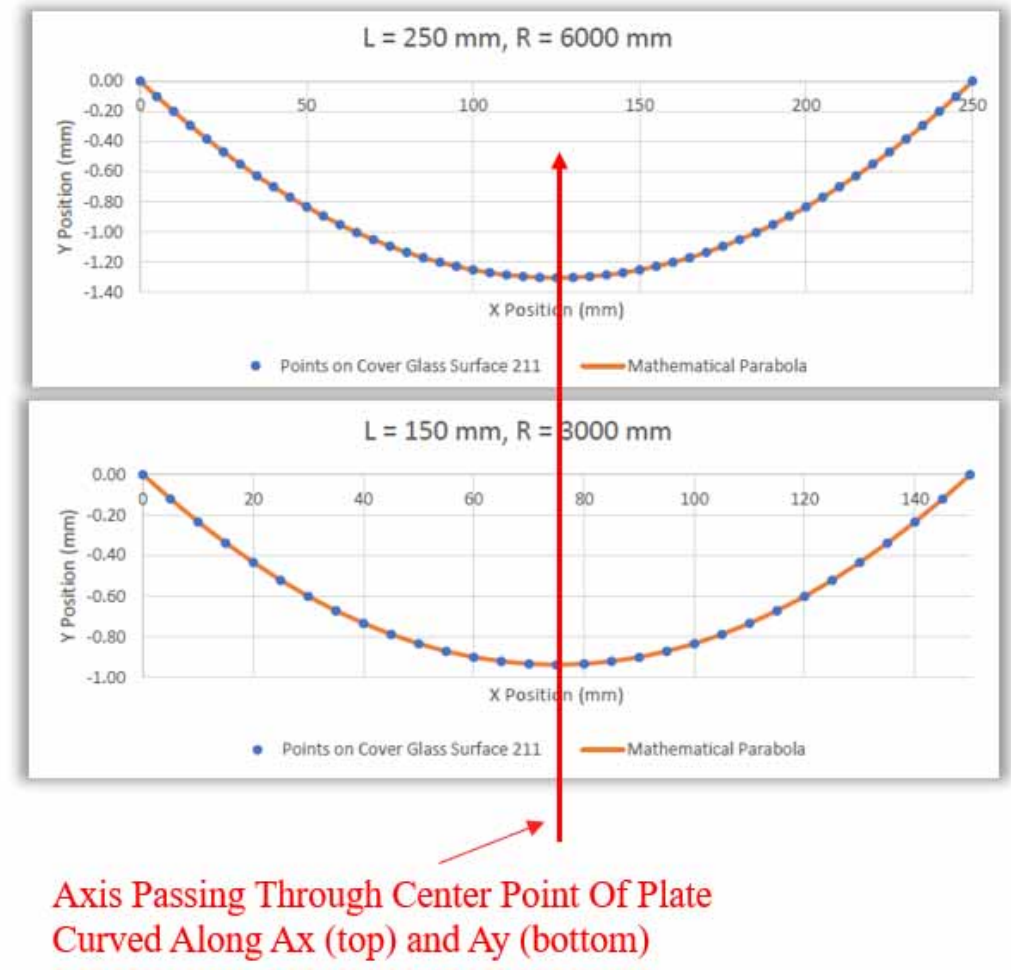
5. Claim 5: "The touch sensing apparatus of claim 3, wherein the first curvature and second curvature are measured along an axis passing through a center point of the plate."

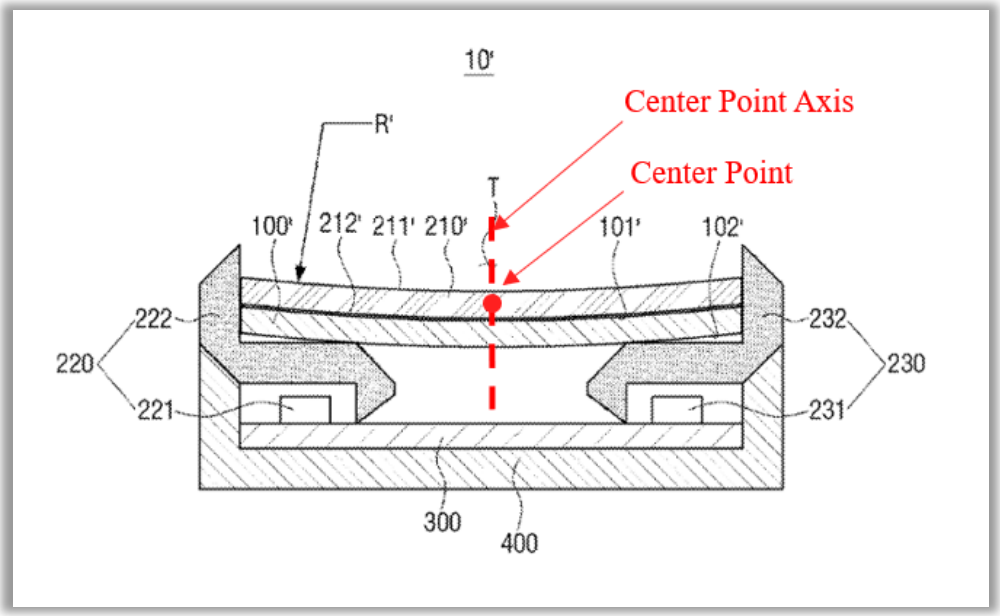
263. In my opinion, Cao in view of Han discloses this element. As I have discussed above, Han teaches a parabolically curved plate (cover glass 210), with curvature relative to both a first (Ax) and second (Ay) axis.



Ex. 1005 at Fig. 9.

264. Han further teaches a parabolic curvature as measured along an axis passing through a center point of the plate (cover glass 210). For example, I have superimposed a "central axis" on plots depicting Han's parabolically curved cover glass 210, below.


L = 250 mm, R = 6000 mm
Y Position (mm)
X Position (mm)
Points on Cover Glass Surface 211
Mathematical Parabola
L = 150 mm, R = 3000 mm
Y Position (mm)
X Position (mm)
Points on Cover Glass Surface 211
Mathematical Parabola
Axis Passing Through Center Point Of Plate
Curved Along Ax (top) and Ay (bottom)



Ex. 1005 at Fig. 7.

265. In order to achieve Han's improved touch detection, it is my opinion that a POSA would have been motivated to modify Cao's glass 300 to have the same parabolic curvature as Han's, also as measured along an axis passing through a center point of modified Cao's glass 300.

266. Thus, in my opinion, Cao in view of Han discloses wherein the first curvature and second curvature are measured along an axis (axis passing through center point of modified Cao's glass 300) passing through a center point of the plate (center point of modified Cao' glass 300).

