

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. 11,281,335

Title: TOUCH DEVICE

**DECLARATION OF DARRAN CAIRNS, PH.D. UNDER 37 C.F.R. § 42.100
REGARDING U.S. PATENT NO. 11,281,335**

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. 11,281,335 (“the ’335 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

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 '335 Patent. Based on my experience and education, and the

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 '335 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 '335 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 '335 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

matter claimed by the '335 Patent. I understand that the '335 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

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;

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
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.
1008	Korean Pub. App. No. KR2018-0037749 to Han et al.

Exhibit No.	Title
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	<i>Reserved</i>
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	<i>FlatFrog Laboratories AB v. Chemtronics Co., LTD.</i> , Case No. 2:23-cv-00306 (E.D. TX), filed on June 26, 2023
1019-1026	<i>Reserved</i>
1027	US Patent Application No. 12/893,381 to Miller et al.
1028	Chinese Published Patent Application CN104808843A to Kang

Exhibit No.	Title
1029	Certified Translation of Chinese Published Patent Application CN104808843A to Kang
1030	U.S. Patent No. 9,207,800 to Eriksson et al.
1031	U.S. Patent No. 11,281,335 to Kocovski et al.
1032	Prosecution History for U.S. Patent No. 11,281,335 to Kocovski et al
1033	Expert Declaration of Darran R. Cairns, Ph.D., regarding U.S. Patent No. 11,281,335
1034	U.S. Patent Pub. No. 20160334942 to Wassvik et al.
1035	U.S. Patent Pub. No. 10860142 to Northcott et al.
1036	U.S. Patent Pub. No. 2017/0308236 to Lee et al.
1037	Chinese Application No. CN102117155 to Liu et al.
1038	Claim Chart for US Patent No 11,281,335 (Case No. 2:23-cv-00306) (E.D. TX)

IV. PERSON OF ORDINARY SKILL IN THE ART

23. It is my understanding that when interpreting the claims of the '335 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 ’335 Patent is December 7, 2016.

24. In my opinion, a POSA for the ’335 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.

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 ’335 Patent’s claims at the time of invention. I have also reviewed and

considered the Patent Owner's construction of the '335 Patent claims as informed by its allegations in co-pending litigation with Chemtronics as well as prior litigation involving the '335 Patent. *See* Exs. 1018, 1038.

VI. TECHNOLOGY BACKGROUND AND THE '335 PATENT

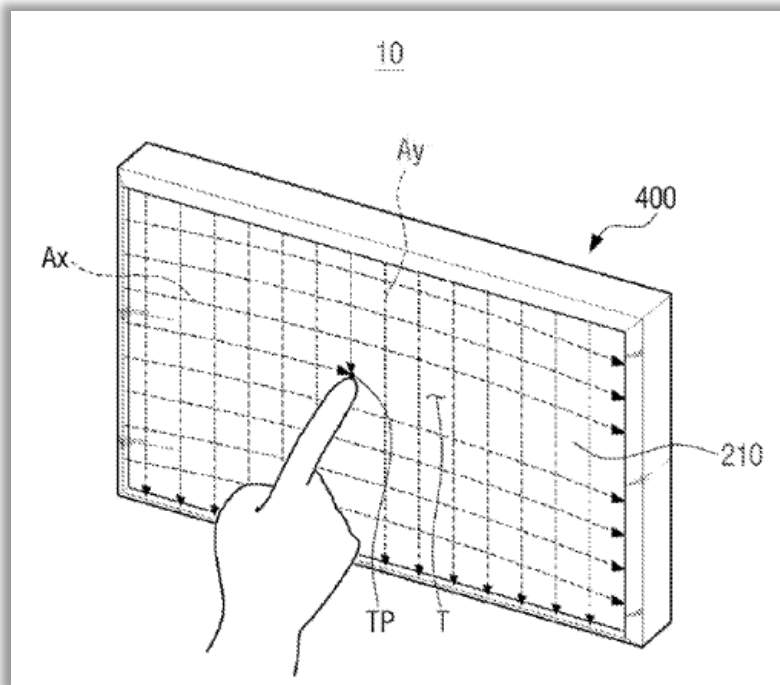
A. State Of The Art

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, concave curvature resulted in reduced emitted light loss and improved touch detection accuracy performance. As cover glass is commonly supported by frame elements, it was known that curved frame elements may be implemented to support a curved cover glass. It was known that cover glass could be induced into a parabolic, concave curvature utilizing configurations of frame

elements imparting force against the cover glass during the assembly process. Further, it was known that light could be transmitted through cover glass (curved or otherwise) via total internal reflection to increase touch detection and visual display performance.

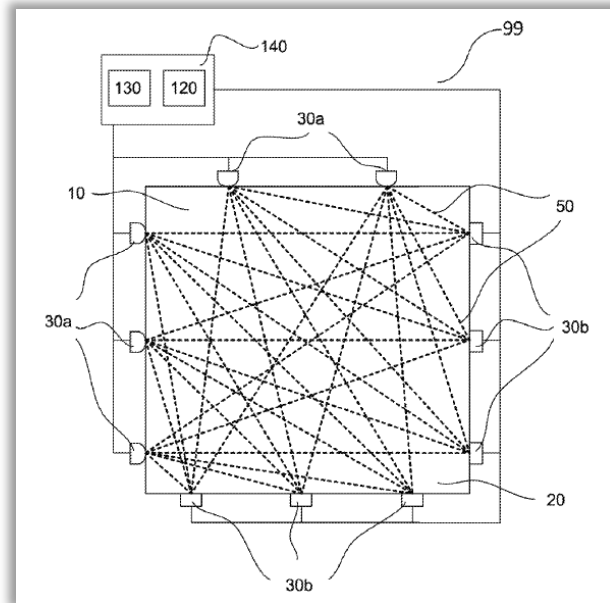
B. Prior Art Background And The '335 Patent

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 '335 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.*



Ex. 1005 at Fig. 2.

30. In my opinion, the '335 Patent claims the same light detection methodology. For example, the '335 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.*

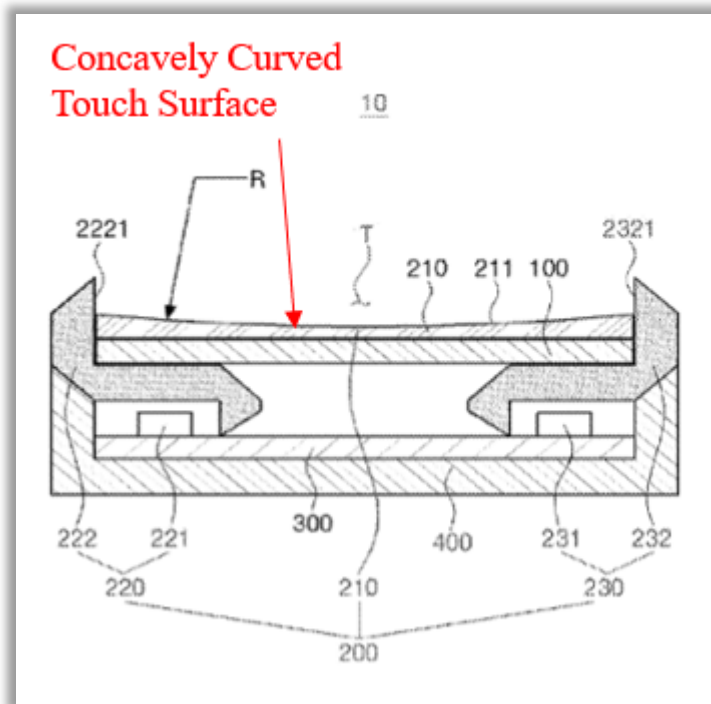


Ex. 1001 at Fig. 9.

31. The '335 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 '335 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].

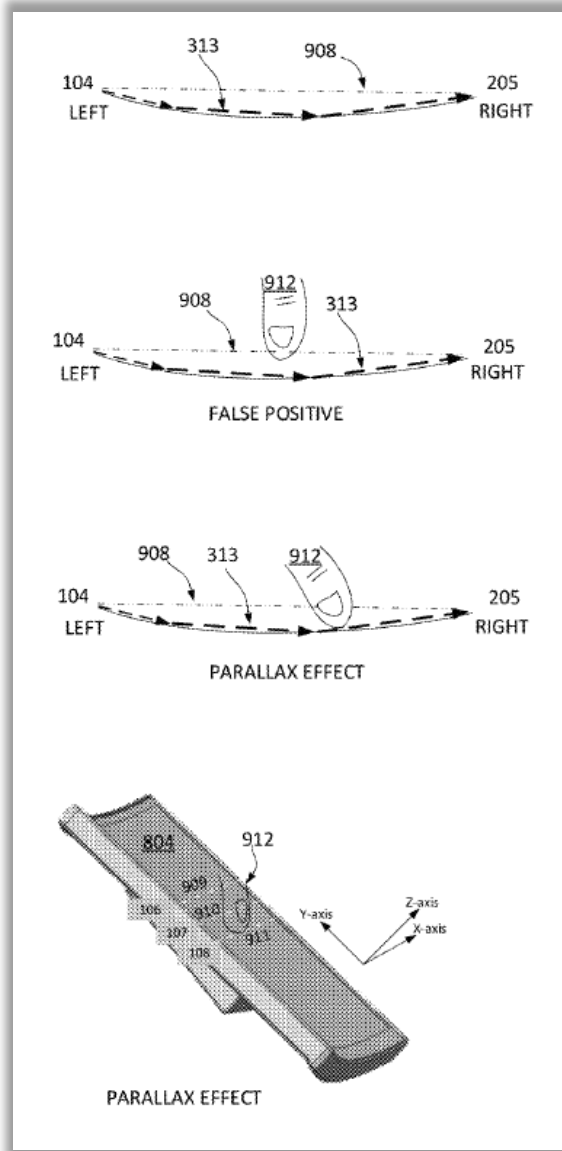


Ex. 1005 at Fig. 3.

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 '335 Patent expressly teach parabolically curved touch surfaces. For example, references including Miller, Kang, Christiansson, and Eriksson teach that touch surfaces of touch devices may

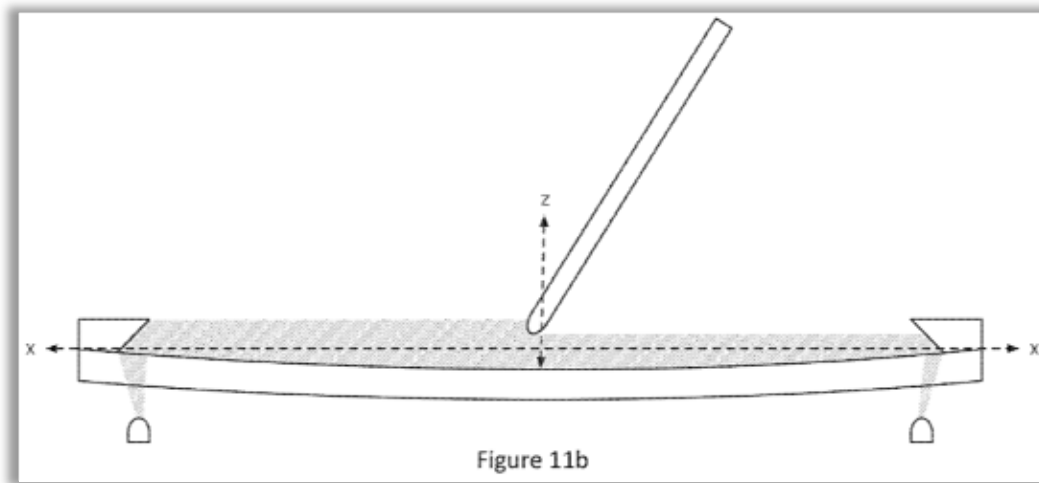
be curved or parabolic in shape. See Ex. 1027 at [0047], [0049], Fig. 9; Ex. 1029 at [0028], [0040]; Ex. 1016 at [0071]; Ex. 1030 at 3:6-46, Figs. 29-31.



Ex. 1030 at Fig. 31.

35. It is my opinion that the '335 Patent claims the same parabolic, concave curvature in the cover plate of a touch sensing method and apparatus. According to

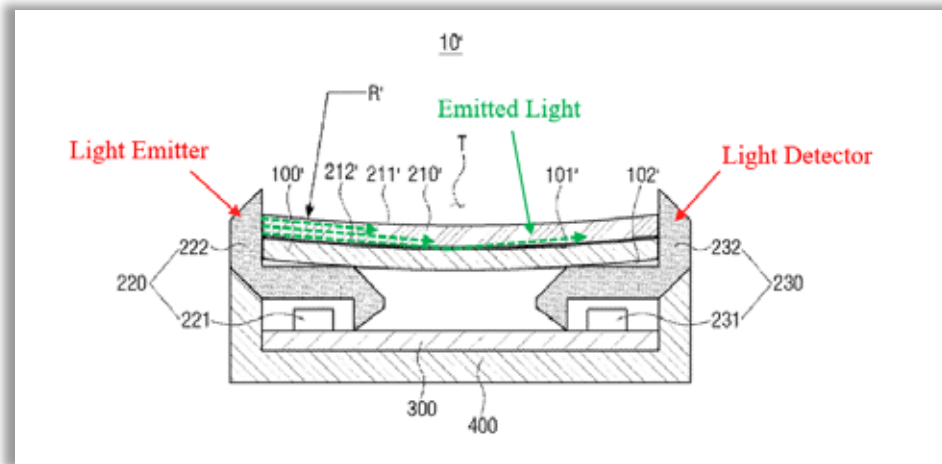
the '335 Patent, a plate having a parabolic curvature increases the amount of light transmitted from the emitters that is received at the detectors (rather than being “lost” above or below the detectors), resulting in a “signal boost” that improves touch recognition. *See id.*, Figs. 13a-17b; 17:48-18:44. In one embodiment, the '335 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. In addition to light transmission above or near a cover glass, Han teaches transmitting light through the cover glass via total internal reflection. Ex. 1005, [0115-16]. Han explains that the inside surface of the cover glass may have the same concave curvature as the outside surface, thus “light [emitted from light emission guide member 222] passing through the inside of the cover glass 210’

may be guided to the incidence surface 2321 of the light reception guide member 232.” *Id.*



Ex. 1005 at Fig. 7.

37. The '335 Patent claims the same total internal reflection through the cover glass, claiming “wherein the plurality of emitters is configured to emit light through the plate by total internal reflection.” Ex. 1031, claim 3.

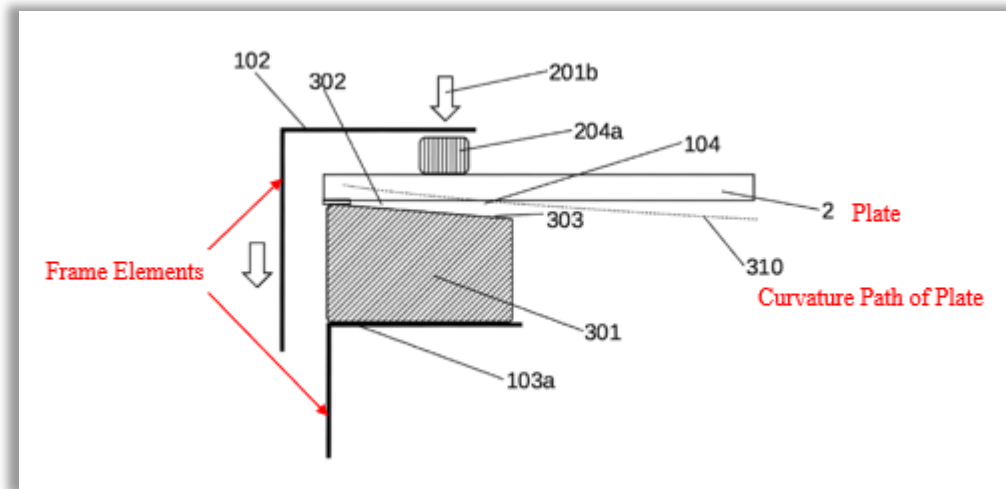
38. From my review, it is my opinion that the prior art teaches that a frame assembly can be used to control curvature of a glass plate in an optical touch sensing apparatus. Ex. 1011 at 18:47-64; Ex. 1010 at 4:13-26. For example, Shin teaches that, as an alternative to pre-curving a plate touch surface,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

39. It is my opinion that the '335 Patent claims the same control of a touch plate curvature using a frame assembly. Just as in Shin and Zhao, the '335 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.



Ex. 1001 at Fig. 7.

40. The '335 Patent claims "...a gasket, wherein the plate is supported by the gasket along the surface of the plate that defines the plate thickness. *Id.* at claim 5.

41. As I describe in specificity below, it is my opinion that the '335 Patent claims known structures and methods to provide solutions to problems that were already well understood in the art.

C. Related And Priority Applications

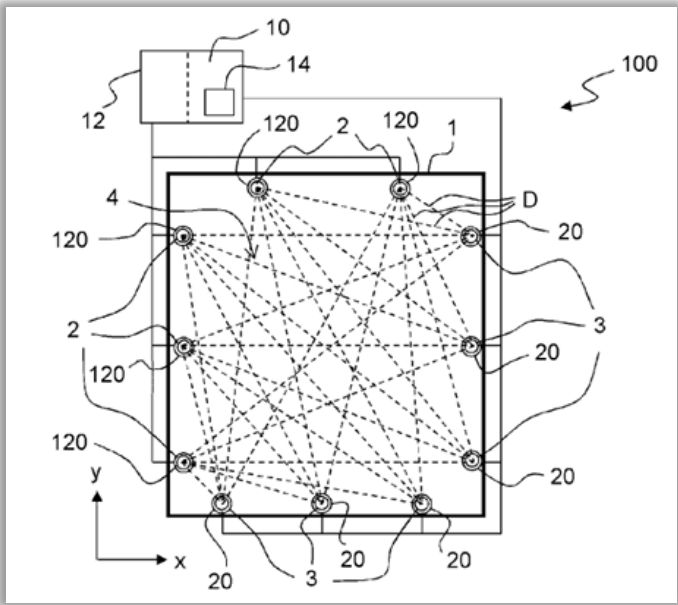
42. From my review of the relevant related and priority applicatoins, I understand that the '335 Patent issued from U.S. Application No. 16/403,283 ("the '283 Application") on March 22, 2022. The '283 Application was filed May 3, 2019, as a continuation of US. Application No. 16/190,907 ("the '907 Application"). The '907 Application was filed November 14, 2018, as a national stage entry from PCT Application PCT/SE2017/051233 ("the '233 PCT"). The '233 PCT was filed

December 7, 2017 and claimed priority to Swedish Application SE1630294, filed December 7, 2016.

D. Prosecution History

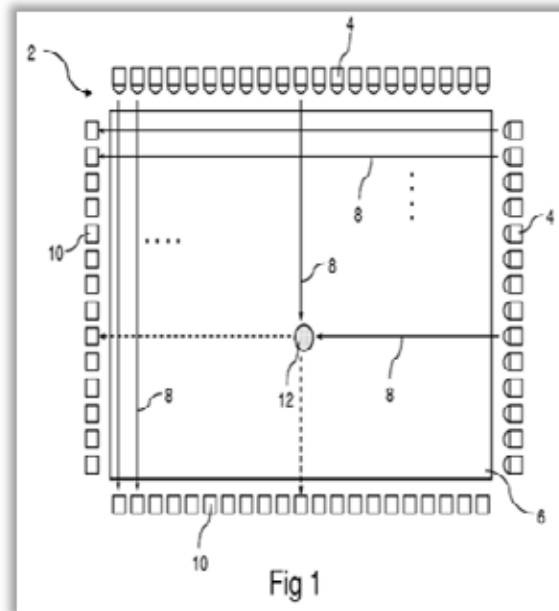
43. I understand that during prosecution, the '335 Patent traversed multiple Office Actions that relied on various combinations of U.S. Patent Pub. No. 20160334942 ("Wassvik"), U.S. Patent Pub. No. 20120223916 ("Kukulj"), U.S. Patent Pub. No. 20160295711 ("Ryu"), U.S. Patent Pub. No. 10860142 ("Northcott"), U.S. Patent Pub. No. 20170308236 ("Lee"), and Chinese Application No. CN102117155 ("Liu"). *See generally*, Ex. 1032.

44. Wassvik disclosed an infrared-style touch screen with emission and detection means along sides of a touch input area and including internal light refraction in a glass plate. Ex. 1034 at Abstract.



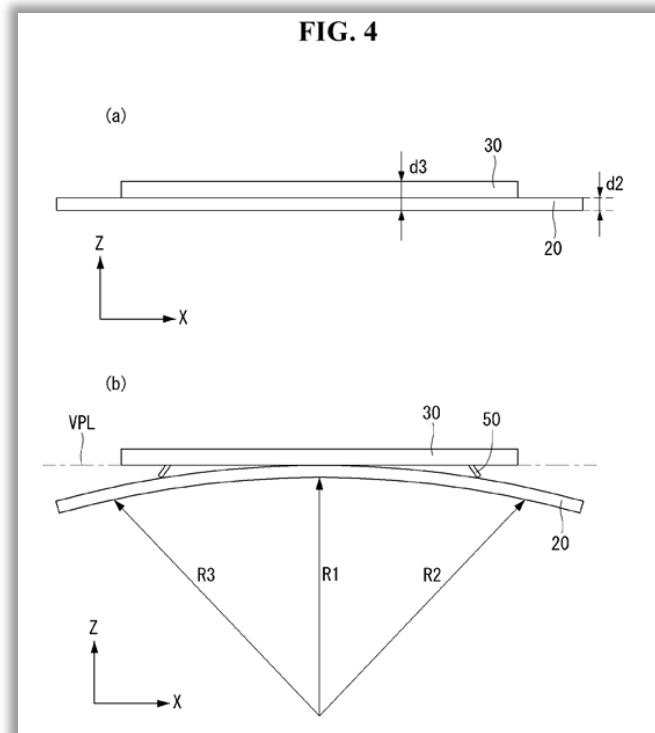
Ex. 1034 at Fig. 2A

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



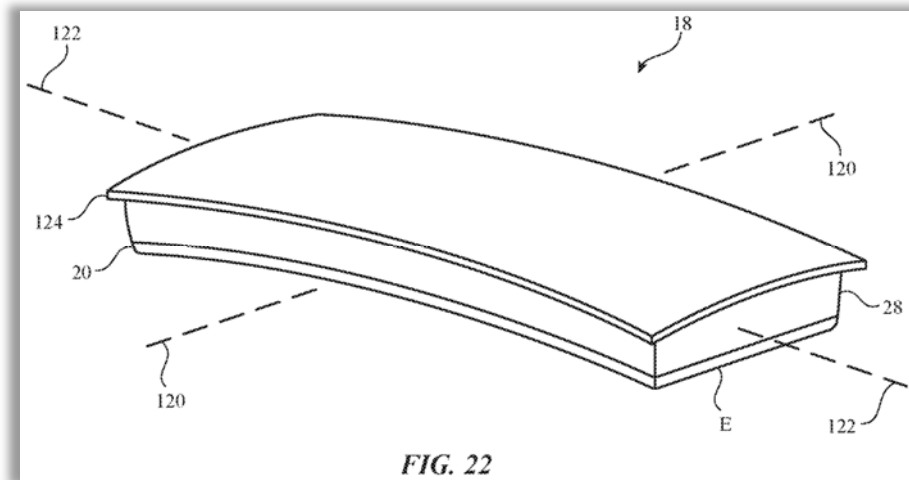
Ex. 1014 at Fig. 1

46. 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 at Abstract, Fig. 4.



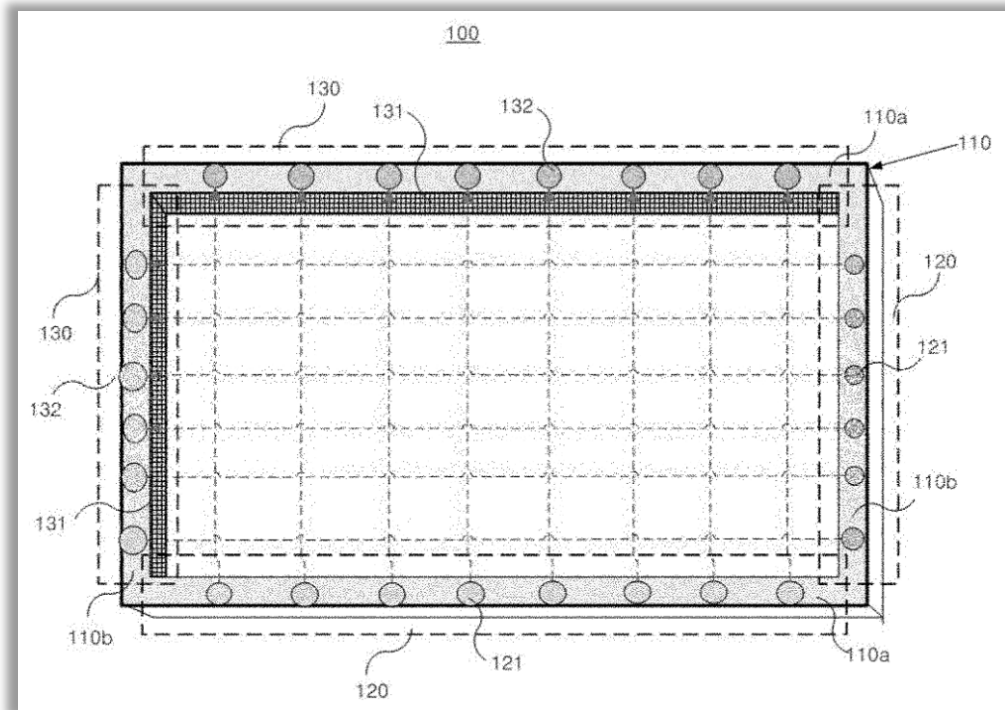
Ex. 1015 at Fig. 4.

47. Northcott disclosed a light-based device with light guide arrays having light emitting diodes and a compound curvature. Ex. 1035 at Abstract.



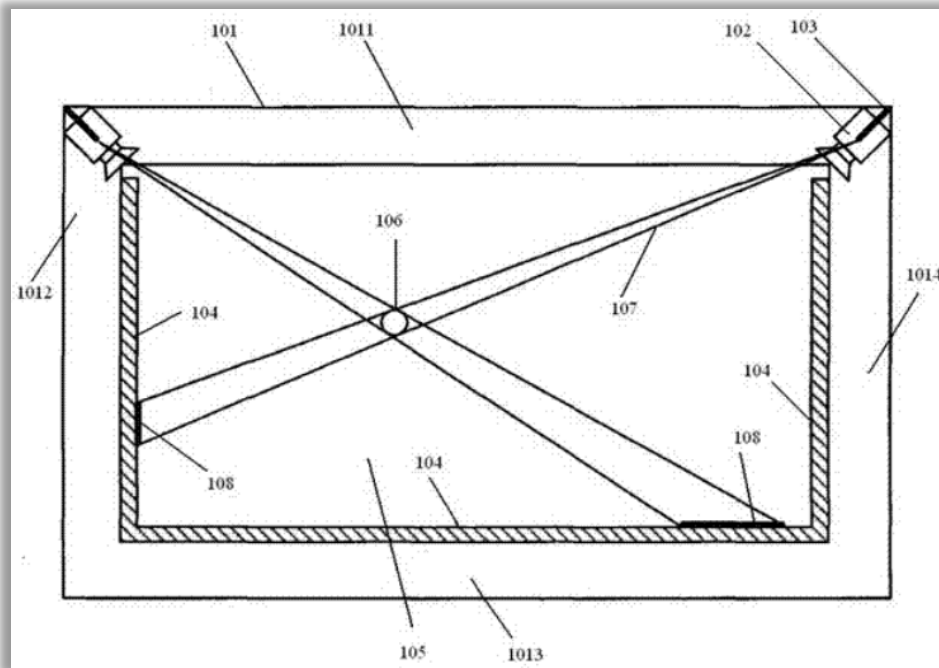
Ex. 1035 at Fig. 22.

48. Lee disclosed an infrared touch screen device with multiple light transmitting elements installed along a vertical and horizontal bezel. Ex. 1036 at Abstract.



Ex. 1036 at Fig. 1.

49. Liu disclosed an optical touch screen comprising a frame, optical sensor, light source, retroreflective bar and touch panel. Ex. 1037 at Abstract. The touch panel included a concave curvature. *Id.*



Ex. 1037 at Fig. 1.

50. On March 26, 2020, the Examiner issued a Non-Final Office Action for the '283 Application. Ex. 1032 at 1034. Claims 2 – 12 were noted as allowable, while claims 13 – 16 and 21 were rejected as anticipated by Wassvik. *Id.* at 1035. Claims 17 – 20 were rejected as obvious over Wassvik in view of Ryu. *Id.*

51. On September 24, 2020, the Applicant amended the claims, primarily focusing on limitations related to the configuration of the plate curvature and frame elements. *See Id.* at 669-672.

2. (Currently Amended) A touch sensing apparatus having a long edge and a short edge, the touch sensing apparatus comprising:

- a display panel;
- a plate including a touch surface;
- a plurality of emitters arranged around a portion of the periphery of the plate and configured to emit light across the touch surface of the plate,
- a plurality of detectors arranged around a portion of the periphery of the plate and configured to receive light from the plurality of emitters, and
- a frame assembly, the frame assembly comprising:
 - a first frame element configured to support the display panel;
 - a second frame element arranged around the periphery of the plate and configured to support the plurality of emitters and plurality of detectors,

wherein the second frame element including a first surface arranged against an edge of the plate and a second surface arranged parallel to the touch surface,

the touch surface including:

- a first edge and a second edge parallel to the short edge; and
- a third edge and a fourth edge parallel to the long edge;

wherein ~~a first plane defined by~~ the touch surface is curved with respect to a second plane defined by the short edge and the long edge; and

wherein a distance between a first line in the ~~first plane~~ touch surface and the second plane varies according to a parabolic function.

Ex. 1032 at 669.

13. (Currently Amended) A touch sensing apparatus comprising:
a display panel;
a rectangular plate including a touch surface;
a plurality of emitters configured to emit light across the touch surface of the rectangular plate, and
a frame element configured to support the display panel, the rectangular plate, and the plurality of emitters, said frame element comprising:
an edge portion ~~including a longitudinal axis and being~~ configured to contact at least arranged along an edge of the plate between a first corner and a second corner of the rectangular plate,
wherein the edge portion is curved such that a distance between the longitudinal axis of the edge portion and a straight line between the first corner and the second corner varies according to a parabolic function and wherein the curved edge portion is configured to enable curvature in the rectangular plate.

Ex. 1032 at 670-71.

21. (Currently Amended) A touch sensing apparatus comprising:
a frame element configured to ~~be arranged along an edge of contact a~~
~~plate at least a portion of an edge of a plate, said plate~~ including a touch surface;
wherein the frame element includes a curvature along a longitudinal axis
of the frame element, and
wherein the curvature of the frame element is configured to induce a
corresponding curvature in the plate ~~such that a distance between the touch~~
~~surface and a straight line parallel to the edge of the plate varies according to a~~
~~parabolic function.~~
22. (New) The touch sensing apparatus of claim 21, wherein the plate has a
first curvature prior to installation and, when assembled, the frame element
induces the plate into having a second curvature greater than the first curvature.
23. (New) The touch sensing apparatus of claim 21, wherein a distance
between the touch surface and a straight line parallel to the edge of the plate
varies according to a parabolic function.

Id. at 672.

52. On October 9, 2020, a Final Office Action was issued for the '283 Application. *Id.*, 630-44 Claims 2 – 12 were noted as allowable. *Id.* at 641. Claims 13-14, 16, 21 and 23 were rejected as being anticipated by Kukulj. Claim 15 was rejected as obvious over Kukulj in view of Wassvik. *Id.* at 637. Claims 17-20 and 22 were rejected as obvious over Kukulj and Ryu. *Id.* at 638.

53. On March 9, 2021, the Applicant amended the claims, this time arguing that the prior art did not disclose frame elements allowing the curvature of the plate or implementing such elements for “large screen sizes” such as 55 inches. Ex. 1032 at 622.

2. (Currently Amended) A touch sensing apparatus having a long edge and a short edge, the touch sensing apparatus comprising:

- a display panel;
- a plate including a touch surface;
- a plurality of emitters arranged around a portion of the periphery of the plate and configured to emit light across the touch surface of the plate,
- a plurality of detectors arranged around a portion of the periphery of the plate and configured to receive light from the plurality of emitters, and
- a frame assembly, the frame assembly comprising:
 - a first frame element configured to support the display panel;
 - a second frame element arranged around the periphery of the plate and configured to support the plurality of emitters and plurality of detectors,

wherein the second frame element including a first surface arranged against an edge of the plate and a second surface arranged parallel to the touch surface,

the touch surface including:

- a first edge and a second edge ~~parallel-adjacent~~ to the short edge;

and

- a third edge and a fourth edge ~~parallel-adjacent~~ to the long edge;

wherein the touch surface is curved relative to with respect to a second flat plane defined in part by the short edge and the long edge; [[and]]

~~wherein a distance between a first line in the touch surface and the second plane varies according to a parabolic function wherein a distance between a first curved line drawn on the first plane and a second straight line drawn on the second flat plane varies according to a concave curve function;~~

wherein the first, second, third, and fourth edges are curved.

Ex. 1032 at 618.

13. (Currently Amended) A touch sensing apparatus comprising:
a display panel;
a rectangular plate including a touch surface;
a plurality of emitters configured to emit light across the touch surface of the rectangular plate, and
a frame configured to support the display panel, the rectangular plate, and the plurality of emitters, said frame comprising:
a[[n]] longitudinal edge portion configured to contact at least a first corner and a second corner of the rectangular plate,
wherein the edge portion is curved such that a distance between the edge portion and a straight line between the first corner and the second corner varies according to a parabolic-concave curve function and wherein the curved edge portion is configured to enable curvature in the rectangular plate,
wherein the rectangular plate is at least 55" wide along an axis.

Ex. 1032 at 620.

54. On March 22, 2021, a Non-Final Office Action was entered for the '283 Application, rejecting claims 2 – 12 under §112(b); rejecting claims 2-3, 5, and 10 – 12 as obvious over Kukulj in view of Northcott; rejecting claim 4 as obvious over Kukulj in view of Northcott and Wassvik; rejecting claim 6 – 9 as obvious over Kukulj in view of Northcott and Ryu; rejecting claims 13 – 14, 16, 21, and 23 as obvious over Kukulj in view of Lee; rejecting claim 15 as obvious over Kukulj in view of Lee and Wassvik; and rejecting claims 17 – 20 and 22 as obvious over Kukulj in view of Lee and Ryu. Ex. 1032 at 569-89.

55. On June 3, 2021, an Applicant-Initiated Interview was conducted, after which a proposed amendment to independent claim 2 to overcome the March 22, 2021 rejections was summarized. *Id.* at 563.

All Participants (applicant, applicants representative, PTO personnel)	Title	Type
VINH T LAM	Examiner	Telephonic
Hamik Shukla	Attorney of Record	
Dominic	Flatfrog	

Date of Interview: 03 June 2021

Issues Discussed:

35 U.S.C. 103
Kukulj (US Patent/PGPub. No. 20120223916) in view of Northcott et al. (US Patent/PGPub. No. 10860142)

Proposed Amendment(s)
"a distance between a first curved line drawn on THE TOUCH SURFACE and a second straight line drawn on the second flat plane varies according to a concave curve function" WOULD OVERCOME MOST RECENT REJECTION.

Ex. 1032 at 563.

56. On June 22, 2021, the Applicant amended the '283 Application's claims reflecting the substance of the June 3, 2021 interview. *Id.* at 551-54.

2. (Currently Amended) A touch sensing apparatus having a long edge and a short edge, the touch sensing apparatus comprising:

- a display panel;
- a plate including a touch surface;
- a plurality of emitters arranged around a portion of the periphery of the plate and configured to emit light across the touch surface of the plate,
- a plurality of detectors arranged around a portion of the periphery of the plate and configured to receive light from the plurality of emitters, and
- a frame assembly, the frame assembly comprising:
 - a first frame element configured to support the display panel;
 - a second frame element arranged around the periphery of the plate and configured to support the plurality of emitters and plurality of detectors,

wherein the second frame element including a first surface arranged against an edge of the plate and a second surface arranged parallel to the touch surface,

the touch surface including:

- a first edge and a second edge adjacent to the short edge; and
- a third edge and a fourth edge adjacent to the long edge;

wherein the touch surface is curved relative to a ~~second~~ flat plane defined in part by the short edge and the long edge;

wherein a distance between a first curved line drawn on ~~the first plane~~ the touch surface and a second straight line drawn on the ~~second~~ flat plane varies according to a concave curve function;

wherein the first, second, third, and fourth edges are curved.

Ex. 1032 at 551.

57. On July 6, 2021, a Final Office Action was entered for the '283 Application, rejecting claims 2-3, 5, and 12 as obvious over Kukulj in view of Liu; rejecting claim 4 as obvious over Kukulj in view of Liu and Wassivk; rejecting claims 6 – 9 as obvious over Kukulj in view of Northcott and Ryu; rejecting claims 10 and 11 as obvious over Kukulj in view of Liu and Northcott; rejecting claims 13, 14,

and 16 as obvious over Kukulj in view of Liu and Lee; rejecting claim 15 as obvious over Kukulj in view of Liu, Lee, and Wassvik; and rejecting claims 17-20 as obvious over Kukulj in view of Liu, Lee, and Ryu. Ex. 1032 at 49- 516.

58. On August 9, 2021, the Applicant responded, arguing that Liu taught neither i) both long and short edges of the plate being curved or ii) using a curved “rectangular plate” where curvature is induced in the rectangular plate by a “curved edge portion.” Ex. 1032 at 492.

59. On August 24, 2021, a Notice of Allowance was issued for the '283 Application. Id. at 448.

60. However, on September 27, 2021, the Applicant submitted a Request for Continued Examination and further amended the claims to specify limitations related to the frame assembly element. *Id.* at 92.

