UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

Caihong Display Devices Co., Ltd.,

Petitioner,

v.

Corning Incorporated,

Patent Owner.

Case No.: IPR2025-01137

U.S. Patent No. 8,627,684

PETITION FOR INTER PARTES REVIEW OF U.S. PATENT NO. 8,627,684

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EX1005	JP20070151027 with certified English translation ("JP '027")
EX1006	KR200407349 with certified English and Japanese translations ("KR '349")
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I. MANDATORY NOTICES UNDER 37 C.F.R. § 42.8

A. Real Party-in-Interest

Caihong Display Devices Co., Ltd. ("Caihong") is the Petitioner and a real party-in-interest.

B. Related Matters

U.S. Patent No. 8,627,684 ("the '684 Patent") is presently the subject of a patent infringement lawsuit filed against Petitioner in the United States District Court for the Eastern District of Virginia and captioned Corning Incorporated v. Caihong Display Devices Co., Ltd. et al, Case No. 1-24-cv-02328. The '684 Patent is also asserted in the investigation captioned Certain Glass Substrates for Liquid Crystal Displays, Products Containing the Same, and Methods for Manufacturing the Same II, Investigation No. 337-TA-1433, at the U.S. International Trade Commission. This is the first case in which the '684 Patent was litigated. The '684 Patent has not been subjected to post-grant review by the Patent Trial & Appeal Board.

C. Lead and Back-up Counsel and Service Information

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II. FEE AUTHORIZATION

The PTO is authorized to charge any fees due during this proceeding to Deposit Account No. 132725.

III. GROUNDS FOR STANDING

Petitioner certifies that the ’684 Patent is available for *inter partes* review and that Petitioner is not barred or estopped from requesting *inter partes* review challenging the patent claims on the grounds identified in this Petition.

IV. REQUESTED RELIEF

Petitioner requests review and cancellation of Claims 1-20 as unpatentable based on the following grounds, supported by a declaration from Murakami Tsugunobu. EX1003.

Ground	Challenged Claims	Asserted Prior Art
1	1-14	JP ’826 in view of one or more of Butts, JP ’027, KR ’349, Ferngren and Smids
2	1-14	KR ’349 in view of one or more of Bogdahn, Ferngren and Fredholm

V. REASONS FOR THE REQUESTED RELIEF

As set forth in detail below in Ground 1 and Ground 2, the asserted prior art render obvious each of the claims of the ’684 Patent.

The ’684 Patent focuses on an apparatus and process for manufacturing glass rolls useful as glass sheets for flat panel displays. The ’684 Patent describes an apparatus that can be used in the known fusion downdraw glass manufacturing process and incorporates a pull roll apparatus that has a low motion drive control that is described as providing better controls in consistency of the tension of the glass ribbon to purportedly improve flatness of the glass sheet and reduce residual stress within the glass sheet. EX1001, Col. 1-2; Col. 4, lines 31-43; EX1003, ¶¶ 0043-0045.

The challenged claims, however, would have been obvious to a person of ordinary skill ("POSITA") in view of the prior art. A POSITA would have found it obvious to combine the teachings of JP '826, Butts, JP '027, KR '349, Ferngren and Smids, as well as to combine the teachings of KR '349, Bogdahn, Ferngren and Fredholm. In particular, all these references are in the same technical field. Thus, JP '826, Butts, JP '027, KR '349, Ferngren and Smids are analogous references, as well as are KR '349, Bogdahn, Ferngren and Fredholm, and a POSITA would have found combining these references to be one of a finite number of identified means for manufacturing glass rolls applicable as glass sheets for flat panel displays, and further, would have had a reasonable expectation of success in combining their teachings, thus rendering all of the challenged claims obvious. EX1003, ¶¶ 0075-0165; 166-232.

This Petition's showing that the cited art renders the challenged claims unpatentable is fully supported by the Declaration of Murakami Tsugunobu (EX1003) who is an expert in glass and material science—including knowledge and experience in, for example, glass processing such as down draw processing; glass properties such as density, strength, structure, and devitrification; and apparatus components, operations, methodology, and know how in the operation of systems for producing glass materials, particularly glass for panels displays. EX1003, ¶¶ 0004-0005; 0034-0037.

Accordingly, the Board should institute trial and cancel the challenged claims.

A. Summary of the ’684 Patent

The ’684 Patent focuses on an apparatus and process for manufacturing glass rolls useful as glass sheets for flat panel displays that incorporates a pull roll apparatus into a known process for glass manufacturing. The details of the pull roll apparatus are described throughout the description and recited in the claims of the ’684 Patent. The ’684 Patent presents a second pair of rollers that are above or below a first pair of rolls which split or apportion the torque among different roll pairs. EX1001, Col. 7, line 57 – Col. 8, line 14; EX1003, ¶¶ 0043-0044.

The various roll pairs are described as allowing glass flattening via improvement of the down-drawn sheet tension. EX1001, Col. 8, lines 14-28; EX1003, ¶ 0045.

B. Priority Date

The ’684 Patent was filed on October 29, 2007. EX1001, cover page. No priority application or claim is identified. *Id.* Accordingly, any patent or printed publication published before October 29, 2007 is prior art under at least 35 U.S.C. § 102(a) (pre-AIA), if more than one year prior to the ‘684 patent filing date then the prior art is available under 35 U.S.C. 102(b) (pre-AIA) and any patent granted on an application filed before October 29, 2007, is prior art under § 102(e) (pre-AIA).

All of the references cited in this Petition qualify as prior art.

C. The Prosecution History of the ’684 Patent

JP ’027 (EX1005) was before the USPTO during prosecution of the ’684 Patent in the form of its priority filing: JP2005237717.

Butts (EX1004), KR ’349 (EX1006), Ferngren (EX1007), and Smids (EX1010) were before the USPTO during prosecution of the ’684 Patent.

Butts (EX1004), Ferngren (EX1007), and Smids (EX1010) were cited in a rejection by the USPTO. EX1011, 000102-000109 [[May 14, 2010 office action/rejection]] (Butts and Smids); EX1011, 000076-000086 [[October 29, 2010 office action]] (Ferngren).

JP ’826 (EX1002), KR ’349 (EX1006), Bogdahn (EX1008) and Fredholm (EX1009) were not cited or identified on any Information Disclosure Statements during the prosecution of the ’684 Patent. EX1003, ¶ 0047.

The USPTO has not previously considered the teachings of JP ’826, Butts, JP ’027, Ferngren, or Smids, particularly when combined with the disclosures in KR ’349, Bogdahn, and/or Fredholm, which describes features of the ’684 Patent claims that were deemed to be patentable by the USPTO. And, more importantly, the Office has not previously considered any of the combinations of these references that form the grounds for this Petition. Thus, this Petition presents substantially new arguments that were not previously considered during prosecution of the ’684 Patent.

VI. CLAIM CONSTRUCTION

In *inter partes* review, claims are “construed using the same claim construction standard that would be used to construe the claim in a civil action under 35 U.S.C. 282(b).” 37 C.F.R. § 42.100(b). Claims must therefore be given their ordinary and customary meaning as understood by a POSITA at the time of the invention in light of the specification and the prosecution history pertaining to the patent. *Id. See also Phillips v. AWH Corp.*, 415 F.3d 1303, 1312-13 (Fed. Cir. 2015 (*en banc*); 83 Fed. Reg. 51340, Vol. 83, No. 197 (Oct. 11, 2018). As such, this Petition and the Murakami declaration construe claim terms consistent with the understanding a POSITA would have in view of the ’684 Patent’s intrinsic evidence and, where appropriate, extrinsic evidence. *Phillips*, 415 F.3d at 1312. EX1003, ¶¶ 0038-0041.

Terms for which a specific construction is not provided below have been given their plain and ordinary meaning, as discussed in more detail for particular terms. Petitioner, however, may pursue constructions of additional claim terms in the related litigations concerning the ’684 Patent to help the Administrative Law Judge and/or jury understand the relevant technical terms and expressly reserves the right to assert that certain claim terms are indefinite.

VII. STATUTORY GROUNDS FOR CHALLENGES AND REFERENCES USED

Claims 1–14 would have been obvious over:

JP ’826 (EX1002) in view of one or more of Butts (EX1004), JP ’027 (EX1005), KR ’349, Ferngren (EX1007), and Smids (EX1010), which constitutes Ground 1 of this Petition; or

KR ’349 (EX1006) in view of one or more of Bogdahn (EX1008), Ferngren (EX1007), and Fredholm (EX1009), which constitutes Ground 2 of this Petition.

Each piece of prior art relied upon in this Petition qualifies as prior art to the ’684 Patent under at least 35 U.S.C. 102(a) (pre-AIA).

VIII. LEVEL OF ORDINARY SKILL IN THE ART

A POSITA is one who is presumed to be aware of all pertinent art, thinks along the lines of conventional wisdom in the art, and is a person of ordinary creativity. A POSITA would have had knowledge of and experience with the concepts of glass and material science relevant to ’684 Patent, for example (but not limited to), glass processing such as downdraw processing; glass properties such as density, strength, structure, and devitrification; and apparatus components, operations, methodology, and know how in the operation of systems for producing glass materials, particularly for use as panels in display devices such as Liquid Crystal Displays (LCDs). EX1003, ¶ 0036.

IX. THE PRIOR ART IN THE APPLIED INVALIDITY GROUNDS

A. JP ’826

JP ’826 was filed on April 16, 1997, and published on November 4, 1998. EX1002, page 1. Therefore, JP ’826 was published more than one year before the filing date of the ’684 Patent. EX1003, ¶ 0054.

Similar to the ’684 Patent, JP ’826 describes manufacturing glass sheets with a pull roll apparatus. As shown in FIGS. 1-3, the glass sheet is manufactured by “allowing molten glass 3 to flow downward and form a sheet using a forming body 2, and then pulling the formed glass sheet 3’ downward between pulling rollers 6” in a drawn down fusion process. EX1002, Abstract. JP ’826 describes roll pairs that are cantilevered vertically downward and the utility of monitoring peripheral speed in the roll pairs as part of the manufacturing process. *Id.*, Abstract, ¶¶ [0004], [0012]-[0014], [0017], [0018], [0028], [0033], [0034], [0040], [0041], [0047], [0049], [0054], FIG. 3; EX1003, ¶ 0055.