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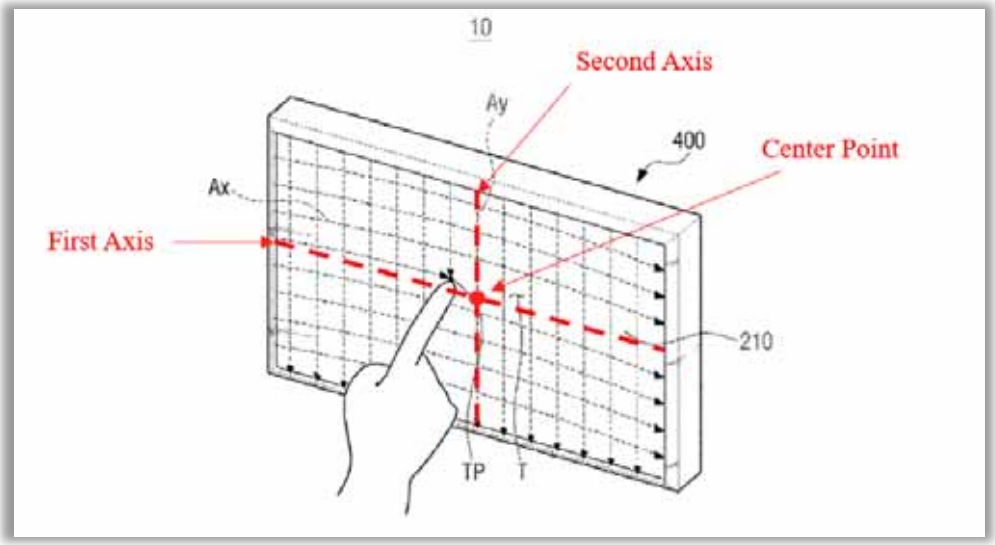
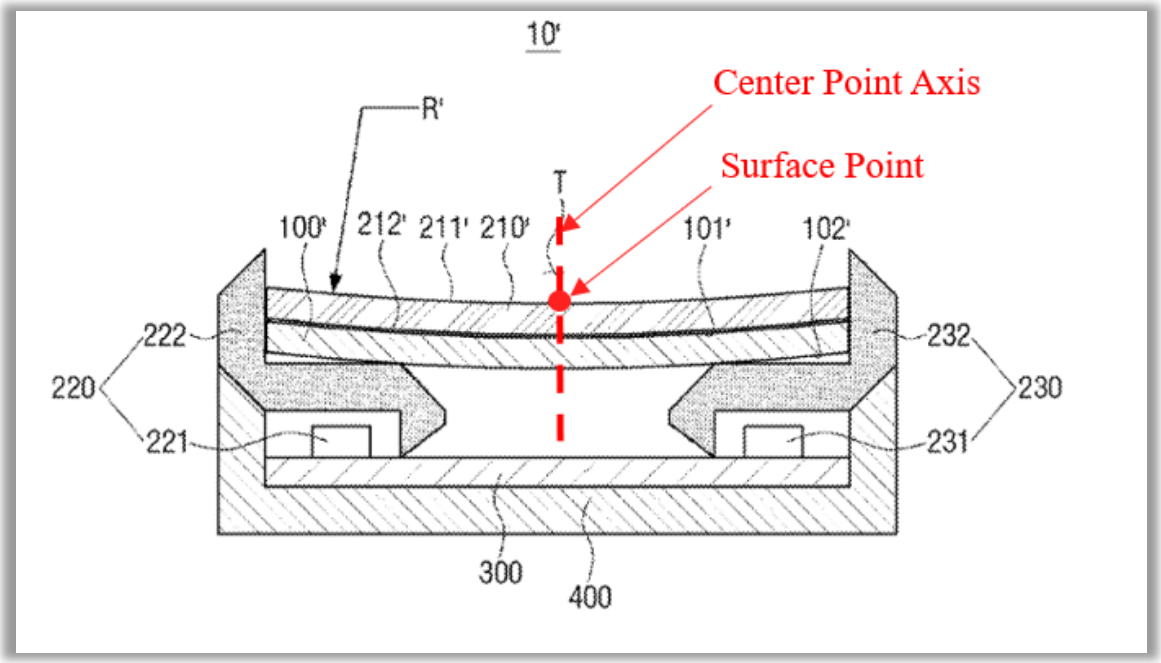
6. Claim 6: "The touch sensing apparatus of claim 3, wherein the first curvature and second curvature are measured along a line passing through a point on the touch surface."

267. In my opinion, Cao in view of Han discloses this element. Han teaches a parabolically curved plate (cover glass 210), with curvature relative to both a first (Ax) and second (Ay) axis. Ex. 1005 at [0074-77]



Ex. 1005 at Fig. 9.

268. Han further teaches a parabolic curvature as measured along an axis passing through a point on the touch surface (surface 211).



Ex. 1005 at Fig. 7.

269. In order to achieve improved touch detection of Han, it is my view that a POSA would have been motivated to modify Cao's glass 300 to have the same parabolic curvature as Han's, also as measured along an axis passing through a point on the surface of modified Cao's glass 300.

270. Thus, in my opinion, Cao in view of Han discloses wherein the first curvature and second curvature are measured along a line (axis passing through point on surface of modified Cao's glass 300) passing through a point on the touch surface (point on surface of modified Cao's glass 300).

7. Claim 7

(a) Preamble: "A touch sensing apparatus comprising:"

271. It is my opinion that each of Cao, Han, and Shin discloses this element. Cao, Han, and Shin disclose a touch sensing apparatus. Ex. 1010 at Abstract, Ex. 1005 at Abstract; Ex. 1011 at Abstract, 10:45-49.

272. Thus, in my opinion, Cao, Han, and Shin each disclose a touch sensing apparatus.

(b) "a display panel;"

273. It is my opinion that each of Cao, Han, and Shin discloses this element. Cao discloses a display panel (screen 200), Han discloses a display panel (display 100), and Shin discloses a display panel (display 151b). Ex. 1010, Abstract; Ex. 1005, Abstract; Ex. 1011, Abstract.

274. Thus, in my opinion, Cao, Han, and Shin disclose a display panel (screen 200, display 100, display 151b).

(c) "a plate having a width, a length and a periphery, the plate further including a touch surface;"

275. In my opinion, Cao discloses this element. Depicted below in Cao's Figs. 1 and 9, Cao discloses a plate (glass 300) having a width, a length, a periphery, and touch surface.