2. (Currently Amended) A touch sensing apparatus having a long edge and a short edge, the touch sensing apparatus comprising:

- a display panel;
- a plate including a top surface that comprises a touch surface;
- a plurality of emitters arranged around a portion of the periphery of the plate and configured to emit light across the touch surface of the plate,
- a plurality of detectors arranged around a portion of the periphery of the plate and configured to receive light from the plurality of emitters, and
- a frame assembly, the frame assembly comprising:
 - a first frame element configured to support the display panel;
 - a second frame element arranged around the periphery of the plate and configured to support the plurality of emitters and plurality of detectors,

wherein the second frame element ~~including~~ includes a first surface portion arranged against extending over an edge portion of the plate and a second surface portion arranged substantially parallel to a surface of the plate that defines the plate thickness, the touch surface,

~~the touch surface including:~~

- ~~a first edge and a second edge adjacent to the short edge; and a third edge and a fourth edge adjacent to the long edge;~~

wherein the touch surface is curved relative to a flat plane defined in part by the short edge and the long edge;

wherein a distance between a first curved line drawn on the touch surface and a second straight line drawn on the flat plane varies according to a concave curve function; and

wherein all of the first, second, third, and fourth edges of the top surface of the plate are curved.

Ex. 1032 at 93.

61. On December 8, 2021, a Notice of Allowance was again issued for the '283 Application, and the '335 Patent issued on March 22, 2022. *See Id.* at 4

62. I understand that Han, Cao, and Shin were included in an IDS by the Applicant, however, the Examiner failed to cite the references in any office action. *See Ex. 1032* at 76. I also understand that neither Cheng nor Zhao were considered during prosecution. *See generally*, *Ex. 1032*. 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– 5 of the '335 Patent.

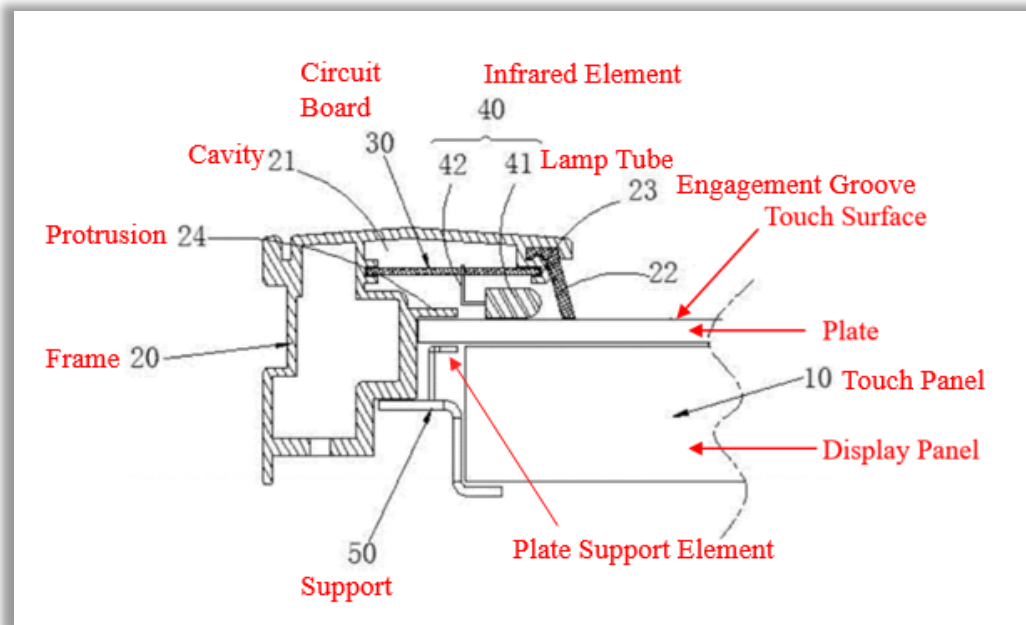
VII. BRIEF OVERVIEW OF SCOPE AND CONTENT OF ASSERTED PRIOR ART REFERENCES

A. Cheng

63. 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.

64. 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 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.

65. 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 typical 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.*

66. 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.*

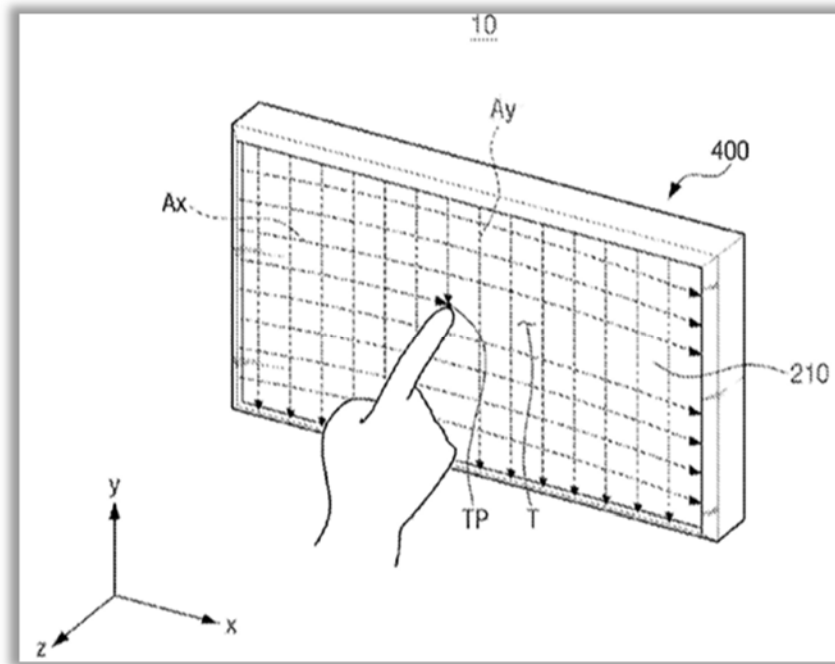
67. Cheng teaches improving the accuracy of touch detection by configuring the frame 20 in relation to the plate of the touch panel 10. Cheng explains that touch screen devices may have lengthy distances between the infrared elements and the touch surface of a touch panel which result in the reduced 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 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

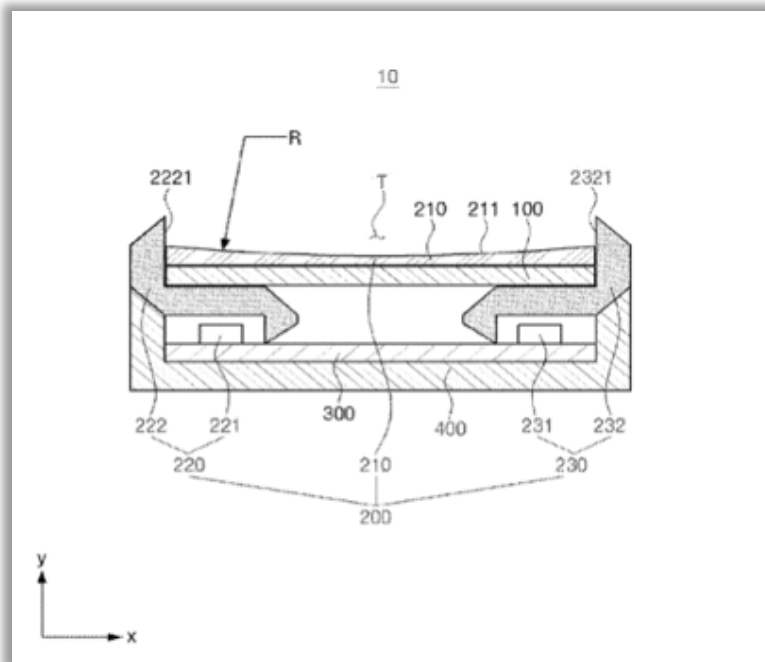
68. Han (U.S. Patent Publication No. 2019/0235701) is a continuation of PCT Application No. PCT/KR2017/000004, which was filed on January 2, 2017 and which claims priority to Korean Patent Application No. 10-2016-0128325, filed on October 5, 2016. I have compared translations of the Korean Application (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.

69. 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:



Ex. 1005 at Fig. 2.

70. Shown in Fig. 3 below, Han's cover glass 210 is coupled 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.

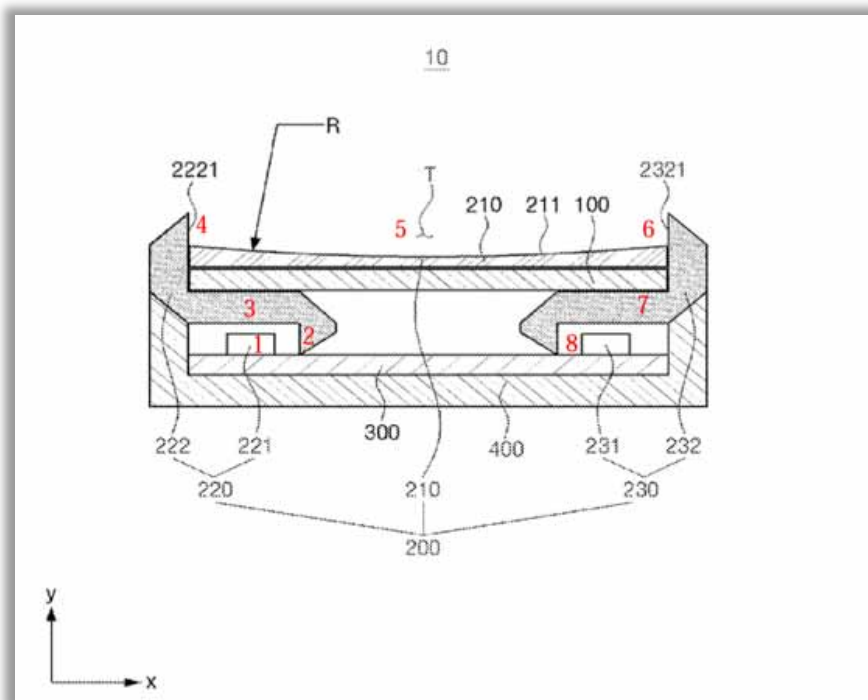


Ex. 1005 at Fig. 3.

71. 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 would have understood Han's LEDs 221 to be "emitters" and photo diodes 231 to be "detectors."

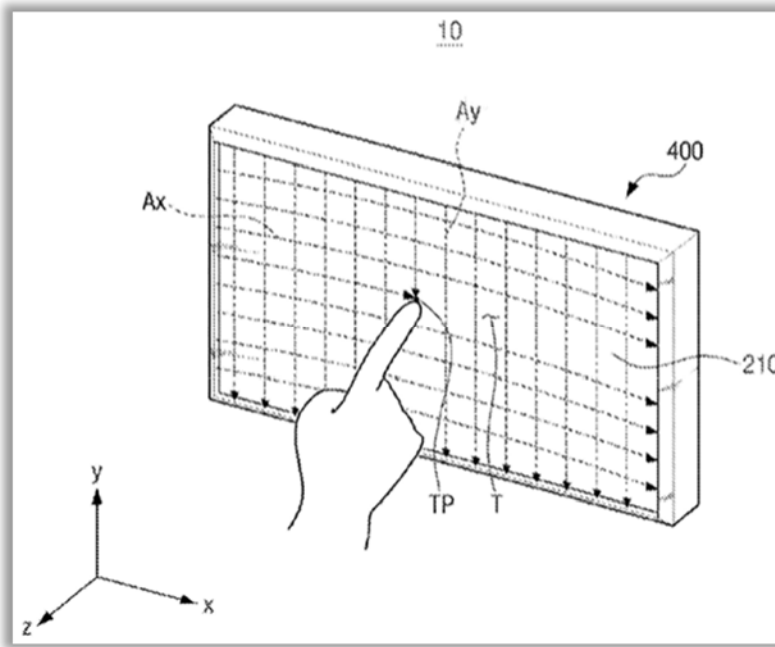
72. With reference to the annotated Han's annotated Fig. 3 below, (1) light is emitted from LEDs 221, (2) that light is introduced into one end of guide member 222, (3) the light is reflected through a plurality of curved parts thereof, (4) the light is then emitted from the light emitting surface 2221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

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.

73. 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.

74. When the light is blocked by a touch as depicted 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.*

75. Just as claimed by the '335 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].

76. 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.***

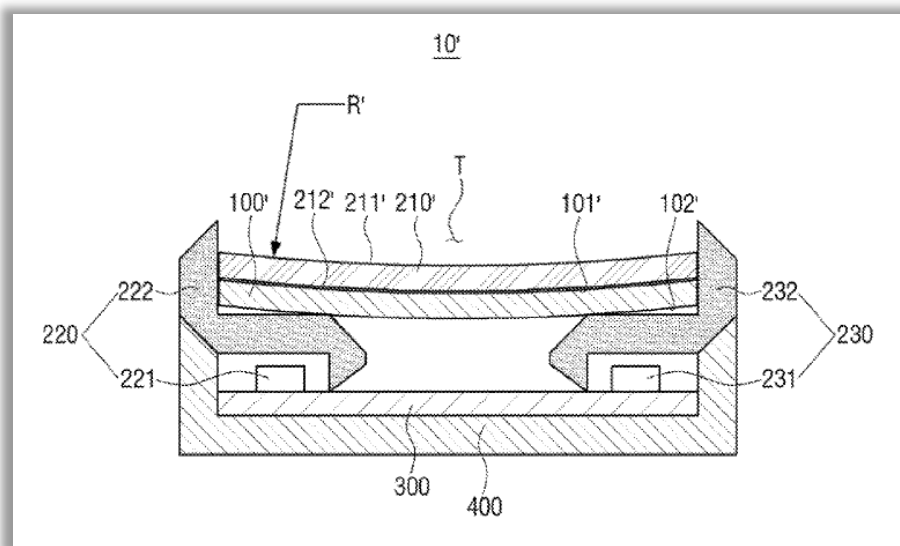
For example, the front surface 211 of the cover glass 210 may be concavely curved along the first direction Ax, as illustrated in FIGS . 2 to 4.

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.***

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

Ex. 1005 at [0074-77].

77. 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].



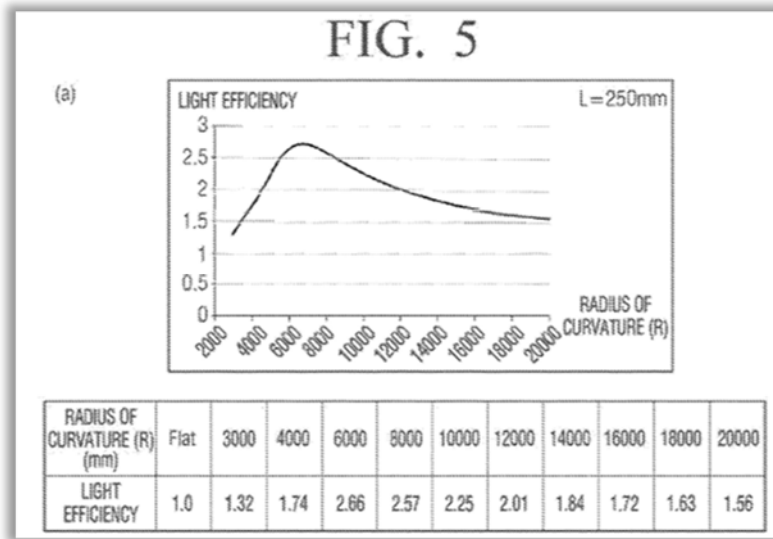
Id. at Fig. 7.

78. 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].

79. 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 '335 Patent. Ex. 1001, 17:48-18:44, Figs. 13a-17b.

80. 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.



81. 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.

82. 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.

83. 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.

84. 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 O, 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.

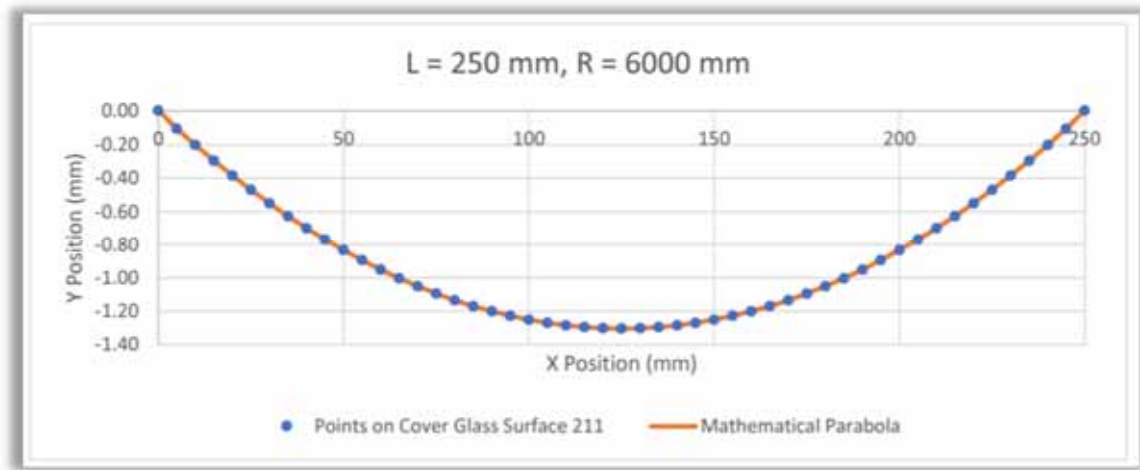
85. Next, using the value of the sagitta, the radius of curvature disclosed in Han, and half the distance between surfaces 2221 and 2321, I calculated the center

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 $a=125\text{mm}$, $b=5998.698\text{mm}$.

86. 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.

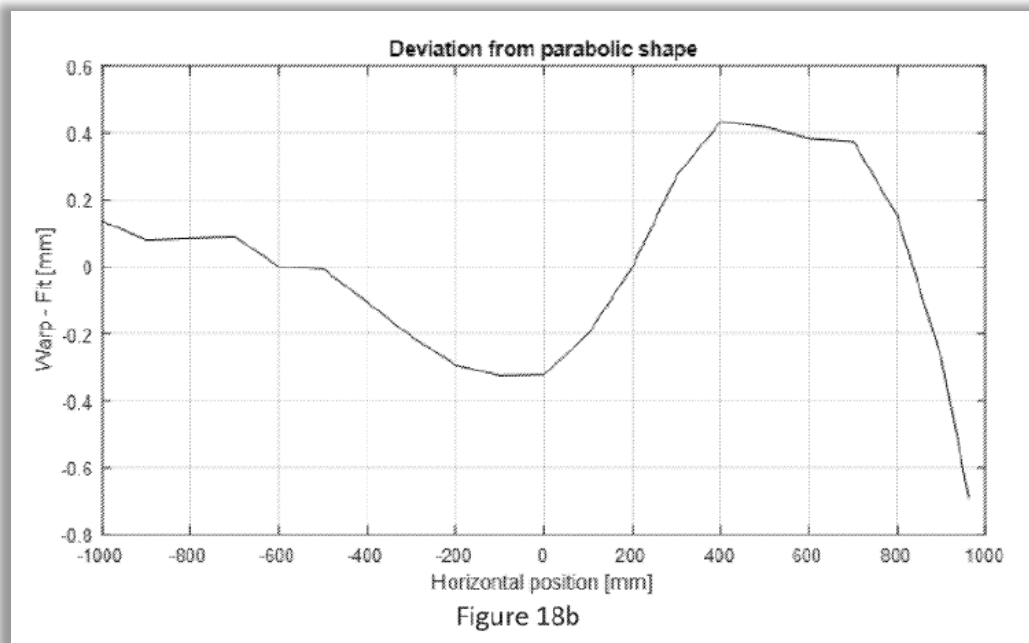
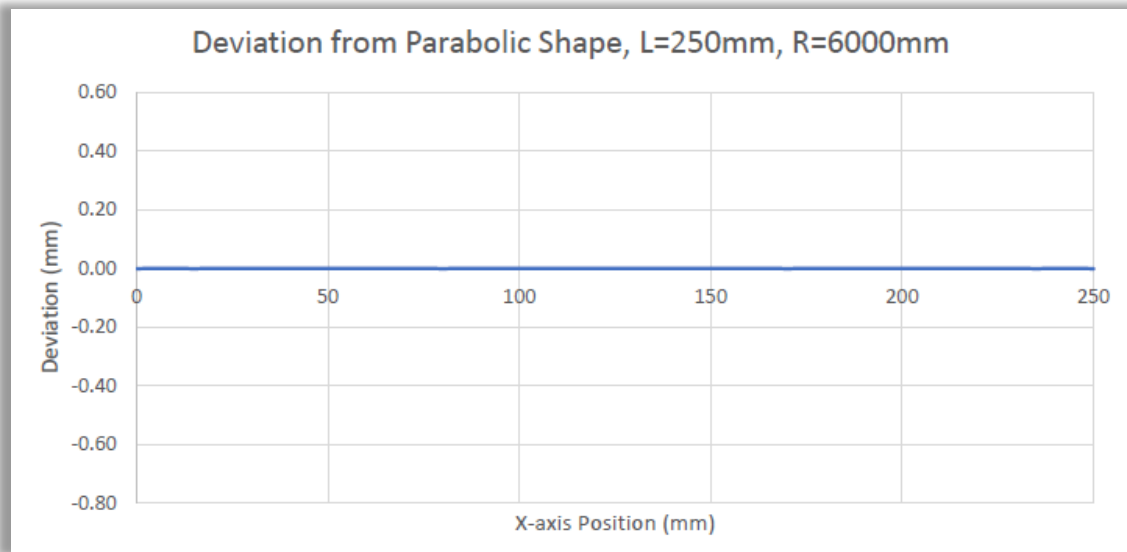
87. Next, using the formula for a mathematical parabola, i.e., $y = a(x - h)^2 + k$, I used a curve analysis tool provided under the name CurveExpert Professional version 2.7.3, by Hyams Development to find the parabola that best fit the values calculated above. The regression analysis determined the 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.

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



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

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. The y-axis scale used in this plot is the same as that used in Fig. 18b of the '335 Patent, which is also reproduced below following the deviation plot.



Ex. 1001 at Fig. 18b.

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 disclosed in the '335

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

92. 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 opinion that a POSA would have been motivated to use such parabolic curvature in both directions.

93. 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

94. 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.

95. 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.*

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

97. Han discloses that one optimal radius of curvature of front surface 211 in the A_x direction, measured at a cross-section taken along a line extending in the A_x direction and centered in the A_y 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.

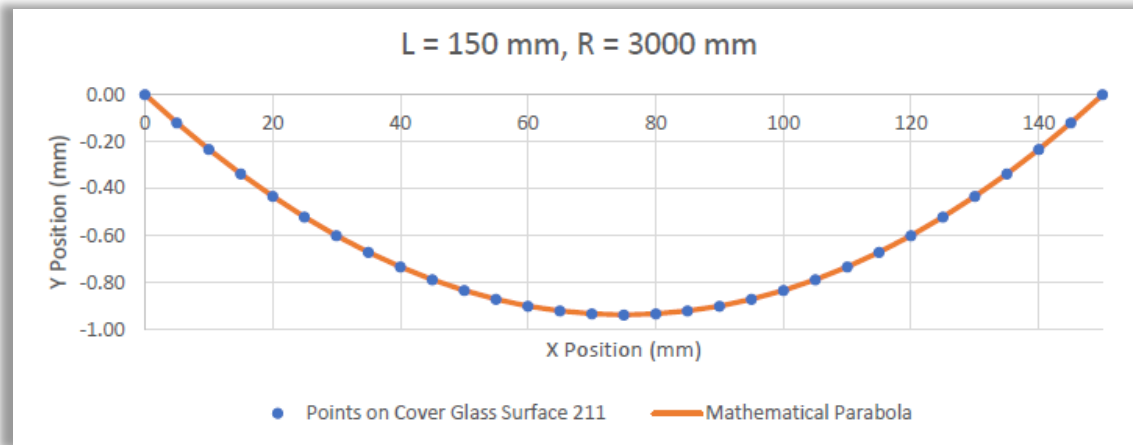
98. Based on the information provided in Han, it is my opinion that a POSA would have determined that dual-curved plate may be parabolic in both directions.

99. 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.

100. 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).

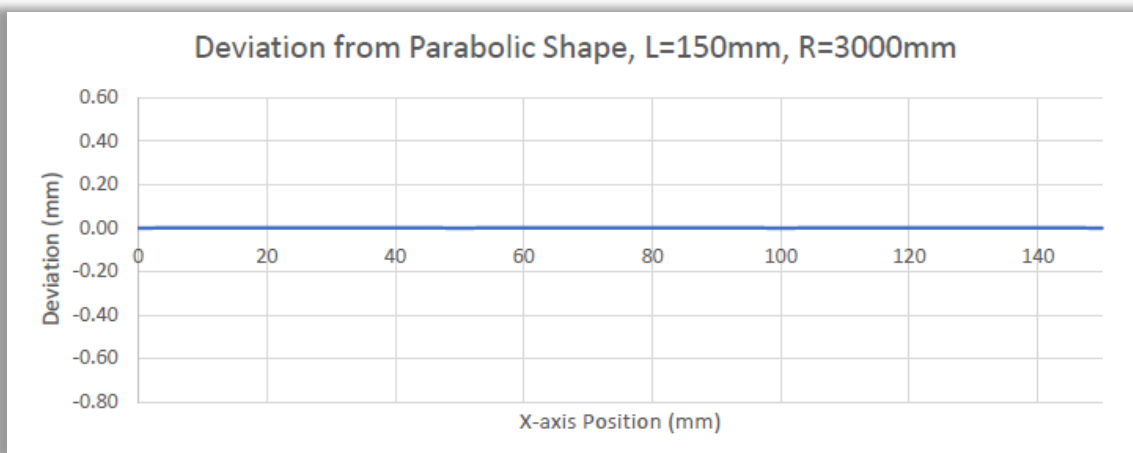
101. In particular, I calculated the y values of the circle at 31 locations between 0mm and 150mm (i.e., beginning at 0, continuing every 5mm, and ending at 150mm). I also used the curve analysis tool to find the parabola that best fit these values. The regression analysis determined the coefficients 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.

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



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

104. 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 '335 Patent.



105. 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 ’335 Patent. *See* Ex. 1001 at 18:50-19:26.

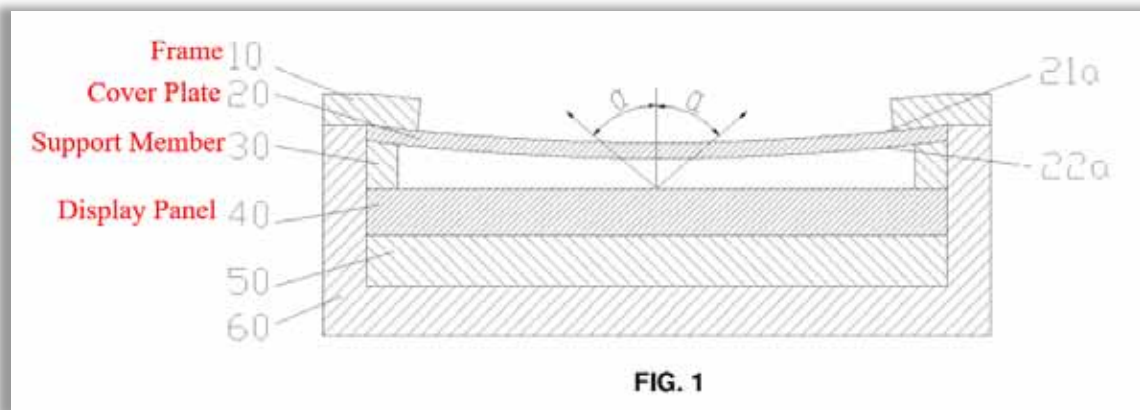
106. Thus, Han teaches that in a double-curved cover glass, a parabolic curvature in the touch surface relative to a first axis and relative to a second axis perpendicular to the first axis.

107. 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 to the Han device.

C. Zhao

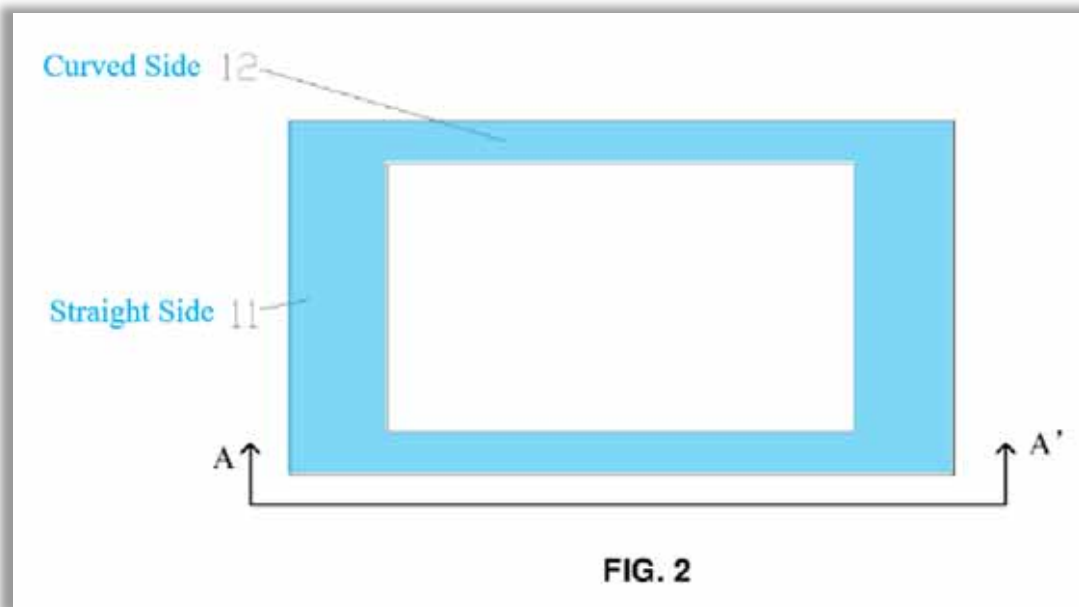
108. Zhao (U.S. Patent Application Publication No. 2017/0123257) is a U.S. Patent Application titled “Curved-Surface Liquid Crystal Display.” Zhao claims priority to Chinese Application 201510727484.4 which has a publication date of December 15, 2015.

109. 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.

110. 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.



Ex. 1012 at Fig. 2.

111. 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].

112. 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

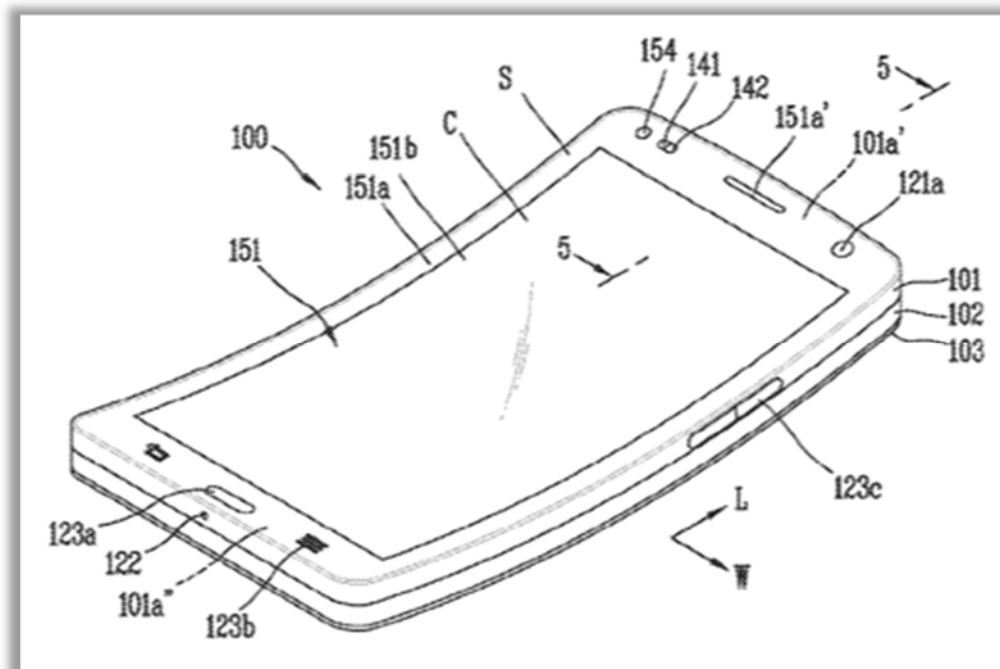
D. Shin

113. 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.

114. 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.

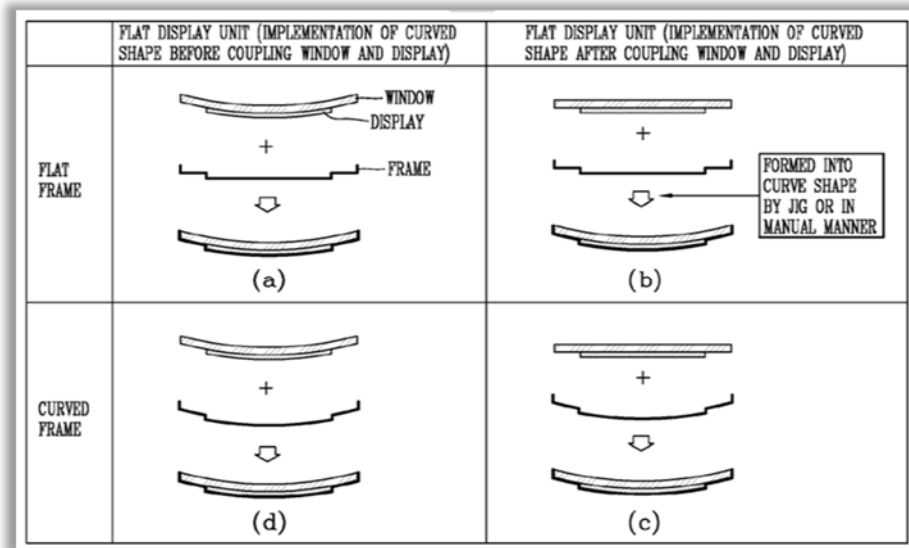
115. Shin, like Han, contemplates touch sensors of various types, including “an infrared type.” *Id.* 10:45-62. In particular, and as shown in Fig. 2 below, Shin describes a mobile terminal 100 having a front case 101 and a rear case 102. *Id.* at 14:4-11. A curved display unit 151 on the front side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

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.

116. 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.



Ex. 1011 at Fig. 4.

117. 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.

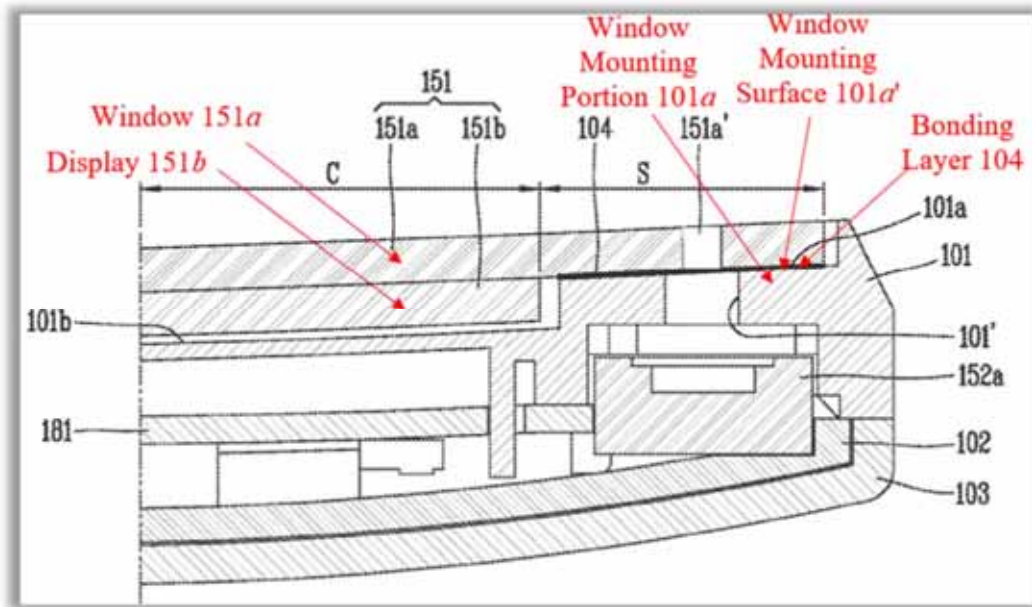
118. As another option, Fig. 4have shows that a flat display unit, including a flat window and a flat display, may be coupled to a curved frame so that the frame induces a curvature into the display unit when it is installed. *Id.* at 20:4-8. For example, Shin explains:

[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).

119. According to Shin, this Fig. 4have 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. 4have. *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.

120. 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.



Ex. 1011 at Fig. 5.

121. 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.

122. 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

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”).

123. 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.

124. 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.

125. 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.

126. 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.

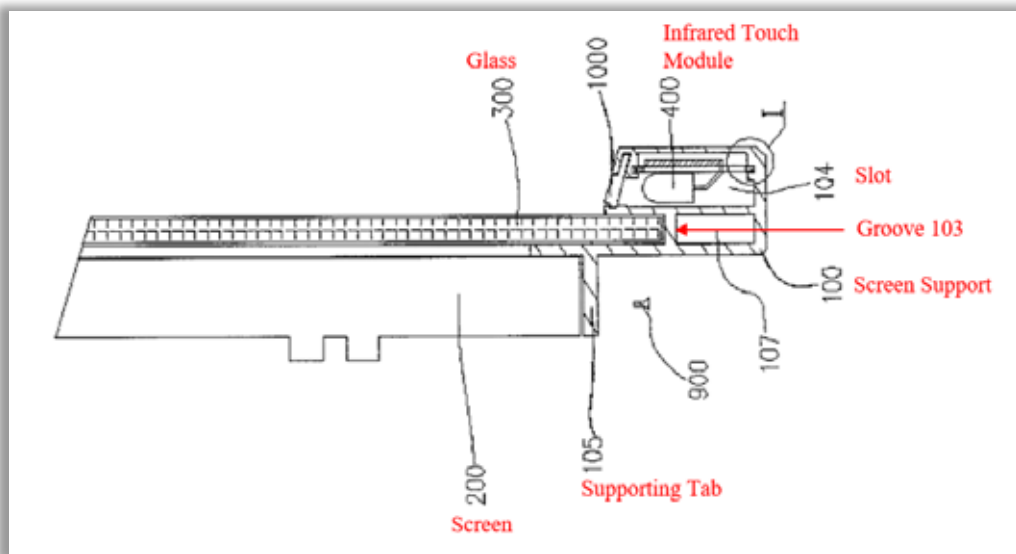
E. Cao

127. 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.