B. Butts

Butts was filed on June 2, 2004, and published on December 8, 2005. EX1004, page 1. Therefore, Butts was published more than one year before the filing date of the ’684 Patent. EX1003, ¶ 0056.

Similar to the ’684 Patent, Butts describes a pull roll assembly used in the production of a glass sheet made by a drawn down fusion process. EX1004, ¶ [0002]. Butts describes the utility of monitoring torque in the disclosed apparatus and method as “controlling the operation of the pull roll assembly based on pulling forces associated with the glass sheet as it is being drawn by the pull roll assembly.” *Id*; EX1003, ¶ 0057.

Butts further discloses that “[i]n operation, the differential drive 214 rather than delivering constant rpm speed to the rolls 206 and 212 operates to deliver equal and constant torque to the rolls 206 and 212 with respect to the required sheet pulling force while allowing the rotational speeds of each of the rolls 206 and 212 to change with respect to one another based on the small but unavoidable difference between the radii of roll 206 and roll 212.” EX1004, ¶ [0021]; EX1003, ¶ 0058.

C. JP ’027

JP ’027 was filed on August 18, 2005, and published on March 1, 2007. EX1005, page 1. Therefore, JP ‘027 was published before the filing date of the ’684 Patent. EX1003, ¶ 0059.

Similar to the ’684 Patent, JP ’027 describes a glass plate manufacturing method that includes a downdraw fusion process. EX1005, ¶¶ [0001]-[0003]. JP ’027 describes in this downdraw fusion process the utility of multiple rollers and monitoring and adjusting speed of the rollers. *Id*., Abstract. JP ’027 further teaches that "[t]he ratio of the circumferential speed of the cooling rollers 5 to that of pulling rollers 4 is set from 1:3.5 to 1:20, and more preferably to from 1:4 to 1:15, and the circumferential speed of auxiliary cooling rollers 6 is set to be at least within the range of the circumferential speed of the cooling rollers 5, and less than 80%, and more preferably less than 70%, of the circumferential speed of pulling rollers 4." *Id*., ¶ [0046]; EX1003, ¶ 0060.

D. KR '349

KR '349 was filed on October 11, 2005, and published on January 31, 2006. EX1006, page 1. Therefore, KR '349 was published more than one year before the filing date of the '684 Patent. EX1003, ¶ 0061.

Similar to the '684 Patent, KR '349 describes manufacturing a glass sheet in a pull roll apparatus that includes multiple rollers. *See*, *e.g.*, EX1006, FIG. 3. KR '349 discloses "a manufacturing device for sheet glass using a downdraw method in which a drawing adjustment plate (resistance body) is inserted into the inner surface of a glass product to make the temperature uniform and control the flow of viscosity in order to form better smoothness and surface quality in the glass product produced by the downdraw method." *Id*., page 2; EX1003, ¶ 0062.

E. Ferngren

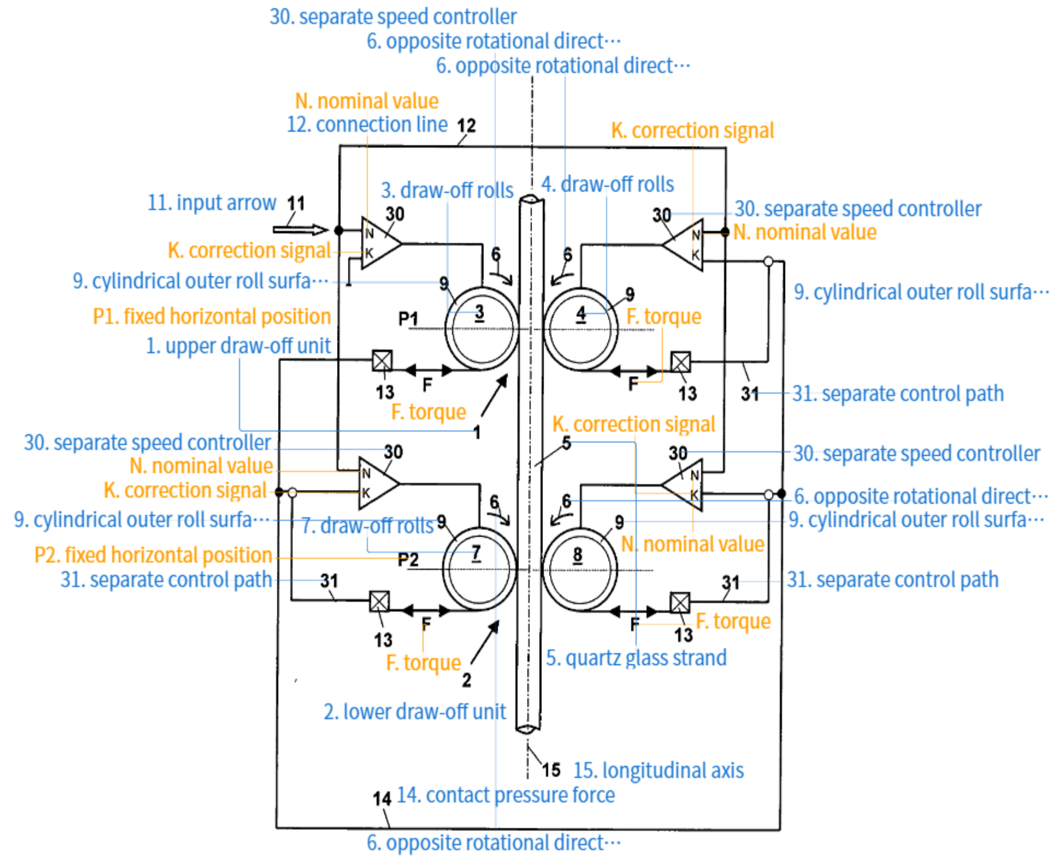
Ferngren was filed on July 7, 1922, and published on June 1, 1926. EX1007, page 1. Therefore, Ferngren was published more than one year before the filing date of the ’684 Patent. EX1003, ¶ 0063.

Similar to the ’684 Patent, Ferngren describes “drawing a continuous sheet of glass, and . . . maintaining a lateral or sidewise stress on the sheet while it is under formative drawing stress lengthwise” in a general glass manufacturing process. EX1007, page 4, lines 1-6. Ferngren describes the utility of monitoring tension included in the apparatus and method to “balance the stresses in the sheet structure.” *Id*., lines 9-10; EX1003, ¶ 0063.

F. Bogdahn

Bogdahn was filed on January 23, 2002, and published on April 14, 2005. EX1008, page 1. Therefore, Bogdahn was published more than one year before the filing date of the ’684 Patent. EX1003, ¶ 0065.

Similar to the ’684 Patent, Bogdahn describes a method for manufacturing glass articles. Bogdahn describes controlling the torque of rollers. EX1008, at ¶¶ [0053]-[0057] and illustrates, in FIG. 1, a diagram for controlling the torque of a device used for manufacturing glass bodies, annotated below with the numerical features described:



EX1003, ¶¶ 0066-0067

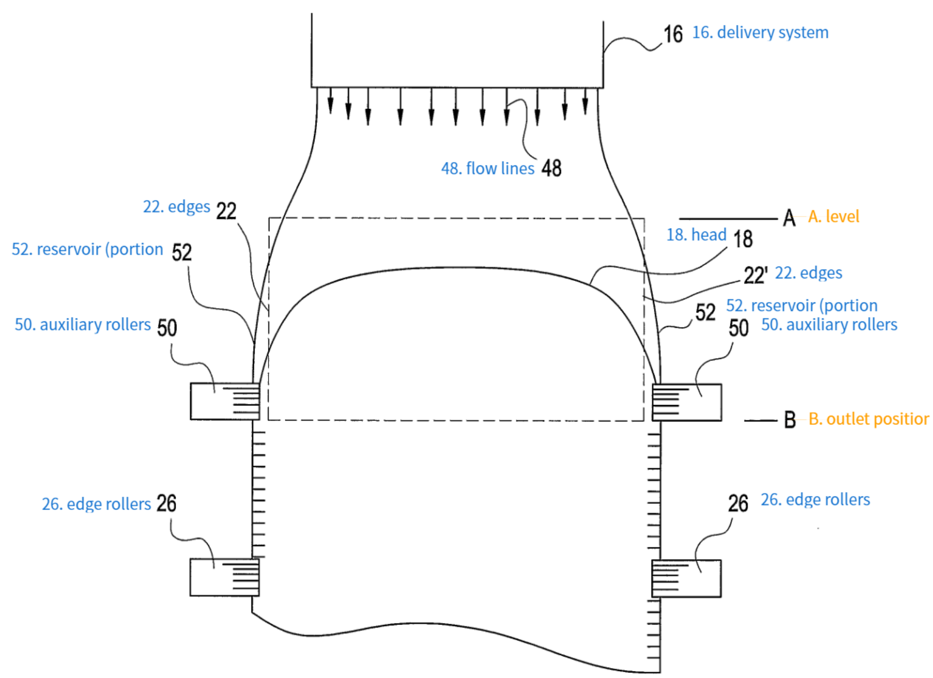
G. Fredholm

Fredholm was filed on March 10, 2006, and published on January 22, 2009. EX1009, page 1. While Fredholm published on January 22, 2009. EX1009, page 1, which is after the filing date of the ‘684 patent filing date of October 29, 2007, the EP priority application published on October 11, 2006, which was more than one year before the filing date of the ‘684 Patent. The disclosures and figures of the U.S. publication of Fredholm and the EP priority document are substantially the same. EX1003, ¶ 0068.

Similar to the ’684 Patent, Fredholm describes manufacturing glass sheets and improving upon “[t]he so-called ‘fusion draw process’ . . . to obtain flat sheets of high surface quality.” EX1009, ¶ [0007]; EX1003, ¶ 0069.

Fredholm describes a plurality of roller pairs that are positioned and configured strategically to control tension, viscosity, and shear stress on the manufactured glass sheet. *Id.*, ¶ [0054] and illustrates in FIG. 8, annotated below with the features labeled based on the description in the specification:

FIG. 8



EX1003, ¶¶ 0070-0072

H. Smids

Smids was filed on June 11, 1985, and published on September 16, 1986. EX1010, page 1. Therefore, Smids was published more than one year before the filing date of the ’684 Patent. EX1003, ¶ 0072.