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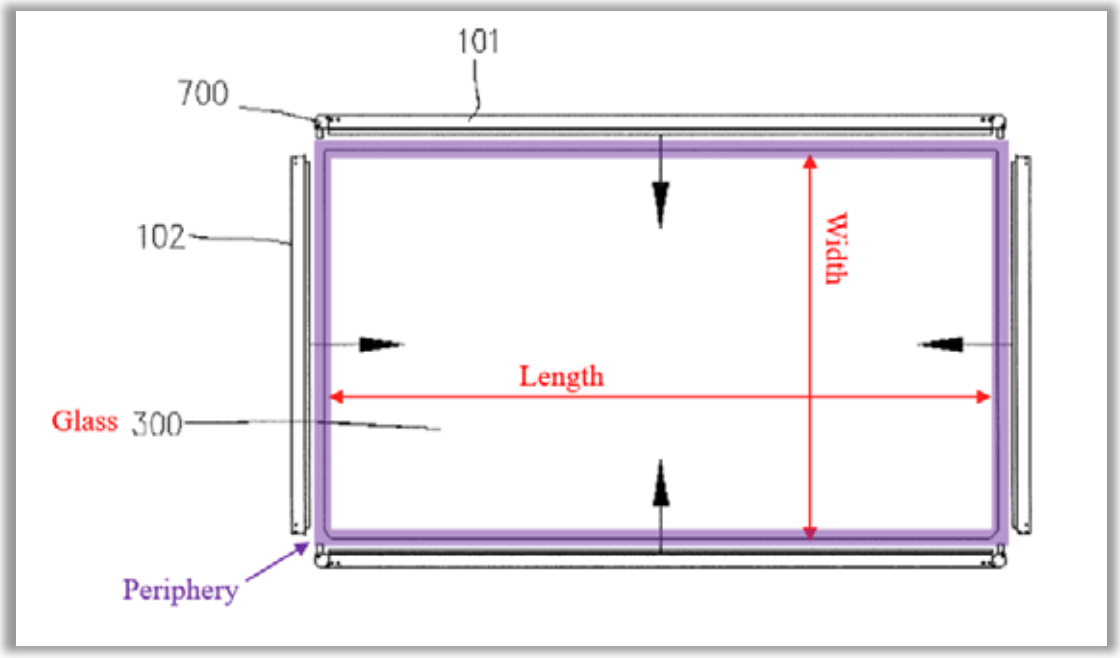
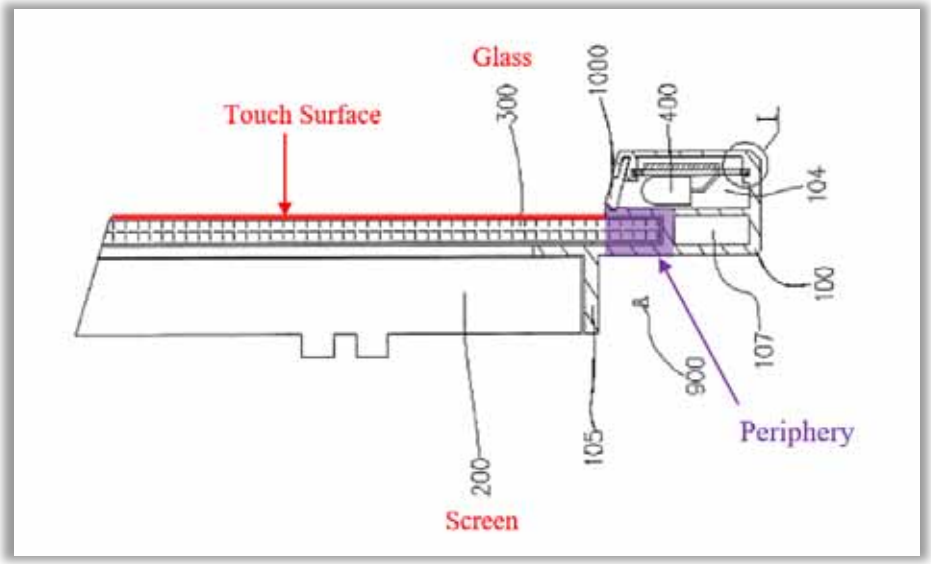


Ex. 1010 at Fig. 1.



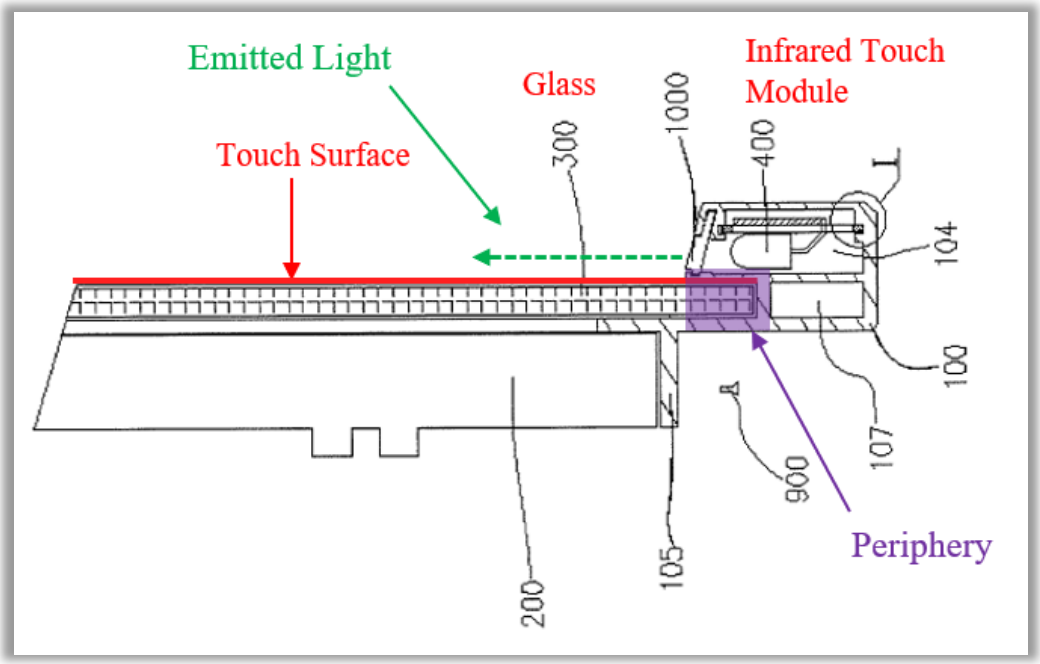
Ex. 1010 at Fig. 9.

276. Thus, it is my opinion that Cao discloses a plate (glass 300) having a width (width of glass 300), a length (length of glass 300) and a periphery (periphery

of glass 300), the plate further including a touch surface (top touch surface of glass 300).

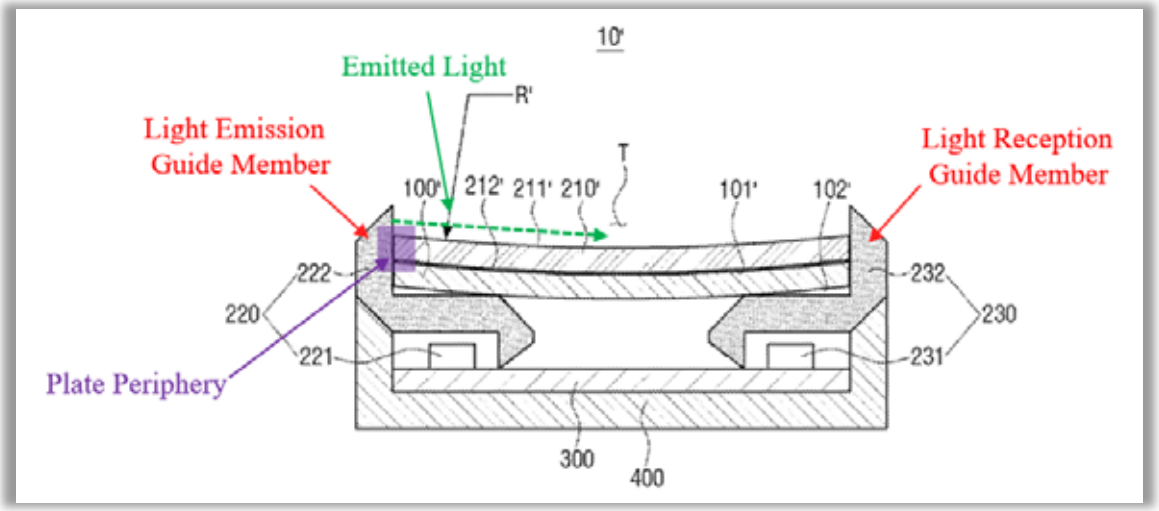
(d) "one or more emitters arranged adjacent to the periphery of the plate and configured to emit light across the touch surface of the plate;"

277. It is my opinion that Cao in view of Han discloses this element. As I discussed above for claim 1, Cao discloses at least one emitter (infrared touch module 400 with emitter) arranged adjacent to the periphery of a plate (glass 300) and configured to emit light across the touch surface of the plate.