128. 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

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

129. 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.

130. 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 curvature 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.

131. As seen 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 – 5 ARE OBVIOUS UNDER 35 U.S.C. § 103
BASED ON CHENG IN VIEW OF HAN AND ZHAO.**

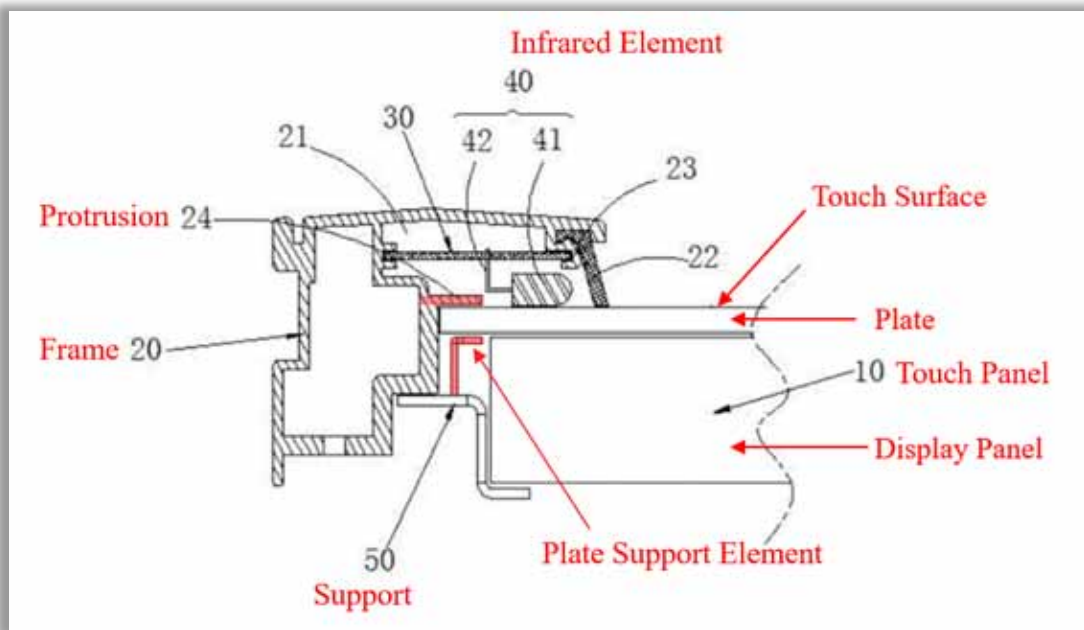
132. In my opinion, Cheng in view of Han and Zhao renders claims 1-5 obvious. Specifically, and as I have detailed below, it would have been obvious for

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 a resulting touch screen display device with improved touch performance, achieved through a simplified manufacturing process.

Motivation to Combine

133. It is my opinion that a POSA would have been motivated to modify the Cheng device using the teachings of Zhao to obtain the technical advantages disclosed in Han. As an initial matter, 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.

134. Cheng discloses an infrared touch device including plate with touch surface, a display, and a frame with 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.

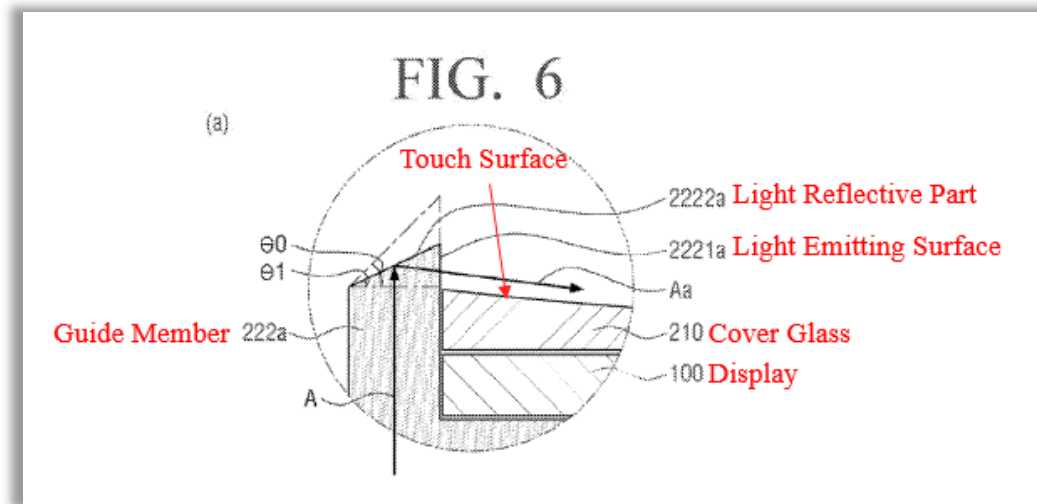


Ex. 1004 at Fig. 1.

135. 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.* at [0013]. Cheng additionally teaches reducing material costs by reducing material requirements of the frame. *Id.* at Abstract, [0018].

136. In my view, Han, like Cheng, teaches improving touch detection accuracy in infrared touch devices. In Han, the front surface of a flat cover glass 210 (plate) is configured to have a concave parabolic curvature. Ex. 1005 at [0077-80]. Further, Han teaches tuning the direction of emitted infrared light to

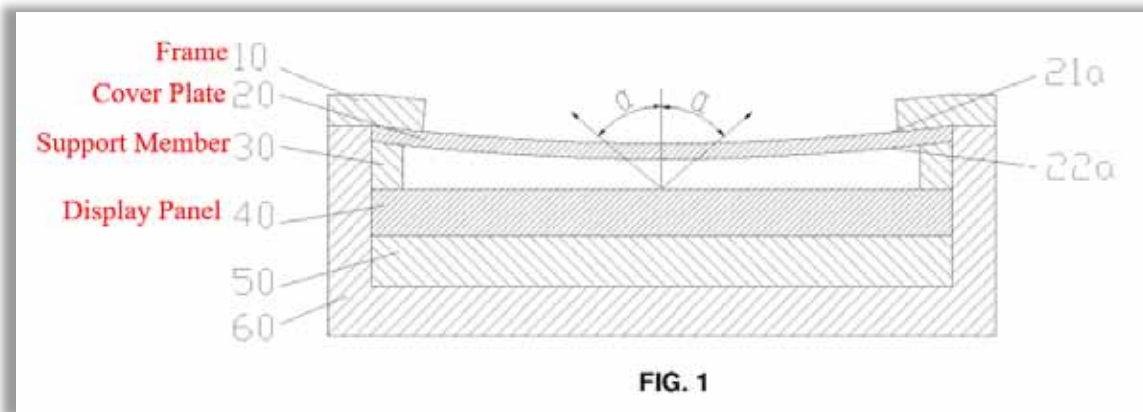
travel along the surface of the curved touch surface of cover glass 210 by tilting a light reflective part 222a of the guide member 222. Ex. 1005 at [106].



Ex. 1005 at Fig. 6(a).

137. 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 [0086-87]. 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, it is my opinion that 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.

138. 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. Ex. 1012, [0045-48]. 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). *Id.* at Fig. 1.



Ex. 1012 at Fig. 1.

139. 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 id.* 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 view, 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 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. *See Id.* at Abstract.

140. To achieve Han's parabolic plate curvature in Cheng, it is my opinion that 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. It is my opinion that as the frame in Cheng already includes a protrusion 24 and frame support element supporting the plate, it would have been obvious for POSA to modify Cheng's protrusion and frame support element according to the curved support member 30 of Zhao. In my view, a POSA would have expected such modification to achieve the same simplified curvature-inducing functionality in the modified Cheng device. It is my further opinion that a POSA would have appreciated Zhao's curved support member 30 to deliver a simplified manufacturing process with reduced cost.

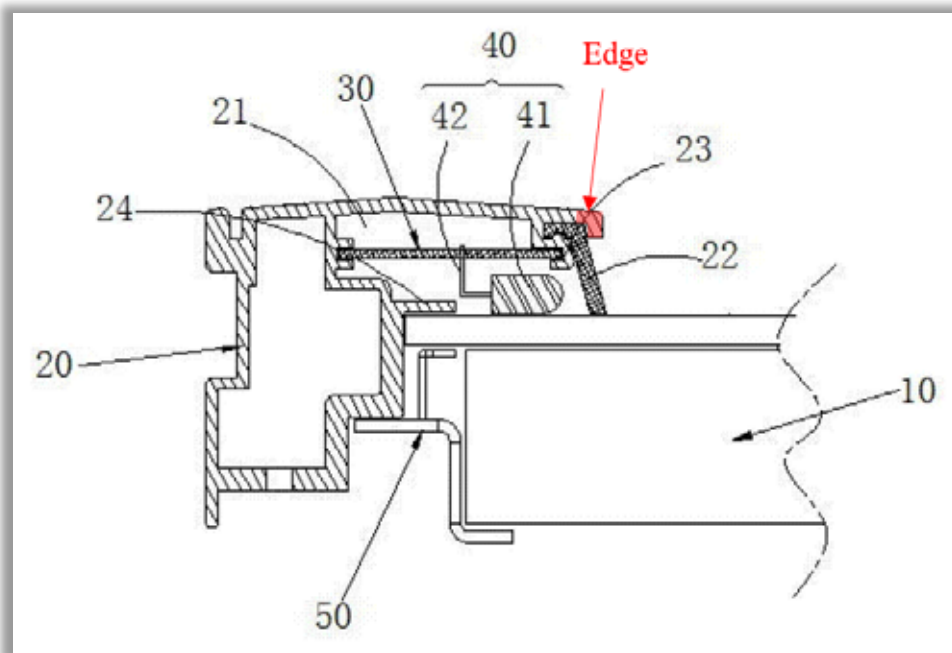
141. Thus, it is my opinion that a POSA combining the teachings of Han and Zhao into the device of Cheng would have expected to achieve the predictable result of a high touch accuracy (Han) infrared touch device (Cheng, Han) and manufacturing method (Cheng, Han, Zhao), meeting the limitations of the '335

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 touch sensing apparatus having a long edge and a short edge,”**

142. 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.

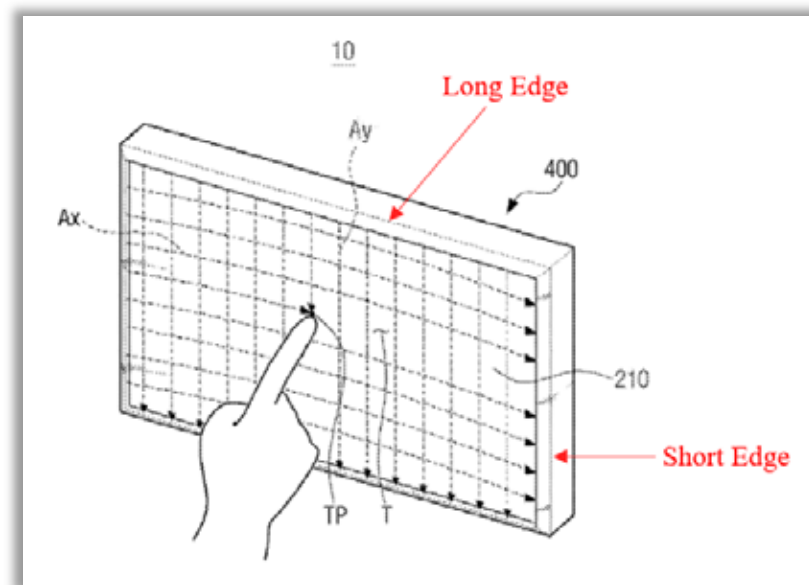


Ex. 1004 at Fig. 1.

143. It is my opinion that a POSA would have further understood Cheng's frame 20 to disclose a frame assembly configured in the common rectangular

geometry of infrared touch screen devices, thus including a first long edge and second short edge. For example, Cheng discloses “a scanning network in horizontal and vertical directions, and it thus possible to determine X and Y coordinates by means of the position of infrared rays in the horizontal and vertical directions.” Ex. 1004 at [0002]. Thus, it is my opinion that Cheng discloses frames 20 with edges in both a horizontal (first long edge) and vertical (second short edge) direction.

144. Further, Han’s frame assembly (including rear cover 400 and guide members 222, 232) depicts a rectangular frame geometry including a first long edge, and a second short edge. Ex. 1005 at Fig. 2.



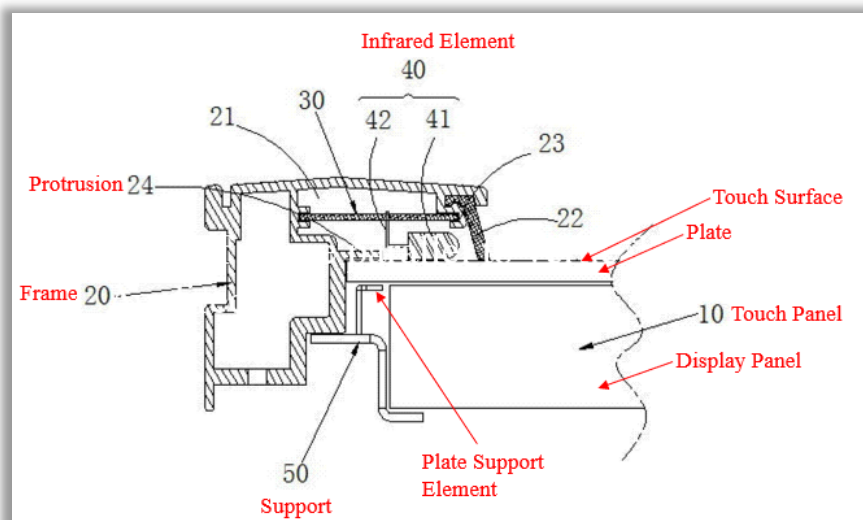
Ex. 1005 at Fig. 2.

145. Thus, it is my opinion that Cheng and Han disclose a touch sensing apparatus having a long edge (Cheng long edge of frame 20, Han frame assembly

long edge) and a short edge (Cheng's short edge of frame 20, Han's frame assembly short edge).

(b) “a display panel;”

146. In my opinion, Cheng, Han and Zhao disclose this element. Cheng discloses a touch panel 10. Ex. 1004 at [0005], Fig.1. In my view, a POSA would have understood Cheng's touch panel 10 to include a display panel. *See id.* at Fig. 1, [0002-3].



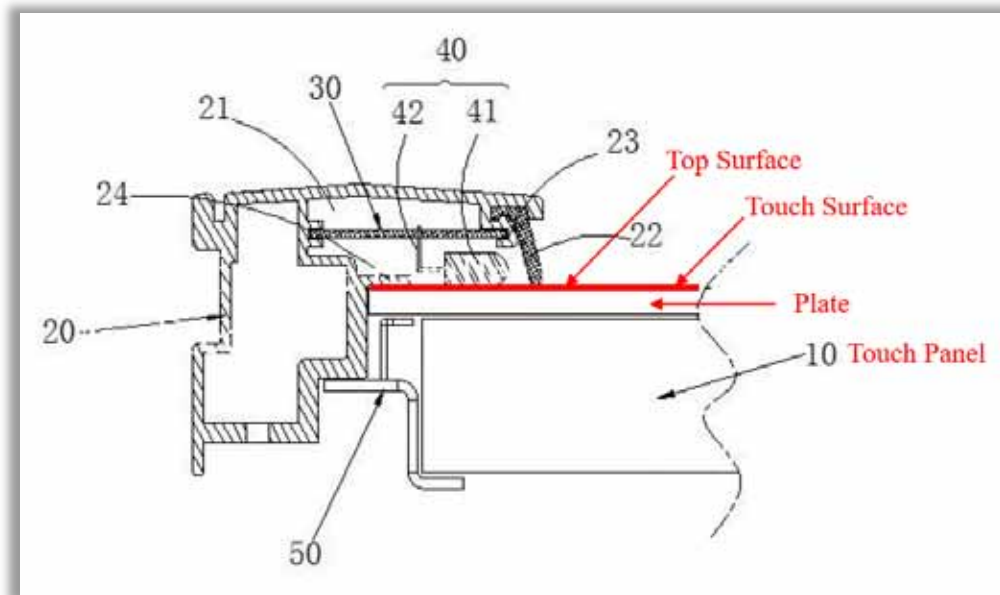
Ex. 1004 at Fig. 1.

147. Further, both Han and Zhao also disclose a display panel. Ex. 1005 at Abstract; Ex. 1012 at Abstract.

148. Thus, it is my opinion that Cheng, Han, and Zhao disclose a display panel (display panel of Cheng's touch panel 10; Han's display 2, Zhao's display panel 40).

(c) “a plate including a top surface that comprises a touch surface;”

149. In my opinion, Cheng and Han disclose this element. As I discussed above, a POSA would have understood the touch panel 10 of touch screen device disclosed in Cheng to include a plate including a top surface that comprises a touch surface.



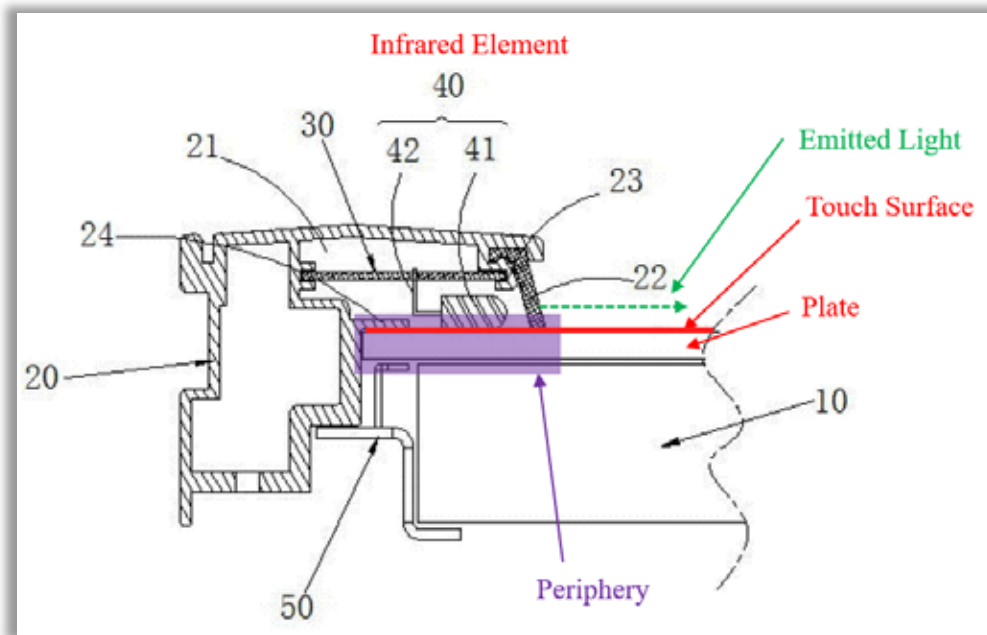
Ex. 1004 at Fig. 1

150. Further, Han discloses a cover glass 210 with a touch surface. Ex. 1004 at [0019], [0038], Fig. 2.

151. Thus, it is my opinion that Cheng and Han disclose a plate (Cheng's plate of touch panel 10; Han's cover glass 210) including a top surface that comprises a touch surface (top surface and touch surface of Cheng's plate; Han's touch surface T).

(d) “a plurality of emitters arranged around a portion of the periphery of the plate and configured to emit light across the touch surface of the plate,”

152. It is my opinion that Cheng and Han disclose this element. Cheng discloses arranging “infrared receivers and **transmitters** [emitters] distributed densely around a display region [to] form a scanning network in horizontal and vertical directions...” Ex. 1004 at [0002] (emphasis added). The infrared element 40 is arranged around a portion of the periphery of the plate. *Id.* at Fig. 1. To achieve touch sensing functionality, it is my view that a POSA would have understood Cheng's lamp tube 41 of infrared element 40 to emit light across the touch surface of the plate.



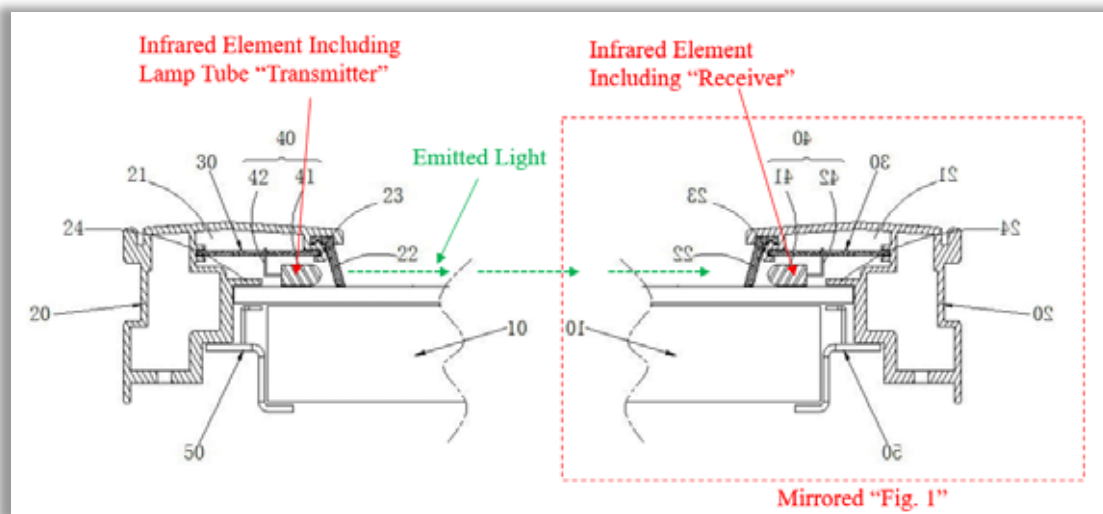
Ex. 1004 at Fig. 1.

153. Further, Han discloses a plurality of emitters configured to emit across the touch surface of the plate. See Ex. 1005 at [0040-43].

154. Thus, in my opinion, Cheng and Han disclose a plurality of emitters (Cheng's infrared element 40 including lamp tubes 41; Han's LEDs light emitting part 220) arranged around a portion of the periphery of the plate (Cheng's plate of touch panel 10; Han's cover glass 210) and configured to emit light across the touch surface of the plate (touch surface of Cheng's plate; Hans touch surface T).

(e) “a plurality of detectors arranged around a portion of the periphery of the plate and configured to receive light from the plurality of emitters,”

155. In my opinion, Cheng and Han disclose 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). Cheng’s infrared element 40 is arranged around a portion of the periphery of the plate. *Id.* at Fig. 1. To achieve touch sensing functionality, it is my opinion that 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.



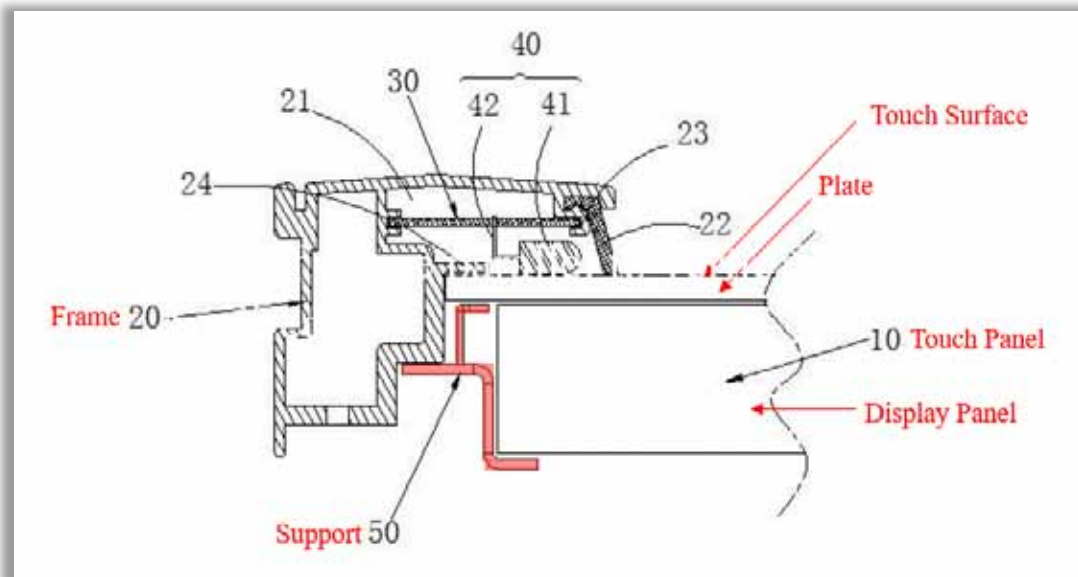
Ex. 1004 at Fig. 1.

156. Further, Han discloses a plurality of detectors configured around a portion of the periphery of the plate and configured to receive light from the plurality of emitter. *See* Ex. 1005 at [0040-43].

157. Thus, it is my opinion that Cheng and Han disclose a plurality of detectors (Cheng's infrared element 40 including a receiver; Han's light receiving part 230) arranged around a portion of the periphery of the plate (Cheng's plate of touch panel 10; Han's cover glass 210) and configured to receive light from the plurality of emitters (Cheng's infrared elements with emitter (transmitter) lamp tube 41; Han's light emitting part 220).

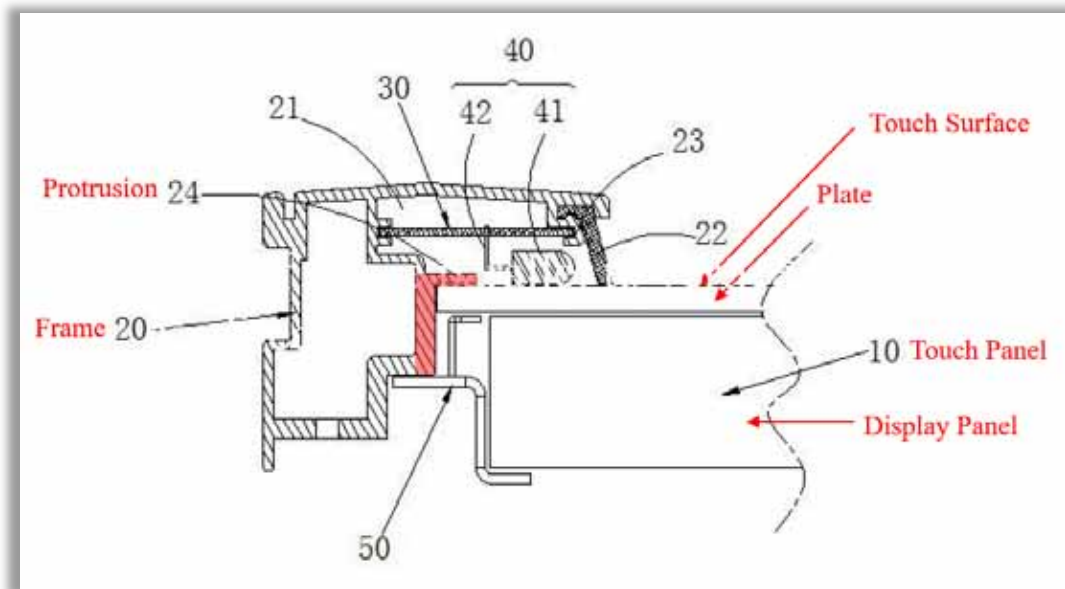
(f) “a frame assembly, the frame assembly comprising; a first frame element configured to support the display panel; a second frame element arranged around the periphery of the plate and configured to support the plurality of emitters and plurality of detectors.”

158. It is my opinion that Cheng discloses this element. For a first frame element, Cheng discloses a frame 20 with protrusion 24 and a support 50. Ex. 1004 at [0007-8]. Specifically, Cheng discloses “the support and the protrusion together clamp the touch panel.” *Id.* at [0008]. As depicted in Fig. 1 of Cheng, the support 50 supports the display panel of the touch panel 10. *Id.* at Fig. 1.



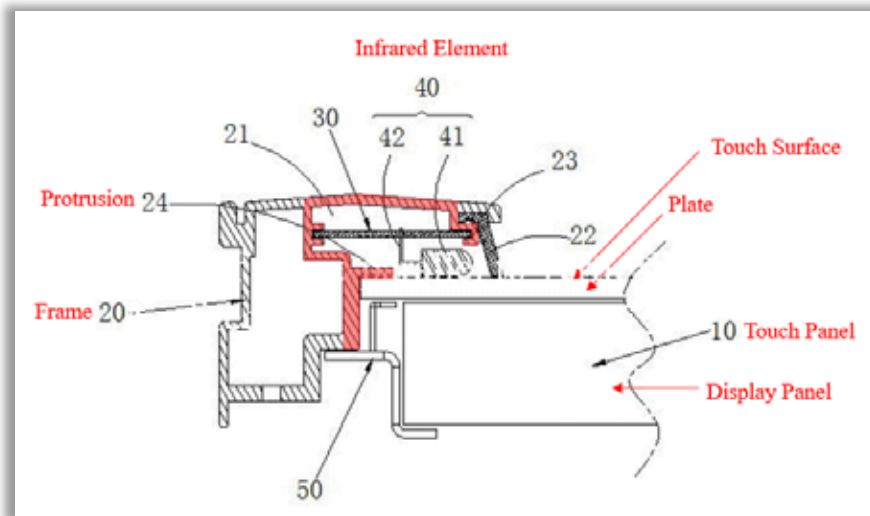
Ex. 1004 at Fig. 1

159. For a second frame 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. Cheng's frame 20 further includes a protrusion 24 that "is placed on an upper surface [touch surface] of the touch panel." *Id.* at [0007]. Shown in Fig. 1, Cheng's protrusion 24 is placed on the touch surface of the plate. *Id.* at Fig. 1.



Ex. 1004 at Fig. 1

160. Cheng's infrared element 40, comprising emitters 41 or detectors, is supported by the frame 20 via grooves 23. *Id.* The grooves 23 are structurally connected to the frame 20 and the protrusion 24, wherein the protrusion 24 rests on the touch surface of the plate. *Id.*



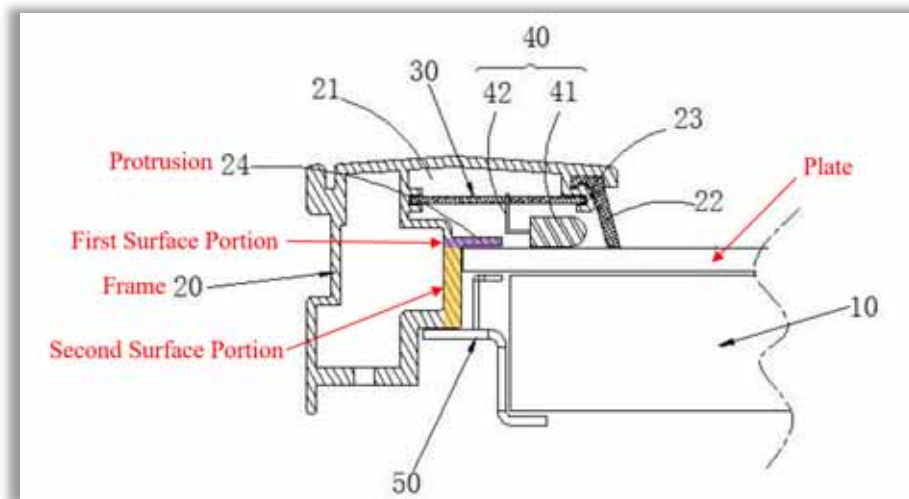
Ex. 1004 at Fig. 1.

161. It is my opinion that a POSA would have understood Cheng's frame 20 and protrusion 24 (second frame element) to support the infrared element 40 (emitters and transmitters) by the protrusion 24 resting on the touch surface of the plate and being structurally connected to the grooves 23.

162. Thus, in my opinion, Cheng discloses a frame assembly, the frame assembly comprising; a first frame element (support 50) configured to support the display panel; a second frame element (frame 20 with protrusion 24) arranged around the periphery of the plate and configured to support the plurality of emitters and plurality of detectors (infrared element having emitters and detectors).

- (g) “wherein the second frame element includes a first surface portion extending over an edge portion of the plate and a second surface portion arranged substantially parallel to a surface of the plate that defines the plate thickness.”

163. It is my opinion that Cheng discloses this element. Cheng’s protrusion 24 (first surface portion) extends over an edge portion of the plate. Ex. 1004 at Fig. 1. While I note that the ’335 Patent’s “surface of the plate that defines the plate thickness” is ambiguous, it is my opinion that a POSA would understand that Cheng’s frame 20 (second surface portion) is arranged substantially parallel to the surface of the plate that defines the plate thickness. *Id.*



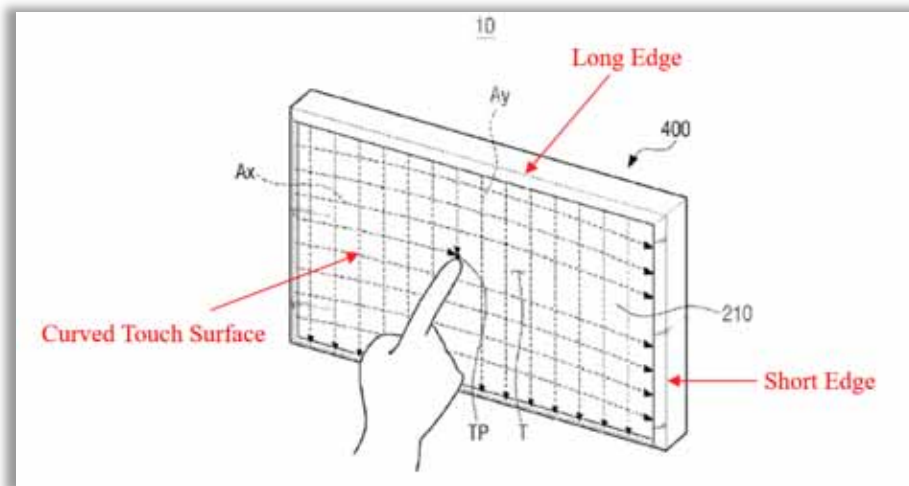
Ex. 1004 at Fig. 1.

164. Thus, it is my opinion that Cheng discloses wherein the second frame element (frame 20 with protrusion 24) includes a first surface portion (protrusion 24)

extending over an edge portion of the plate (plate of touch panel 10) and a second surface portion (frame 20) arranged substantially parallel to a surface of the plate that defines the plate thickness (“thickness” edge of plate).

(h) “wherein the touch surface is curved relative to a flat plane defined in part by the short edge and the long edge.”

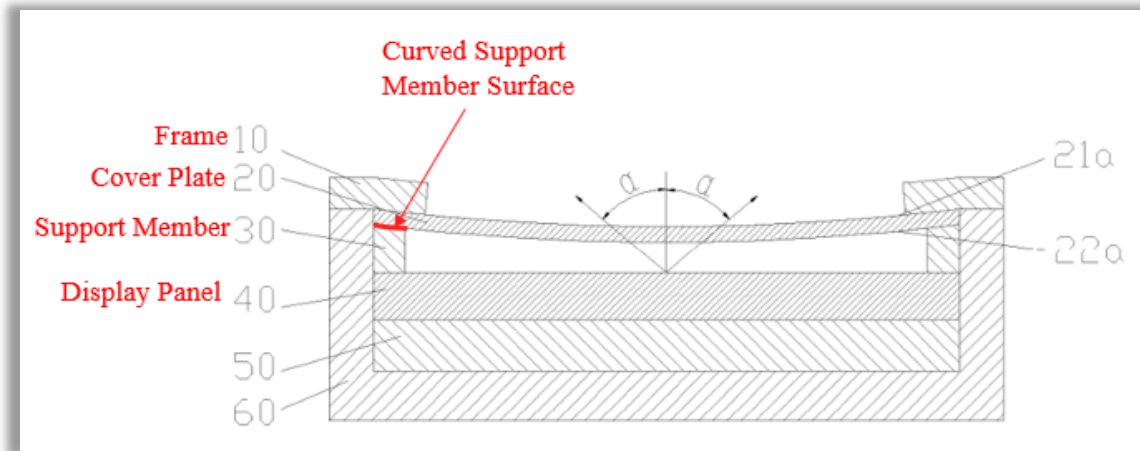
165. It is my opinion that Cheng in view of Han and Zhao discloses this element. As I discussed above, it would have been obvious to a POSA to modify Cheng’s plate to incorporate Han’s parabolic touch screen curvature along A_x and A_y directions to improve touch detection accuracy.



Ex. 1005 at Fig. 2.

166. In my view, it would have been obvious to a POSA to modify Cheng’s frame 20 with protrusions 24 and plate support elements of supports 50 according to

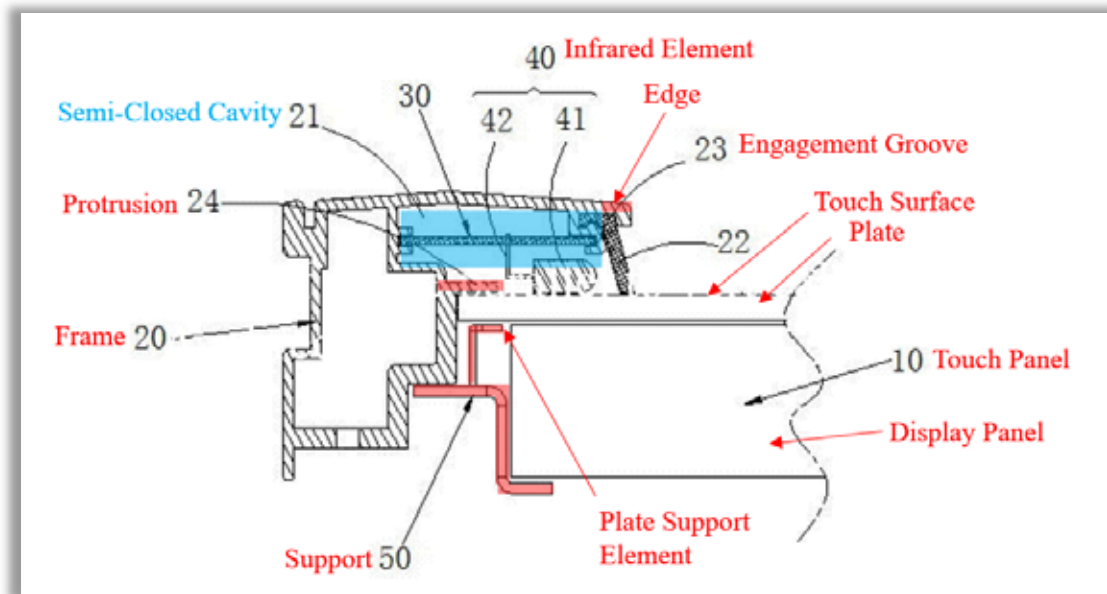
Zhao's curved mounting surfaces 30 and frame 10 to reach Han's touch screen curvature.