Similar to the ’684 Patent, Smids describes a method and apparatus for glass manufacturing. Smids teaches the utility of monitoring tension in the process of “feeding the laminated molten fixture into the feed side of a pair of counterrotating forming rolls which press the molten glass mixture into a continuous plastic elongated sheet, stretching the plastic continuous elongated sheet in the machine direction, i.e., the direction of travel of the feed rolls while simultaneously stretching the plastic continuous elongated sheet in a direction transverse to the machine direction, and annealing the stretched glass sheet.” *Id*. at Col. 1, lines 40-49; EX1003, ¶¶ 0073-0074.

I. Motivation to Combine

As set forth below in more detail with respect to the specific claim limitations, a POSITA would have found it obvious to combine teachings of JP ’826, Butts, JP ’027, KR ’349, Ferngren, Bogdahn, Fredholm, and Smids. In particular, all eight references are in the same technical field. Thus, JP ’826, Butts, JP ’027, KR ’349, Ferngren, Bogdahn, Fredholm, and Smids are analogous references, and a POSITA would have found combining these references to be one of a finite number of identified means for manufacturing glass rolls applicable as glass sheets for flat panel displays, and further, would have had a reasonable expectation of success in combining their teachings. EX1003, ¶¶ 0075-0232.

X. CLAIMS 1-14 ARE UNPATENTABLE

I. Ground 1: Claims 1-14 would have been obvious over JP ’826 in view of one or more of Butts, JP ’027, KR ’349, Ferngren, and Smids

A. Independent Claim 1

There are several limitations in Claim 1 and each is addressed in turn.

Limitation 1[p]

JP ’826 describes a method for manufacturing glass sheets. EX1001, Title, ¶ [0001]. JP ’826 also teaches that several kinds of methods for manufacturing glass sheets were known in the prior art, including the down-draw method. *Id.*, ¶¶ [0002], [0003]; EX1003, ¶ 0075.

Butts also describes a method for manufacturing glass that uses the fusion process. EX1004, ¶¶ [0018], [0019], [0038], Fig.1, Fig.8; EX1003, ¶ 0076.

Therefore, this limitation is taught by either JP ’826 or Butts. EX1003, ¶ 0077.

Limitation 1[a]

Melting batch materials and forming the glass sheet is disclosed by, and inherent to, the manufacturing methods described in JP ’826 and Butts. Glass manufacturing necessarily requires melting the starting materials. Thus, JP ’826 teaches that several kinds of methods for manufacturing glass sheets were known in the prior art and can be classified according to the direction in which the molten glass moves (*e.g.*, horizontal, down-draw). EX1002, ¶¶ [0002], [0003], [0021]-[0026]. Likewise, Butts discloses that a first basic manufacturing step is to "melt batch materials to form [a] glass sheet." EX1004, ¶ [0038], FIG. 8; EX1003, ¶ 0078.

Therefore, this limitation is taught by either JP '826 or Butts. EX1003, ¶ 0079.

Limitation 1[b]

JP '826 describes delivering the glass sheet to a pull roll apparatus. For example, FIGS. 1-3 show glass sheet 3' being delivered downward to pulling rollers 6 and cooling rollers 7. EX1002, Overview, ¶¶ [0012]-[0014], [0017]-[0019], [0028]-[0035], [0046]; EX1003, ¶ 0080.

In addition, Butts describes delivering the glass sheet to a pull roll assembly in a fusion process. EX1004, Abstract, ¶¶ [0002], [0017]-[0038], FIGS. 1-8; EX1003, ¶ 0081.

Therefore, this limitation is taught by either JP '826 or Butts. EX1003, ¶ 0082.

Limitation 1[c1]:

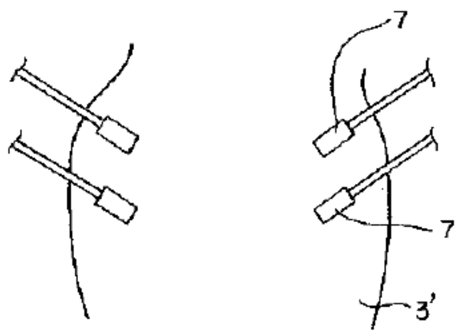
Figures 1-3 of JP '826 show drawing glass sheet 3' and using pulling rollers 6 and cooling rollers 7 to create tension in the glass sheet in a transverse direction and a longitudinal direction. EX1002, ¶¶ [0011], [0019], [0028], [0032], [0054], [0055]; EX1003, ¶ 0083.

Accordingly, this limitation is taught by JP '826. EX1003, ¶ 0084.

Limitation 1[c2]:

Figure 3 of JP ’826 depicts first and second cantilevered vertically downtilted stub roll pairs 7:

【図3】



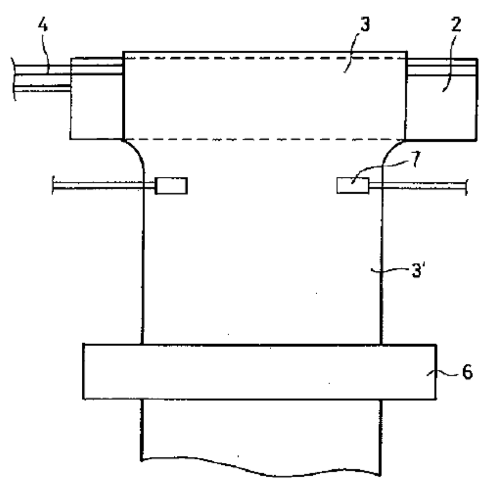
JP ’826 also teaches that “[b]ecause the edges of the glass sheet are cooled before the center of the glass sheet, tension acts in the widthwise direction of the glass sheet. Because a pulling force acts between the cooling rollers and the pulling rollers, tension also acts in the lengthwise direction of the glass sheet.” *Id*., ¶ [0028]. Thus, the first stub roll pair 7 draws a first edge portion of glass sheet 3’ out away from a center of the glass sheet 3’, and the second stub roll pair 7 draws a second edge portion of the glass sheet 3’ out away from the center of the glass sheet 3’ at a location transversely opposite the first stub roll pair, thereby creating a cross-tension in the glass sheet 3’ between the first stub roll pair 7 and the second stub roll pair 7. *Id*., ¶¶ [0011], [0019], [0028], [0032], [0054], [0055]; EX1003, ¶¶ 008-0086.

Therefore, this limitation is disclosed by JP ’826. EX1003, ¶ 0087.

<u>*Limitation 1[c4]:*</u>

Figure 2 of JP ’826 shows a pull roll pair 6 disposed below the first and second stub roll pairs 7 for drawing the first edge portion and the opposing second edge portion of the glass sheet 3’ and creating a vertical draw tension on the glass sheet between the pull roll pair and the first and second stub roll pairs:

【図2】



EX1003, ¶ 0088

JP ’826 teaches that “[b]ecause a pulling force acts between the cooling rollers and the pulling rollers, tension also acts in the lengthwise direction of the glass sheet.” EX1002, ¶ [0028] EX1003, ¶ 0089.

Thus, JP ’826 discloses this limitation. EX1003, ¶ 0090.

<u>*Limitation 1[d]:*</u>

JP ’826 teaches setting the peripheral speed of the cooling rollers to be lower than the peripheral speed of the pulling rollers, that “the peripheral speed of these cooling rollers is set to be lower than the peripheral speed of the pulling rollers. By setting the peripheral speed of the cooling rollers to be lower than the peripheral speed of the pulling rollers (glass pulling speed), the molten glass stopped by the cooling rollers has a longer contact time with the cooling rollers, resulting in greater cooling of the edges of the glass sheet." EX1002, ¶ [0028]; EX1003, ¶ 0091.

As another example, JP ’826 discloses setting the peripheral speed of the cooling rollers to be a predetermined percentage of the peripheral speed of the pulling rollers: "the peripheral speed of the cooling rollers is preferably set to be 30 to 90% of the peripheral speed of the pulling rollers." *Id*. ¶ [0033]; EX1003, ¶ 0092.

JP ’826 further discloses that "the peripheral speed of the cooling rollers is more preferably set to be 40 to 80% of the peripheral speed of the pulling rollers." *Id.*, ¶ [0034]; EX1003, ¶ 0093.

Butts also teaches monitoring and controlling the torque of the first and second rolls of the pull roll assembly. EX1004, ¶¶ [0021], [0024]; EX1003, ¶¶ 0094-0095.

From these descriptions in JP ’826 and Butts, it would be clear to a POSITA that all of the limitations of claim 1 of the ’684 Patent are disclosed. For example, although JP ’826 does not explicitly disclose monitoring and controlling the torque of each roller, or setting the ratio of the torque of the cooling rollers to the pulling rollers to a preset value, Butts teaches setting the rotational speed of the cooling rollers to a preset value that is lower than the rotational speed of the pulling rollers.

At the same time, Butts discloses that one of the defects of traditional speed control is "slippage" that occurs between the rolls and the glass surface when "only the rotational speeds of the two rolls are controlled" instead of the torque. EX1004, ¶ [0006]. Butts teaches that "controlling torque rather than speed can allow for a speed difference between the rolls, enabling the surface speed of the glass sheet to match the speed of the rolls, thereby preventing the rolls from slipping relative to the glass plate." *Id.*, ¶ [0021]. Butts thus provides a technical reason for a POSITA to optimize speed control with torque control—to improve slippage between the rolls and the glass plate and prevent damage to both. EX1003, ¶¶ 0096-0097.

JP '826 discloses setting the speed ratio between the cooling roller and the pulling roller to a preset value to improve the warping of the glass plate. EX1002, ¶ [0028]. As the torque control in Butts offers more benefits than speed control, it would have motivated a POSITA to set the torque ratio between the cooling rollers and pulling rollers in JP '826 to a preset value. Moreover, a POSITA would recognize that there is no technical barrier to combining the teachings of Butts and JP '826 to achieve the benefits of torque control. For at least this reason, a POSITA would have been motivated to modify the process described in JP '826 with the torque control disclosed in Butts to improve the manufacture of glass sheets . EX1003, ¶ 0098.