Ex. 1010 at Fig. 9.

278. Han further teaches that "light A2 emitted from the light emitting surface 2221 of the light emission guide member 222 is reflected in a curved way along the concavely curved front surface 211 of the cover glass 210…" Ex. 1005 at [0085].



Ex. 1005 at Fig. 7.

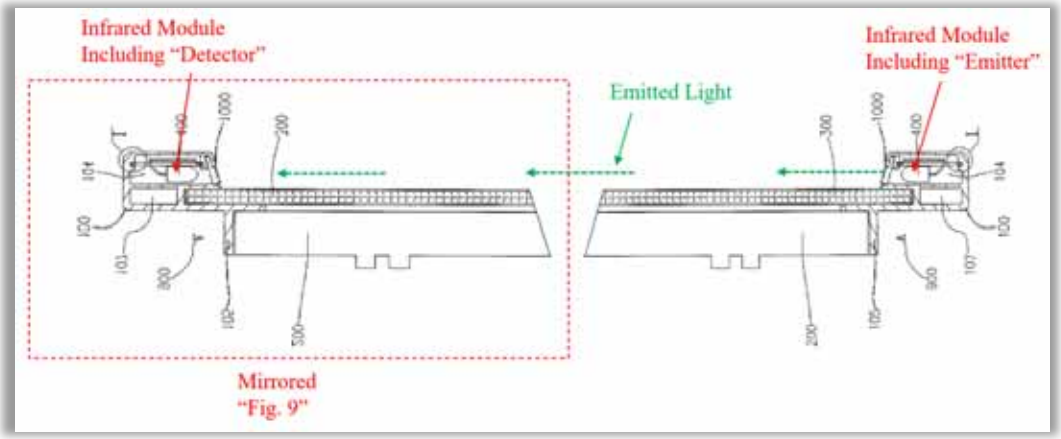
279. In modifying Cao to achieve Han's improve touch detection accuracy, it is my view that a POSA would have continued to implement an emitter adjacent to the periphery of the (curved) plate and configured to emit light across the surface of the curved glass 300.

280. Thus, in my opinion, Cao in view of Han discloses one or more emitters (Cao's infrared touch module 400 with emitter, Han's light emission guide member 222) arranged adjacent to the periphery of the plate (Cao's glass 300, Han's cover

glass 210) and configured to emit light across the touch surface (Cao's surface of glass 300, Han's front surface 211) of the plate.

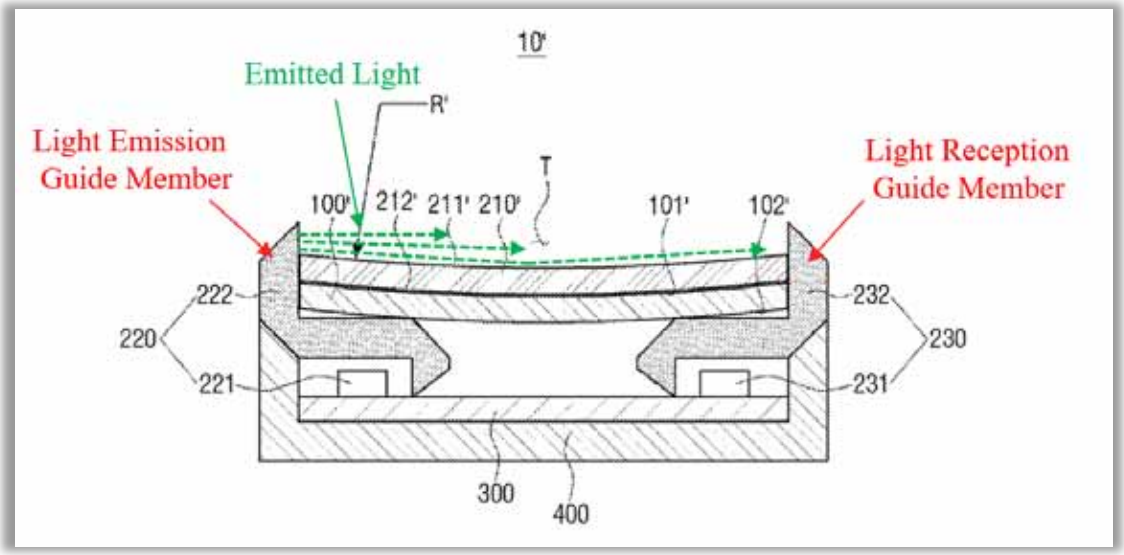
(e) "a set of detectors arranged adjacent to the periphery of the plate and configured to receive light from the set of emitters, and"

281. It is my opinion that Cao in view of Han discloses this element. As I also discussed above for claim 1, a POSA would have understood Cao to disclose at least one detector arranged adjacent to the periphery of a plate (glass 300). *See* Ex. 1010 at Fig. 9. In my view, a POSA would have understood Cao's disclosure of an infrared touch module 400 (with a depicted emitter) to also teach a detector, as this would have enabled infrared touch functionality by a touch interrupting light transmission between said emitter and detector. Such a configuration was widely known in the art. *See*, *e.g.*, Ex. 1001 at 1:26-46, 15:62-16:3.



Ex. 1010 at Fig. 9.

282. Further, Han teaches that light "irradiated from the light emitting surface 2221 of the light emission guide member 222 [] passes through the touch area T to the incident surface 2321 of the light reception guide member 232.



Ex. 1005 at Fig. 7.

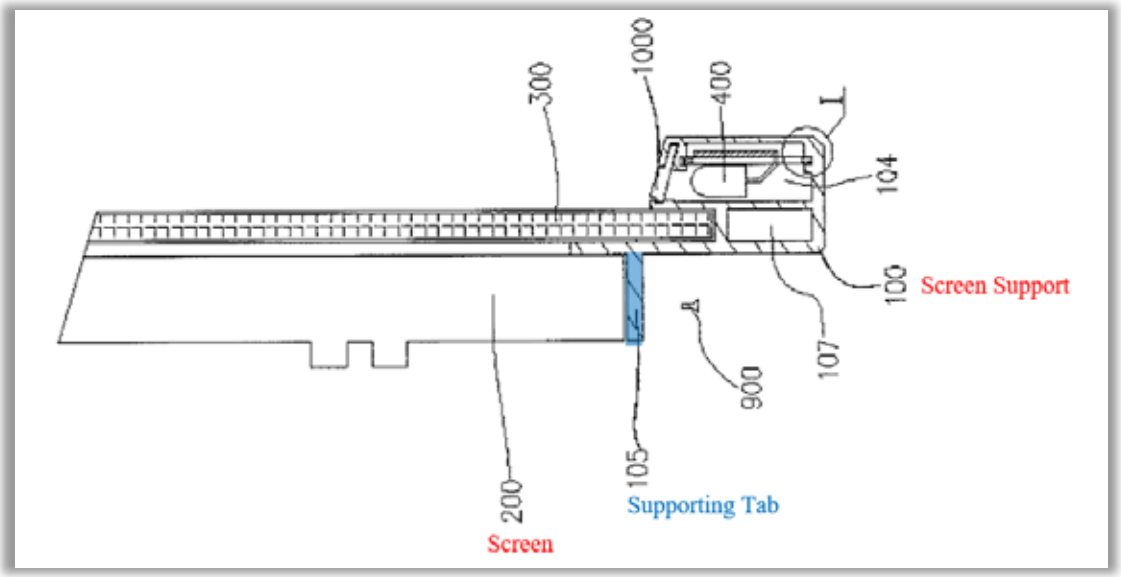
283. In modifying Cao to achieve Han's improved touch detection accuracy plate curvature, in my view, a POSA would have continued to implement a detector adjacent to the periphery of the (curved) plate and configured to receive light from the set of emitters.