Ex. 1012 at Fig. 1.

167. Like in Zhao, the curved modified plate support elements of Cheng would induce curvature into Cheng's plate in a simplified manufacturing step, and the curved modified frame 20 with protrusions 24 of Cheng would secure the curved touch surface side of the curved plate.

168. The modified Cheng device has curved short and long edges. Cheng's frame 20 includes semi-enclosed cavity 21 and engagement groove 23 for supporting the circuit board 30 and infrared element 40. Ex. 1004 at [0013].

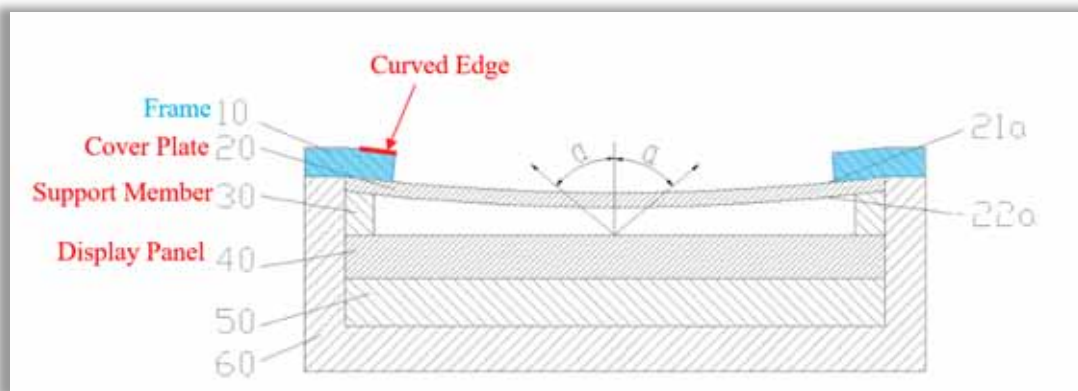


Ex. 1004 at Fig. 1.

169. Cheng discloses 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]. From Cheng’s lamp tube 41-to-surface-of-panel configuration, Cheng explains “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.* at [0018]. 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 a result, the respective first and second (short and long) edges of Cheng’s modified frame 20 would also be curved. In this configuration, it is my opinion that a POSA would have expected Cheng’s lamp tube

41 to remain in contact with the curved touch surface of Cheng's modified curved plate and provide the same touch detection performance by emitting light in close proximity to the surface of the plate disclosed in the unmodified Cheng device.

170. Additionally, it is my opinion that curved first and second edges in the modified Cheng device would have been obvious based on Zhao's curved frame 10.



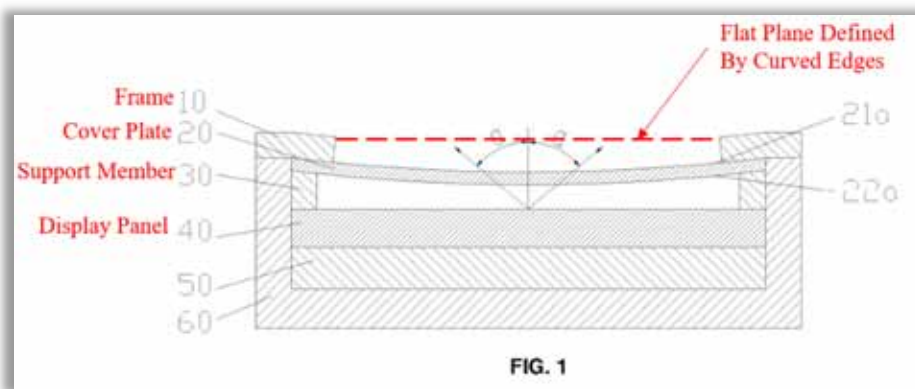
Ex. 1012 at Fig. 1.

171. Zhao discloses one embodiment having a frame with “curved sides.” Ex. 1012 at [0051-52]. Zhao discloses that 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.*

172. It is my opinion that a POSA would have been motivated to implement Zhao's curved frame 10 into Cheng's frame 20 with protrusion 24. It is my further

opinion that a POSA would have expected such a modification in Cheng to achieve Zhao's structural loosening prevention in the modified Cheng device. As a result, the curved frame 20 of the modified Cheng device would thus also have a curved first and second (long and short) edge.

173. Cheng's modified curved plate touch surface would be curved relative to a flat plane defined in part by the short and long edges of frame 20. As I have discussed above, Cheng's modified long and short edges would be curved according to Zhao. A flat plane would be defined, at least in part, by Cheng's modified curved edges. Given that Cheng's modified edges would be curved, the flat plane would intersect Cheng's edges at least at the extremum of the edges, such as the corners of the edges or the slope inflection regions of the edges.



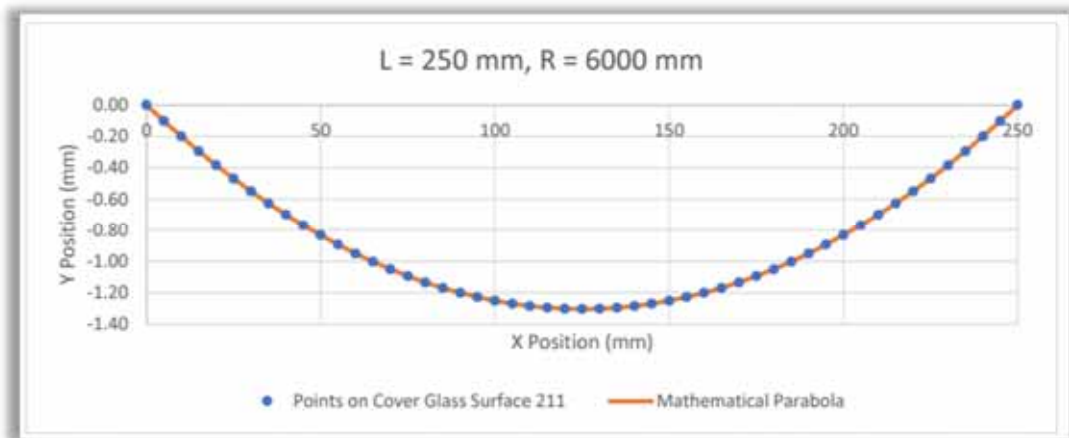
Ex. 1012 at Fig. 1

174. Cheng's modified curved plate would be curved relative to the flat plane formed in part by the long and short edges of frame 20.

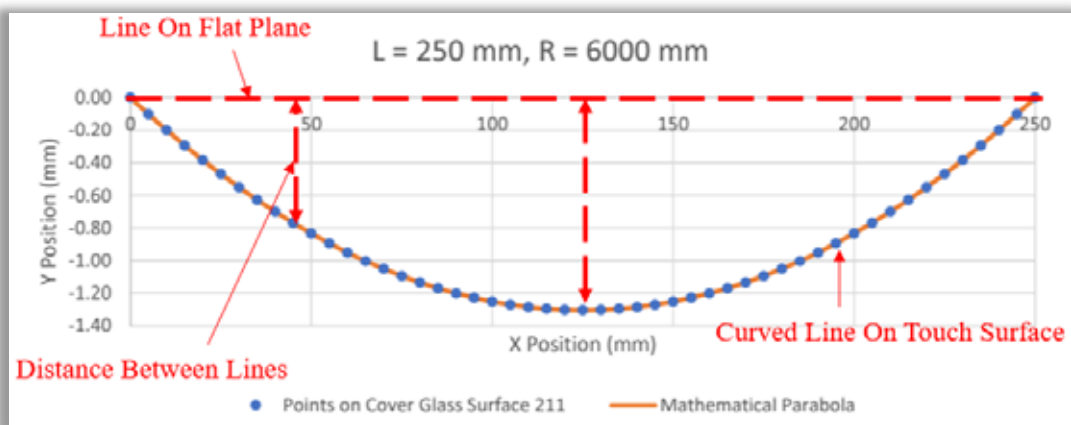
175. Thus, it is my opinion that Cheng in view of Han and Zhao discloses wherein the touch surface (Cheng's plate of touch panel 10) is curved relative to a flat plane (flat plane across curved long and short edges) defined in part by the short edge (short edge of Cheng's frame 20) and the long edge (long edge of Cheng's frame 20).

- (i) **“wherein a distance between a first curved line drawn on the touch surface and a second straight line drawn on the flat plane varies according to a concave curve function.”**

176. In my opinion, Cheng in view of Han and Zhao discloses this element. Han discloses a parabolically curved touch surface on cover glass 210. Ex. 1005 at [0074-77]. More specifically, Han discloses one 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]. Plotting the resulting curvature disclosed by Han yields a curve described by a parabolic function. See Section VII(b). In my view, a POSA would have been motivated to adopt the same parabolic, concave, curvature of Han in Cheng's modified plate to achieve improved touch performance. *Id.*



177. As I discussed above, a flat plane can be established across the long and short edges of the modified Cheng frame 20—according to Zhao. Shown below, a line can be drawn along Cheng’s flat plane and a line may be drawn along the concavely curved touch surface of Cheng’s modified plate.

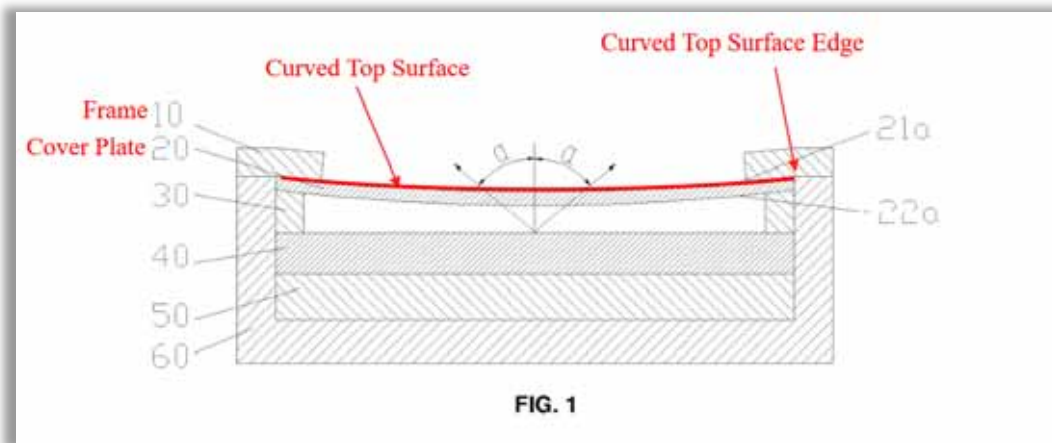


178. The distance between the lines drawn on the flat plane line and the curved line on Cheng’s modified concave touch surface vary according to a parabolic function that, in my opinion, a POSA would have understood as equating to a “concave function.”

179. Thus, it is my opinion that Cheng in view of Han and Zhao and discloses wherein a distance between a first curved line (curved line drawn along Cheng's modified curved plate) drawn on the touch surface (Cheng's modified curved plate) and a second straight line (straight line) drawn on the flat plane (flat plane across Cheng's modified long and short edges) varies according to a concave curve function.

(j) “wherein all of the edges of the top surface of the plate are curved.”

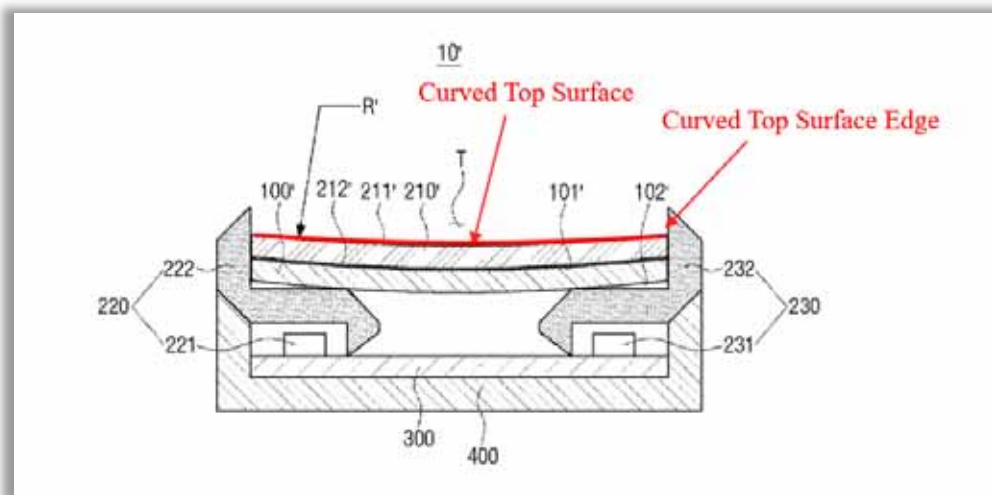
180. In my opinion, Cheng in view of Han and Zhao disclose this element. Han and Zhao each disclose a plate having a top surface with curved edges. Ex. 1005 at Fig. 7, Ex. 1012 at Fig. 1.



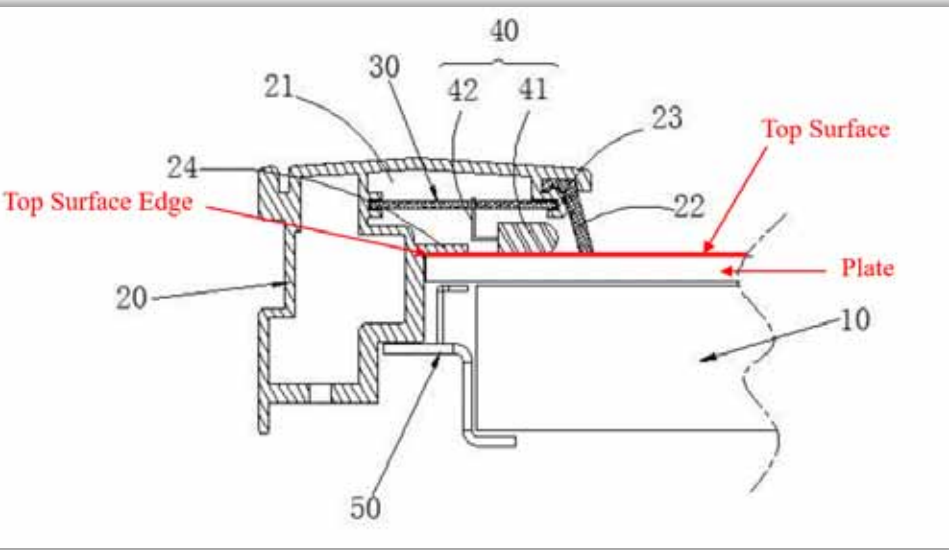
Ex. 1012 at Fig. 1

181. As shown above, Zhao's support member 30 and frame 10 are curved along the full length of contact with Zhao's curved cover plate 20, up to and

including the cover plate 20's edge. *Id.* at Fig.1, [0055]. Accordingly, the edges of Zhao's cover plate 20 (including a top surface) are curved. *Id.* In the modified Cheng device, Cheng's frame protrusions 24 and plate support elements of supports 50 along both the long and short sides would be curved according to Zhao, resulting in Cheng's modified plate also being curved up to edges along both long and short edges. Cheng's curved plate up to its edges would match the edges of Han's plate curved along both Ax and Ay directions. See Ex. 1005 at [0087-89].



Ex. 1005 at Fig. 7.



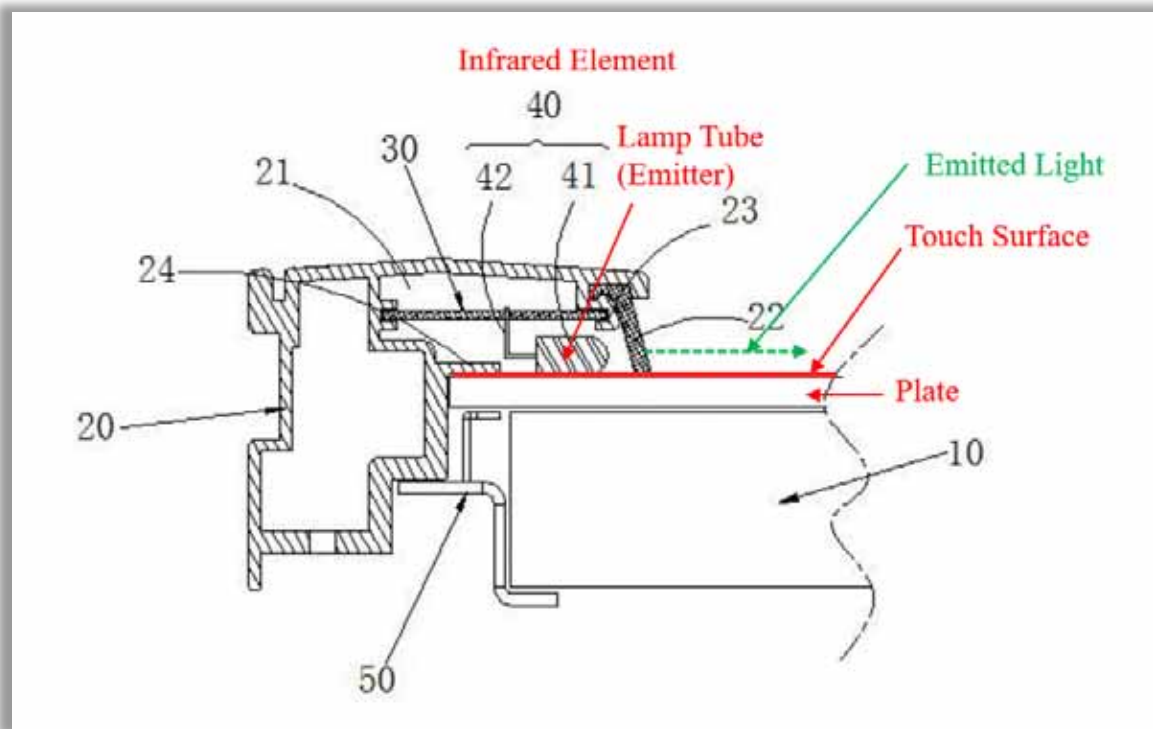
Ex. 1004 at Fig. 1.

182. Thus, in my opinion, Cheng in view of Han and Zhao disclose wherein all of the edges (edges of Cheng's modified plate) of the top surface of the plate (top surface of Cheng's modified plate) are curved.

2. Claim 2: The touch sensing apparatus of claim 1, wherein the plurality of emitters is configured to emit light to propagate over the touch surface.

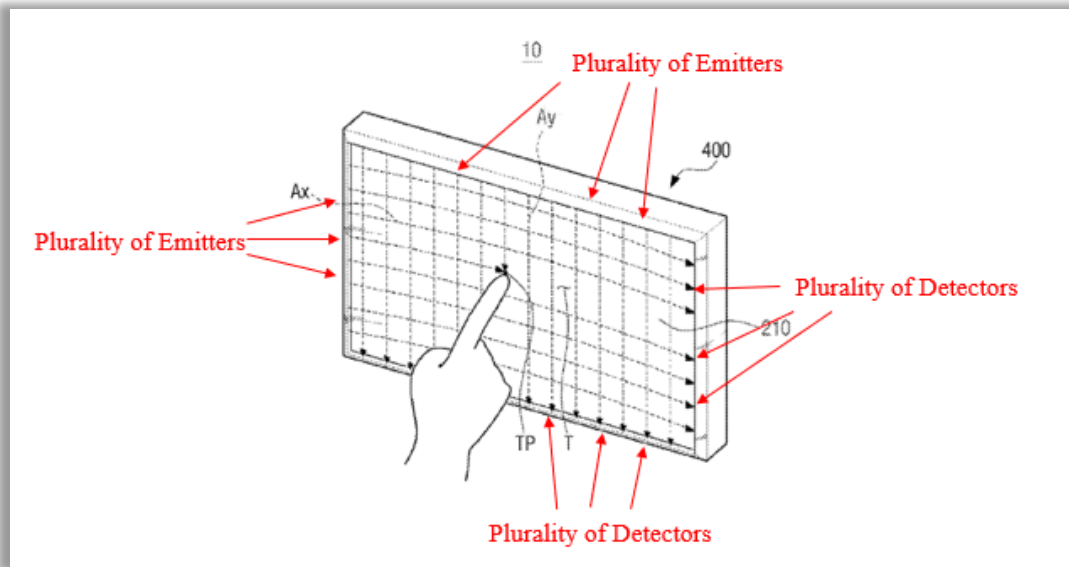
183. In my opinion, Cheng and Han disclose this element. Cheng discloses arranging “infrared receivers and **transmitters** [emitters] distributed densely around a display region [to] form a scanning network in horizontal and vertical directions...” Ex. 1004 at [0002] (emphasis added). The infrared element 40 is arranged adjacent to a periphery of the plate. *Id.* at Fig. 1. To achieve touch sensing functionality, it

is my opinoin that a POSA would have understood Cheng's lamp tube 41 of infrared element 40 to emit light to propagate over the touch surface of the plate.



Ex. 1004 at Fig. 1.

184. Further, Han discloses a plurality of emitters (light emitting parts 220) configured to emit light across a touch surface. See Ex. 1005 at [0040].



Ex. 1005 at Fig. 2

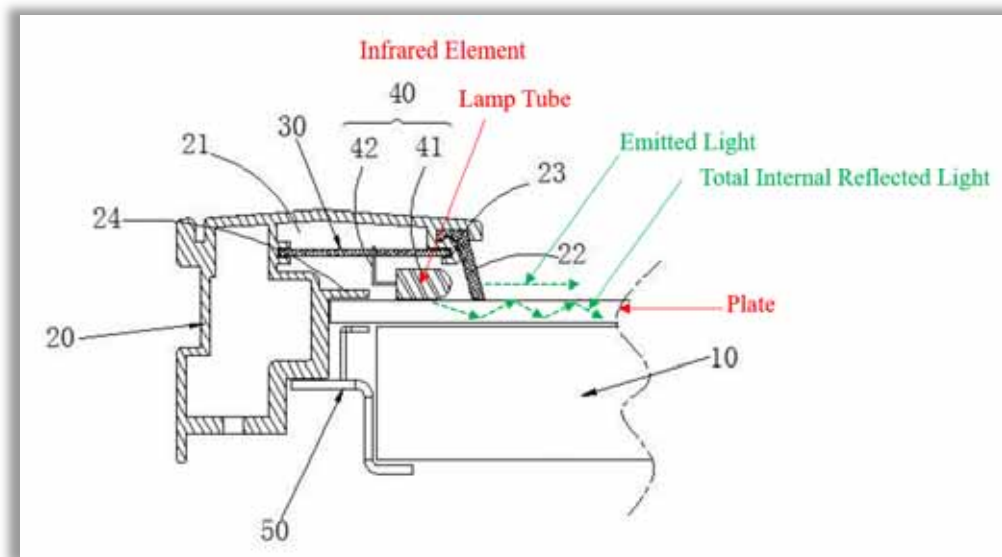
185. Thus, it is my opinion that Cheng and Han disclose wherein the plurality of emitters (Cheng's infrared element 40 including lamp tubes 41; Han's light emitting parts 220) is configured to emit light to propagate over the touch surface (surface of Cheng's plate; Han's touch surface T).

3. Claim 3: The touch sensing apparatus of claim 1, wherein the plurality of emitters is configured to emit light through the plate by total internal reflection.

186. In my opinion, Cheng in view of Han discloses this element. While the '335 Patent fails to explain or specify emitters configured to emit light *through the plate by total internal reflection*, it is my opinion that a POSA would have understood Cheng to disclose this element. For example, a POSA would have

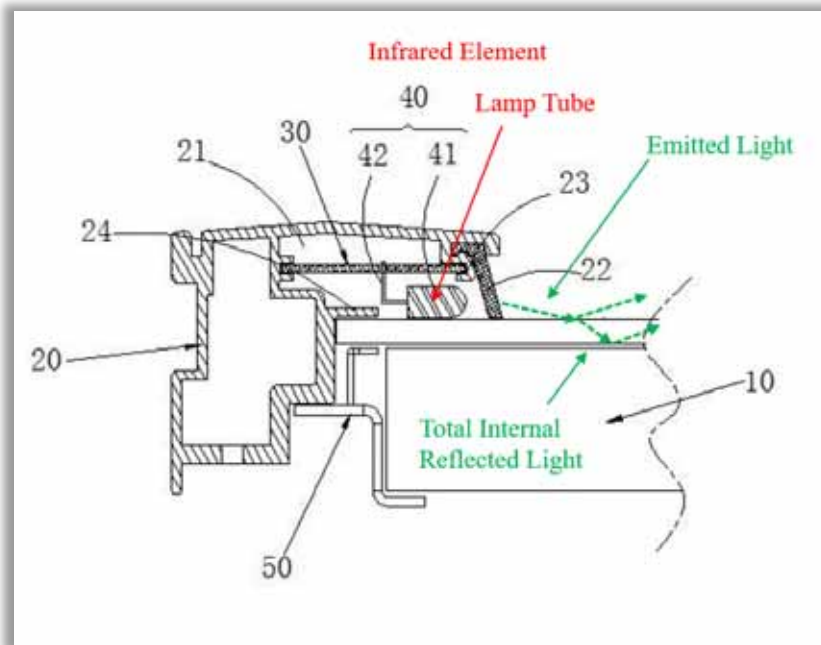
understood Cheng's infrared element 40 with lamp tube 41 (emitter) to emit light through Cheng's plate by total internal reflection ("TIR") via several modes.

187. First, in my view, a POSA would have understood TIR to have occurred in Cheng from light emitting from the lamp tube 41 (in contact with the plate) and passing directly into the plate. See Ex. 1004 at [0005-0010], Fig. 1.



Ex. 1004 at Fig. 1.

188. Second, in my view, a POSA would have understood TIR to have occurred from light emitted from the lamp tube 41 in a non-parallel vector with the surface of the plate such that the emitted light would intersect the plate. At the light-to-frame intersection point, a POSA would have understood light to both reflect away from and enter the plate. In my opinion, a POSA would have further understood light entering the plate to subsequently travel along the plate via TIR.



Ex. 1004 at Fig. 1.

189. Further, Han discloses TIR. One embodiment of Han's touch accuracy improving touch device is described as follows:

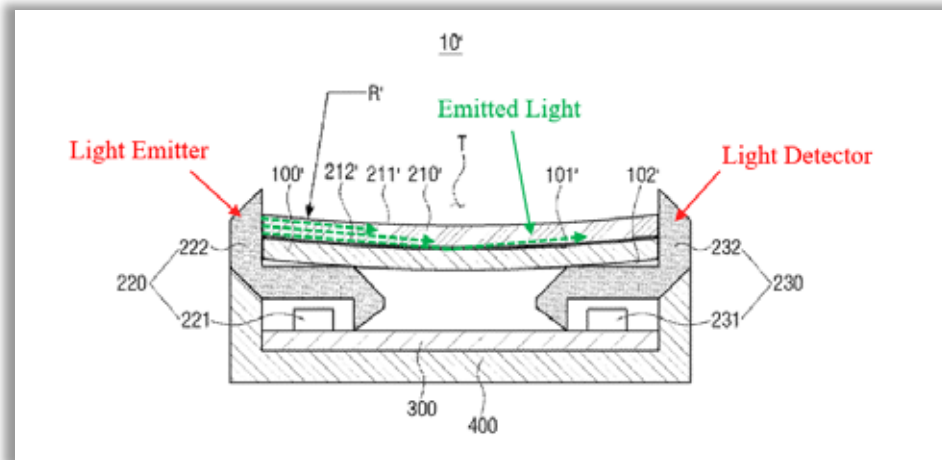
As the cover glass 210' includes a light permeable material, **light emitted from the light emitting surface 2221 of the light emission guide member 222 may move along the inside of the cover glass 210,' and may be incident on the incidence surface 2321 of the light reception guide member 232.**

Accordingly, the rear surface of the cover glass 210' may also be concavely curved along the moving direction of light moving through the touch area T, and thus **light passing through the inside of the cover glass 210'** may be guided to

the incidence surface 2321 of the light reception guide member 232.

Ex. 1005 at [0115-116]. (emphasis added).

190. In my view, a POSA would have understood Han to describe a plurality of emitters (light emitting surface 2221 of the light emission guide member 222) emitting light through the plate (cover glass 210') by TIR.

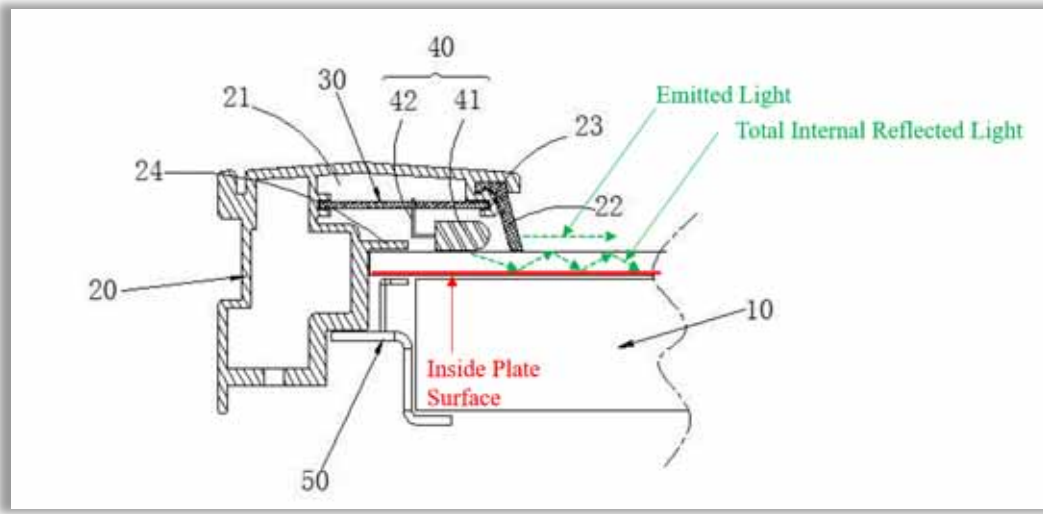


Ex. 1005 at Fig. 7.

191. As I described above, the inside surface of Han's cover glass 210 is curved to facilitate TIR. *Id.* at [0116]. Along with Han's concave touch surface curvature, it is my view that a POSA would have further understood that Han teaches improving touch detection accuracy by utilizing TIR to deliver light—that would otherwise escape and be undetected—to the light detection guide member 232. Additionally, it is my opinion that a POSA would have understood Han's TIR of

emitted light to limit interference between the light emitters and the display, as light would be conveyed, via TIR in the cover glass 210, substantially orthogonal to the display as opposed to intersecting the display and resulting in a “washing out” effect. Further, it is my view that a POSA would have appreciated TIR within Han’s cover glass 210 to increase the total light signal detected by Han’s detector in the absence of a touch. This increase in “base” light signal would proportionally increase the amount of signal attenuated during a touch, as well as increase the “signal-to-noise” ratio of the detector, thus increasing overall touch detection sensitivity. Further, it is my view that a POSA would have appreciated an increased base signal and “signal-to-noise” from TIR to allow for comparably less sensitive and costly detector components to achieve the same touch detection performance as more sensitive and expensive detectors without TIR.

192. It is my opinion that a POSA implementing the touch accuracy improving *external* cover glass curvature of Han into Cheng’s plate would have similarly been motivated to incorporate Han’s *internal* cover glass curvature into the internal surface of Cheng’s modified plate.



Ex. 1004 at Fig. 1.

193. In the modified Cheng device, the curved back surface of the plate would (like in Han) facilitate “guiding” totally internally reflected light through Cheng’s modified plate. See Ex. 1005 at [0115-116]. As Cheng’s modified plate would be concavely curved according to Han, additional vectors of emitted light would further intersect the plate, increasing the incidence of TIR. In my view, a POSA would have expected the modified Cheng device implementing TIR to result in limited emitter-to-display interference, increased touch accuracy thanks in part to increased base light signal and “signal-to-noise” ratio, and reduced detector sensitivity and cost requirements (like in Han).

194. Thus, it is my opinion that Cheng in view of Han discloses wherein the plurality of emitters (Cheng’s infrared elements 40 with lamp tube 41; Han’s light

emitting parts 220) is configured to emit light through the plate (Cheng's plate; Han's cover glass 210) by total internal reflection (entered light traveling via total internal reflection).

4. Claim 4: The touch sensing apparatus of claim 1, further comprising a processing element configured to determine, based on output signals of the plurality of detectors, a position of an object on the touch surface.

195. It is my opinion that Cheng and Han disclose this element. Cheng discloses a circuit board 30 in connection with infrared element 40. Ex. 1004 at [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]. Han's 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, it is my opinion that 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.

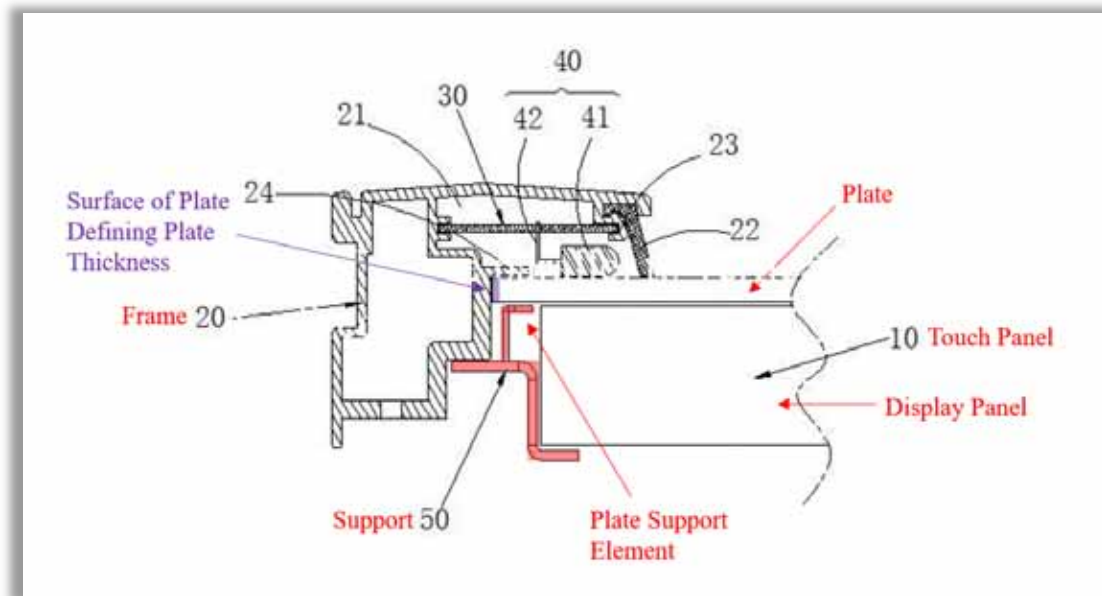
196. It is also my opinion that a POSA would have understood Cheng to include a processing element—embodied in Cheng's circuit board 30 or otherwise—

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 processing element and function confirms as much. Ex. 1005 at [0012-13].

197. Thus, it is my opinion that Cheng and Han discloses a processing element (Cheng's circuit board 30; Han's integrated circuit IC) configured to determine, based on output signals of the plurality of detectors (Cheng's infrared element 40 with detector; Han's photo diodes 231 and light reception guide members 231), a position of an object (a user touch) on the touch surface (surface of Cheng's plate; Han's front surface 211).

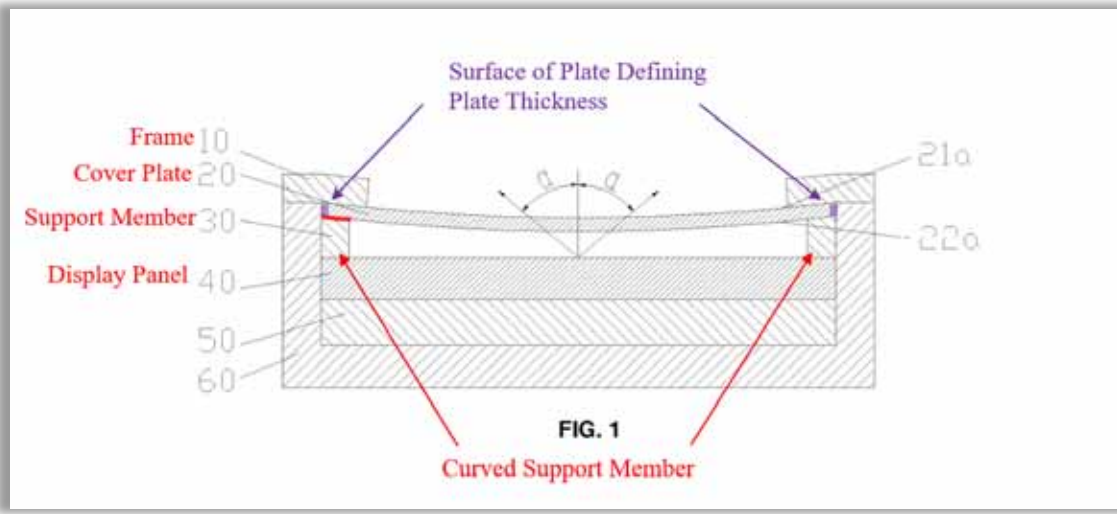
5. Claim 5: The touch sensing apparatus of claim 1, further comprising a gasket, wherein the plate is supported by the gasket along the surface of the plate that defines the plate thickness.

198. In my opinion, Cheng in view of Han and Zhao discloses this element. As seen in Cheng's Fig. 1, Cheng's support 50 includes a plate support element. Ex. 1004 at Fig. 1. Cheng's plate support element supports the plate along the surface of the plate that defines the plate thickness. *See id.*



Ex. 1004 at Fig. 1.

199. 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.

200. In my view, a POSA would have understood Zhao's support member 30 to have the same function as a "gasket" as described in the '335 Patent. As the '335 Patent discloses "[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. 1031 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].

201. It is my opinion that 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. Like Zhao, Cheng's modified plate support element would support the plate along the surface of the plate that defines the plate thickness.