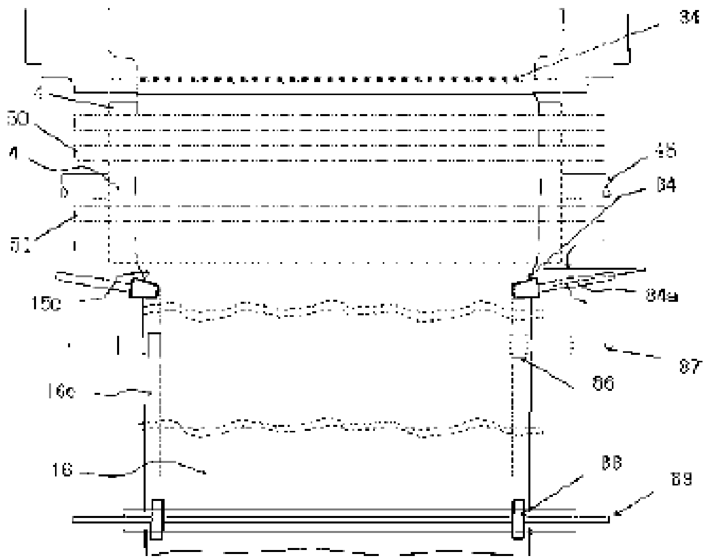
Accordingly, limitations 1[d]-[g] are taught by JP ’826 in view of Butts and as all of the limitations of claim 1 are taught by these citations, Claim 1 would have been obvious. EX1003, ¶ 0099.

B. Dependent Claim 2

JP ’826 discloses that, “as shown in FIG. 3, a plurality of cooling rollers may be provided in the vertical direction, or may be provided in a diagonal direction with respect to the glass sheet. This allows for further adjustment of horizontal and vertical tension.” EX1002, ¶ [0054]; EX1003, ¶ 0100.

KR ’349 teaches controlling and adjusting the height of a diffusion roller having a tilted angle as shown in Figure 3, that “[t]he diffusion roller (84) is configured to be moved up and down in height so that it can be pressed as close as possible to the bottom of the resistor (4) by forming the edges thinly.” EX1006, page 7; EX1003, ¶ 0101.

Figure 3



Moreover, KR ’349 teaches that “the diffusion roller (84) has a tapered structure and is equipped with a heating and cooling structure at the same time so that the drawing speed, the surface temperature of the roller, and ***the tilted angle are comprehensively controlled.***” *Id.* (emphasis added); EX1003, ¶ 0102.

A POSITA would have been motivated to combine the teachings of JP ’826 and KR ’349 to arrive at the limitation in claim 2. The cooling rollers in JP ’826 are “provided in a diagonal direction” (*i.e.*, downtilt position) which “allows for further adjustment of the horizontal and vertical tension.” EX1002, ¶ [0054]. KR ’349 teaches that a roller “with an angle (84a) tilted outward” (*i.e.*, down) can be moved up and down to prevent the edges of the glass sheet from becoming “thick and round due to the convergence phenomenon caused by surface tension at both ends,” and also that the “tilted angle” of the roller can be “comprehensively controlled.”

EX1006, page 7. Thus, KR ’349 teaches a known technique that is applicable to JP ’826 because both references are directed to managing the tension of the glass sheet with pairs of rollers to achieve a desired thickness while improving surface quality and reducing warping. A POSITA would understand that adjusting and controlling the downtilt position of the cooling rollers in JP ’826 according to the technique discloses in KR ’349 would yield predictable results and lead to the method described in claim 2. EX1003, ¶ 0103.

Therefore, Claim 2 is taught by JP ’826 in view of Butts and further in view of KR ’349 and would have been obvious. EX1003, ¶ 0104.

C. Dependent Claim 3

Ferngren describes the process step of “ironing out” the thickened edges of a glass sheet using a series of roller pairs positioned at successively decreasing angles relative to the glass surface. EX1007, Col. 4, line 91 – Col. 5, line 5; FIGS. 6-11; EX1003, ¶ 0105.

A POSITA would have been motivated to combine the teachings of JP ’826 and Ferngren to arrive at the limitation in claim 3. Both references teach process steps that precipitate annealing of the glass sheet. JP ’826 teaches the desirability of minimizing warping of the glass as much as possible during forming of the sheet by applying horizontal and vertical tension before the annealing step. EX1002, ¶¶ [0008]-[0011]. Ferngren, in turn, teaches that flattening out the edges of the glass sheet using pairs of successively angled rollers to achieve a uniform thickness "facilitates . . . the handling of the sheet in the flattening and annealing mechanism." EX1007, Col. 4, line 91 – Col. 5, line 5. A POSITA would have recognized the advantage of performing both steps—applying horizontal and vertical tension, and flattening out the edges of the glass—before the glass sheet is annealed. Thus, Ferngren teaches a known technique that would yield predictable results and lead to the method described in claim 3. EX1003, ¶ 0106.

Therefore, claim 3 is taught by JP '826 in view of Butts and further in view of Ferngren and would have been obvious. EX1003, ¶ 0107.

D. Dependent Claim 4 and 5

Figure 6 of Butts depicts a pull roll assembly with two rolls supported by four support arms that each incorporate a sensor (electrical strain gage module) for measuring torque. EX1004, ¶ [0026]; EX1003, ¶ 0108.

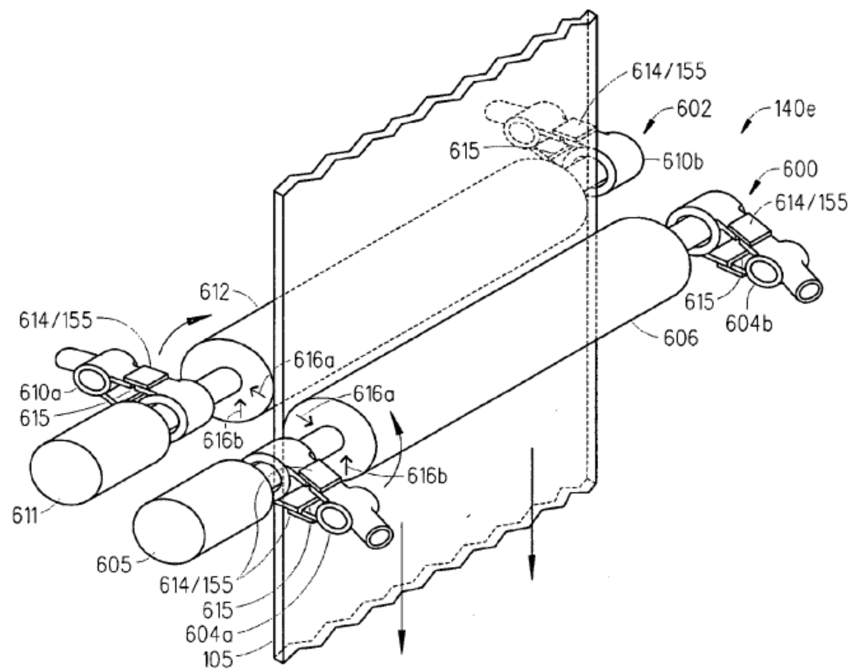


FIG. 6

Butts teaches that the pulling forces exerted by the rolls on the glass sheet are converted into an electrical signal that is sent to a drive/motor that controls the rotational speed of the motors coupled to the rolls for maintaining the required pulling force on the glass sheet. *Id.*, ¶¶ [0027]-[0031]; EX1003, ¶ 0109.

Angular velocity generally refers to how fast an object rotates around an axis. Butts discloses that upon receiving an electrical signal from the electrical strain module, "the corresponding drive precisely ***controls the rotational speed of the motors 605 and 611 coupled to rolls 606 and 612*** which enables one to maintain the required pulling force on the drawn glass sheet 105 . . ." *Id.*, ¶ [0027] (emphasis added). Butts also teaches that "the electrical signals can be used in a wide variety of control schemes other than the one described above to help draw the glass sheet 105." *Id;* EX1003, ¶ 0110.

A POSITA would understand that one such control scheme would involve controlling and adjusting the angular velocity of at least one roll in a pair while idling the other roll. Accordingly, the limitation of claim 4 is disclosed in Butts. Therefore, when the process described in JP '826 is modified with the torque control disclosed in Butts to improve the manufacture of glass sheets for the reasons discussed above in claim 1, a POSITA would understand that the resulting combination teaches claim 4 and thus would have been obvious. EX1003, ¶¶ 0110, 0112.

The drive in Butts "precisely controls the rotational speed of the ***motors 605 and 611*** coupled to rolls 606 and 612" (*Id.*, ¶ [0027], emphasis added) and as such when the process described in JP '826 is modified with the torque control disclosed in Butts to improve the manufacture of glass sheets for the reasons discussed above in claim 1, a POSITA would understand that the resulting combination teaches the combination of JP '826 and Butts teaches claim 5 and thus would have been obvious. EX1003, ¶¶ 0111-0112.

E. Dependent Claim 6

JP '826 discloses that the peripheral speed of the cooling rollers is preferably 30 to 90% (and more preferably 40 to 80%) of the peripheral speed of the pulling rollers. EX1002, ¶¶ [0033]-[0034]; EX1003, ¶ 0113.

Thus, when the process described in JP ‘826 is modified with the torque control disclosed in Butts to improve the manufacture of glass sheets for the reasons discussed above in claim 1, a POSITA would understand that the resulting combination teaches claim 6. Therefore, Claim 6 would have been obvious in view of JP ‘826 and Butts. EX1003, ¶ 0114.

F. Independent Claim 7

There are several limitations in Claim 7 and each is addressed in turn.

Limitation 7[p]:

JP ’826 describes a method for manufacturing glass sheets. EX1001, Title, ¶ [0001]. JP ’826 also teaches that several kinds of methods for manufacturing glass sheets were known in the prior art, including the down-draw method. *Id.*, ¶¶ [0002], [0003]; EX1003, ¶ 0115.

Butts also describes a method for manufacturing glass that uses the fusion process. EX1004, ¶¶ [0018], [0019], [0038], Fig.1, Fig.8; EX1003, ¶ 0116.

Therefore, this limitation is taught by either JP ’826 or Butts. EX1003, ¶ 0117.

Limitation 7[a]:

Melting batch materials and forming the glass sheet is disclosed by, and inherent to, the manufacturing methods described in JP ’826 and Butts. Glass manufacturing necessarily requires melting the starting materials. Thus, JP ’826 teaches that several methods for manufacturing glass sheets were known in the prior art and can be classified according to the direction in which the molten glass moves (*e.g.*, horizontal, down-draw). EX1002, ¶¶ [0002], [0003], [0021]-[0026]. Likewise, Butts discloses that a first basic manufacturing step is to “melt batch materials to form [a] glass sheet.” EX1004, ¶ [0038], FIG. 8; EX1003, ¶ 0118.