284. Thus, in my opinion, Cao in view of Han discloses a set of detectors (Cao's infrared touch module 400 with detector, Han's light reception guide member 232) arranged adjacent to the periphery of the plate (Cao's glass 300, Han's cover

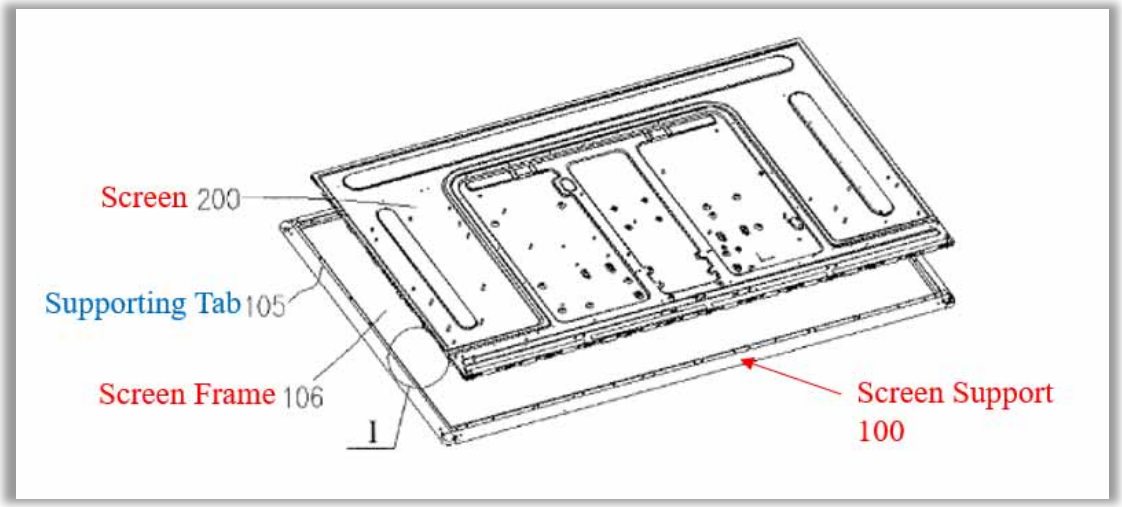
glass 210') and configured to receive light from the set of emitters (Cao's infrared touch module 400 with emitter, Han's light emission guide member 222).

(f) "a frame assembly, the frame assembly comprising: a first frame element configured to support the display panel; and"

285. It is my opinion that Cao discloses this element. Each screen support 100 of Cao defines a supporting tab 105 that, when four screen supports are joined together, define a screen frame 106. Ex. 1010 at 4:7:10, 5:34-36, 7:21-27, Figs. 3, 9, 14. Depicted below in Cao's Figs. 9 and 3, a screen 200 (display panel) is positioned into screen frame 106 and fixed by a screw 900 passing through screw holes defined in supporting tab 105 and screen back plate 203. *Id.* at 7:21-27, Fig. 9.



Ex. 1010 at Fig. 9.



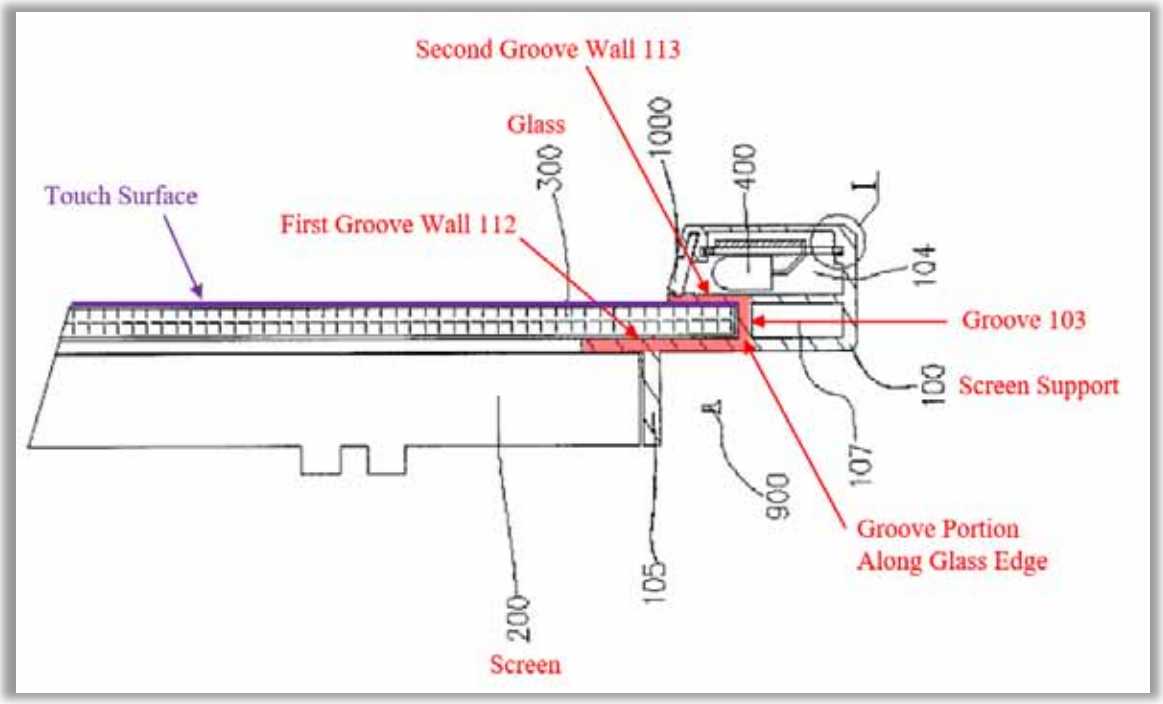
Ex. 1010 at Fig. 3.

286. Thus, in my opinion, Cao discloses a frame assembly (screen support 100), the frame assembly comprising: a first frame element (supporting tab 105 defining screen frame 106) configured to support the display panel (screen 200).