202. Thus, in my opinion, Cheng in view of Han and Zhao discloses a gasket (Cheng's modified curved plate support member; Zhao's support member 30), wherein the plate (Cheng's plate) is supported by the gasket along the surface of the plate (Cheng's modified plate support element along edge of plate) that defines the plate thickness.

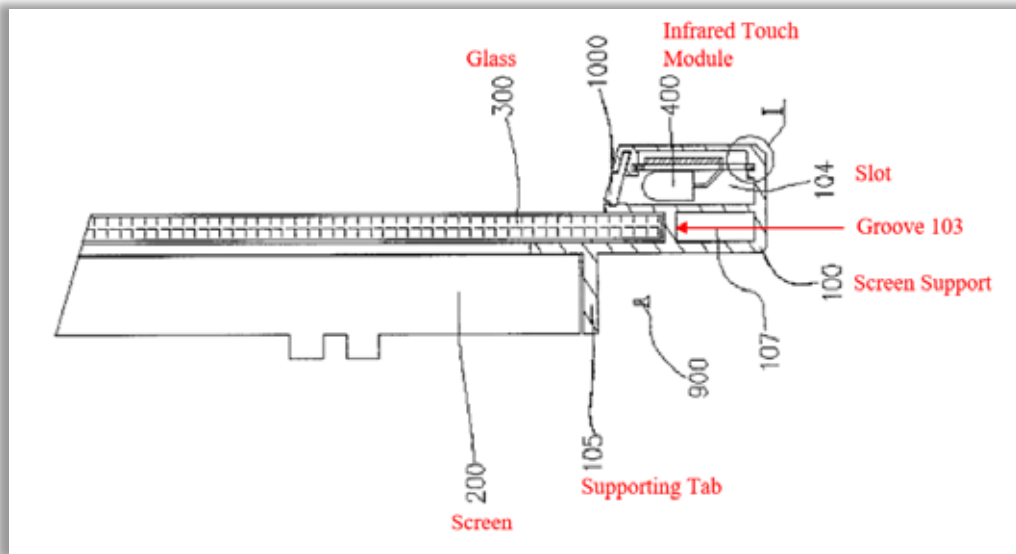
**IX. GROUND 2 - CLAIMS 1-5 ARE OBVIOUS UNDER 35 U.S.C. § 103
BASED ON CAO IN VIEW OF HAN AND ZHAO.**

203. In my opinion, Cao in view of Han and Zhao renders claims 1-5 obvious as follows. 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 Zhao. In my view, a POSA would have expected a resulting touch screen display device having improved touch performance, achieved through a simplified manufacturing process.

Motivation to Combine

204. It is my opinion that a POSA would have been motivated to modify the Cao device using the teachings of Zhao to obtain the technical advantages disclosed in Han. As an initial matter, Cao, Han, and Zhao each relate to similar devices including a display, a covering panel, and a supporting frame assembly. See Ex. 1010 at Abstract, Fig. 1; Ex. 1005 at Abstract; Ex. 1012 at Abstract.

205. 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 certain implementation details to the reader.

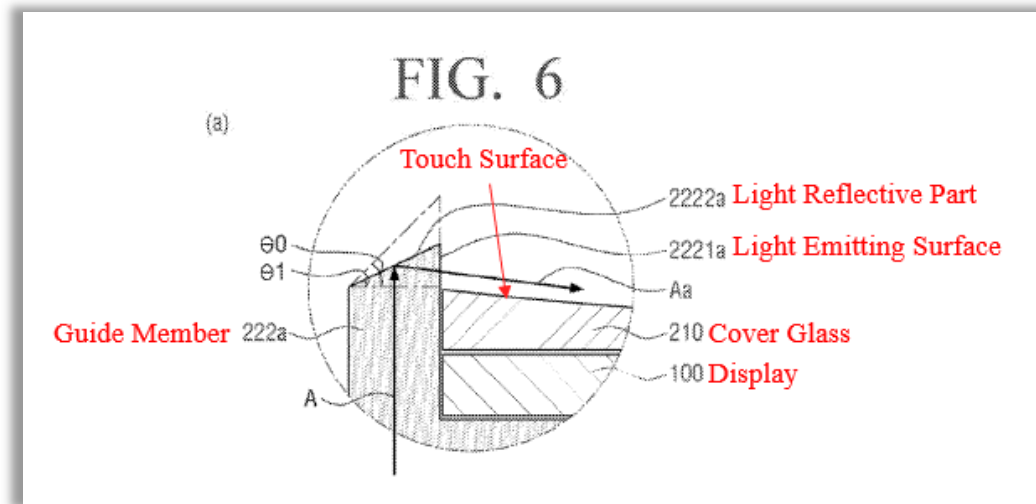


Ex. 1010 at Fig. 9

206. Where Cao discloses a relatively flat touch surface to improve a glass-to-frame fit (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 (A_x , A_y) 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].

207. Han teaches improving touch detection accuracy in infrared touch devices—such as Cao's device. In Han, the front surface of a flat cover glass 210 (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

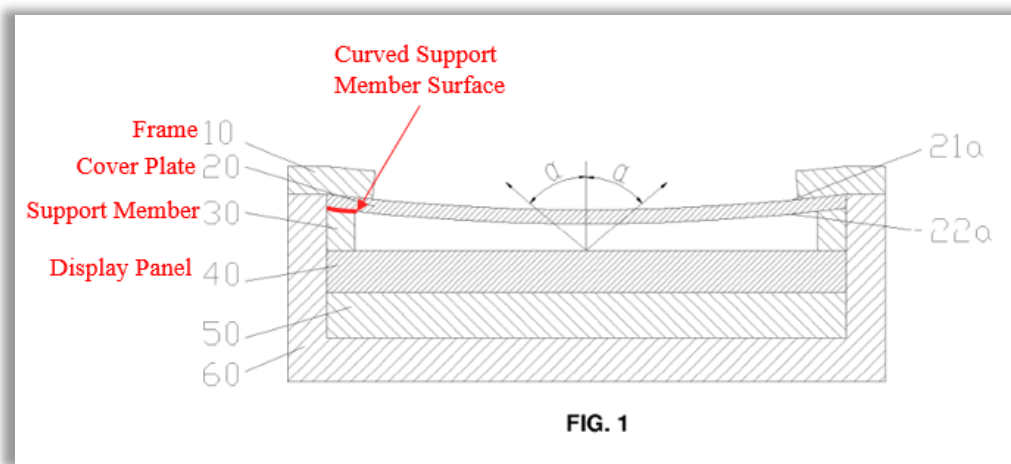
touch surface of cover glass 210 by tilting a light reflective part 222a of the guide member 222. Ex. 1005 at [106].



Ex. 1004 at Fig. 6(a).

208. 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]. Han further 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, it is my opinion that Han discloses improvements of the same objectives (improved touch detection accuracy and frame size reduction) in the same technological field (infrared touch devices) as Cao.

209. 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. Ex. 1012 at [0045-48]. Like Cao, Zhao teaches supporting its cover plate 20 with a frame 10 (Cao's screen support 100) and a support member 30 (Cao's groove 103 having groove wall 112).



Ex. 1012 at Fig. 1.

210. 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 id.* 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 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 discloses that the curved cover panel 20 improves the optical performance of emitted light by reducing the amount of light leak. *See id.* at Abstract.

211. 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 to achieve Han's parabolic plate curvature in Cao. As Cao's frame already supports the plate via groove 103, it is my view that it would have been obvious for POSA to modify Cao's groove 103 with groove walls 112 and 113 according to the curved support member 30 of Zhao. In my opinion, a POSA would have expected such modification to achieve the same simplified curvature-inducing functionality of Zhao in the modified Cao device. As Zhao teaches that the surface of the Zhao's support member 30 in contact with Zhao's cover plate 20 matches that of the cover plate, the modified Cao groove 103 would also match the curvature of the resulting curved plate. In my view, this modification would agree with the original Cao's configuration improving a glass-to-frame fit.

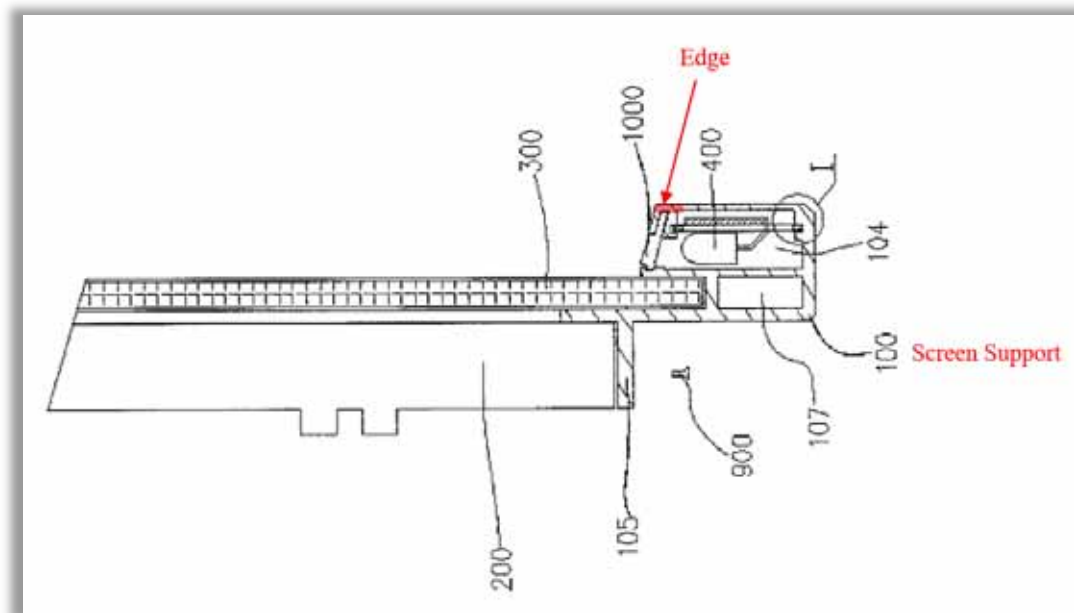
212. Thus, it is my opinion that a POSA combining the teachings of Han and Zhao into the device of Cao would have expected to achieve the predictable result

of a high touch accuracy (Han) infrared touch device (Cao, Han) and simplified manufacturing method (Zhao), meeting the limitations of the '335 Patent. In my opinion, such modifications would have merely embodied implementing known techniques to improve a similar device in a similar way.

1. Claim 1

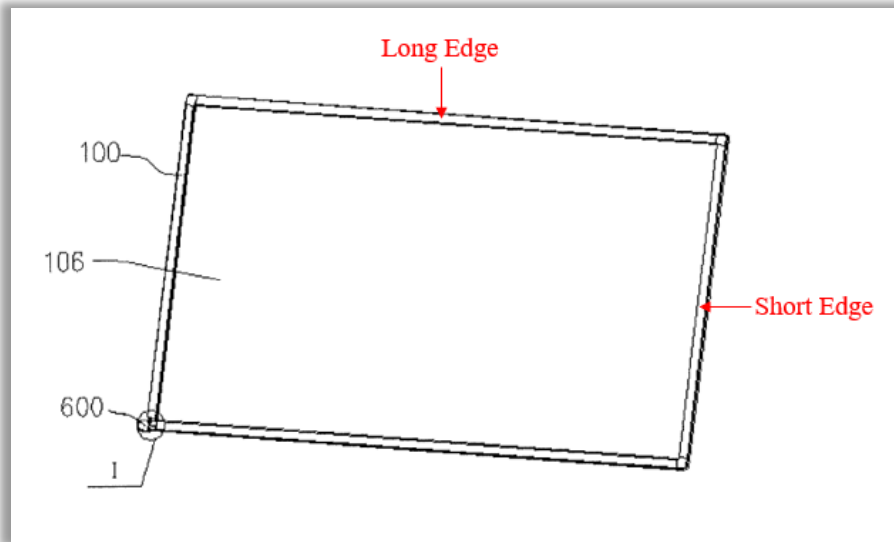
(a) Preamble: “A touch sensing apparatus having a long edge and a short edge,”

213. In my opinion, Cao and Han disclose this element. Cao discloses touch sensing device having a long edge and a short edge. Ex. 1010 at Figs. 1, 8. Shown below, Cao’s screen support 100 includes an edge portion.



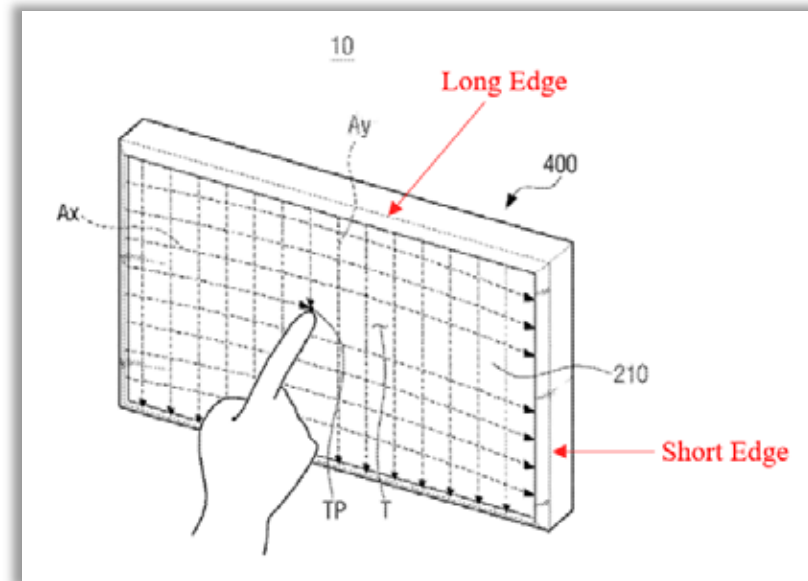
Ex. 1010 at Fig. 9.

214. Cao's screen support 100 makes up a screen frame 106 having a long edge and a short edge.



Ex. 1010 at Fig. 14.

215. Han's frame assembly (including rear cover 400 and guide members 222, 232) further includes a first long edge, and a second short edge. See Ex. 1005 at Fig. 2.

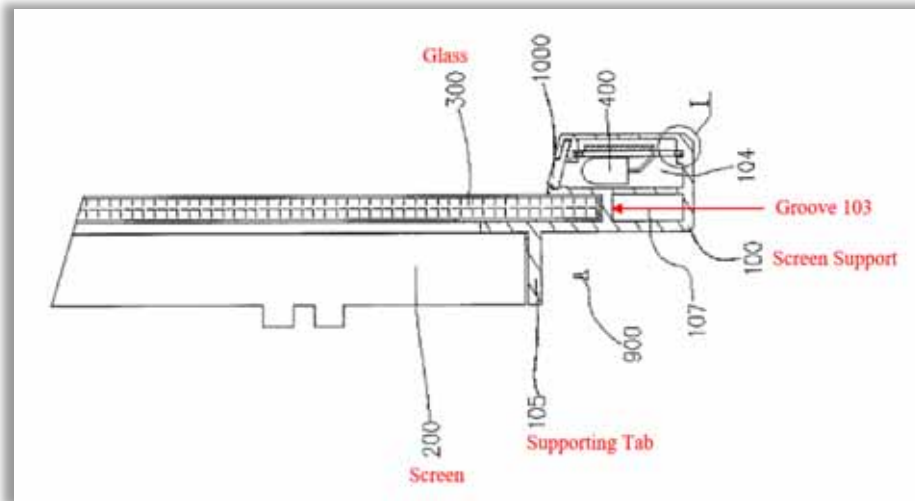


Ex. 1005 at Fig. 2.

216. Thus, it is my opinion that Cao and Han disclose a touch sensing apparatus (Cao's touch device, Han's touch device) having a long edge (Cao's screen frame 106 long edge, Han's long edge) and a short edge (Cao's screen frame 106 short edge, Han's long edge).

(b) "a display panel;"

217. In my opinion, Cao, Han, and Zhao each disclose this element. Shown below, Cao's touch device includes a screen 200 (display panel).



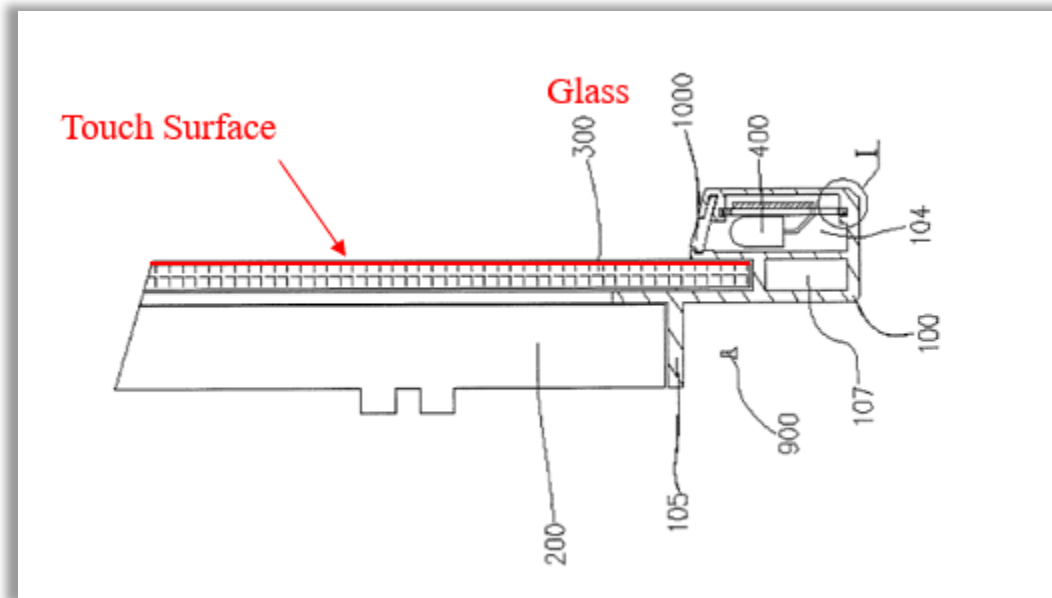
Ex. 1010 at Fig. 9.

218. Further, Han and Zhao each include a display panel. Ex. 1005 at Abstract (Han's display 100); Ex. 1010 at Abstract (Zhao's display panel 40).

219. Thus, it is my opinion that Cao, Han and and Zhao disclose a display panel (Cao's screen 200, Han's display 100, Zhao's display panel 40).

(c) “a plate including a top surface that comprises a touch surface;”

220. In my opinion, Cao and Han disclose this element. Cao discloses touch device including a glass 300 (plate). Ex. 1010 at 3:66-4:12. In my opinion and as shown below, a POSA would have understood Cao's glass 300 to include a top surface that comprises a touch surface.



Ex. 1010 at Fig. 9.

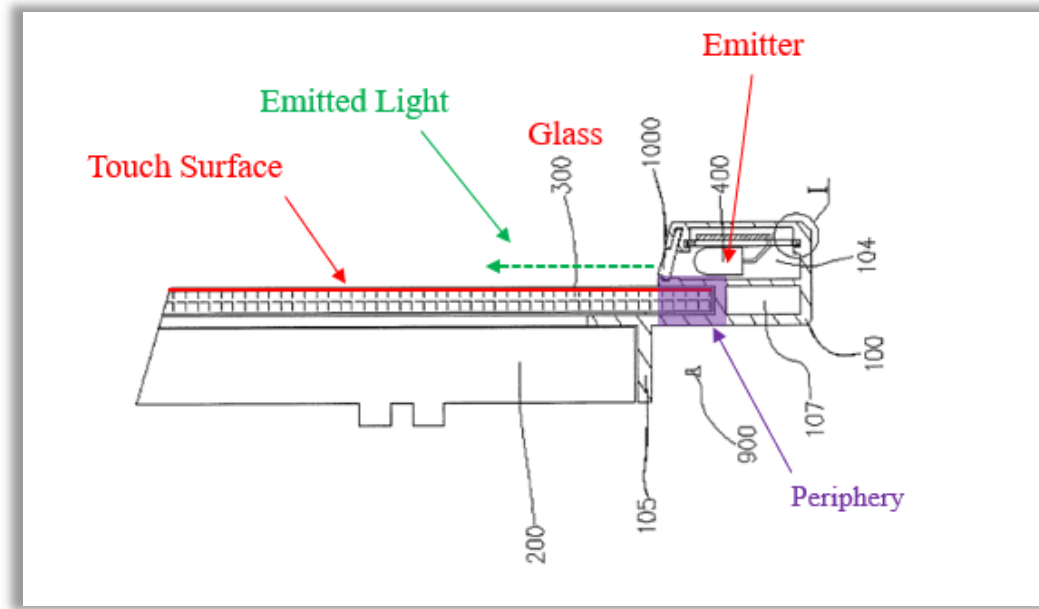
221. Further, Han discloses a cover glass 210 with a touch surface. Ex. 1005 at [0019], [0038], Fig. 2.

222. Thus, it is my opinion that Cao and Han disclose a plate (Cao's glass 300; Han's cover glass 210) including a top surface that comprises a touch surface (Cao's touch surface of glass 300; Han's touch surface T).

(d) “a plurality of emitters arranged around a portion of the periphery of the plate and configured to emit light across the touch surface of the plate,”

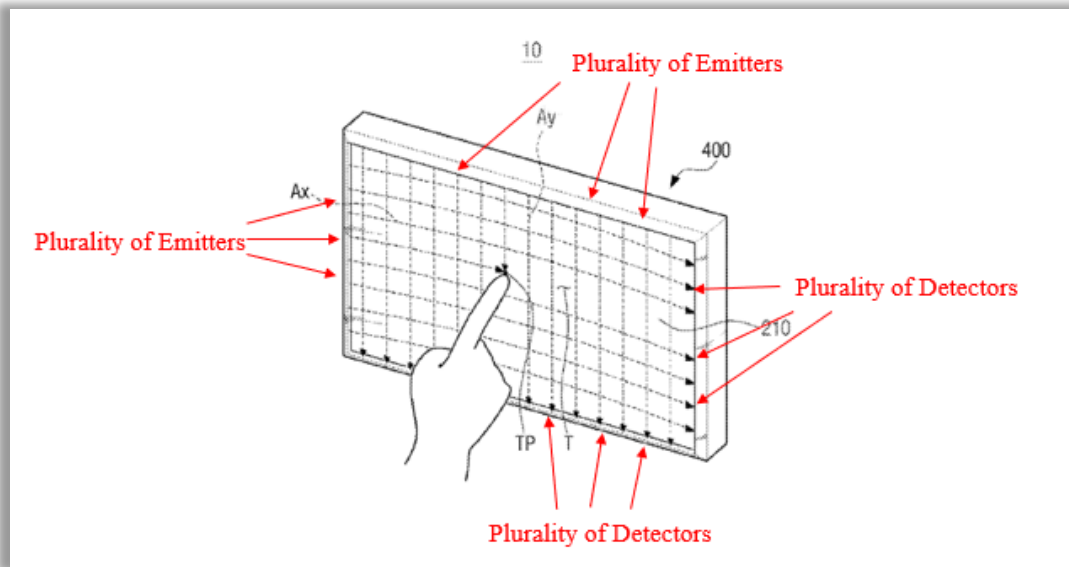
223. In my opinion, Cao in view of Han discloses this element. In Cao, the infrared touch modules 400 are arranged adjacent to (or around a portion of) the periphery of the plate 300. See Ex. 1010 at Fig. 9. While Cao only describes

“infrared modules 400,” it is my view that a POSA would have understood infrared modules to disclose an emitter.



Ex. 1010 at Fig. 9.

224. It is my opinion that a POSA would have understood the emitter to emit light across the (touch) surface of the glass 300 based on the orientation of Cao’s emitter in relation to glass 300. Further, while Cao does not explicitly describe a plurality of emitters, it is my view that it would have been obvious to a POSA to implement a plurality of emitters as taught by Han and as known generally in the prior art. Ex. 1005 at [0040]; Ex. 1031 at 1:26-46, 15:62-16:3.



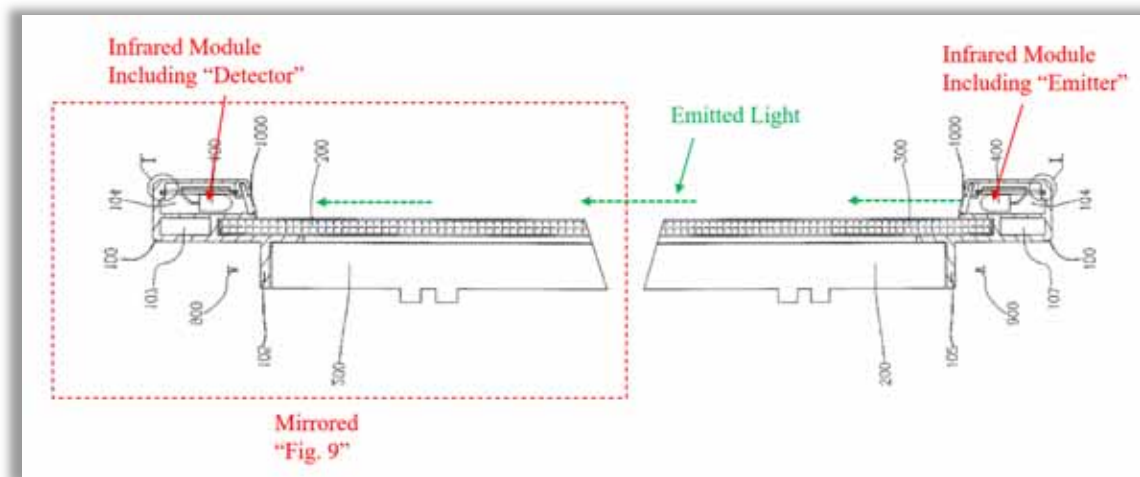
Ex. 1005 at Fig. 2.

225. In my opinion, 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.

226. Thus, it is my opinion that Cao in view of Han discloses arranging a plurality of emitters (Cao's infrared touch modules 400 with emitters, Han's plurality of emitters) arranged around a portion of the periphery of the plate (Cao's glass 300) and configured to emit light across the touch surface of the plate (top surface of Cao's glass 300).

(e) “a plurality of detectors arranged around a portion of the periphery of the plate and configured to receive light from the plurality of emitters,”

227. It is my opinion that Cao in view of Han discloses this element. While Cao only describes “infrared modules 400,” a POSA would have understood infrared 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.

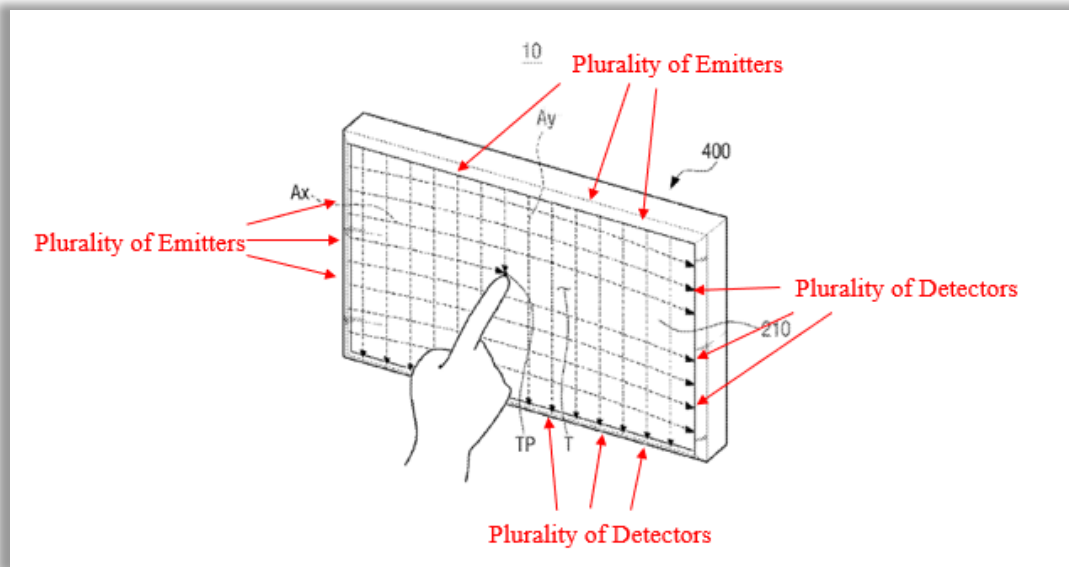


Ex. 1010 at Fig. 9.

228. As I discussed above for claim 1(d), it is my opinion that it would have been obvious to a POSA to include a plurality of detectors according to Han. In my view, 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. 1031 at 1:26-46, 15:62-16:3.

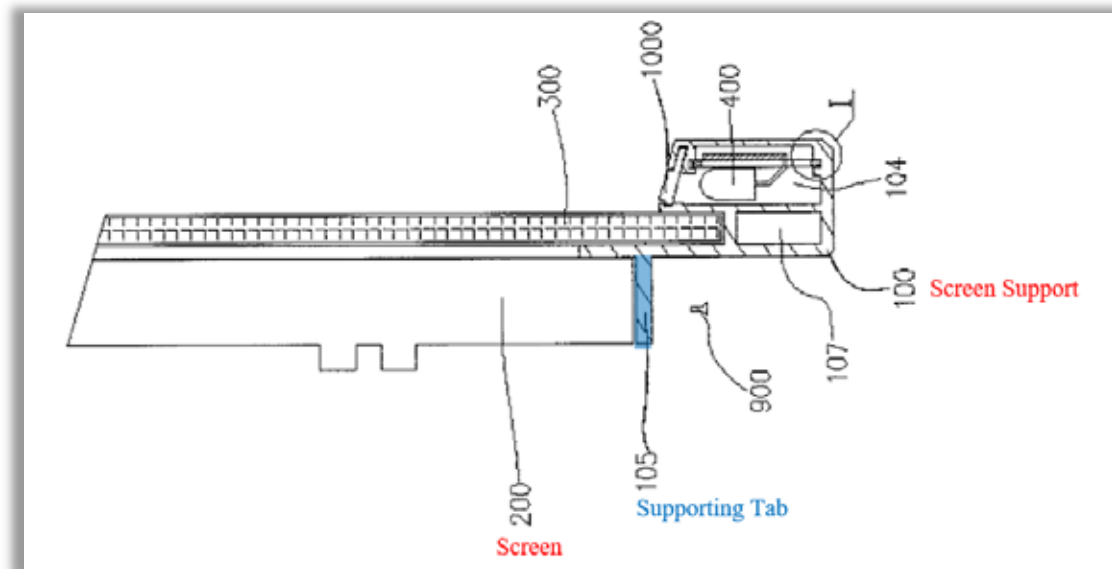


Ex. 1005 at Fig. 2.

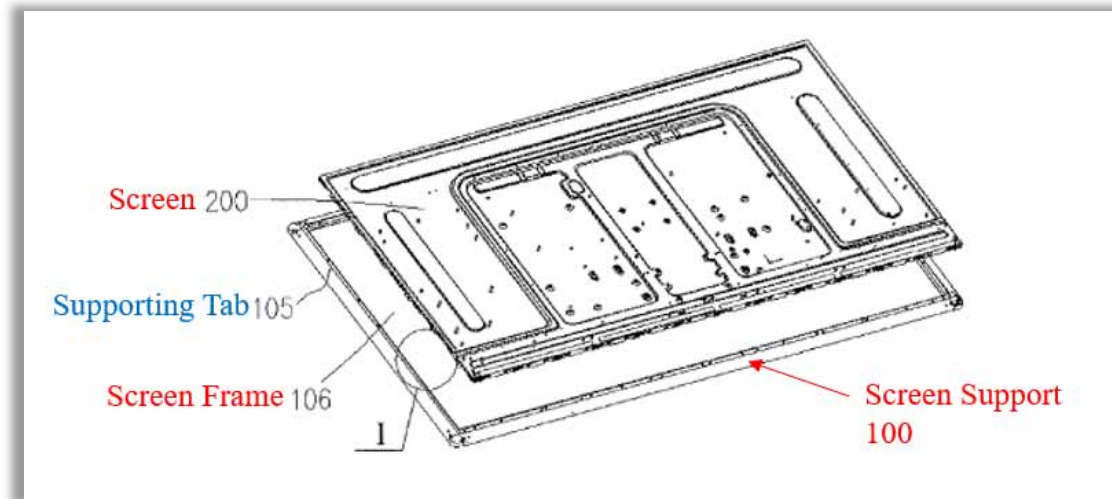
229. Thus, in my opinion, Cao in view of Han discloses a plurality of detectors (Cao's infrared touch modules 400 including detectors, Han's plurality of detectors) arranged adjacent to the periphery of the plate (Cao's glass 300), said plurality of detectors configured to receive light from the set of emitters (Cao's opposing infrared touch modules 400 including emitters, Han's plurality of emitters).

- (f) “a frame assembly, the frame assembly comprising; a first frame element configured to support the display panel; a second frame element arranged around the periphery of the plate and configured to support the plurality of emitters and plurality of detectors.”

230. It is my opinion that Cao discloses this element. For a first frame element, each of Cao’s screen supports 100 define a supporting tab 105 that define a screen frame 106 when the four screen supports are joined together. Ex. 1010 at 4:7:10, 5:34-36, 7:21-27, Figs. 3, 9, 14. 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.



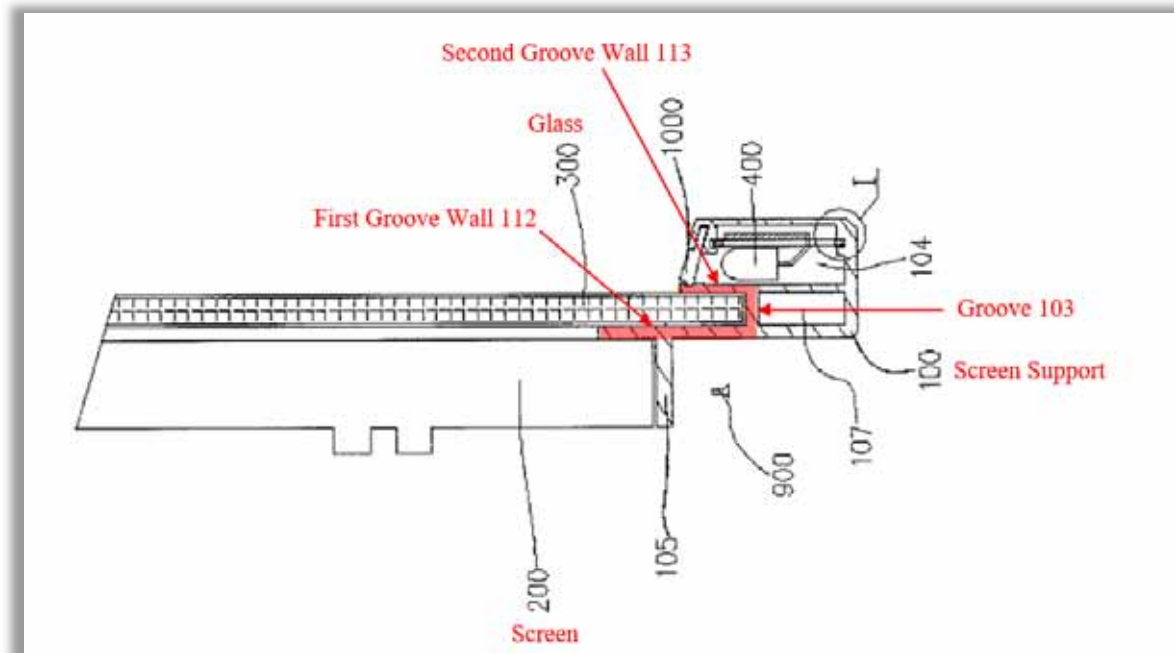
Ex. 1010 at Fig. 9.



Ex. 1010 at Fig. 3.

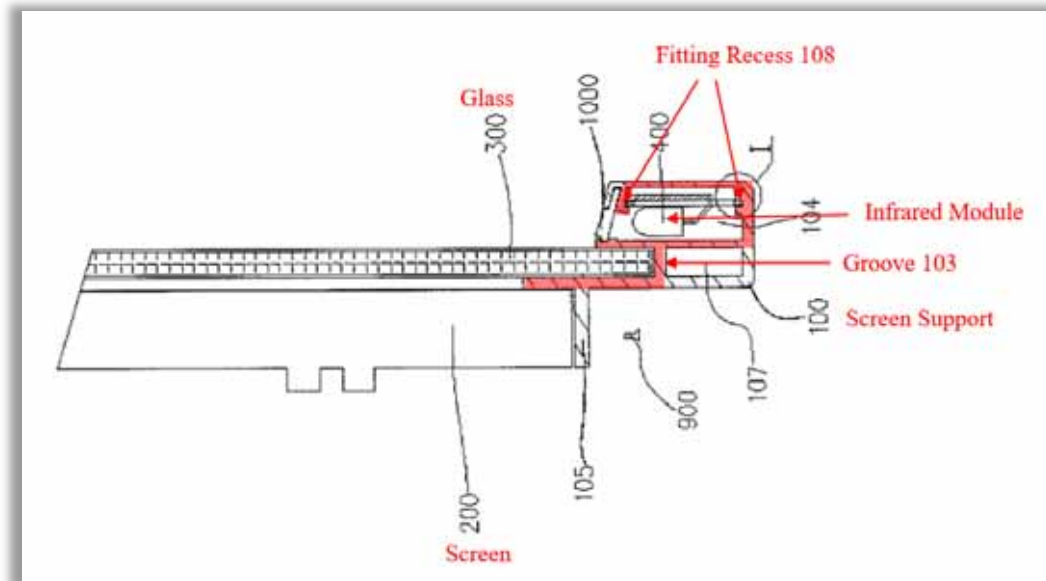
231. Thus, it is my opinion that Cao discloses a frame assembly (screen support 100), the frame assembly comprising a first frame element (supporting tab 105 defining screen frame 106) configured to support the display panel (screen 200).

232. For a second frame element, Cao discloses a screen support 100 including a groove 103 having a first groove wall 112 and second groove wall 113. Ex. 1010 at 5:47-53. Shown below, Cao's groove 103, first groove wall 112 and second groove wall 113 are arranged around the periphery of the glass 300. *Id.* at Fig. 9.



Ex. 1010 at Fig. 9.