Therefore, this limitation is taught by either JP ’826 or Butts. EX1003, ¶ 0119.

Limitation 7[b]:

JP ’826 describes delivering the glass sheet to a pull roll apparatus. For example, FIGS. 1-3 show glass sheet 3’ being delivered downward to pulling rollers 6 and cooling rollers 7. EX1002, Overview, ¶¶ [0012]-[0014], [0017]-[0019], [0028]-[0035], [0046]; EX1003, ¶ 0120.

In addition, Butts describes delivering the glass sheet to a pull roll assembly in a fusion process. EX1004, Abstract, ¶¶ [0002], [0017]-[0038], FIGS. 1-8; EX1003, ¶ 0121.

Therefore, this limitation is taught by either JP ’826 or Butts. EX1003, ¶ 0122.

Limitation 7[c1]:

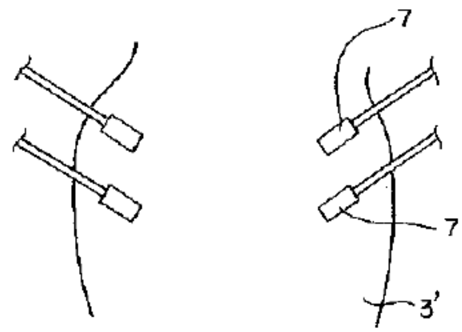
Figures 1-3 of JP ’826 show drawing glass sheet 3’ and using pulling rollers 6 and cooling rollers 7 to create tension in the glass sheet in a transverse direction and a longitudinal direction. EX1002, ¶¶ [0011], [0019], [0028], [0032], [0054], [0055]; EX1003, ¶ 0123.

Accordingly, this limitation is taught by JP ’826. EX1003, ¶ 0124.

Limitation 7[c2]:

Figure 3 of JP ‘826 depicts first and second cantilevered vertically downtilted stub roll pairs 7:

【図3】



EX1003, ¶ 0125.

JP ’826 also teaches that “[b]ecause the edges of the glass sheet are cooled before the center of the glass sheet, tension acts in the widthwise direction of the glass sheet. Because a pulling force acts between the cooling rollers and the pulling rollers, tension also acts in the lengthwise direction of the glass sheet.” *Id.*, ¶ [0028]. Thus, the first stub roll pair 7 draws a first edge portion of glass sheet 3’ out away from a center of the glass sheet 3’, and the second stub roll pair 7 draws a second edge portion of the glass sheet 3’ out away from the center of the glass sheet 3’ at a location transversely opposite the first stub roll pair, thereby creating a cross-tension in the glass sheet 3’ between the first stub roll pair 7 and the second stub roll pair 7. *Id.*, ¶¶ [0011], [0019], [0028], [0032], [0054], [0055]; EX1003, ¶ 0126.

Therefore, this limitation is disclosed by JP ’826. EX1003, ¶ 0127.

Limitation 7[c4]-[c5]:

As discussed above in the context of limitations 7[c2] and 7[c3], JP ’826 describes a plurality of cantilevered vertically downtilted rollers, as shown in Figure 3. EX1003, ¶ 0128.

Smids discloses a glass manufacturing method and apparatus, and in particular describes “feeding the laminated molten fixture into the feed side of a pair of counterrotating forming rolls which press the molten glass mixture into a continuous plastic elongated sheet, stretching the plastic continuous elongated sheet in the machine direction, i.e., the direction of travel of the feed rolls while simultaneously stretching the plastic continuous elongated sheet in a direction transverse to the machine direction, and annealing the stretched glass sheet.” EX1010, Col. 1, lines 40-49; EX1003, ¶ 0129.

Smids also teaches varying rotational speeds of multiple rollers to facilitate glass stretching during the manufacturing process. EX1010, Col. 2, lines 39-60; EX1003, ¶ 0130. It would have been obvious to a POSITA to incorporate Smids’ third and fourth cantilevered vertically downtilted stub roll pairs in the method of JP ’826 to better control and improve the consistency of the tension in the glass sheet in the vertical and horizontal directions, which would predictably reduce warping during the manufacturing process. Accordingly, limitations 7[c4] and 7[c5] are taught by JP ’826 in view of Smids. EX1003, ¶ 0131.

Limitation 7[d]-[g]:

Butts teaches monitoring and controlling the torque of the first and second rolls of the pull roll assembly. EX1004, ¶¶ [0021], [0024]; EX1003, ¶¶ 0132-0133.

JP ’826 discloses first and second cantilevered vertically downtilted stub roll pairs, Smids discloses a series of five cantilevered vertically downtilted stub roll pairs that stretch the glass in the machine direction and in a direction transverse to the machine direction. EX1010, Col. 2, lines 39-60, FIGS. 2-3. It would have been obvious to a POSITA to incorporate Smids’ third and fourth cantilevered vertically downtilted stub roll pairs in the method of JP ’826 to better control and improve the consistency of the tension in the glass sheet in the vertical and horizontal directions, which would predictably reduce warping during the manufacturing process. EX1003, ¶ 0134.

In addition, although JP ’826 does not explicitly disclose monitoring and controlling the torque of each roller, or setting the ratio of the torque of the cooling rollers to the pulling rollers to a preset value, Butts teaches setting the rotational speed of the cooling rollers to a preset value that is lower than the rotational speed of the pulling rollers. At the same time, Butts discloses that one of the defects of traditional speed control is “slippage” that occurs between the rolls and the glass surface when "only the rotational speeds of the two rolls are controlled" instead of the torque. EX1004, ¶ [0006]. Butts teaches that "controlling torque rather than speed can allow for a speed difference between the rolls, enabling the surface speed of the glass sheet to match the speed of the rolls, thereby preventing the rolls from slipping relative to the glass plate." *Id.*, ¶ [0021]. Butts thus provides a technical reason for a POSITA to optimize speed control with torque control—to improve slippage between the rolls and the glass plate and prevent damage to both. EX1003, ¶ 0134.

JP '826 discloses setting the speed ratio between the cooling roller and the pulling roller to a preset value to improve the warping of the glass plate. EX1002, ¶ [0028]. As the torque control in Butts offers more benefits than speed control, it would have motivated a POSITA to set the torque ratio between the cooling rollers and pulling rollers in JP '826 (modified to include third and fourth stub roll pairs as disclosed in Smids) to a preset value. Moreover, a POSITA would recognize that there is no technical barrier to combining the teachings of Butts and JP '826 (as modified by Smids) to achieve the benefits of torque control. For at least this reason, a POSITA would have been motivated to modify the process described in JP '826 (as modified by Smids) with the torque control disclosed in Butts to improve the manufacture of glass sheets. EX1003, ¶ 0136-0139.

Accordingly, limitations 7[c4]-[g] are taught by JP ’826 in view of Smids and Butts. EX1003, ¶¶ 0135-0139.

As all of the limitations in Claim 7 are taught and obvious in view of the prior art, Claim 7 would have been obvious. EX1003, ¶ 0139.

G. Dependent Claim 8

Butts, referring to Figure 2 below, teaches monitoring and controlling the torque of the rolls in the pull roll assembly using “differential drive 214” that “delivers equal torque to both rolls 206 and 212 and allows the ***angular velocity*** of each roll 206 and 212 to change” such that “any variations in diameters between rolls 206 and 212 are compensated for by allowing changes in the ***angular speeds*** of the rolls 206 and 212.” EX1004, ¶ [0021] (emphasis added).

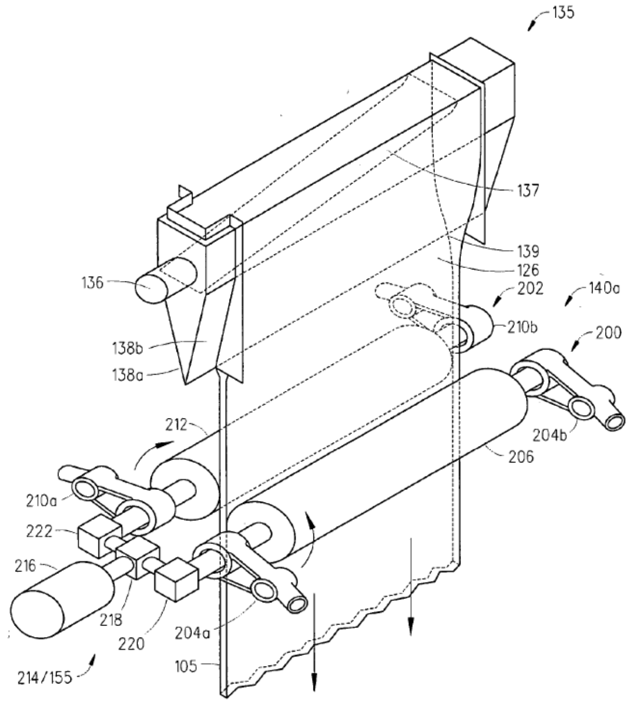


FIG. 2

EX1003, ¶ 0140.

In addition, referring to Figure 4 below, Butts teaches that "first and second drives/motors 405 and 411 operate at the same torque and share the load of drawing the glass sheet 105 between rolls 406 and 412," which "requires the drives to control the ***angular speeds*** of the rolls 406 and 412 to insure a steady velocity of the glass sheet 105." *Id.*, ¶ [0024] (emphasis added).

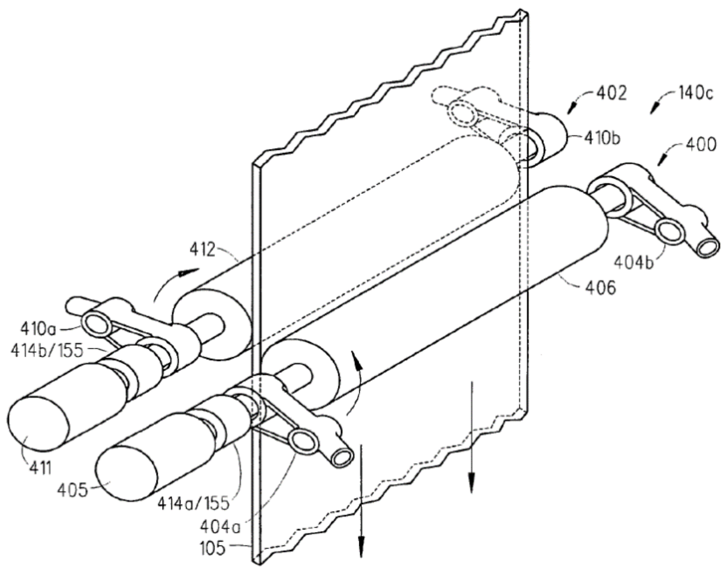


FIG. 4

EX1003, ¶ 0141.