(g) "a second frame element arranged around at least a portion of the periphery of the plate, the second frame element having a first portion extending along an edge of the plate and a second portion opposed to the touch surface;"

287. In my opinion, Cao discloses this element. Cao discloses a screen support 100 including a groove 103 with a first groove wall 112 and second groove wall 113. Ex. 1010 at 5:47-53. Visible in Cao's Fig. 9 below, the groove 103 has a portion extending along the edge of the glass 300. From my understanding of Patent Owner's construction of "opposed" depicted in the co-pending litigation, Cao's

second groove wall 113 is opposed to the touch surface of glass 300. *Id.* at Fig. 9; *see* Ex 1019 at 203.



Ex. 1010 at Fig. 9.

288. Thus, in my opinion, Cao discloses a second frame element (screen support 100) arranged around at least a portion of the periphery of the plate (glass 300), the second frame element having a first portion (groove portion along edge of glass 300) extending along an edge of the plate and a second portion (second groove wall 113) opposed to the touch surface.

(h) "wherein the plate has a first curvature in the touch surface when not installed in the frame assembly, and wherein the plate has a second curvature along the width and along the length in the touch surface when the plate is installed in the frame assembly, said second curvature is parabolic; and"

289. In my opinion, Cao in view of Han and Shin discloses this element. As I explained above in an embodiment of the modified Cao device, the pre-installed glass 300 has an initial curvature according to the well-known material property of pre-installed stock tempered glass. *See* Ex. 1010 at 2:20-24; Ex. 1023; Ex. 1025; Ex. 1026; *see also* Ex. 1001 at 2:5-9. As the glass 300 is assembled into the modified Cao curved screen supports 100 and grooves 103 according to Shin, they apply a bending force to Cao's glass 300, which induces glass 300 to curve into a second curvature greater than the first curvature based on the slope of the grooves 103 along both Ax and Ay directions. According to Han's teaching of improving touch detection accuracy, the induced second curvature of the modified Cao glass 300 would be parabolic and would comprise a first axis component along the length of glass 300 (Ax) and second axis component along the width of glass 300 (Ay).

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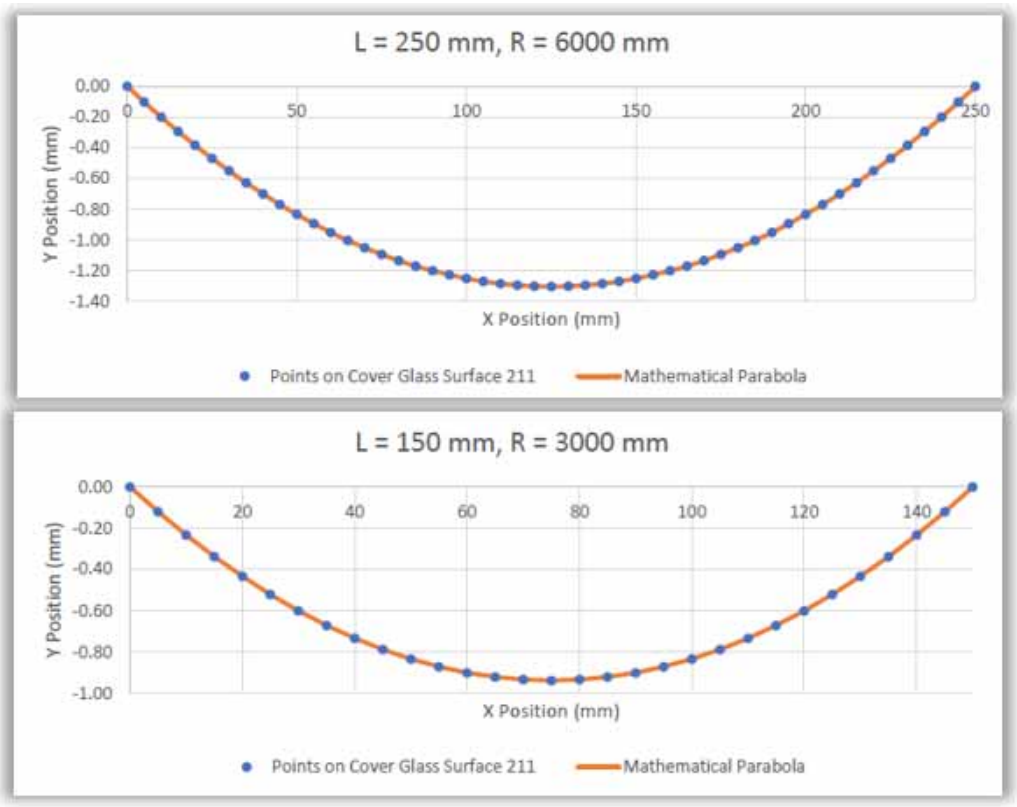

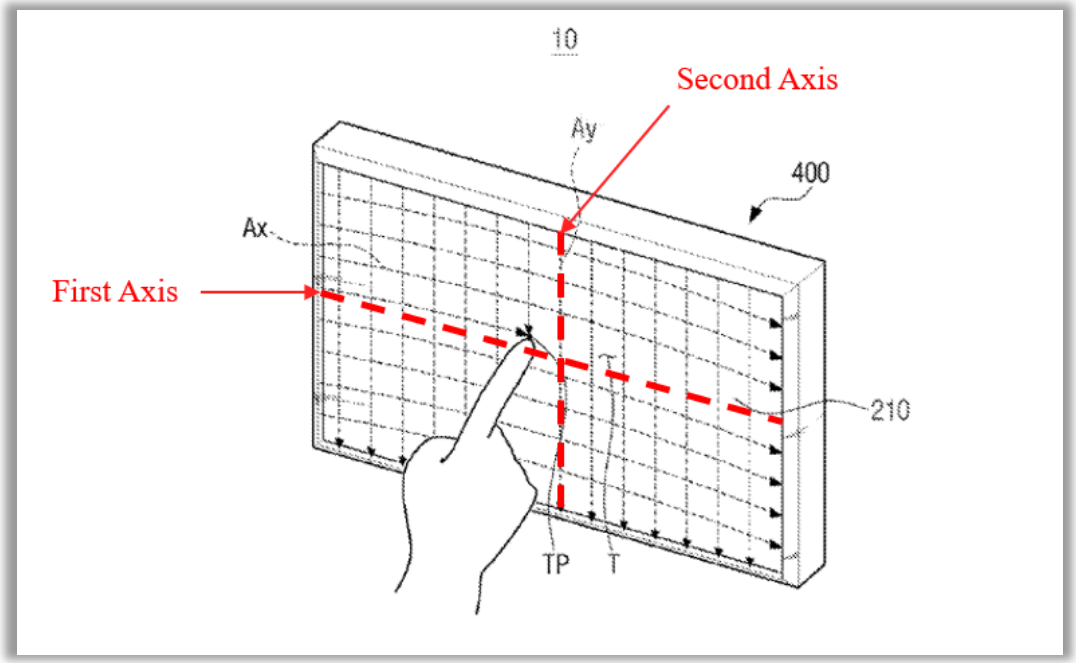

Ex. 1005 at Fig. 2.

290. Thus, in my opinion, Cao in view of Han and Shin discloses wherein the plate has a first curvature (stock material curvature of Cao's pre-installed glass 300) in the touch surface when not installed in the frame assembly, and wherein the plate has a second curvature (induced post-assembly curvature) along the width and along the length in the touch surface when the plate is installed in the frame assembly, said second curvature is parabolic (post-installed parabolic curvature of modified Cao glass 300).