233. Cao's infrared module 400 (including emitters and detectors as I discussed above) is fitted into fitting recesses 108. *Id.* at 4:59-63. Fitting recesses 108 are structurally connected to Cao's groove 103, first groove wall 112 and second groove wall 113 (together a second frame element) as each are components of Cao's screen support 100. *See id.* at Fig. 9.



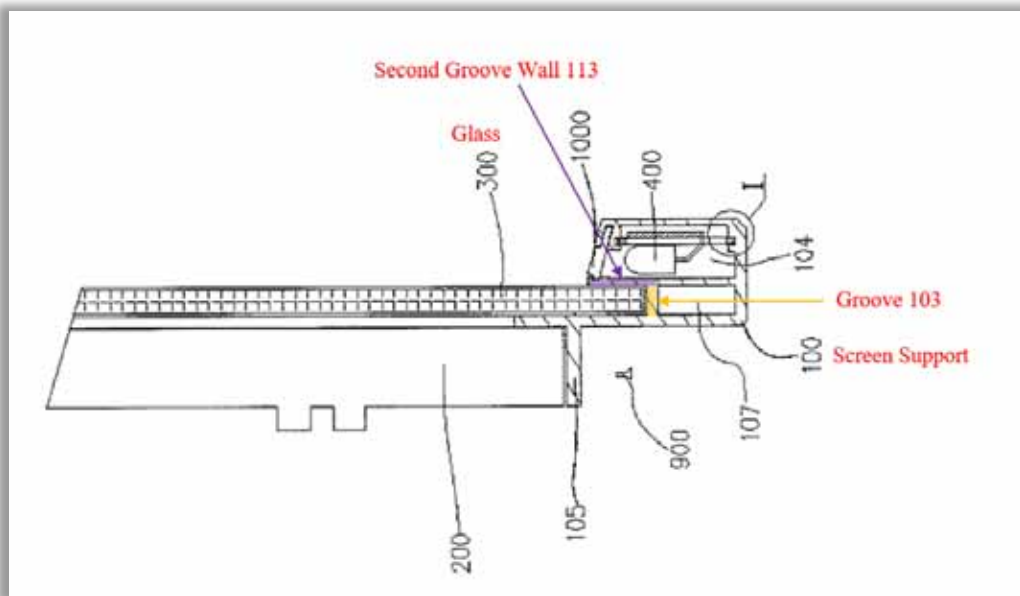
Ex. 1010 at Fig. 9.

234. In my view, a POSA would have understood Cao's groove 103, first groove wall 112 and second groove wall 113 to support the emitters and detectors of the infrared module 400 by means of structural connection through screen support 100.

235. Thus, it is my opinion that 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); a second frame element (groove 103, first groove wall 112 and second groove wall 113) arranged around the periphery of the plate (glass 300) and configured to support the plurality of emitters and plurality of detectors (infrared module 400 including emitters and detectors).

- (g) **“wherein the second frame element includes a first surface portion extending over an edge portion of the plate and a second surface portion arranged substantially parallel to a surface of the plate that defines the plate thickness.”**

236. In my opinion, Cao discloses this element. Cao’s second groove wall 113 extends over an edge portion of the glass 300 (plate). See Ex. 1010 at Fig. 9. While I note that the ’335 Patent’s “surface of the plate that defines the plate thickness” is ambiguous, it is my opinion that a POSA would understand that Cao’s groove 103 includes a portion arranged substantially parallel to the surface of Cao’s plate that defines its thickness. See Ex. 1010 at Fig. 9.

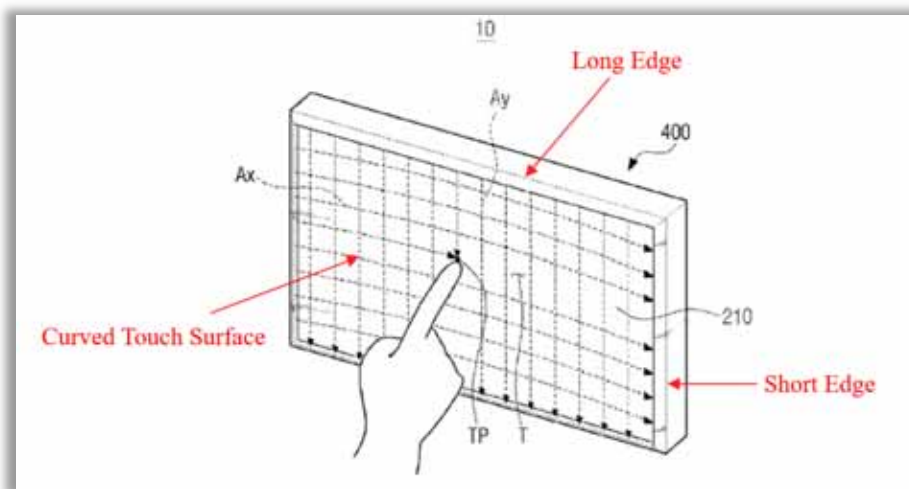


Id.

237. Thus, in my opinion, Cao discloses wherein the second frame element (groove 103, first groove wall 112 and second groove wall 113) includes a first surface portion (second groove wall 113) extending over an edge portion of the plate (glass 300) and a second surface portion (surface of groove 103) arranged substantially parallel to a surface of the plate that defines the plate thickness (thickness edge of glass 300).

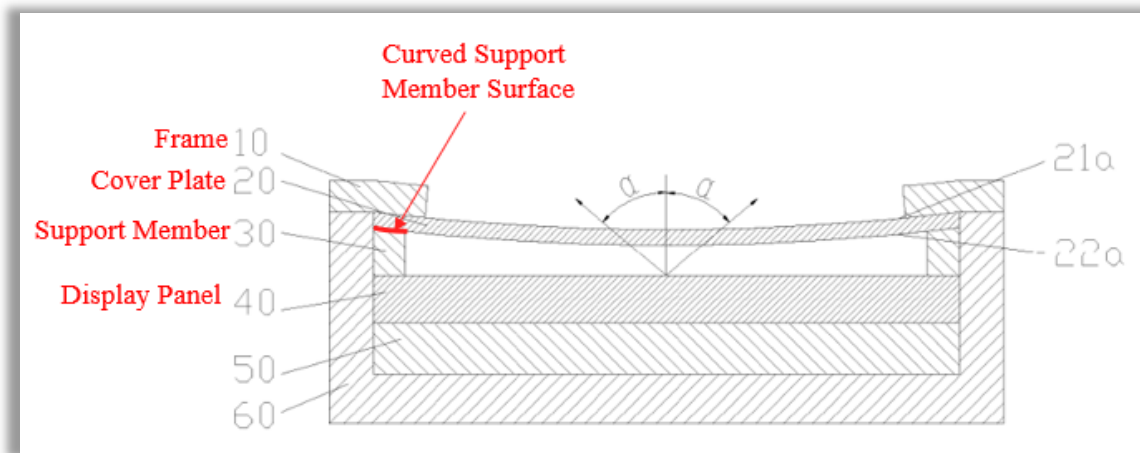
(h) “wherein the touch surface is curved relative to a flat plane defined in part by the short edge and the long edge.”

238. It is my opinion that Cao in view of Han and Zhao discloses this element. As I discussed above, it would have been obvious to a POSA to modify Cao's glass 300 to incorporate Han's concave touch screen curvature long A_x and A_y directions to improve touch detection accuracy.



Ex. 1005 at Fig. 2.

239. To reach Han's touch screen curvature, it is my view that it would have been obvious to a POSA to modify Cao's groove 103, first groove wall 112 and second groove wall 113 according to Zhao's curved mounting surfaces 30 and frame 10.

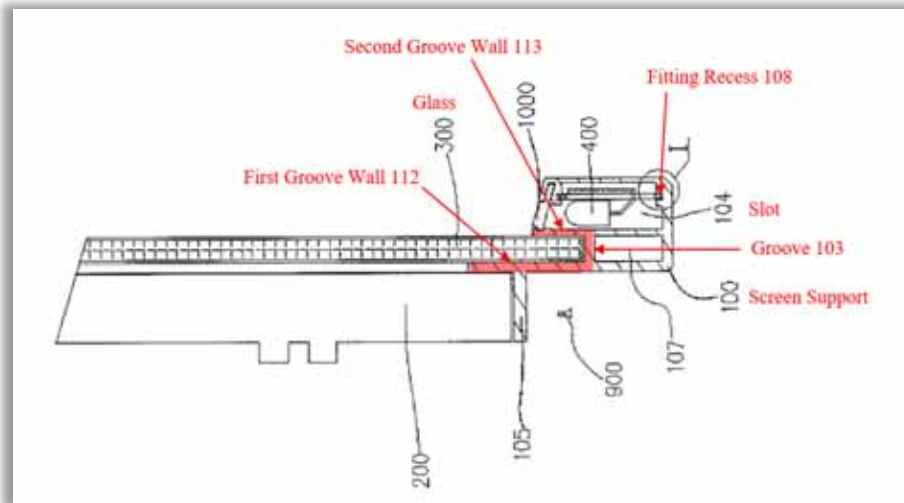


Ex. 1012 at Fig. 1.

240. The curved modified groove 103, first groove wall 112 and second groove wall 113 of Cao would induce curvature into Cao's plate in a simplified manufacturing step (like in Zhao). Cao's modified curved groove 103 would also secure the curved touch surface side of the curved plate similar to Zhao's curved frame 10.

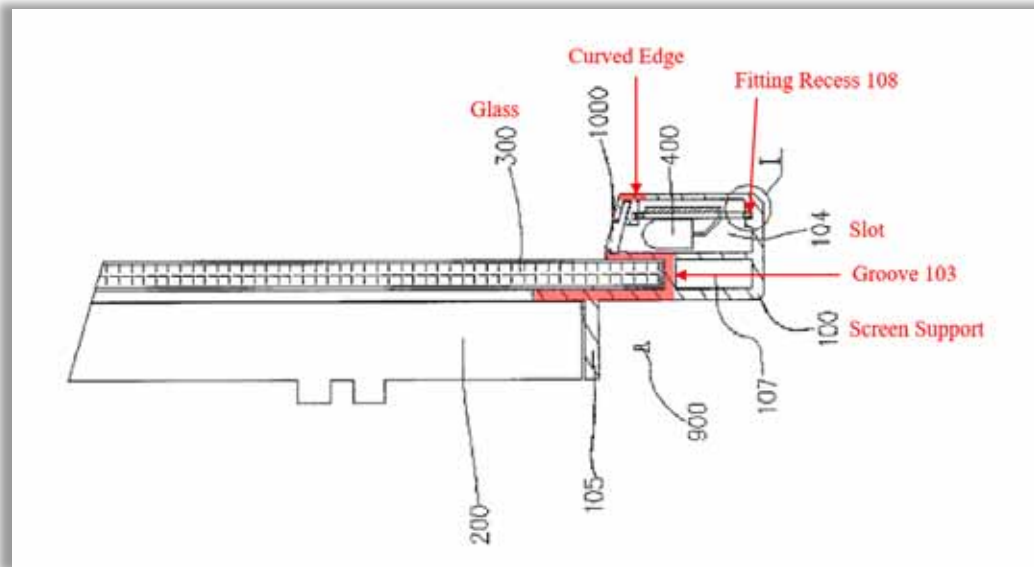
241. The modified Cao device has curved short and long edges. Cao's screen support 100 includes a slot 104 and fitting recesses 108 that secure the infrared element 400. Ex. 1010 at 4:59-63, Fig. 9. Connected to Cao's fitting

recesses 108 via screen support 100 are groove 103, first groove wall 112 and second groove wall 113 which prevent “oversized gap between the glass 300 and the front frame...” *Id.* at 4:13-19.

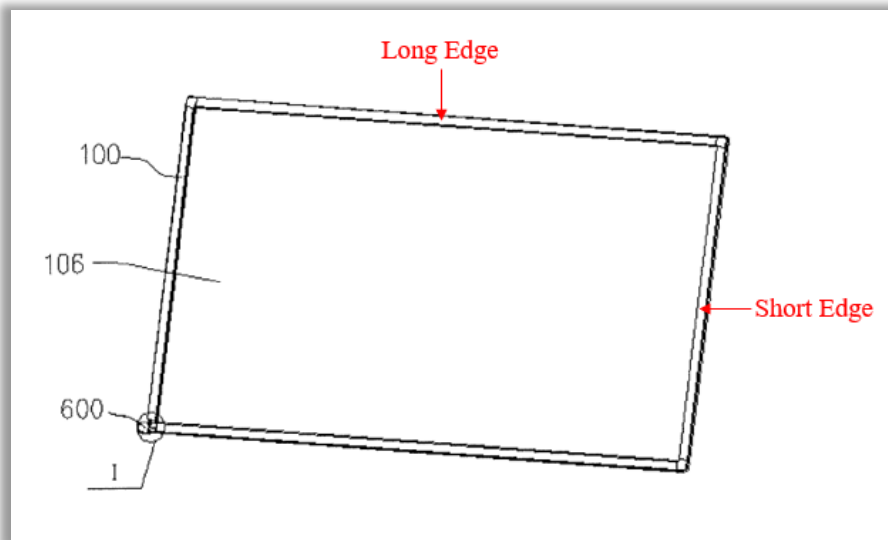


Ex. 1010 at Fig. 9.

242. In the modified Cao device having curved groove 103, first groove wall 112 and second groove wall, the slot 104 and fitting recesses 108 would also be curved. The respective long and short edges of Cao’s modified screen support 100 would also be curved as a result.



Ex. 1010 at Fig. 9.

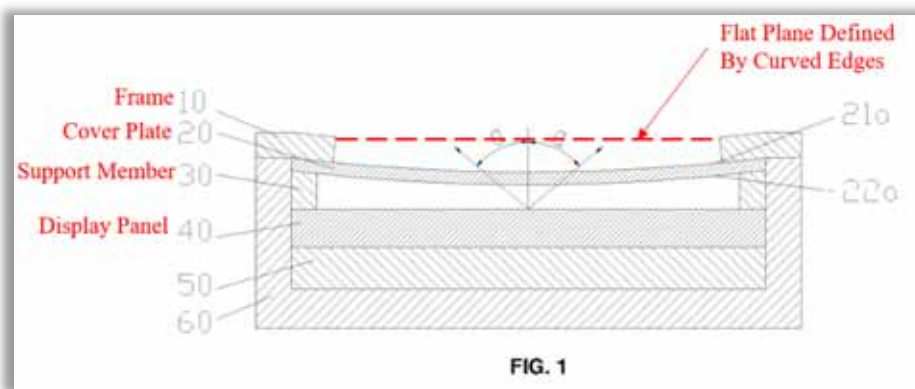


Id. at Fig. 14.

243. It is my opinion that in this configuration, a POSA would have expected Cao's curved edges to contribute in preventing any "oversized gap" between the screen support 100 (frame) and the glass 300 (panel)—such as what a POSA would

otherwise expect to occur between curved plate and a straight frame. It is also my opinion that a POSA would further have expected to achieve Zhao's improved structural loosening performance from Zhao's curved frame 10 by curving Cao's screen support 100 (having long and short edges). See Ex. 1010 at [0051-52].

244. Cao's modified curved plate touch surface would be curved relative to a flat plane defined in part by the short and long edges of screen support 100. . As I discussed above, Cao's modified long and short edges would be curved according to Zhao. A flat plane would be defined (at least in part) by Cao's modified curved edges. Given that the modified edges would be curved, the flat plane would intersect the edges at least at the extremum of the edges, such as the corners of the edges or the slope inflection regions of the edges.



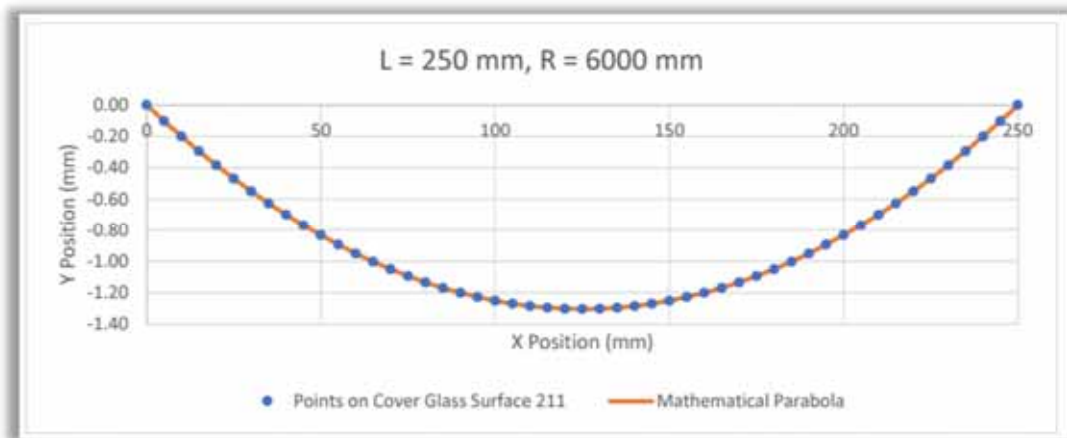
Ex. 1012 at Fig. 1

245. Thus, it is my opinion that Cao in view of Han and Zhao discloses wherein the touch surface (surface of Cao's glass 300) is curved relative to a flat

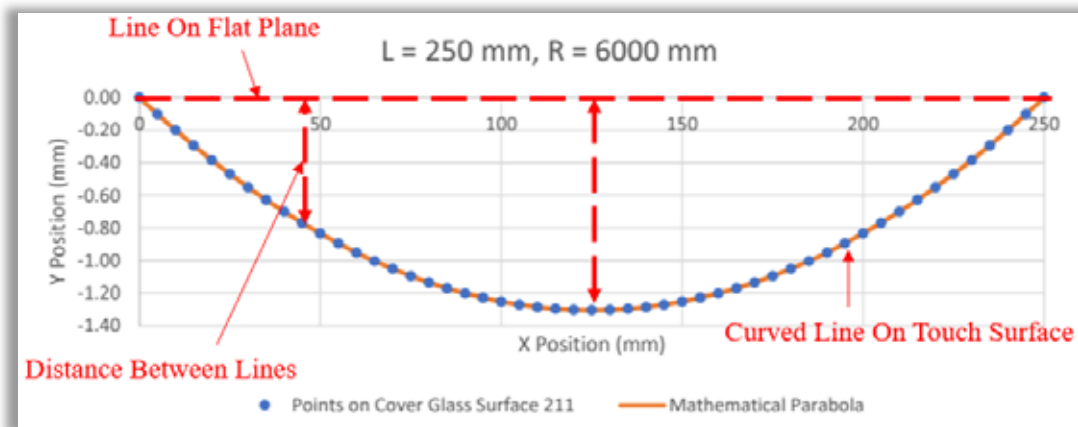
plane (flat plane across curved long and short edges) defined in part by the short edge (short edge of Cao's screen support 100) and the long edge (long edge of Cao's screen support 100).

- (i) **“wherein a distance between a first curved line drawn on the touch surface and a second straight line drawn on the flat plane varies according to a concave curve function.”**

246. In my opinion, Cao in view of Han and Zhao discloses this element. Han discloses a parabolically curved touch surface on cover glass 210. Ex. 1005 at [0074-77]. 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]. Plotting the resulting curvature disclosed by Han yields a curve described by a parabolic function. *See* Section VII(b). In my view, a POSA would have been motivated to adopt the same parabolic (concave) curvature of Han into Cao's modified glass 300 to achieve Han's improved touch performance. *Id.*



247. As I discussed above, a flat plane can be established across the long and short edges of the modified Cao screen support 100 (according to Zhao). Shown below, a line can be drawn along Cao's flat plane and a line can be drawn along the concavely curved touch surface of Cao's modified glass 300.



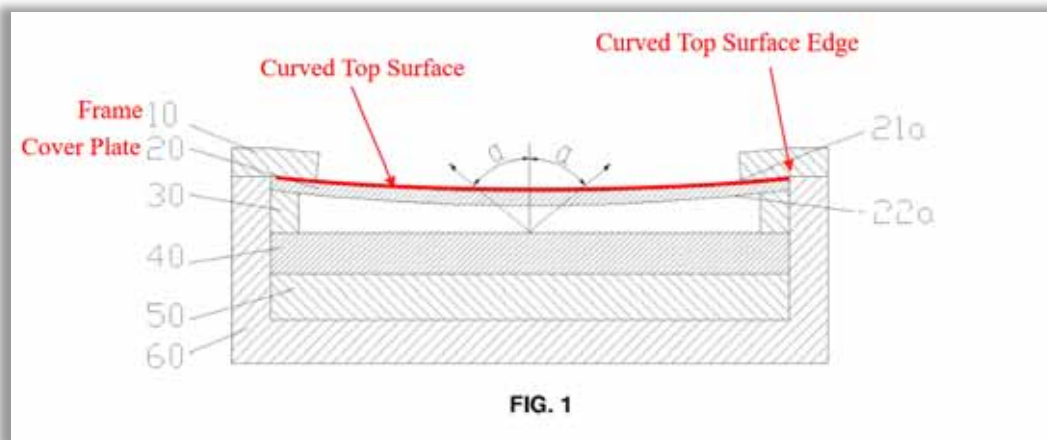
248. The distance between the lines drawn on the flat plane line and the curved line on Cao's modified concave touch surface varies according to a parabolic

function that, in my view, a POSA would have understood as equating to a “concave function.”

249. Thus, it is my opinion that Cao in view of Han and Zhao discloses wherein a distance between a first curved line (curved line drawn along Cao’s modified curved glass 300) drawn on the touch surface (Cao’s modified curved glass 300) and a second straight line (straight line) drawn on the flat plane (flat plane across Cao’s modified long and short edges) varies according to a concave curve function.

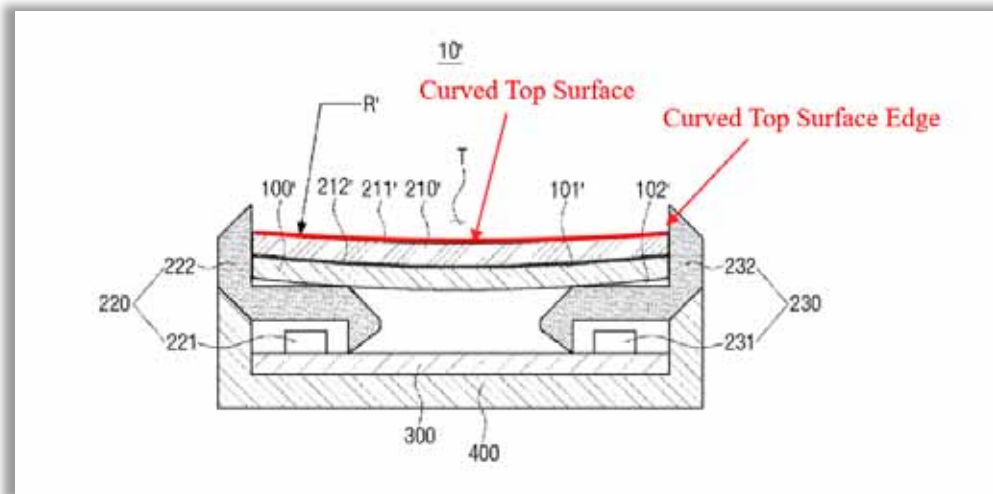
(j) “wherein all of the edges of the top surface of the plate are curved.”

250. It is my opinion that Cao in view of Han and Zhao disclose this element. Han and Zhao each disclose a plate having a top surface with curved edges. Ex. 1005 at Fig. 7, Ex. 1012 at Fig. 1.

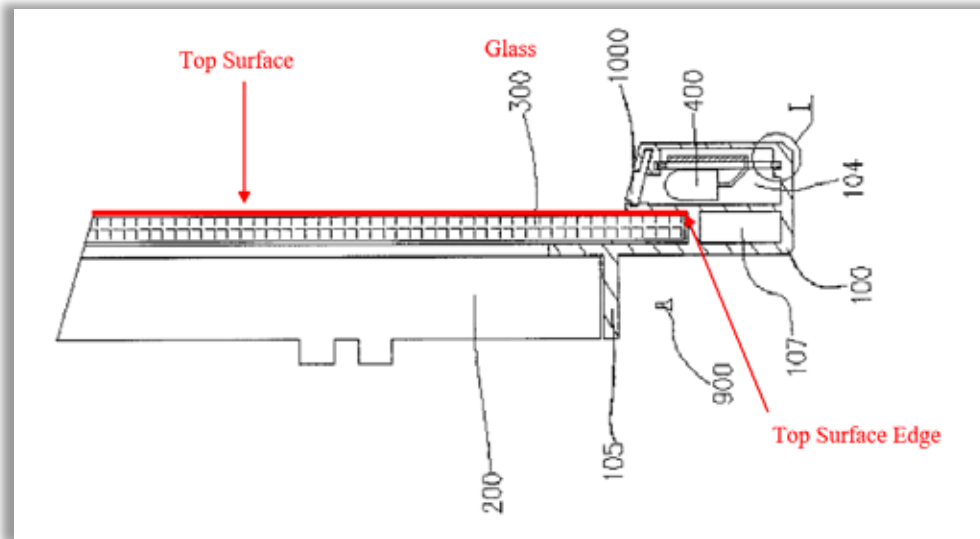


Ex. 1012 at Fig. 1

251. As shown above, Zhao's support member 30 and frame 10 are curved along the full length of contact with Zhao's curved cover plate 20, up to and including the cover plate 20's edge. *Id.*; Ex. 1012 at [0055]. Accordingly, the edges of Zhao's cover plate 20 (including a top surface) are curved. *Id.* In the modified Cao device, Cao's groove 103 and first and second groove walls, 112 and 113, along both the long and short sides would be curved according to Zhao. This would result in Cao's modified glass 300 being curved up to its edges along both the long and short edges of screen support 100. Cao's curved glass 300 up to its edges would match the edges of Han's cover glass 210 curved along both Ax and Ay directions. See Ex. 1005 at [0087-89].



Ex. 1005 at Fig. 7.

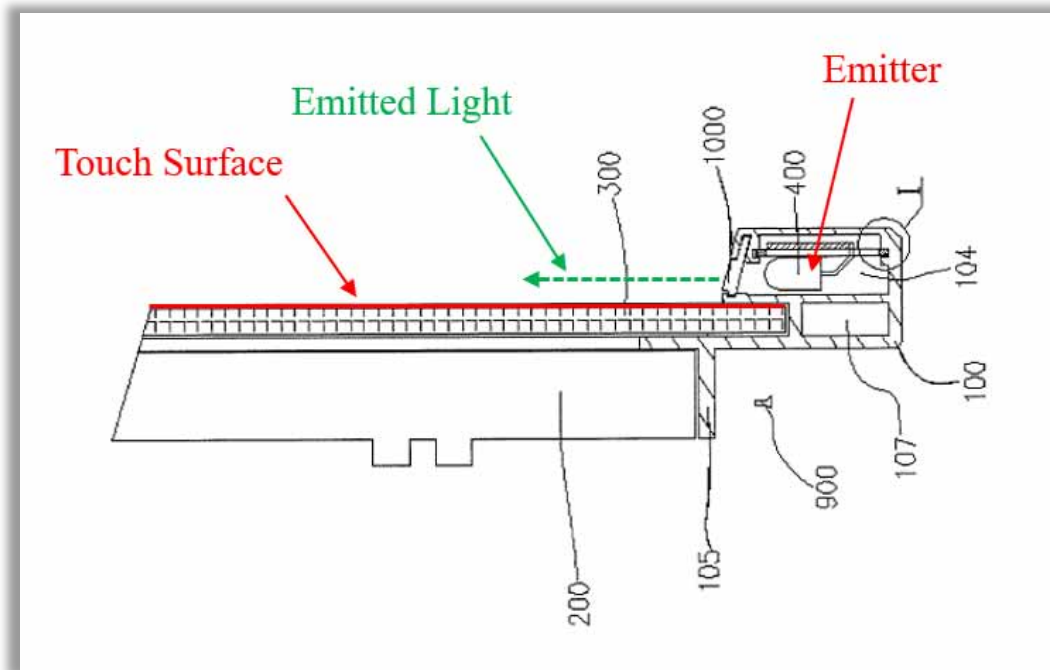


Ex. 1010 at Fig. 9.

252. Thus, it is my opinion that Cao in view of Han and Zhao discloses wherein all of the edges (edges of Cao’s modified glass 300) of the top surface of the plate (top surface of Cao’s modified glass 300) are curved.

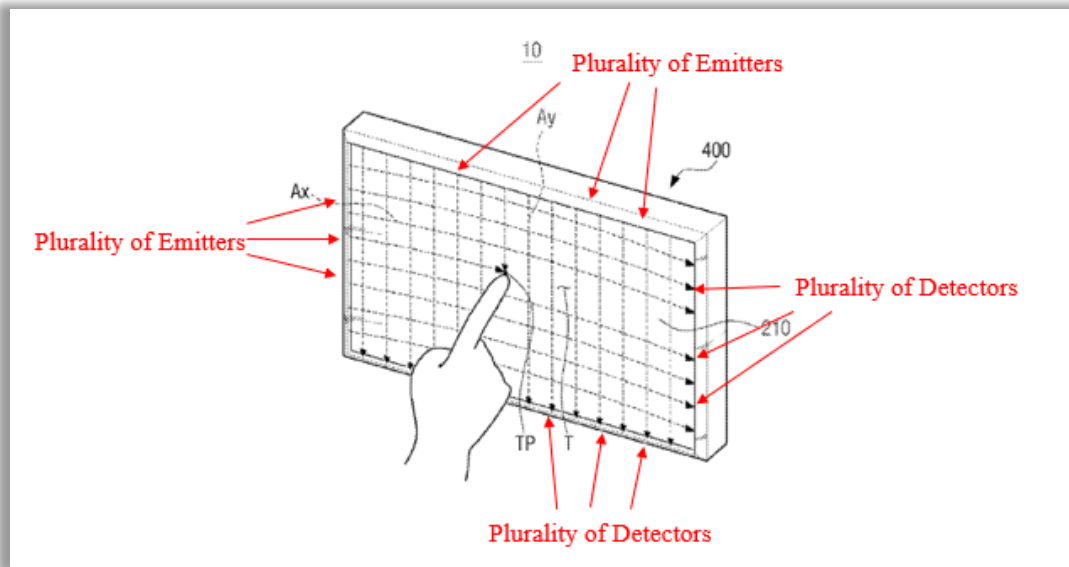
2. Claim 2: “The touch sensing apparatus of claim 1, wherein the plurality of emitters is configured to emit light to propagate over the touch surface.”

253. 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 modules 400,” it is my opinion that a POSA would have understood Cao’s infrared modules 400 to disclose an emitter.



Ex. 1010 at Fig. 9.

254. In my opinion, a POSA would have understood the emitter to emit light to propagate across the (touch) surface of the glass 300 based on the orientation of Cao's emitter in relation to glass 300. Further, while Cao does not explicitly describe a plurality of emitters, it is my view that it would have been obvious to a POSA to implement a plurality of emitters as taught by Han and as known generally in the prior art. Ex. 1005 at [0040]; Ex. 1031 at 1:26-46, 15:62-16:3.



Ex. 1005 at Fig. 2.

255. In my opinion, 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.

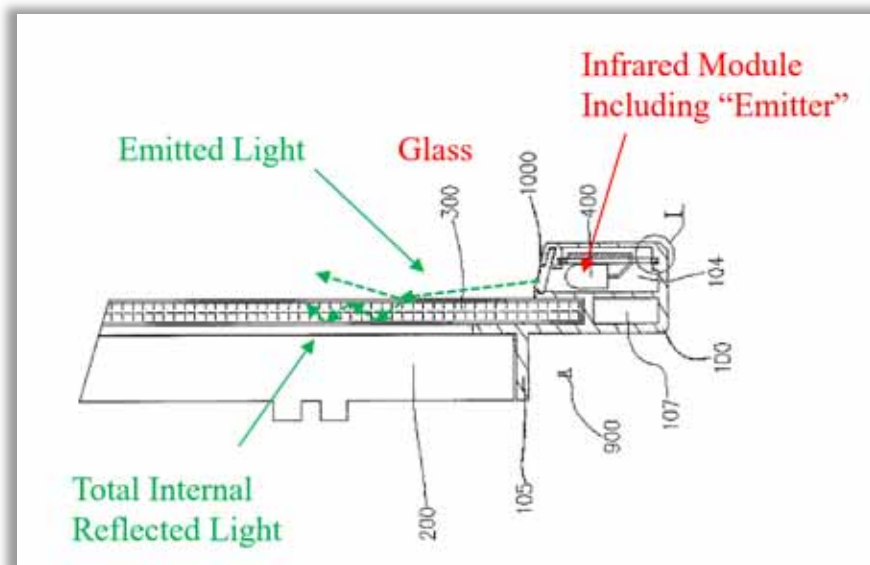
256. Thus, it is my opinion that Cao in view of Han discloses wherein the plurality of emitters (Cao's infrared touch modules 400 with emitters) is configured to emit light to propagate over the touch surface (top surface of Cao's glass 300). *Id.*

3. Claim 3: "The touch sensing apparatus of claim 1, wherein the plurality of emitters is configured to emit light through the plate by total internal reflection."

257. In my opinion, Cao in view of Han discloses this element. As I discussed above, the '335 Patent fails to depict or explain TIR. Nonetheless, it is

my opinion a POSA would have understood Cao's infrared module (with emitter) to emit light through Cao's glass 300 plate by TIR via several modes.

258. First, it is my opinion that a POSA would have understood TIR to have occurred from light emitted from Cao's emitter in a non-parallel vector with the surface of the glass 300 such that the emitted light would intersect the plate. At the light-to-glass intersection point, a POSA would have understood light to both reflect away from and enter Cao's glass 300. *Id.* In my view, a POSA would have further understood light entering the plate to subsequently travel along the plate via TIR.



Ex. 1010 at Fig. 9.

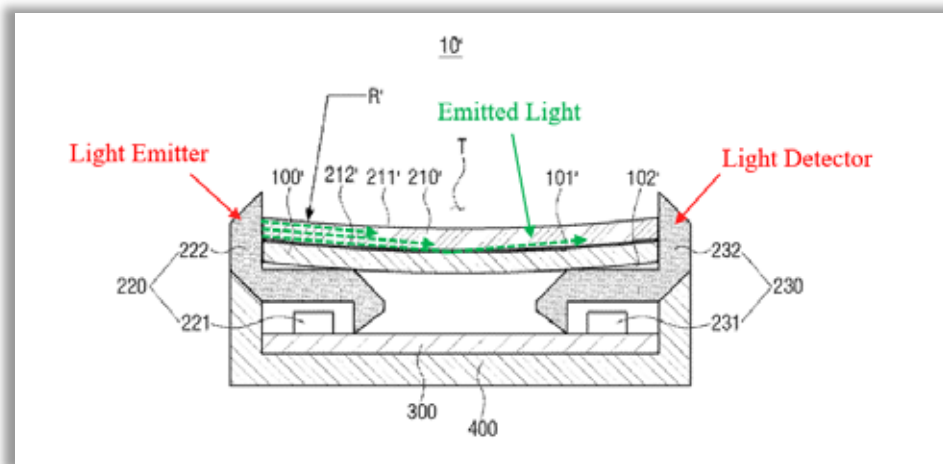
259. Further, Han discloses TIR. One embodiment of Han's touch accuracy improving touch device is described as follows:

As the cover glass 210' includes a light permeable material, **light emitted from the light emitting surface 2221 of the light emission guide member 222 may move along the inside of the cover glass 210,' and may be incident on the incidence surface 2321 of the light reception guide member 232.**

Accordingly, the rear surface of the cover glass 210' may also be concavely curved along the moving direction of light moving through the touch area T, and thus **light passing through the inside of the cover glass 210'** may be guided to the incidence surface 2321 of the light reception guide member 232.

Ex. 1005 at [0115-116]. (emphasis added).

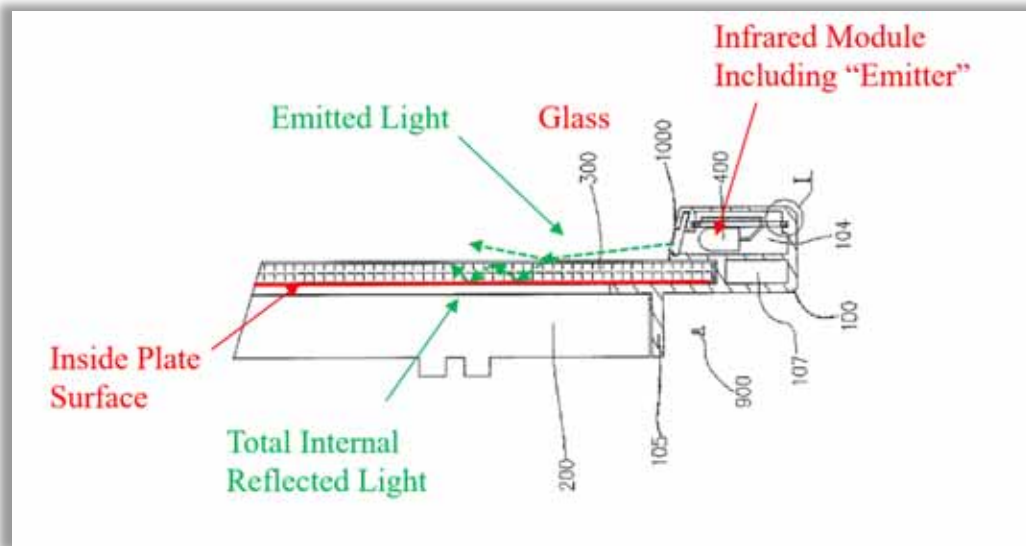
260. In my opinion, a POSA would have understood Han to describe a plurality of emitters (light emitting surface 2221 of the light emission guide member 222) emitting light through the plate (cover glass 210') by TIR.



Ex. 1005 at Fig. 7.