A POSITA would understand that controlling and adjusting the angular velocity of rolls 206 and 212 in Figure 2, or the angular velocity of rolls 406 and 412 in Figure 4, necessarily implies controlling and adjusting the angular velocity of the motors to which the rolls are operatively connected. EX1003, ¶ 0142.

Moreover, as discussed above for claim 7, it would have been obvious to a POSITA to combine the teachings of Butts with the method in JP ’826 (modified to include third and fourth stub roll pairs disclosed in Smids) because the torque control of Butts offers technical benefits over the speed control disclosed in JP ’826. Further, as discussed above for claim 7, a POSITA would have been motivated to control the torque of at least one roller in each of the first two pairs to be a predetermined percentage of the torque of at least one roller in each of the third and fourth pairs. And, because the torque of at least one roll in each of the first two pairs (and thus the motors connected to those pairs) is a predetermined percentage of the torque of at least one roll in each of the third and fourth pairs (and thus the motors connected to those pairs), the latter motors are the reference point for former motors. In other words, the motors connected to the third and fourth roller pairs are "master" motors and the motors connected to the first two roller pairs are "slave" motors. EX1003, ¶ 0143.

For the foregoing reasons, the combination of JP '826, Smids, and Butts teaches the limitations of claim 8. EX1003, ¶ 0144.

H. Dependent Claim 9

JP '027 discloses a method for manufacturing sheet glass that includes a wedge-shaped forming body 3 used to form sheet glass 1, which is then held and pulled between cooling rollers 5 and 6 and pulling rollers 4. EX1005, Abstract, ¶¶ [0042], [0043], FIGS. 2-3; EX1003, ¶ 0145.

JP '027 "found that (1) the viscosity of the portion of the sheet-shaped glass sandwiched between the cooling rollers was too high, (2) the distance between the bottom of the forming body and the cooling rollers was too great, and (3) the circumferential speed of the cooling rollers was too high compared to the circumferential speed of the pulling rollers, and identified the specific ranges for the numerical values in elements (1) to (3) above on this basis." *Id.*, ¶ [0016]; EX1003, ¶ 0146.

Accordingly, with respect to element (3), one aspect of the invention in JP '027 is "the ratio B/A of the circumferential speed A of the cooling rollers to the circumferential speed B of the pulling rollers being set from 3.5 to 20." *Id.*, ¶ [0017]. JP '027 discloses that "if the ratio B/A of the circumferential speed A of the cooling rollers to the circumferential speed B of the pulling rollers is set to 3.5 to 20, the warping rate of the sheet glass obtained is 0.03% or less . . . ." *Id.*, ¶ [0020]; EX1003, ¶ 0147.

JP '027 also discloses that "[t]he ratio of the circumferential speed of the cooling rollers 5 to that of pulling rollers 4 is set from 1:3.5 to 1:20, and more preferably to from 1:4 to 1:15, and the circumferential speed of auxiliary cooling rollers 6 is set to be at least within the range of the circumferential speed of the cooling rollers 5, and less than 80%, and more preferably less than 70%, of the circumferential speed of pulling rollers 4." *Id.*, ¶ [0046]. Further, JP '027 discloses "[t]he circumferential speed of the pulling rollers 4 was set to 200 cm/min, and the circumferential speed of the cooling rollers 5 was set to 40 cm/min." *Id.*, ¶ [0050]; EX1003, ¶ 0147.

A ratio of the circumferential speed of cooling rollers to pulling rollers of from 1:3.5 to 1:20 equals a range of 5% to 28.5%. A POSITA would understand that circumferential speed is directly proportional to rotational speed, and that both circumferential speed and rotational speed are inversely related to torque in most cases (*e.g.*, assuming power is constant). That is, as circumferential or rotational speed increases, the available torque generally decreases, and vice versa. Therefore, a POSITA would know that torque can be controlled by adjusting the circumferential or rotational speed and a POSITA would optimize the rotational speed and thus torque such that the speed of the pulling rollers translates to torque of the cooling rollers being 0% to 10% of the torque of the pulling rollers. EX1003, ¶ 0148.

A POSITA with the understanding of JP ’826, Smids, and Butts—and particularly the stated goal of JP ’826 to “significantly reduce warping of glass sheets” (EX1002, Abstract)—would have been motivated to incorporate the teaching in JP ’027 of setting the circumferential speed of the cooling rollers to between 5% and 28.5% of the circumferential speed of the pulling rollers, resulting in the torque of the cooling rollers being in range of 0% to 10% of the torque of the pulling rollers. JP ’826 already teaches setting the peripheral speed of the cooling rollers lower than the peripheral speed of the pulling rollers, and more preferably in the range of 40% to 80%. *Id.*, Abstract, ¶¶ [0028], [0033], [0034]. A POSITA with the goal of reducing warping of glass sheets as disclosed in JP ’826 would have been motivated to further reduce the speed of the cooling rollers to between 5% and 28.5% of the speed of the pulling rollers to achieve a warping rate of less than 0.3% as taught by JP ’027.

EX1005, ¶ 20. Therefore, it would have been obvious to incorporate the teachings of JP ’027 in the combination of JP ’826, Smids, and Butts. EX1003, ¶ 0149.

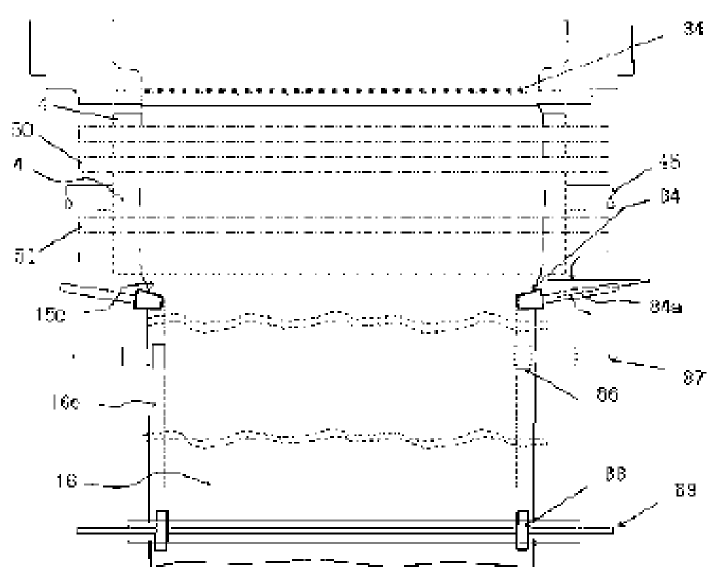
Thus, the combination of JP ’826, Smids, Butts, and JP ’027 teaches the limitations of claim 9 and thus would have been obvious. EX1003, ¶ 0150.

I. Dependent Claim 10

JP ’826 discloses that, “as shown in FIG. 3, a plurality of cooling rollers may be provided in the vertical direction, or may be provided in a diagonal direction with respect to the glass sheet. This allows for further adjustment of horizontal and vertical tension.” EX1002, ¶ [0054]; EX1003, ¶ 0151.

KR ’349 teaches controlling and adjusting the height of a diffusion roller having a tilted angle as shown in Figure 3. EX1006, page 7; EX1003, ¶ 0152.

Figure 3



KR ’349 teaches that “the diffusion roller (84) has a tapered structure and is equipped with a heating and cooling structure at the same time so that the drawing speed, the surface temperature of the roller, and ***the tilted angle are comprehensively controlled.***” *Id.* (emphasis added). EX1003, ¶ 0152.

A POSITA would have been motivated to combine the teachings of JP ’826 (as modified by Smids and Butts) and KR ’349 to arrive at the limitation in claim 10. The cooling rollers in JP ’826 are “provided in a diagonal direction” (*i.e.*, downtilt position) which “allows for further adjustment of the horizontal and vertical tension.” EX1002, ¶ [0054]. KR ’349 teaches that a roller “with an angle (84a) tilted outward” (*i.e.*, down) can be moved up and down to prevent the edges of the glass sheet from becoming “thick and round due to the convergence phenomenon caused by surface tension at both ends,” and also that the “tilted angle” of the roller can be “comprehensively controlled.” EX1006, page 7. Thus, KR ’349 teaches a known technique that is applicable to JP ’826 because both references are directed to managing the tension of the glass sheet with pairs of rollers to achieve a desired thickness while improving surface quality and reducing warping. A POSITA would understand that adjusting and controlling the downtilt position of the cooling rollers in JP ’826 according to the technique discloses in KR ’349 would yield predictable results and lead to the method described in claim 10. EX1003, ¶ 0153.

Therefore, this limitation is taught by JP ’826 in view of Smids and Butts, and further in view of KR ’349 and thus would have been obvious. EX1003, ¶ 0154.

J. Dependent Claim 11

Claim 11 is identical to claim 10, except that it refers to controlling and adjusting a downtilt position of the third and fourth stub roll pairs instead of the first and second stub roll pairs. As claim 11 is taught by JP ’826 in view of Smids and Butts, and further in view of KR ’349 for the same reasons discussed above in claim 10, claim 10 would have been obvious. EX1003, ¶ 0155.

K. Dependent Claim 12

Ferngren describes the process step of “ironing out” the thickened edges of a glass sheet using a series of roller pairs positioned at successively decreasing angles relative to the glass surface. EX1007, Col. 4, line 91 – Col. 5, line 5; FIGS. 6-11; EX1003, ¶ 0156.

A POSITA would have been motivated to combine the teachings of JP ’826 (as modified by Smids and Butts) and Ferngren to arrive at the limitation in claim 12. Both references teach process steps that precipitate annealing of the glass sheet. JP ’826 teaches the desirability of minimizing warping of the glass as much as possible during forming of the sheet by applying horizontal and vertical tension before the annealing step. EX1002, ¶¶ [0008]-[0011]. Ferngren, in turn, teaches that flattening out the edges of the glass sheet using pairs of successively angled rollers to achieve a uniform thickness "facilitates . . . the handling of the sheet in the flattening and annealing mechanism." EX1007, Col. 4, line 91 – Col. 5, line 5. A POSITA would have recognized the advantage of performing both steps—applying horizontal and vertical tension, and flattening out the edges of the glass—before the glass sheet is annealed. Thus, Ferngren teaches a known technique that would yield predictable results and lead to the method described in claim 12. EX1003, ¶ 0157.