(i) "wherein the first curvature is concave."

291. In my opinion, Cao discloses this element. Cao discloses utilizing a frame assembly 100 to force the "four rising corners of the glass" to "remain flat…" Ex. 1010 at 2:20-24, 2:39-44. In my view, a POSA would have understood Cao's glass 300 outside of the frame assembly 100 (i.e. before installation) to have unrestrained "four rising corners." *See* Ex. 1010 at at 2:20-24. A POSA would have further understood the "four rising corners" of Cao's pre-installed glass 300 to equate to either a "concave" first curvature and "convex" first curvature, depending on the orientation of the pre-installed glass 300 relative to the frame assembly 100. *Id.* In the case where the rising corners of the pre-installed glass 300 lift upward and away from the screen supports 100, Cao discloses a concave first curvature. *Id.*

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292. Further, bow curvature of stock tempered glass is commonly described in the art as being "concave." *See* Ex. 1023; Ex. 1025; Ex. 1026. A POSA would thus be familiar not only with stock glass being curved, but stock glass being *concavely* curved.

293. Thus, in my opinion, Cao discloses wherein the first curvature is concave ("four rising corners" of glass 300 lifting away from screen supports 100 before installation).

8. Claim 8: "The touch sensing apparatus of claim 7, further comprising a processing element configured to determine, based on output signals of the set of detectors, a position of an object proximate to the touch surface."

294. In my opinion, Cao in view of Han discloses this element. Cao discloses a "smart" tablet PC. Ex. 1010 at Abstract. In my view, a POSA would understand "smart" to denote computational functionality executed at least by a processor. Further, Han discloses a controller integrated circuit ("IC") that "performs the role of identifying the location where a signal was generated according to occurrence of contact or change of electrical capacity, and transmitting the information on the location to a controller IC" Ex. 1005 at [0012]. The IC "modif[ies] an analog signal transmitted from a touch detecting unit into a digital

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signal and chang[es] the signal to a form of a coordinate which can be displayed on the screen…" *Id.* At [0013]. In my view, a POSA would have understood Han's IC to embody a typical element performing typical functions to enable touch sensing functionality in infrared touch devices, including the infrared touch device of Cao.

295. Further in my view, a POSA would have understood Cao to include a processing element for determining a touch location relative to the touch surface of the glass 300 based on output signals of the infrared modules 400 (having detectors) as this would embody a typical configuration to enable optical touch sensing functionality. Han's teachings confirms the same. *See* Ex. 1005 at [0012-13].

296. Thus, in my opinion, Cao in view of Han discloses a processing element (Han's integrated circuit IC) configured to determine, based on output signals of the set of detectors (Han's photo diodes 231 and light reception guide members 231), a position of an object (a touch at touchpoint at Han's TP) proximate to the touch surface (Han's front surface 211).

9. Claim 9: "The touch sensing apparatus of claim 7, wherein the first curvature and second curvature are measured along an edge of the plate."

297. In my opinion, Cao in view of Han and Shin discloses this element.

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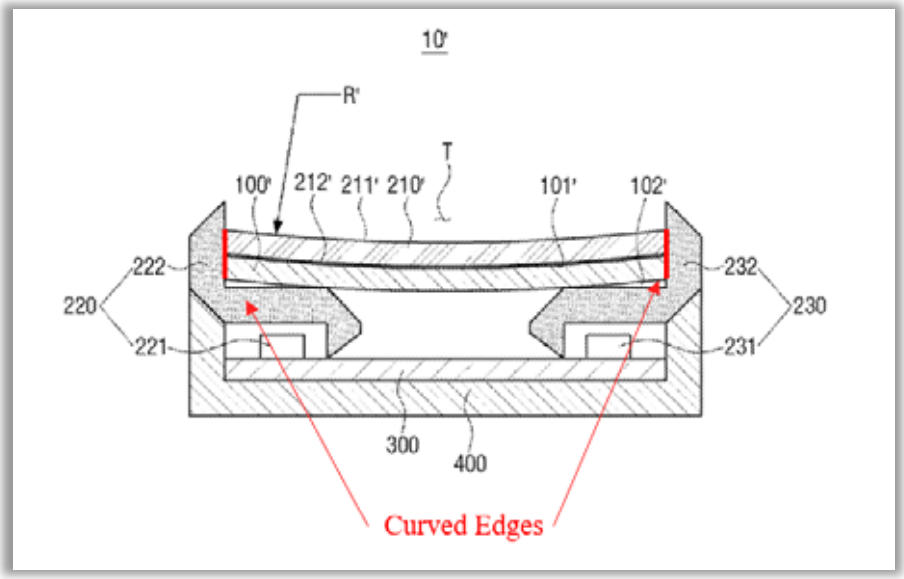

Ex. 1005 at Fig. 7.

298. For at least the same reasons and rationale I have laid out above for claim 4, it is my opinion that Cao in view of Han and Shin discloses the first curvature and second curvature are measured along an edge (edges of Cao's modified screen 300 curved along Ax and Ay directions according to Han) of the plate (Cao's modified screen 300).

10. Claim 10: "The touch sensing apparatus of claim 7, wherein the first curvature and second curvature are measured along an axis passing through a center point of the plate."

299. In my opinion,Cao in view of Han discloses this element.

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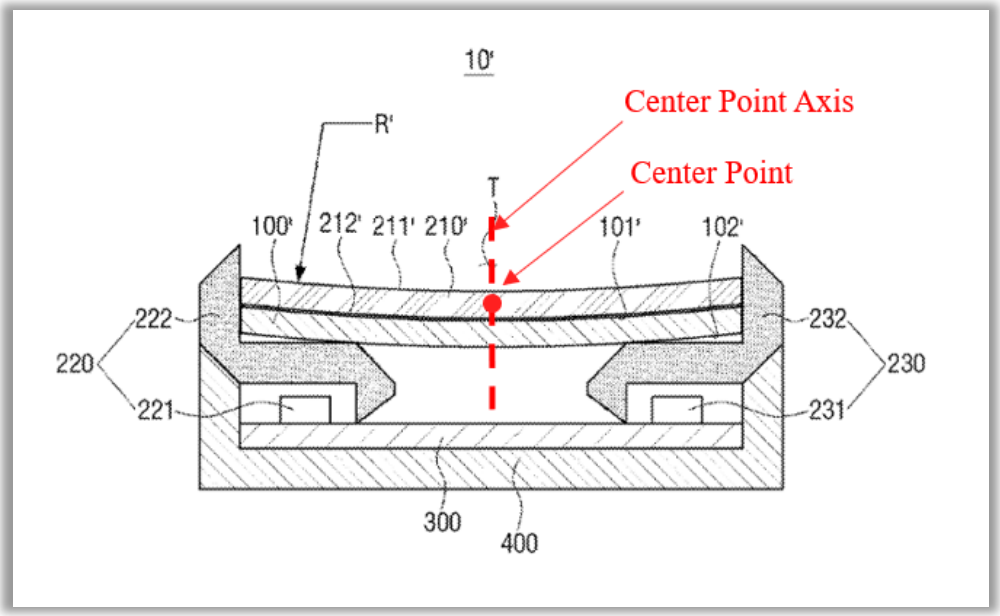
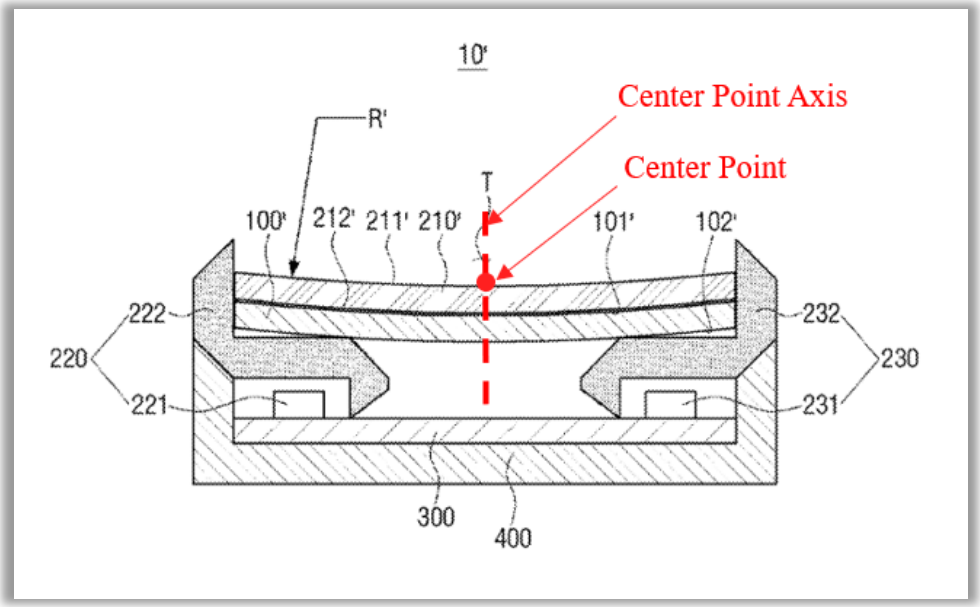