261. Further, as I described above, the inside surface of Han's cover glass 210 is curved to facilitate TIR. *Id.* at [0116]. Along with Han's concave touch surface curvature, it is my view that a POSA would have understood Han to further teach improving touch detection accuracy by utilizing TIR to deliver light (that would otherwise escape and be undetected) to the light detection guide member 232. Additionally, it is my opinion that a POSA would have understood Han's TIR of emitted light to limit interference between the light emitters and the display, as light would be conveyed (via TIR in the cover glass 210) substantially orthogonal to the display as opposed to intersecting the display and resulting in a "washing out" effect. Further, it is my opinion that a POSA would have appreciated TIR in Han's cover glass 210 to increase the total light signal detected by Han's detector in the absence of a touch. This increase in "base" light signal would proportionally increase the amount of signal attenuated during a touch, as well as increase the "signal-to-noise" ratio of the detector, thus increasing overall touch detection sensitivity. Further, it is my view that a POSA would have appreciated an increased base signal and "signal-to-noise" from TIR to allow for comparably less sensitive and costly detector components to achieve the same touch detection performance as more sensitive and expensive detectors without TIR.

262. In my opinion, a POSA, implementing the touch accuracy improving *external* cover glass curvature of Han into Cao's plate would have similarly been motivated to incorporate Han's *internal* cover glass curvature into the internal surface of Cao's modified glass 300.



Ex. 1010 at Fig. 9.

263. In the modified Cheng device, the curved back surface of the plate would (like in Han) facilitates "guiding" totally internally reflected light through Cheng's modified plate. See Ex. 1005 at [0115-116]. As Cao's modified glass 300 would be concavely curved according to Han, additional vectors of emitted light would further intersect the glass, increasing the incidence of TIR. *Id.* A POSA would have expected the modified Cao device implementing TIR to result in limited emitter-to-display interference, increased touch accuracy thanks in part to increased

base light signal and “signal-to-noise” ratio, and reduced detector sensitivity and cost requirements (like in Han).

264. Thus, it is my opinion that Cao in view of Han discloses wherein the plurality of emitters (Cao’s infrared module 400 with emitters; Han’s light emitting parts 220) is configured to emit light through the plate (Cao’s glass 300; Han’s cover glass 210) by TIR (entered light traveling via TIR).

4. Claim 4: “The touch sensing apparatus of claim 1, further comprising a processing element configured to determine, based on output signals of the plurality of detectors, a position of an object on the touch surface.”

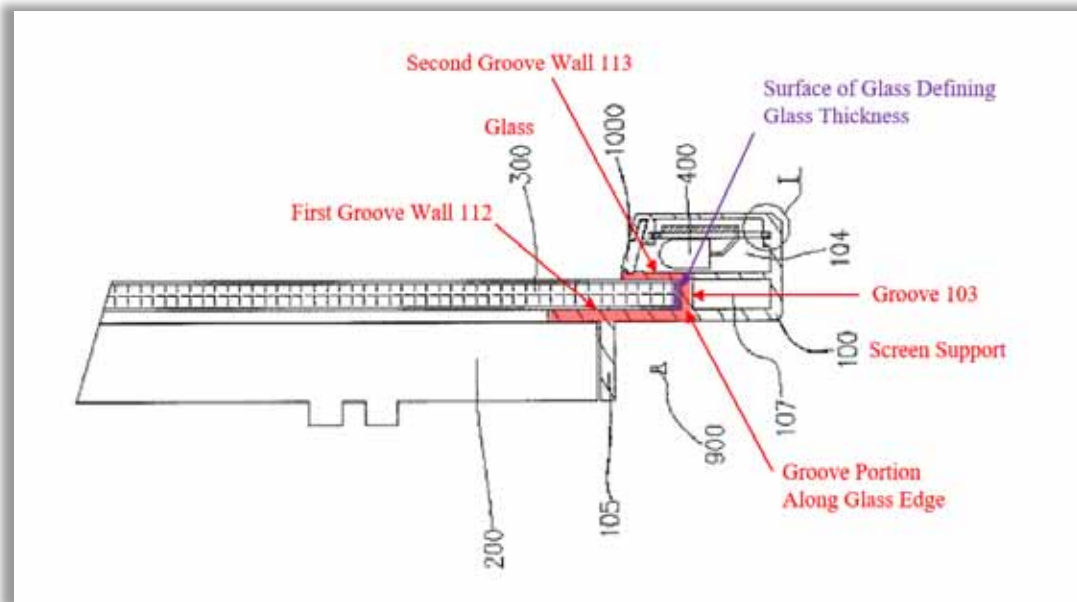
265. It is my opinion that Cao and Han disclose this element. Cao discloses a “smart” tablet PC. Ex. 1010 at Abstract. Han discloses a controller integrated circuit (“IC”) that “performs the role of identifying the location where a signal was generated according to occurrence of contact or change of electrical capacity, and transmitting the information on the location to a controller IC” Ex. 1005 at [0012]. Han’s 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]. 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.

266. In my opinion, 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 teaching of the same processing element and function confirms as much. Ex. 1005 at [0012-13].

267. Thus, it is my opinion that 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).

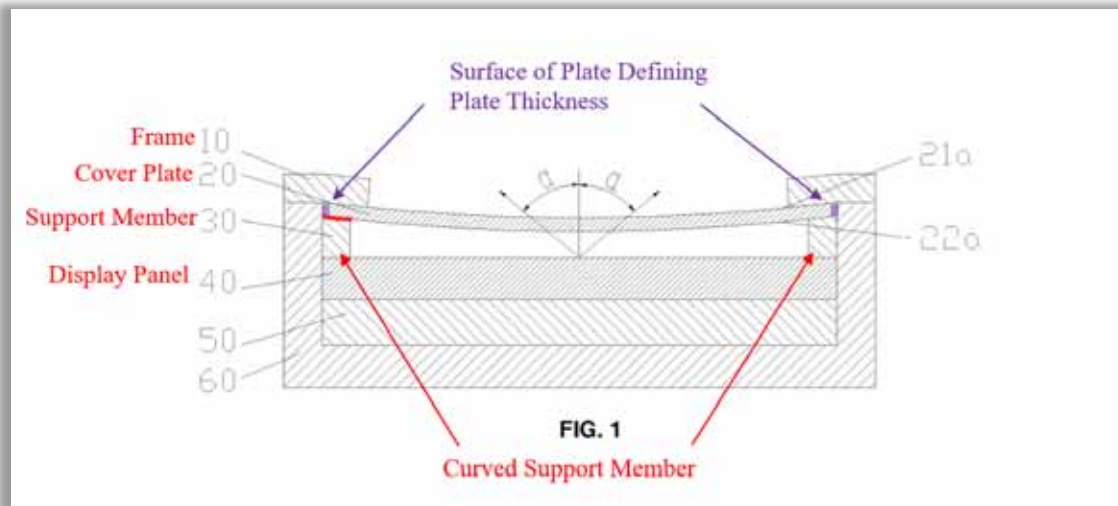
5. Claim 5: "The touch sensing apparatus of claim 1, further comprising a gasket, wherein the plate is supported by the gasket along the surface of the plate that defines the plate thickness."

268. In my opinion, Cao in view of Han and Zhao discloses this element. Cao's screen support 100 includes a groove 103 with groove walls 112 and 113. Ex. 1010 at 5:47-53, Figs. 9, 12, 13. Cao's groove 103 supports the glass 300 along the surface of the glass that defines the glass thickness. *See id.*



Ex. 1010 at Fig. 9.

269. In the modified Cao device according to Zhao, the surfaces of Cao's modified groove 103 with groove walls 112 and 113 in contact with the plate are curved (like in Zhao) to induce curvature into the glass (according to Han) with a simplified process by applying a bending force near the edge of the glass during installation.



Ex. 1012 at Fig. 1.

270. In my view, a POSA would have understood Zhao's support member 30 to have the same function as a "gasket" as described in the '335 Patent. As the '335 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. 1031 at 11:44-55 (emphasis added). Similarly, Zhao teaches that 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].

271. In my opinion, a POSA would have expected to achieve Zhao's curvature-inducing gasket function by modifying Cao's groove 103 with groove walls 112 and 113 according to Zhao's curved support member 30. Cao's modified groove 103 with groove walls 112 and 113 would support the glass along the surface of the glass that defines the glass thickness (like Zhao).

272. Thus, it is my opinion that Cao in view of Han and Zhao discloses a gasket (Cao's modified curved groove 103 with groove walls 112 and 113; Zhao's support member 30), wherein the plate (Cao's glass 300) is supported by the gasket along the surface of the plate (Cao's groove 103 along glass thickness) that defines the plate thickness.

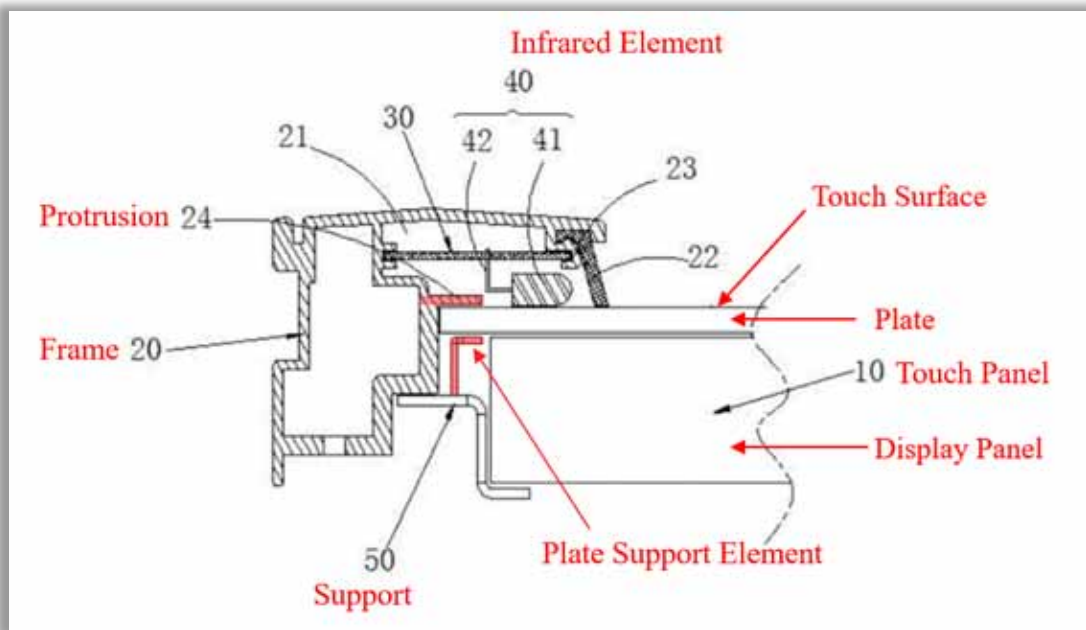
**X. GROUND 3 - CLAIMS 1-4 ARE OBVIOUS UNDER 35 U.S.C. § 103
BASED ON CHENG IN VIEW OF HAN AND SHIN.**

273. In my opinion, Cheng in view of Han and Shin renders claims 1-5 obvious as follows. 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 Cheng, 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 a resulting touch screen display device with improved touch performance, achieved through a simplified manufacturing process.

Motivation to Combine

274. In my opinion, a POSA would have been motivated to modify the touch device of Cheng using the simplified glass curvature inducing frame teachings of Shin to obtain the technical advantages of Han's parabolically curved touch surface. As an initial matter, Cheng, 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. 1004 at Abstract; Ex. 1011 at Abstract; Ex. 1005 at Abstract.

275. Cheng discloses an infrared touch device including plate with touch surface, a display, and a frame with a bezel 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. Shown below, Cheng's frame 20 includes a protrusion 24 and plate support element for supporting a plate with a touch surface. *Id.* at Fig. 1.

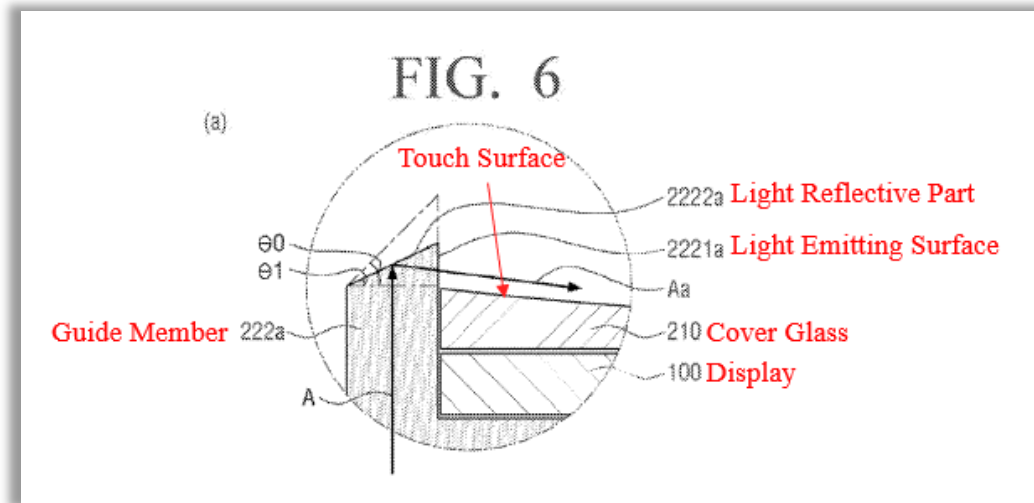


Ex. 1004 at Fig. 1.

276. 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* at [0018], Fig. 1. Cheng additionally teaches reducing material costs by reducing material requirements of the frame. *Id.* at Abstract, [0018].

277. Han (like Cheng) teaches improving touch detection accuracy in infrared touch devices. *See* Ex. 1005 at [0082-83], [0084-86]. In Han, the front surface of the flat cover glass 210 (plate) is configured to have a concave parabolic curvature to reduce the amount of light lost by reflection and increasing the amount of light received at light reception guide member 232. *Id.* Further, Han teaches

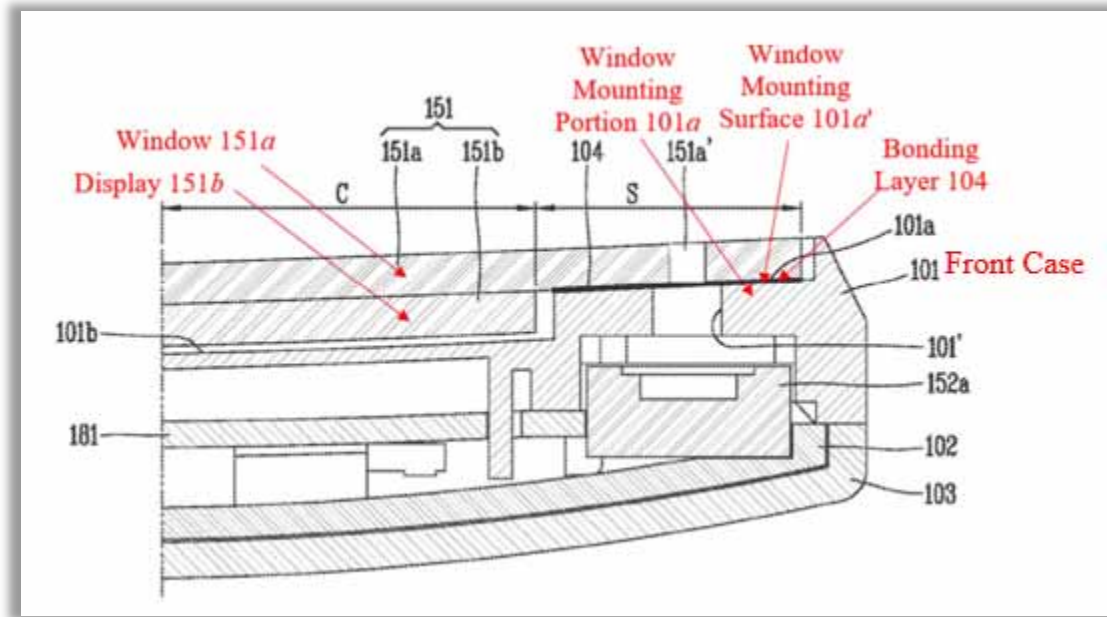
tuning the direction of emitted infrared light to travel along the surface of the curved touch surface of cover glass 210 by tilting a light reflective part 222a of the guide member 222. Ex. 1005 at [106].



Ex. 1005 at Fig. 6(a).

278. 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.

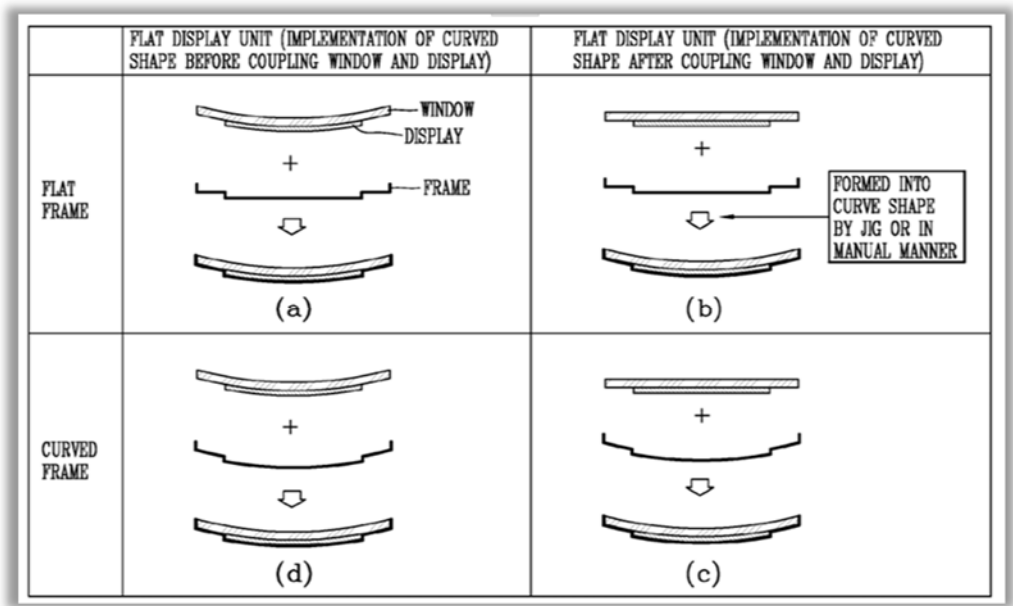
279. Shin discloses an infrared touch-sensitive device and method of manufacture including inducing a curvature into an initially flat cover glass and display utilizing a curved frame. See Ex. 1011 at 1:52-2:22, 3:4058, 10:45-49.



Ex. 1011 at Fig. 5.

280. 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.* 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.

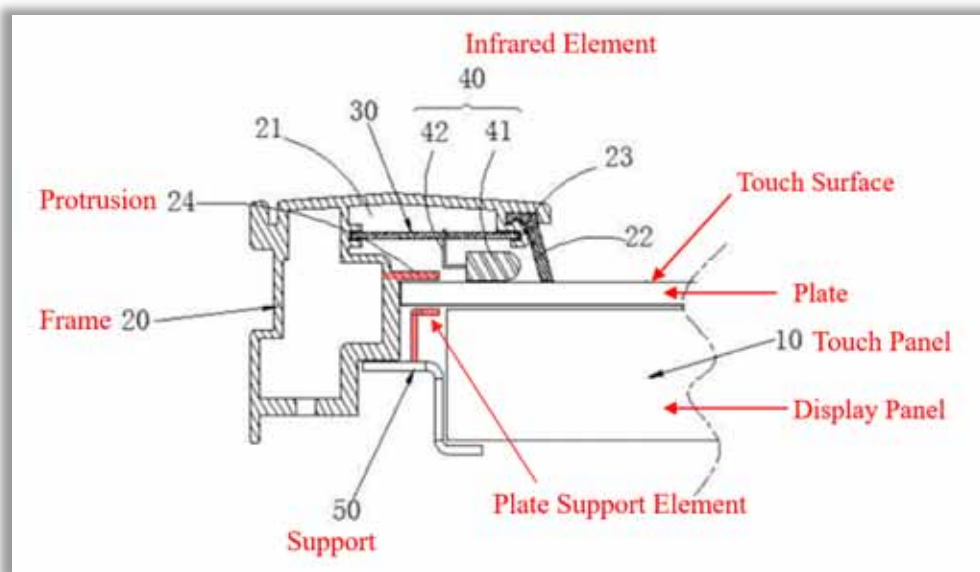


Ex. 1011 at Fig. 4.

281. Shin teaches by utilizing the curved mounting portions 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 number of steps needed to create a touch device with 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.

282. In my opinion, 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' to achieve Han's parabolic plate curvature

in Cheng's device. As Cheng's frame support 50 with frame support element, it is my view that it would have been obvious for POSA to modify Cheng by curving the frame support element according to the curved frame mounting surface 101a' of Shin. In my opinion, a POSA would have expected such modification to Cheng to achieve the same simplified curvature-inducing functionality of Shin.



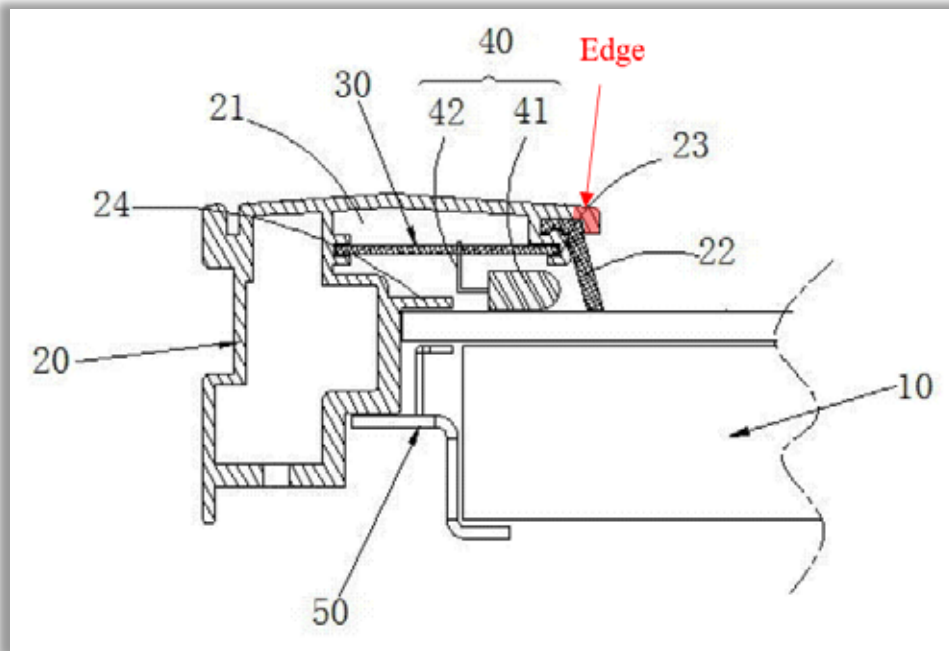
Ex. 1004 at Fig. 1.

283. Thus, it is my opinion that a POSA combining the teachings of Han and Shin into the device of Cheng would have expected to achieve the predictable result of high touch detection accuracy (Han) infrared touch device (Cheng, Han, Shin) and manufacturing method (Shin) meeting the limitations of the '335 Patent. In my opinion, such modifications would have merely embodied known techniques to improve a similar device in a similar way.

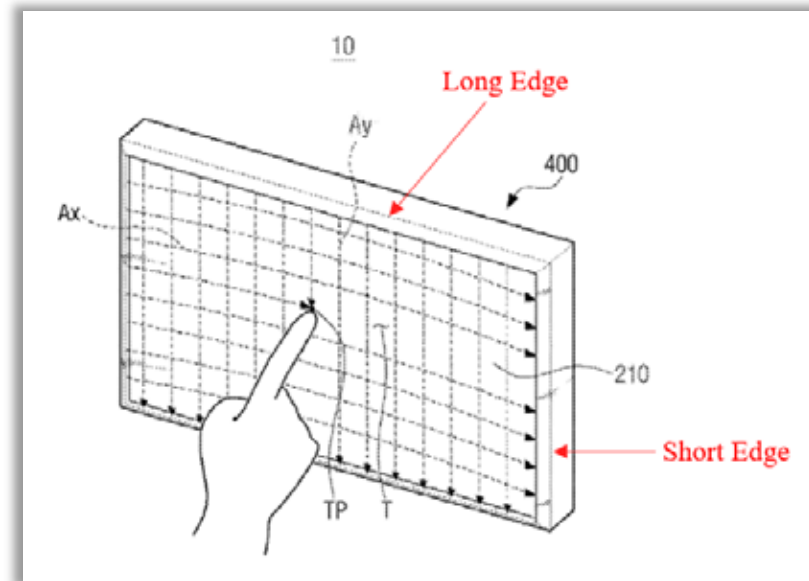
1. Claim 1

(a) Preamble: “A touch sensing apparatus having a long edge and a short edge,”

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



Ex. 1004 at Fig. 1

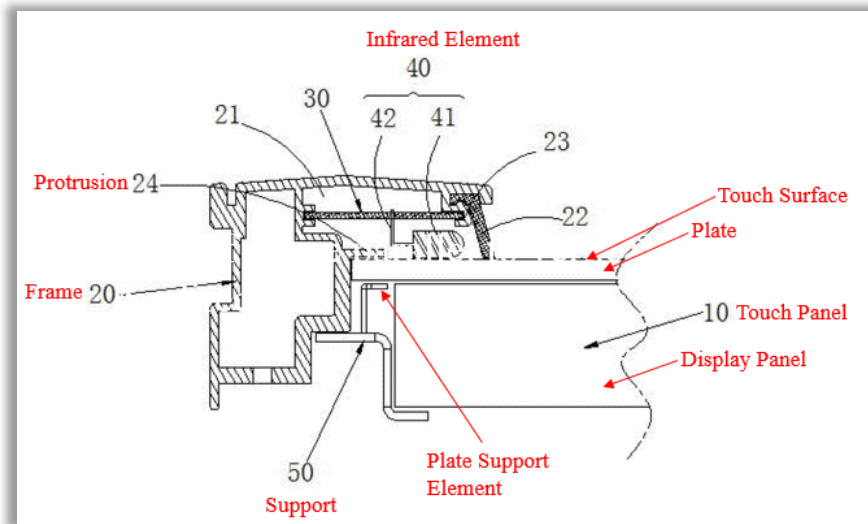


Ex. 1005 at Fig. 2

285. For at least the reasons I have discussed in Ground 1, claim 1(a), it is my opinion that Cheng in view of Han disclose a touch sensing apparatus having a long edge (Cheng long edge of frame 20, Han frame assembly long edge) and a short edge (Cheng's short edge of frame 20, Han's frame assembly short edge).

(b) “a display panel;”

286. In my opinion, Cheng, Han, and Shin disclose this element. Cheng discloses a touch panel 10. Ex. 1004 at [0005], Fig.1. In my view, a POSA would have understood Cheng's touch panel 10 to include a display panel. *See id.* at Fig. 1, [0002-3].



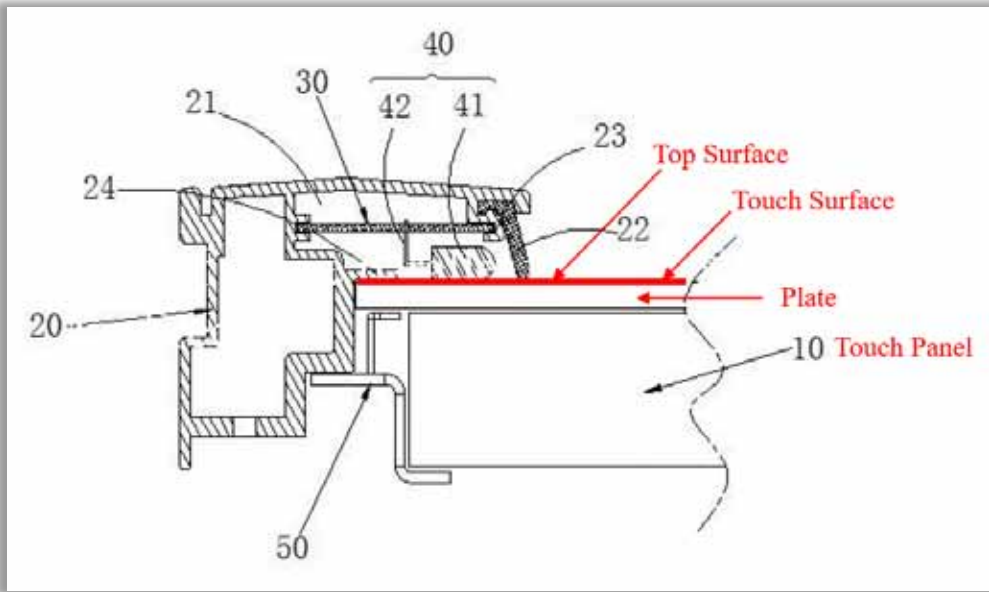
Ex. 1004 at Fig. 1.

287. Further, both Han and Shin also disclose a display panel. Ex. 1005 at Abstract; Ex. 1011 at Abstract.

288. Thus, it is my opinion that Cheng, Han, and Shin disclose a display panel (display panel of Cheng's touch panel 10; Han's display 2, Shin's display 151b).

(c) “a plate including a top surface that comprises a touch surface;”

289. In my opinion, Cheng and Han disclose this element. As I discussed above, it is my view that a POSA would have understood the touch panel 10 of touch screen device disclosed in Cheng to include a plate including a top surface that comprises a touch surface.



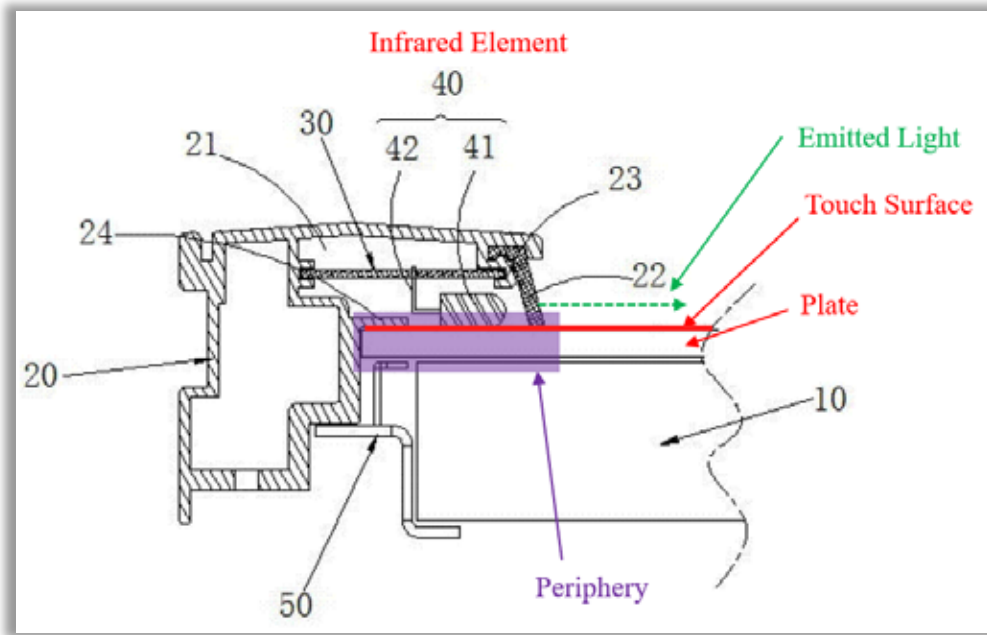
Ex. 1004 at Fig. 1

290. Further, Han discloses a cover glass 210 with a touch surface. Ex. 1005 at [0019], [0038], Fig. 2.

291. Thus, it is my opinion that Cheng and Han disclose a plate (Cheng's plate of touch panel 10; Han's cover glass 210) including a top surface that comprises a touch surface (top surface and touch surface of Cheng's plate; Han's touch surface T).

(d) “a plurality of emitters arranged around a portion of the periphery of the plate and configured to emit light across the touch surface of the plate,”

292. In my opinion, Cheng and Han disclose this element.

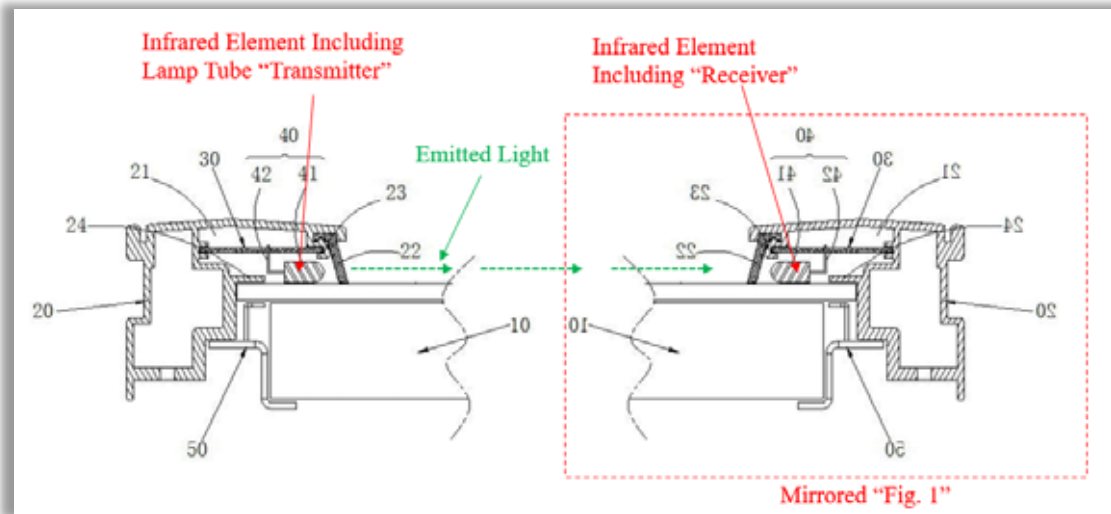


Ex. 1004 at Fig. 1

293. For at least the reasons I discussed above for Ground 1, claim 1(d), it is my opinion that Cheng and Han disclose a plurality of emitters (Cheng's infrared element 40 including lamp tubes 41; Han's LEDs light emitting part 220) arranged around a portion of the periphery of the plate (Cheng's plate of touch panel 10; Han's cover glass 210) and configured to emit light across the touch surface of the plate (touch surface of Cheng's plate; Hans touch surface T).

(e) **“a plurality of detectors arranged around a portion of the periphery of the plate and configured to receive light from the plurality of emitters,”**

294. In my opinion, Cheng and Han disclose this element.

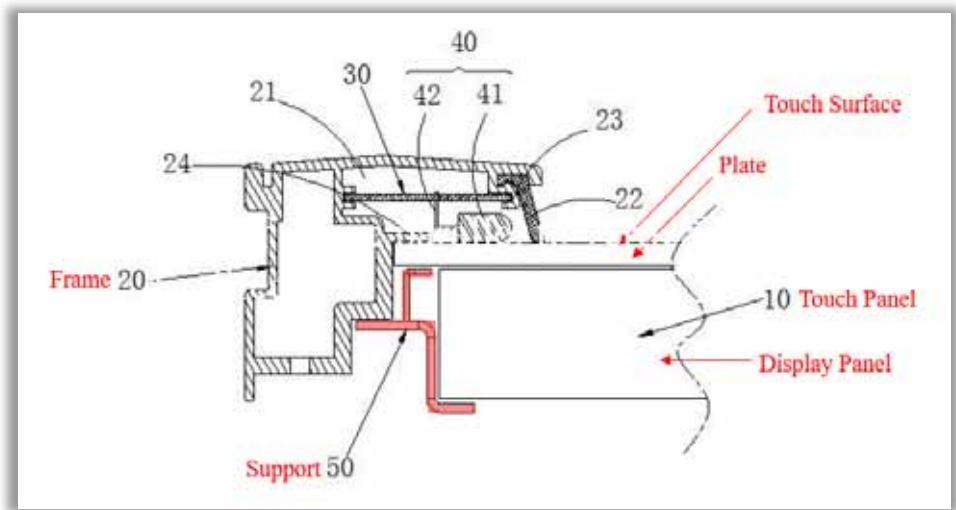


Ex. 1004 at Fig. 1.

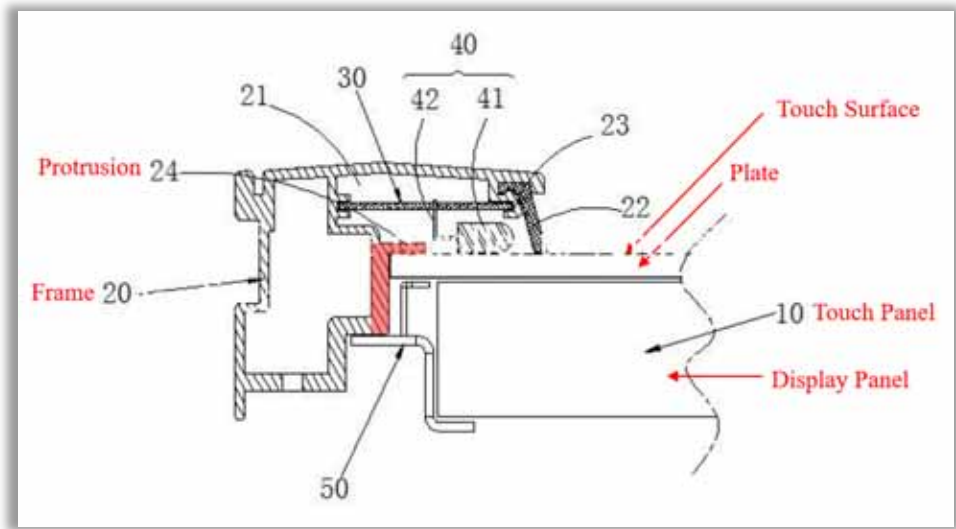
295. For at least the reasons I have discussed above for Ground 1, claim 1(e), it is my opinion that Cheng and Han disclose a plurality of detectors (Cheng's infrared element 40 including a receiver; Han's light receiving part 230) arranged around a portion of the periphery of the plate (Cheng's plate of touch panel 10; Han's cover glass 210) and configured to receive light from the plurality of emitters (Cheng's infrared elements with emitter (transmitter) lamp tube 41; Han's light emitting part 220).