As the limitations of claim 12 are taught by JP '826 in view of Smids and Butts, and further in view of Ferngren, claim 12 would have been obvious. EX1003, ¶ 0158.

L. Dependent Claim 13 and 14

Figure 6 of Butts depicts a pull roll assembly with two rolls supported by four support arms that each incorporate a sensor (electrical strain gage module) for measuring torque. EX1004, ¶ [0026]; EX1003, ¶ 0159.

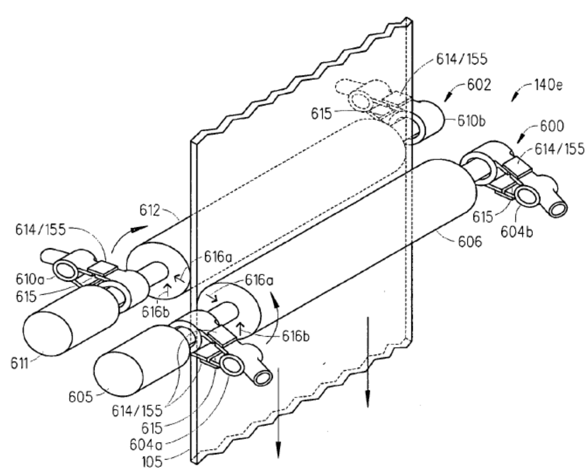


FIG. 6

The pulling forces exerted by the rolls on the glass sheet are converted into an electrical signal that is sent to a drive/motor that controls the rotational speed of the motors coupled to the rolls for maintaining the required pulling force on the glass sheet. *Id.*, ¶¶ [0027]-[0031]; EX1003, ¶ 0160.

Angular velocity generally refers to how fast an object rotates around an axis. Butts discloses that upon receiving an electrical signal from the electrical strain module, "the corresponding drive precisely ***controls the rotational speed of the motors 605 and 611 coupled to rolls 606 and 612*** which enables one to maintain the required pulling force on the drawn glass sheet 105. . ." *Id.*, ¶ [0027] (emphasis added). Butts also teaches that "the electrical signals can be used in a wide variety of control schemes other than the one described above to help draw the glass sheet 105." *Id.* A POSITA would understand that one such control scheme would involve controlling and adjusting the angular velocity of at least one roll in a pair while idling the other roll. Accordingly, the limitation of claim 13 is disclosed in Butts. Therefore, when the process described in JP '826 (as modified by Smid) incorporates the torque control disclosed in Butts to improve the manufacture of glass sheets for the reasons discussed above in claim 7, a POSITA would understand that the resulting combination teaches claim 13. EX1003, ¶ 0161.

Moreover, because the drive in Butts "precisely controls the rotational speed of the ***motors 605 and 611*** coupled to rolls 606 and 612" (*id.*, ¶ [0027], emphasis added), the combination of JP ’826 and Butts also teaches the limitation of claim 14. EX1003, ¶ 0162.

Thus, claims 13 and 14 are taught by JP ’826 in view of Smids and Butts and would have been obvious. EX1003, ¶ 0165.

II. Ground 2: Claims 1-14 would have been obvious over KR ’349 in view of one or more of Bogdahn, Ferngren, and Fredholm

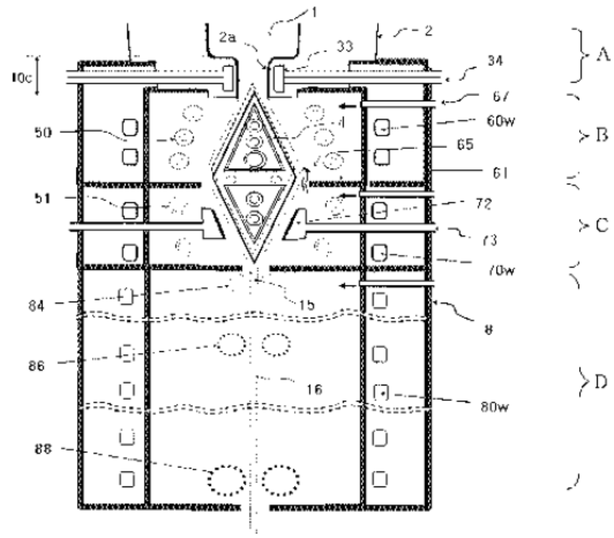
A. Independent Claim 1

There are several limitations in Claim 1 and each is addressed in turn.

Limitation 1[p],[a] and [b]:

KR ’349 discloses an “apparatus for manufacturing sheet glass using the downdraw method.” EX1006, Title. Figure 1 of KR ’349 shows “a conceptual diagram of a downdraw method using a drawing control plate (resistance body) of a sheet glass manufacturing device using the downdraw method of the present invention.” *Id.*, page 2. Figure 2 below shows “the process in which molten glass is formed into sheet glass through four elaborate process steps . . . .” *Id.*, page 6; EX1003, ¶ 0164.

Figure 2



The diffusion section (D) includes lower tension rollers 86 and 88 for pulling the sheet glass (14) downward. *Id.*, page 7; EX1003, ¶ 0167. Accordingly, limitations 1[p]-[b] are disclosed in KR '349. EX1003, ¶ 0166.

Limitation 1[c1], [c2], [c3], [c4] and [d]:

KR '349 teaches the "sheet glass (14) is pulled downward while being pulled taut to a more accurate size in the diffusion section (D)." EX1006, page 6. According to the specification, Japanese patents PTC/JP2000/04898 and 10-291826 teach methods of glass forming that include "applying mechanical tension in the width direction by installing rollers in multiple inclined positions." *Id.*, page 3; EX1003, ¶ 0167.

Figure 3 of KR '349 shown below is a simplified frontal schematic diagram of the apparatus in Figure 2, where "a diffusion roller (84) is installed", and "in order to compensate for the sheet expanding thinly during diffusion, it is installed with an angle (84a) tilted outward." EX1006, page 7. Additionally, "[t]he lower tension rollers (86 and 88) of Figure 3 are examples of rollers applied to the downdraw method." *Id*. EX1003, ¶¶ 0168-0169.

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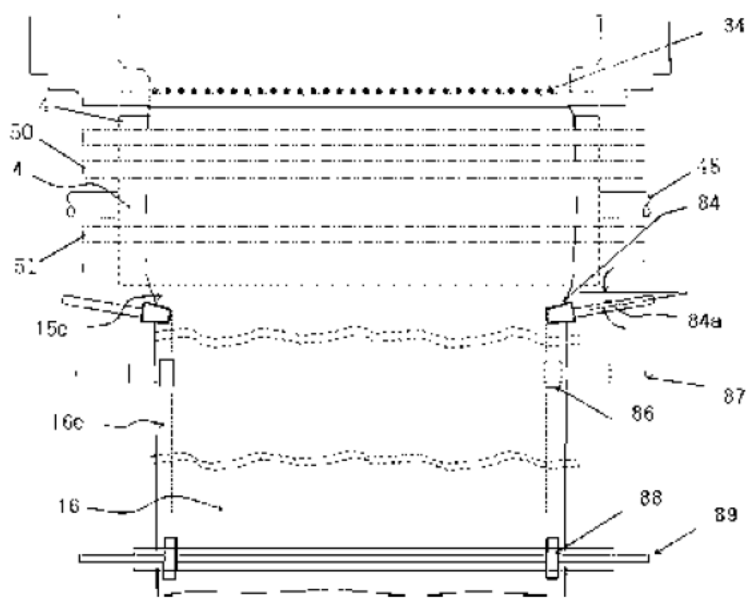
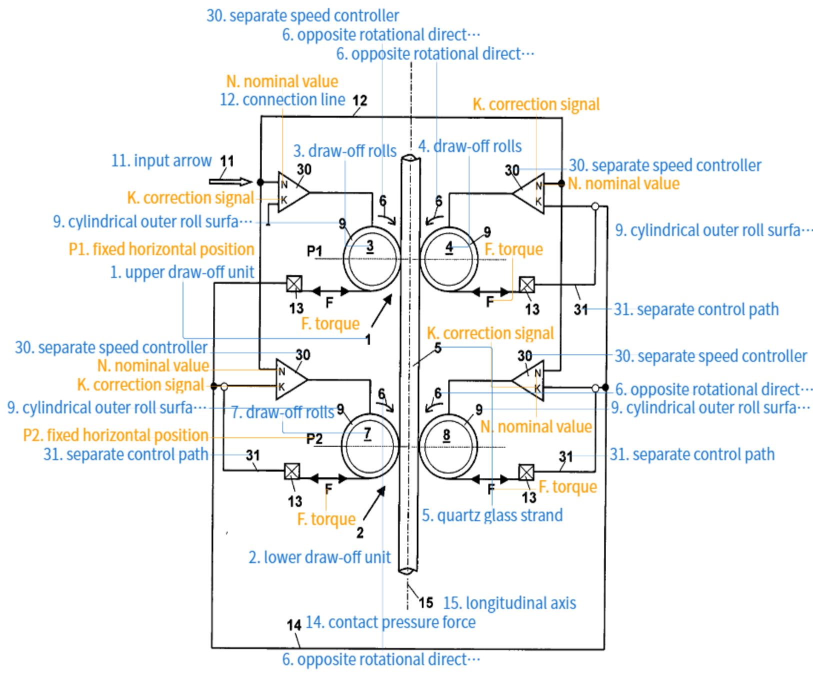


The apparatus and method of KR '349, and the diffusion roller (84) and lower tension rollers (86 and 88) described above, satisfy limitations 1[c1]-[c4]. EX1003, ¶ 0170.

Bogdahn discloses a method and device for manufacturing cylindrical glass bodies. EX1008, Title. Figure 1 is "a diagram for controlling the torque of a draw-off device for performing the vertical drawing method" with numerical features described in the specification. *Id.*, ¶¶ [0047], [0053]-[0057]; EX1003, ¶ 0171.