Ex. 1005 at Fig. 7.

300. For at least the same reasons and rationale I have laid out in claim 5 above, it is my opinion that Cao in view of Han discloses the first curvature and second curvature are measured along an axis (center point axis passing through Cao's modified glass 300) passing through a center point (center point of Cao's modified glass 300) of the plate.

11. Claim 11: "The touch sensing apparatus of claim 7, wherein the first curvature and second curvature are measured along a line passing through a point on the touch surface."

301. It is my opinion that Cao in view of Han discloses this element.

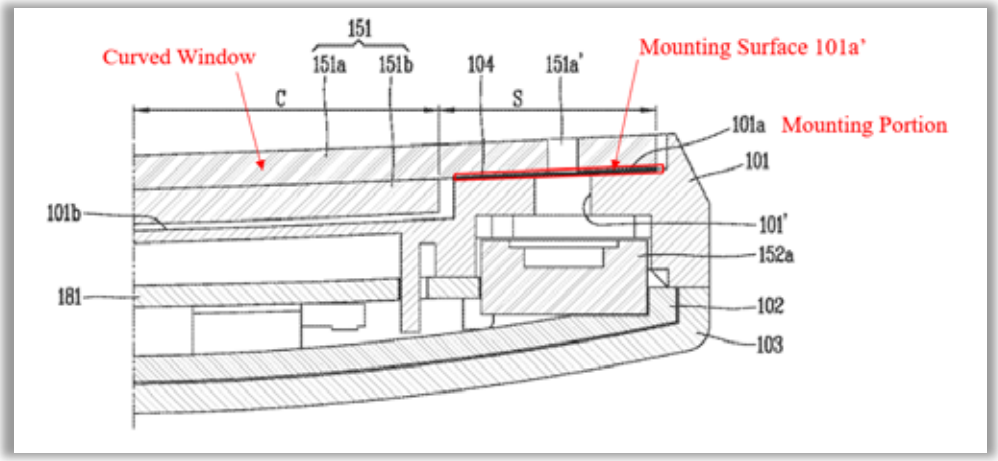


Ex. 1005 at Fig. 7.

302. For at least the same reasons and rationale I have laid out in claim 6 above, it is my opinion that Cao in view of Han discloses the first curvature and second curvature (curved pre-installed screen and curved screen 300 in Ax and Ay directions) are measured along a line passing through a point (axis passing through center point of Cao's glass 300) on the touch surface (surface of Cao's glass 300).

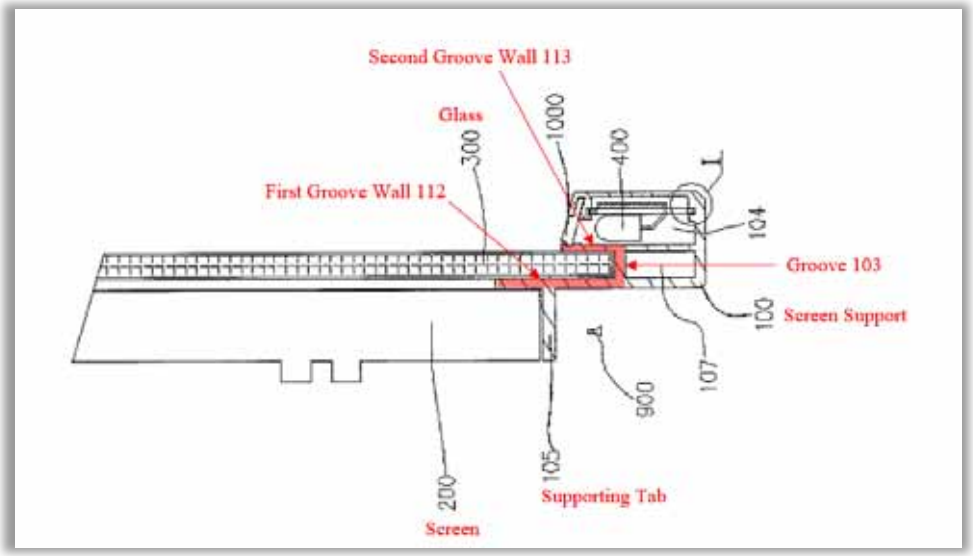
12. Claim 14: "The apparatus of claim 7, wherein the second frame element is curved."

303. It is my opinion that Cao in view of Shin discloses this element. As I discussed above, the curved mounting surface 101a' in Shin induces curvature in the window 151a. Ex. 1011 at 22:53-63.



Ex. 1011 at Fig. 5.

304. In the modified Cao device according to Shin, Cao's groove 103 including first and second groove walls 112, 113 would also be curved to induce curvature in Cao's glass 300. In other words, the second frame element (groove 103) in the modified Cao element would be curved. In my view, a POSA would have expected such a modification to result in a simplified manufacturing process of achieving a curved glass 300, as taught by Shin. *See* Ex. 1011 at 18:57-64.



Ex. 1010 at Fig. 9

305. Thus, in my opinion, Cao in view of Shin discloses wherein the second frame element is curved (Modified Cao's curved groove 103 including first and second groove walls 112, 113).

X. CONCLUSION

306. For the reasons and rationales I have discussed herein, it is my opinion that with regards to the '935 Patent, claims 1-14 are obvious under Cheng in view of Han and Zhao. It is my further opinion that claims 1-11, and 14 are obvious under Cao in view of Han and Shin.

* * *