- (f) **“a frame assembly, the frame assembly comprising; a first frame element configured to support the display panel; a second frame element arranged around the periphery of the plate and configured to support the plurality of emitters and plurality of detectors.”**

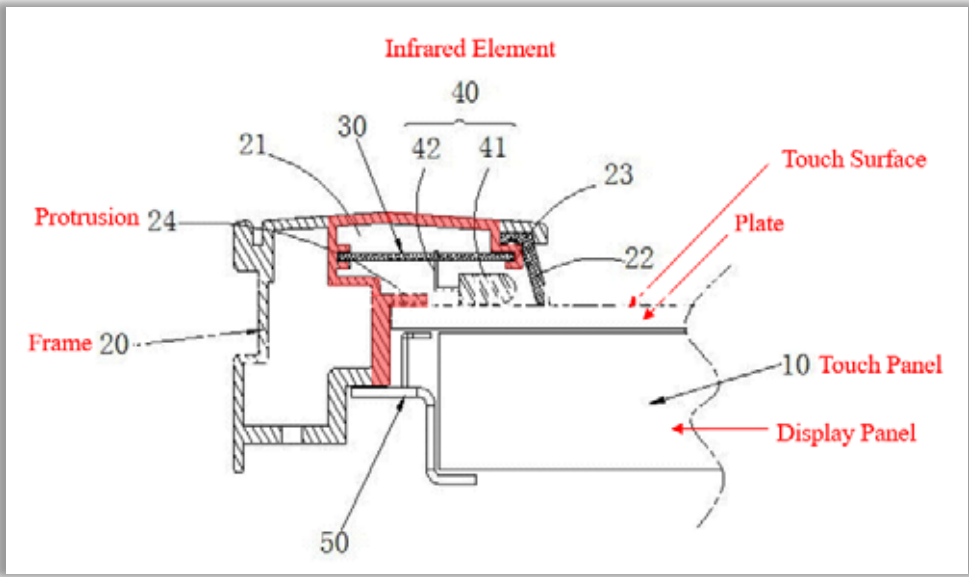
296. It is my opinion that Cheng discloses this element.



Ex. 1004 at Fig. 1



Ex. 1004 at Fig. 1

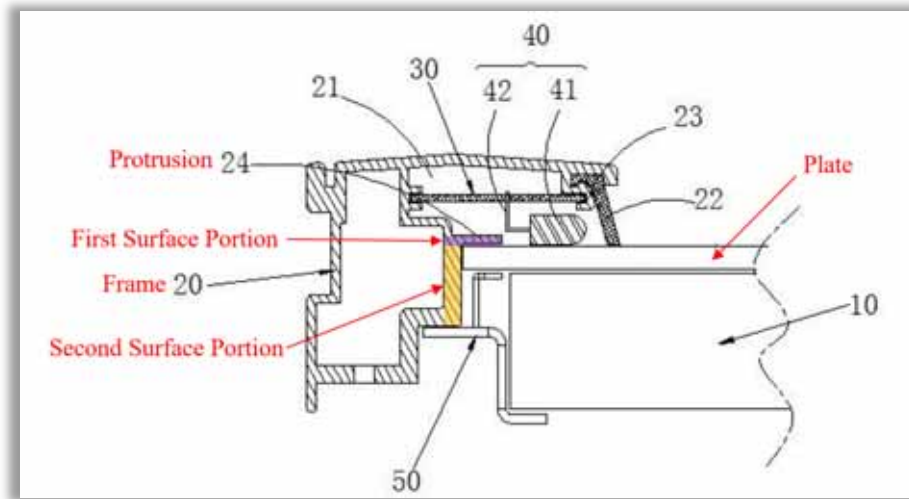


Ex. 1004 at Fig. 1

297. For at least the reasons I have discussed above in Ground 1, claim 1(f), it is my view that Cheng discloses a frame assembly, the frame assembly comprising; a first frame element (support 50) configured to support the display panel; a second frame element (frame 20 with protrusion 24) arranged around the periphery of the plate and configured to support the plurality of emitters and plurality of detectors (infrared element having emitters and detectors).

(g) “wherein the second frame element includes a first surface portion extending over an edge portion of the plate and a second surface portion arranged substantially parallel to a surface of the plate that defines the plate thickness.”

298. It is my opinion that Cheng discloses this element.

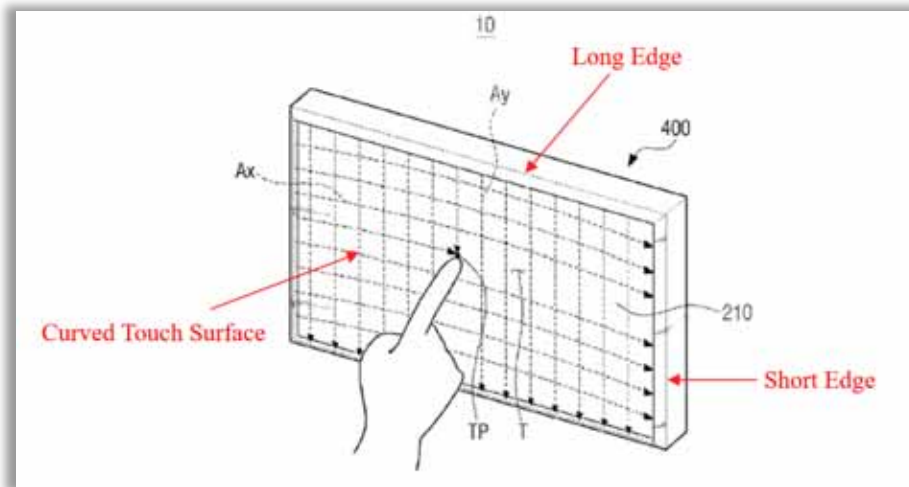


Ex. 1004 at Fig. 1.

299. For at least the reasons that I have discussed above in Ground 1, claim 1(g), it is my opinion that Cheng discloses wherein the second frame element (frame 20 with protrusion 24) includes a first surface portion (protrusion 24) extending over an edge portion of the plate (plate of touch panel 10) and a second surface portion (frame 20) arranged substantially parallel to a surface of the plate that defines the plate thickness (“thickness” edge of plate).

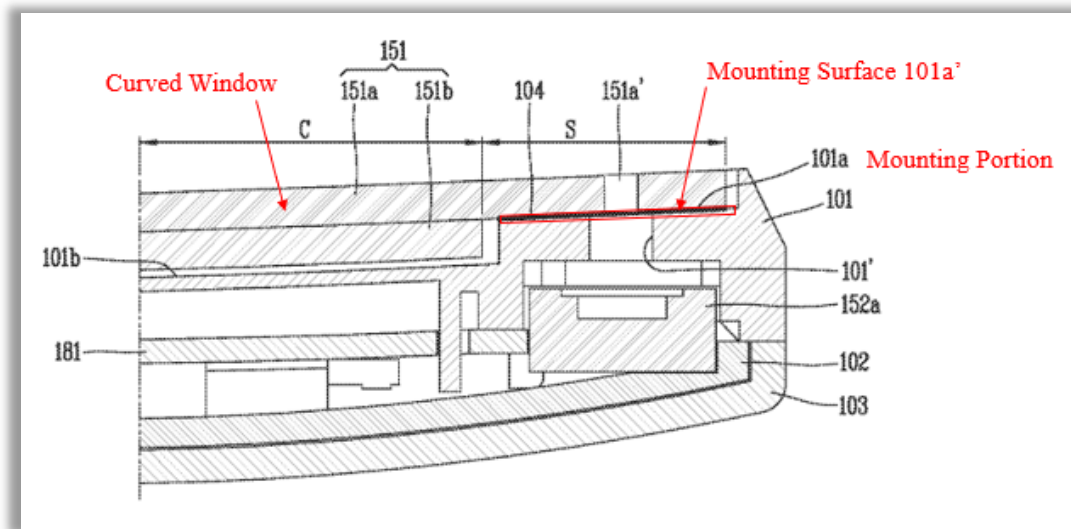
(h) “wherein the touch surface is curved relative to a flat plane defined in part by the short edge and the long edge.”

300. It is my opinion that Cheng in view of Han and Shin discloses this element. 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.



Ex. 1005 at Fig. 2.

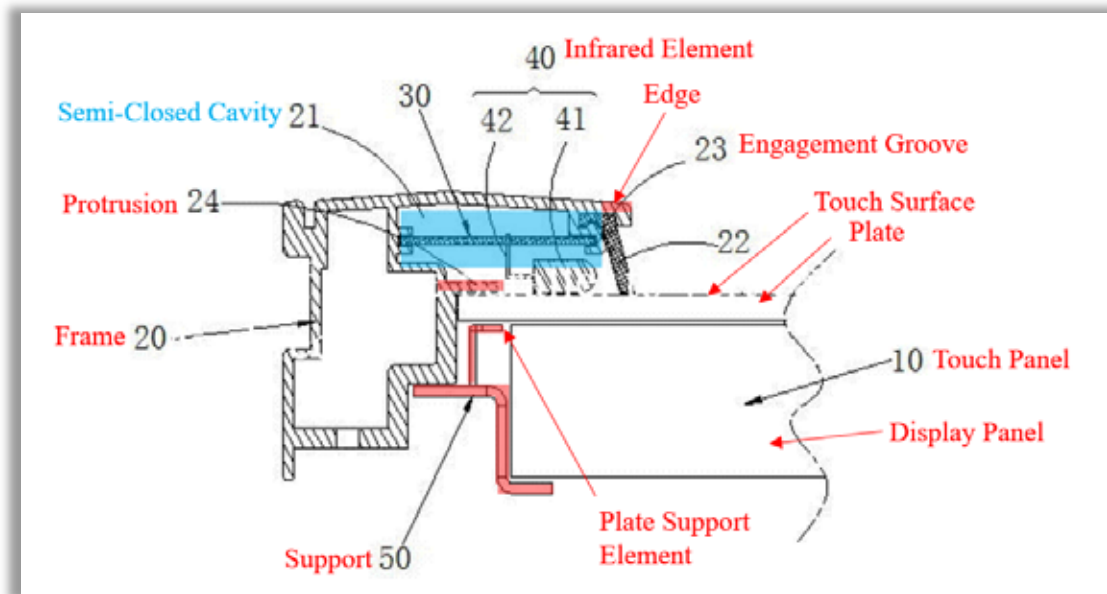
301. In my view, it would have been obvious to a POSA to modify Cheng's protrusion 24 and plate support element according to the curved mounting surfaces 101a' of Shin to reach Han's touch screen curvature. By incorporating Shin's curved mounting surface 101a,' it is my opinion that a POSA would have expected to achieve a simplified manufacturing process for producing a curved plate, as taught by Shin. See Ex. 1011 at 18:57-64.



Ex. 1011 at Fig. 5

302. The curved modified plate support elements of Cheng would induce curvature into the plate in a simplified manufacturing step, and the curved modified protrusions 24 of Cheng would secure the curved touch surface side of the curved plate (like in Shin).

303. The modified Cheng device has curved short and long edges. Cheng's frame 20 includes semi-enclosed cavity 21 and engagement groove 23 for supporting the circuit board 30 and infrared element 40. Ex. 1004 at [0013].

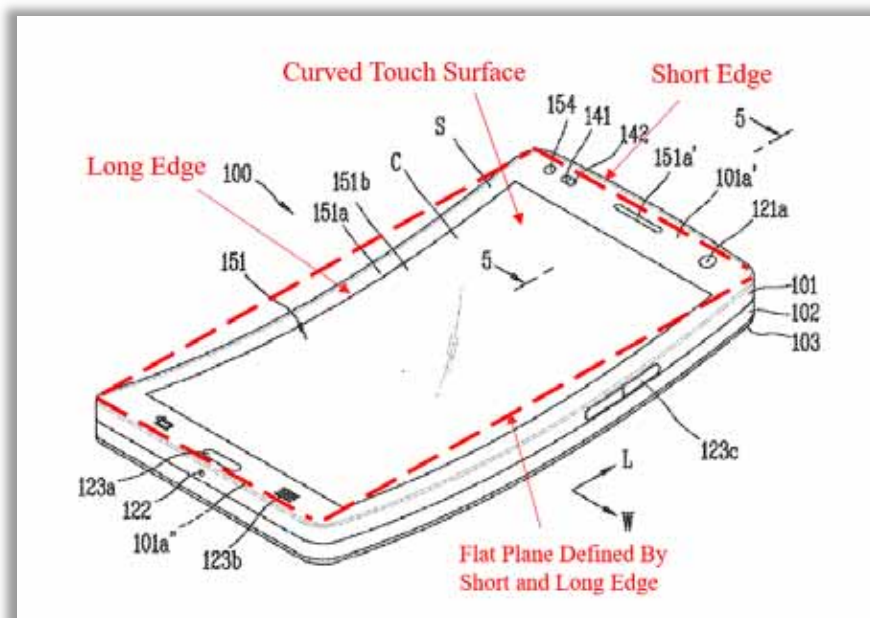


Ex. 1004 at Fig. 1.

304. 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]. From this lamp tube 41-to-surface-of-panel configuration, Cheng explains “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 Shin, Cheng’s modified semi-closed cavity 21 and engagement groove 23 would be curved. As a result, the respective first and second (short and long) edges of Cheng’s modified frame 20 would also be curved. In this configuration, it is my view that 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 by emitting light in close proximity to the surface of the plate disclosed in the unmodified Cheng device.

305. Cheng's modified curved plate touch surface would be curved relative to a flat plane defined in part by the short and long edges of frame 20. Discussed above, Cheng's modified long and short edges would be curved according to Shin and Han. A flat plane would be defined (at least in part) by Cheng's modified curved edges. A flat plane would intersect the edges at least at the extremum of the edges, such as the corners of the edges or the slope inflection regions of the edges.



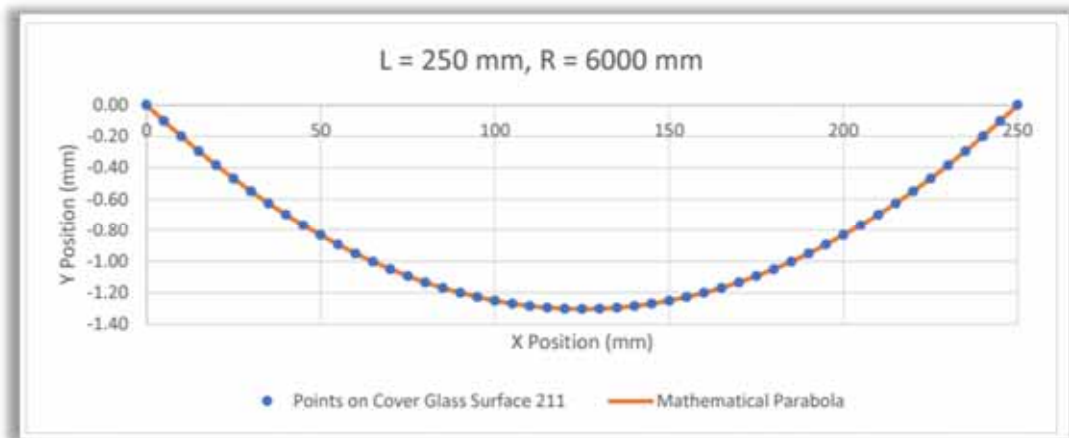
Ex. 1011 at Fig. 2.

306. Cheng's modified curved plate would be curved relative to the flat plane formed in part by the long and short edges of frame 20.

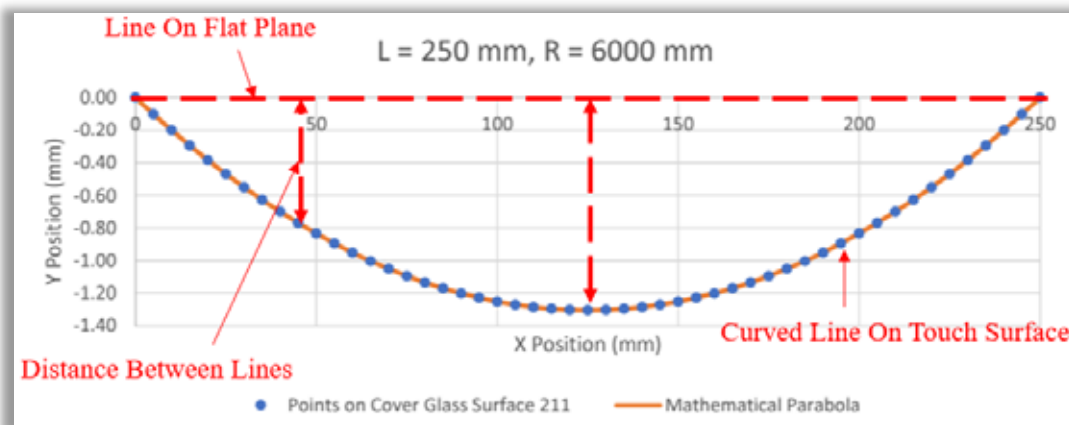
307. Thus, it is my opinion that Cheng in view of Han and Shin discloses wherein the touch surface (Cheng's plate of touch panel 10) is curved relative to a flat plane (flat plane across curved long and short edges) defined in part by the short edge (short edge of Cheng's frame 20) and the long edge (long edge of Cheng's frame 20).

- (i) **“wherein a distance between a first curved line drawn on the touch surface and a second straight line drawn on the flat plane varies according to a concave curve function.”**

308. It is my opinion that Cheng in view of Han and Shin discloses this element. Han discloses a parabolically curved touch surface on cover glass 210. Ex. 1005 at [0074-77]. More specifically, 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 at [0093], [0095]. Plotting the resulting curvature disclosed by Han yields a curve described by a parabolic function. *See* Section VII(b). In my view, a POSA would have been motivated to adopt the same parabolic (concave) curvature of Han in Cheng's modified plate to achieve improved touch performance.



309. As I discussed above, a flat plane can be established across the curved long and short edges of the modified Cheng frame 20 (according to Shin). Shown below, a line can be drawn along Cheng's flat plane and a line may be drawn along the concavely curved touch surface of Cheng's modified plate.

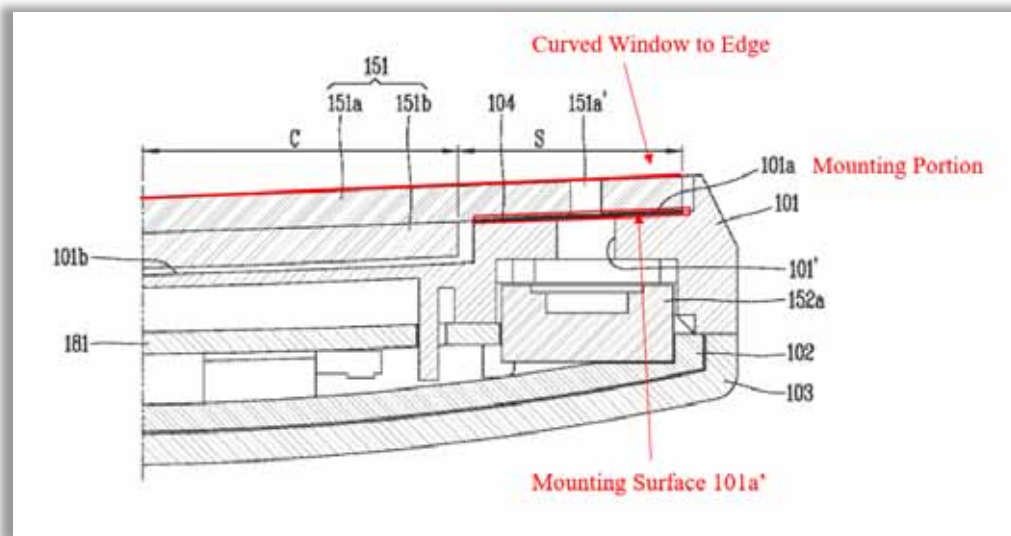


310. The distance between the lines drawn on the flat plane line and the curved line on Cheng's modified concave touch surface vary according to a parabolic function that, in my opinion, a POSA would have understood as equating to a "concave function."

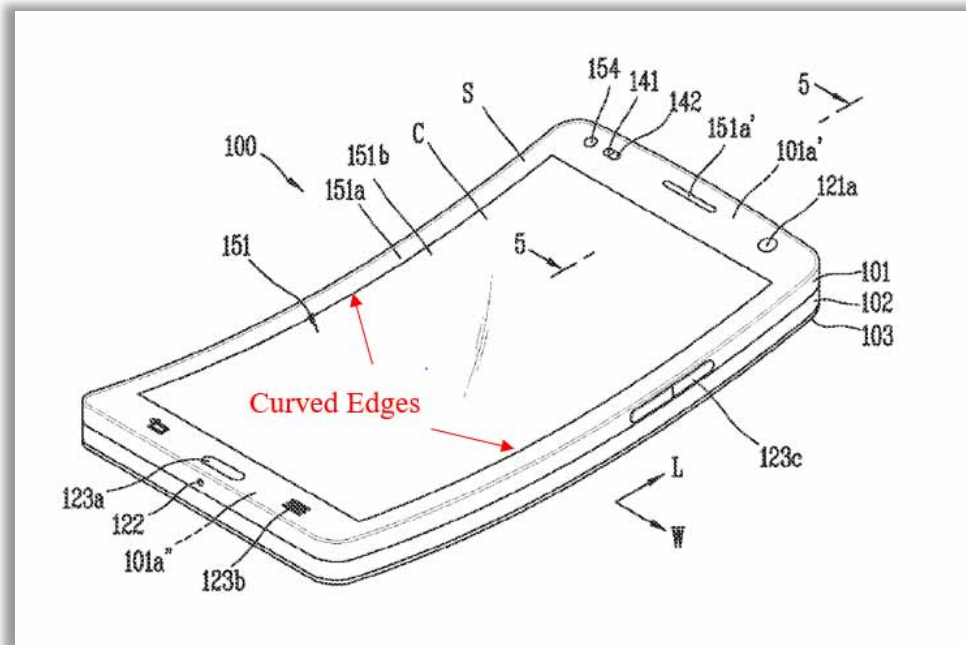
311. Thus, it is my opinion that Cheng in view of Han and Shin discloses wherein a distance between a first curved line (curved line drawn along Cheng's modified curved plate) drawn on the touch surface (Cheng's modified curved plate) and a second straight line (straight line) drawn on the flat plane (flat plane across Cheng's modified long and short edges) varies according to a concave curve function.

(j) “wherein all of the edges of the top surface of the plate are curved.”

312. It is my opinion that Cheng in view of Han and Shin discloses this element. Han and Shin each disclose a plate having a top surface with curved edges. See Ex. 1005 at Fig. 7, Ex. 1011 at Figs. 5, 7.

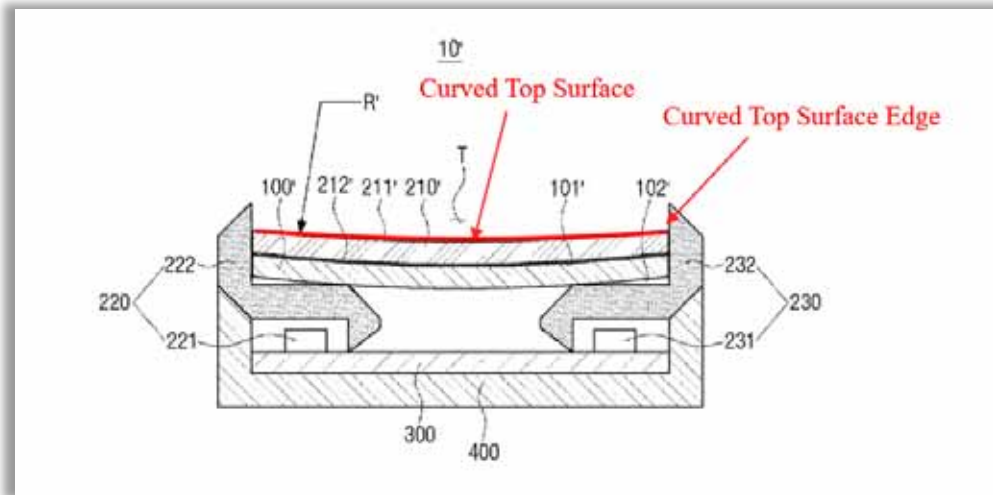


Ex. 1011 at Fig. 5.

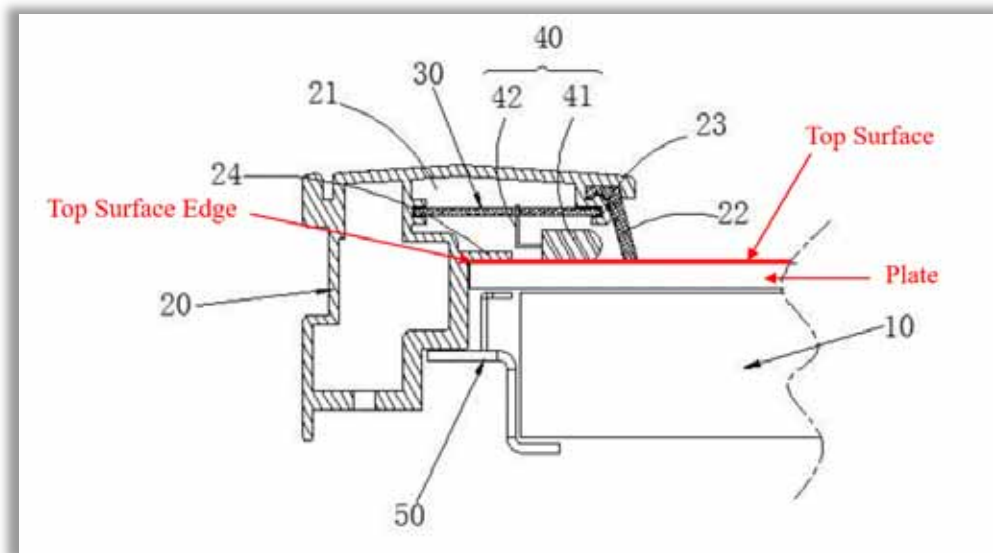


Ex. 1011 at Fig. 2

313. As shown above, Shin's mounting surface 101a' is curved along the full length of contact with Shin's curved window 151a, up to and including its edges. Ex. 1011 at Fig. 5. Accordingly, the edges of Shin's window 151a (including a top surface) are curved. *Id.* In the modified Cheng device, Cheng's frame protrusions 24 and plate support elements of supports 50 along both the long and short sides would be curved according to Shin, resulting in Cheng's modified plate also being curved up to edges along both long and short edges. Cheng's curved plate up to its edges would match the curvature of Han's edges curved along both Ax and Ay directions. See Ex. 1005 at [0087-89].



Ex. 1005 at Fig. 7.

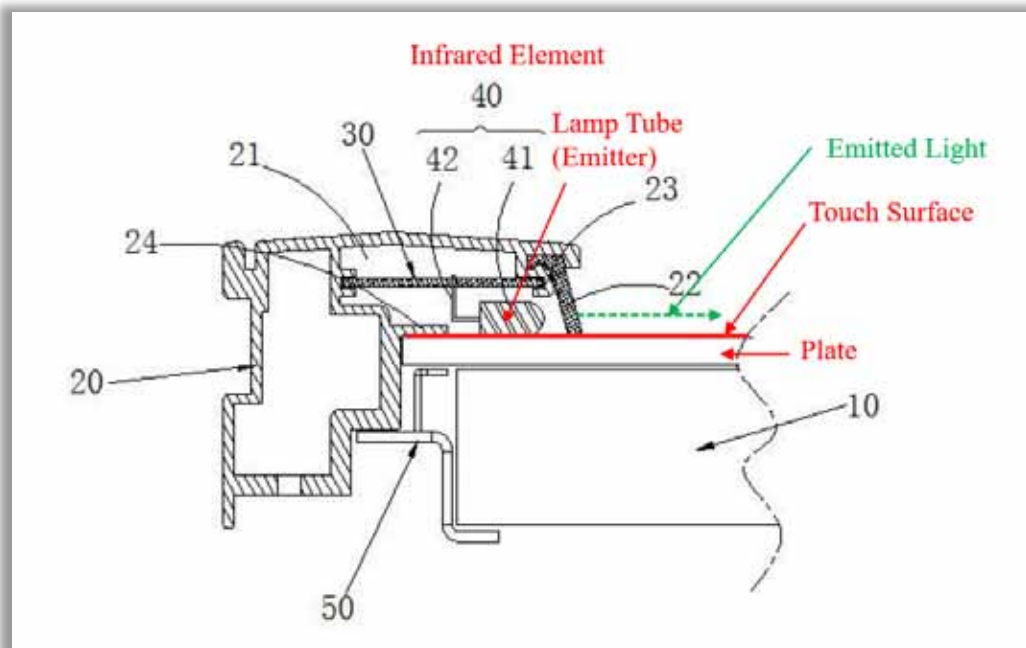


Ex. 1004 at Fig. 1.

314. Thus, it is my opinion that Cheng in view of Han and Shin discloses wherein all of the edges (edges of Cheng's modified plate) of the top surface of the plate (top surface of Cheng's modified plate) are curved.

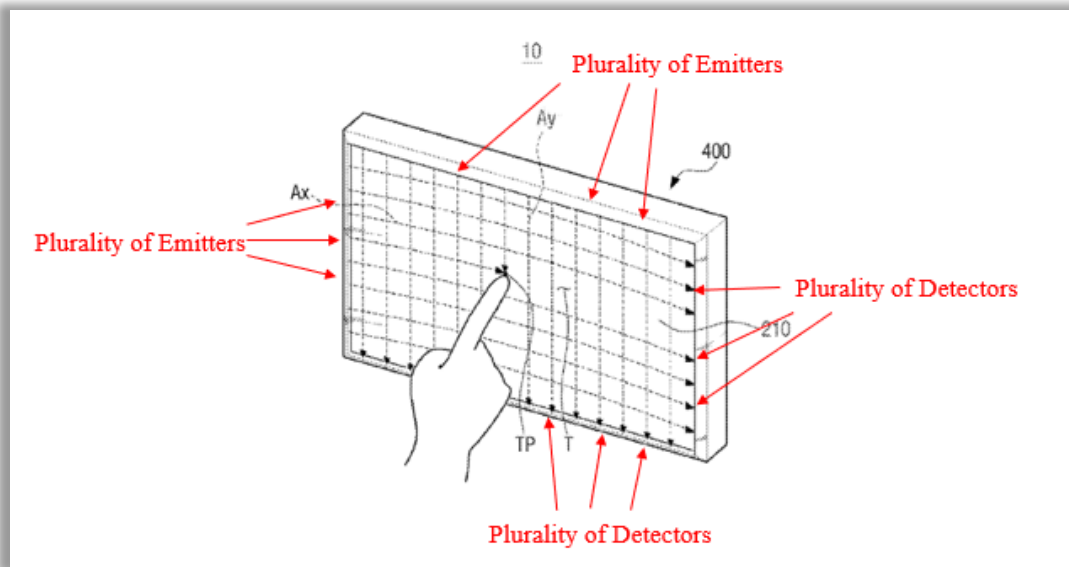
2. **Claim 2: “The touch sensing apparatus of claim 1, wherein the plurality of emitters is configured to emit light to propagate over the touch surface.”**

315. In my opinion, Cheng and Han disclose this element. Cheng discloses arranging “infrared receivers and **transmitters** [emitters] distributed densely around a display region [to] form a scanning network in horizontal and vertical directions...” Ex. 1004 at [0002] (emphasis added). The infrared element 40 is arranged adjacent to a periphery of the plate. *Id* at Fig. 1. It is my opinion that to achieve touch sensing functionality, a POSA would have understood Cheng’s lamp tube 41 of infrared element 40 to emit light to propagate over the touch surface of the plate.



Ex. 1004 at Fig. 1.

316. Additionally, Han discloses a plurality of emitters (light emitting parts 220) configured to emit light across a touch surface. *See* Ex. 1005 at [0040]

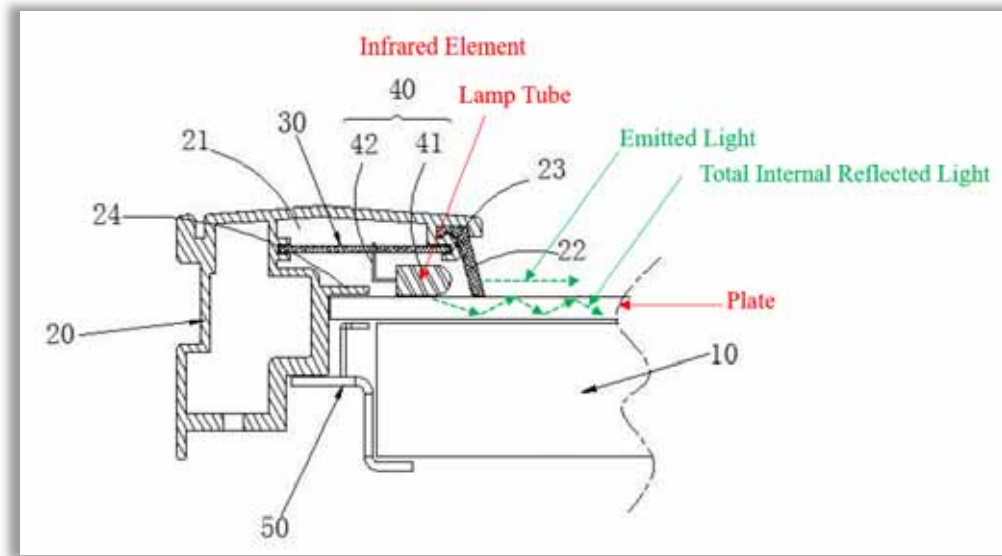


Ex. 1005 at Fig. 2

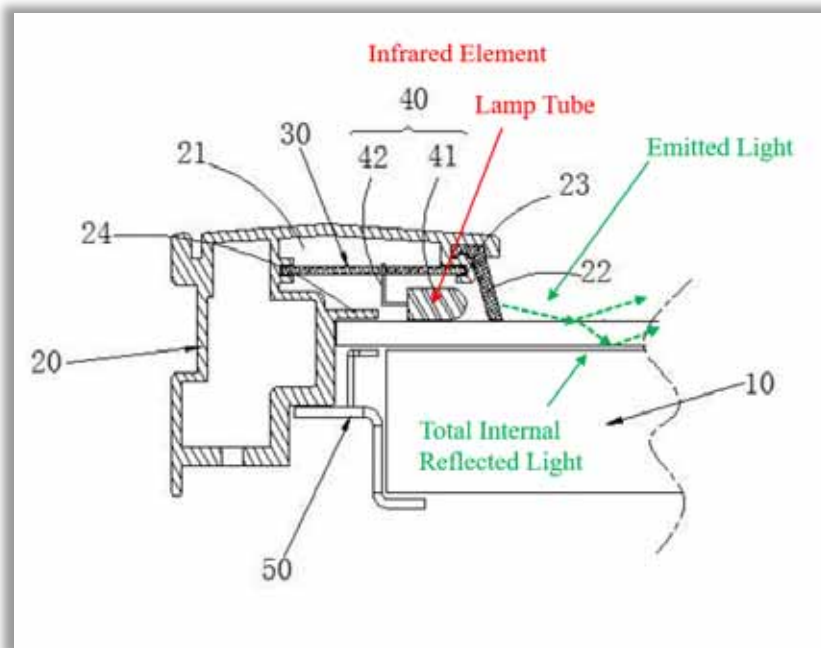
317. Thus, it is my opinion that Cheng and Han disclose wherein the plurality of emitters (Cheng's infrared element 40 including lamp tubes 41; Han's light emitting parts 220) is configured to emit light to propagate over the touch surface (surface of Cheng's plate; Han's touch surface T).

3. Claim 3: “The touch sensing apparatus of claim 1, wherein the plurality of emitters is configured to emit light through the plate by total internal reflection.”

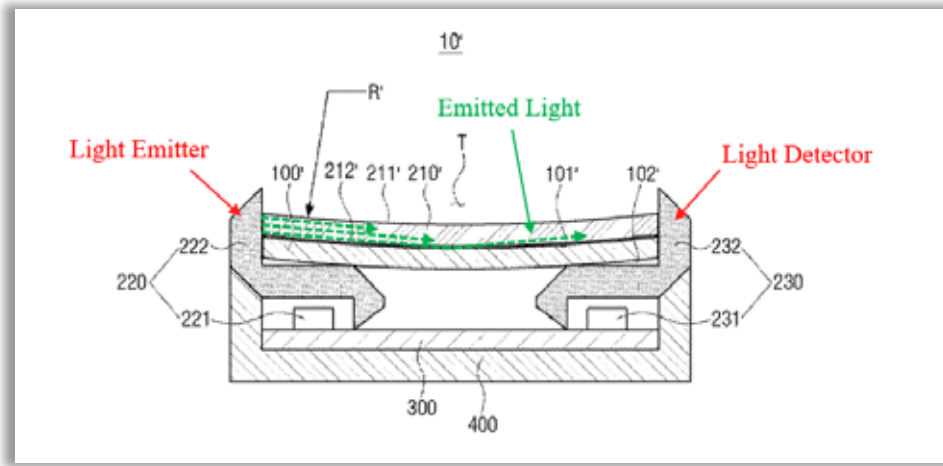
318. In my opinion, Cheng in view of Han discloses this element.



Ex. 1004 at Fig. 1.



Ex. 1004 at Fig. 1.



Ex. 1005 at Fig. 7.

319. For at least the reasons I have discussed in Ground 1, claim 3, it is my view that Cheng in view of Han discloses wherein the plurality of emitters (Cheng's infrared elements 40 with lamp tube 41; Han's light emitting parts 220) is configured to emit light through the plate (Cheng's plate; Han's cover glass 210) by TIR (entered light traveling via TIR).

4. Claim 4: "The touch sensing apparatus of claim 1, further comprising a processing element configured to determine, based on output signals of the plurality of detectors, a position of an object on the touch surface."

320. It is my opinion that Cheng and Han disclose this element. For at least the reasons I have discussed for Ground 1, claim 4, it is my opinion that Cheng and Han disclose a processing element (Cheng's circuit board 30; Han's integrated circuit IC) configured to determine, based on output signals of the plurality of

detectors (Cheng's infrared element 40 with detector; Han's photo diodes 231 and light reception guide members 231), a position of an object (a user touch) on the touch surface (surface of Cheng's plate; Han's front surface 211).

XI. CONCLUSION

321. For the reasons and rationales I have discussed herein, it is my opinion that with regards to the '335 Patent, claims 1-5 are obvious under Cheng in view of Han and Zhao. It is my opinion that claims 1-5, are obvious under Cao in view of Han and Zhao. It is my further opinion that claims 1-4 are obvious under Cheng in view of Han and Shin.

* * *