Bogdahn teaches that it is possible "to reduce or prevent gearing differences between the individual rolling bodies [and the resulting damage to the glass surface] by coordinating the torques." *Id.*, ¶¶ [0021], [0037]. A POSITA would understand that these benefits obtained through torque control can also be applied to flat glass production, and a POSITA would have been motivated to apply torque control to the flat glass manufacturing process of KR '349 for at least the same reason. As is clear from the descriptions cited above, Bogdahn teaches that the torques of rolls 4, 7, and 8 are set equal to the torque of the reference roll 3, which can be understood as the torque ratio of rolls 4, 7, and 8 to the reference roll being preset to 1. Thus, Bogdahn provides a basis for setting the torque ratio between rolls positioned vertically above and below to a preset value in the KR '349 method. EX1003, ¶¶ 0172-0173.

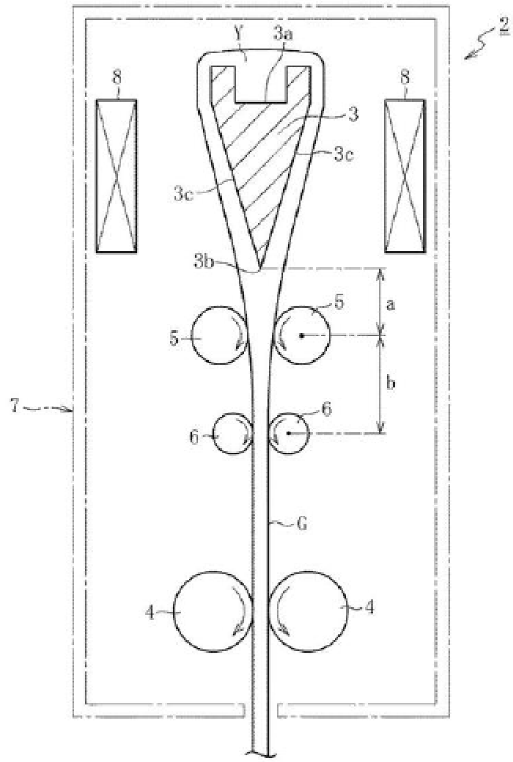
The differences between claim 1 and KR ’349 are: (1) monitoring and controlling the torque of each roll; and (2) the ratio of the torque of the short roll to the long roll is a preset value. KR ’349, which describes flat glass production, and Bogdahn, which describes cylindrical glass production, are both clearly glass manufacturing processes, but more importantly, both KR ’349 and Bogdahn provide teachings relevant for vertically stretching glass. Vertically stretching glass is a key aspect of manufacturing flat glass as well as cylindrical glass. Therefore, KR ’349 and Bogdahn would be understood by a POSITA to be closely related technical references in the same field and, as such, a POSITA would be motivated to use the teachings of Bogdahn to achieve the beneficial technical improvements obtained by torque control in the glass manufacturing process of KR ’349. EX1003, ¶ 0174.

Thus, limitations 1[e]-[f] are taught by the combination of KR ’349 and Bogdahn. EX1003, ¶ 0175.

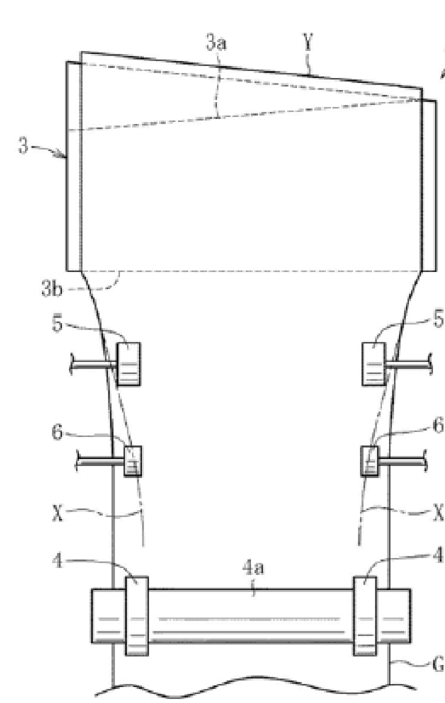
Limitation 1[g]:

JP ’027 discloses a method for manufacturing sheet glass that includes a wedge-shaped forming body 3 used to form sheet glass 1, which is then held and pulled between cooling rollers 5 and 6 and pulling rollers 4, as shown in Figures 2 and 3 below. EX1005, Abstract, ¶¶ [0042], [0043]; EX1003, ¶ 0176.

[FIG. 2]



[FIG. 3]



Additionally, JP ’027 teaches setting the cooling rollers and pulling rollers to different speeds. *Id.* ¶ [0029]; EX1003, ¶ 0177.

Although JP ’027 does not explicitly refer to the controlling the torque of the rollers, a POSITA would understand that circumferential speed is directly proportional to rotational speed, and that both circumferential speed and rotational speed are inversely related to torque in most cases (*e.g.*, assuming power is constant). That is, as circumferential or rotational speed increases, the available torque generally decreases, and vice versa. Therefore, a POSITA would know that torque can be controlled by adjusting the circumferential or rotational speed. EX1003, ¶ 0178.

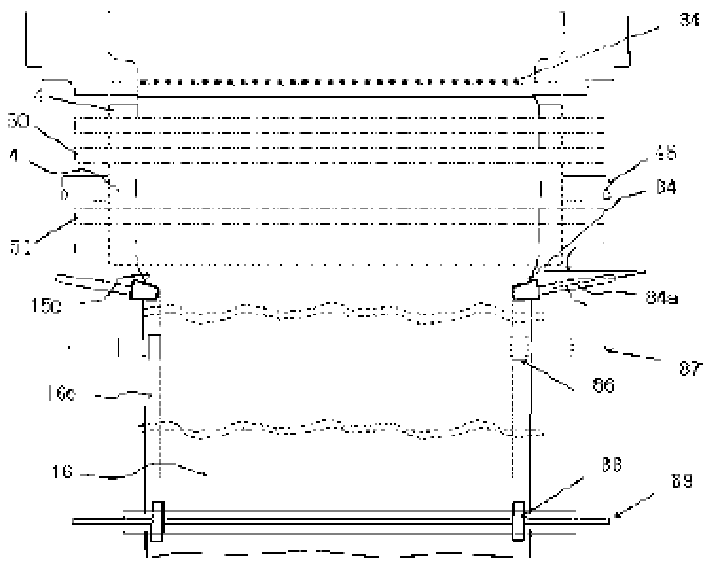
Moreover, a POSITA with the understanding from Bogdahn of the benefits of torque control, as described above, would likewise be motivated to control the torque of at least one roller in each of the cooling roller pairs in the method of KR ’349. And, because JP ’027 discloses setting the cooling roller circumferential speed A and the pulling roller circumferential speed B so that the ratio of B/A is between 3.5 and 20 (*i.e.*, the cooling roller speed is a predetermined percentage of the pulling roller speed), a POSITA would have been motivated to control the torque of at least one roller in each of the cooling roller pairs to be a predetermined percentage of the torque of the pulling roller. EX1003, ¶ 0179.

Thus, limitation 1[g] is taught by the combination of KR ’349, Bogdahn, and JP ’027 and as all of the limitations of claim 1 are taught by these citations, Claim 1 would have been obvious. EX1003, ¶ 0180.

B. Dependent Claim 2

KR ‘349 teaches controlling and adjusting the height of diffusion roller (84) having a tilted angle as shown in Figure 3. EX1006, page 7; EX1003, ¶ 0181.

Figure 3

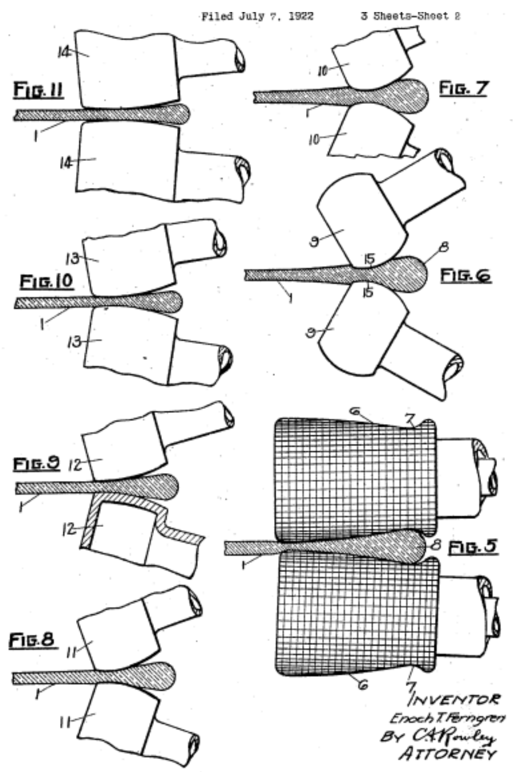


Moreover, KR ’349 teaches that “the diffusion roller (84) has a tapered structure and is equipped with a heating and cooling structure at the same time so that the drawing speed, the surface temperature of the roller, and the tilted angle are comprehensively controlled.” *Id;* EX1003, ¶ 0182.

Accordingly, claim 2 is disclosed by KR ’349 and would thus have been obvious. EX1003, ¶ 0183.

C. Dependent Claim 3

Ferngren describes the process step of “ironing out” the thickened edges of a glass sheet using a series of roller pairs positioned at successively decreasing angles relative to the glass surface. EX1007, Col. 4, line 91 – Col. 5, line 5. FIGS. 6-11; EX1003, ¶ 0184:



A POSITA would have been motivated to combine the teachings of KR '349 (as modified by Bogdahn) and Ferngren to arrive at the limitation in claim 3 as Ferngren teaches that it was well-known to utilize differing splay angles of rollers to facilitate the glass processing for thickness modification to yield predictable results as in the method described in claim 3. EX1003, ¶ 0185.

Therefore, claim 3 is taught by KR '349 in view of Bogdahn and JP '027, and further in view of Ferngren and would have been obvious. EX1003, ¶ 0186.

D. Dependent Claim 4, 5 and 6

Each of claims 4, 5, and 6 provide features for controlling torque in roll pairs and pull rolls. Bogdahn provides a detailed description of "speed and torque control" with respect to the rollers in the manufacture of cylindrical glass. EX1008 ¶¶ [0053]-[0057]; EX1003, ¶ 0187.

A POSITA would understand from Bogdahn's description of controlling the speed and torque of reference roll 3 (which serves as a "setpoint torque" for the remaining draw-off rolls 4, 7, and 8) that the angular velocity of at least one roll in a pair can be controlled and adjusted while idling the other roll. A POSITA would likewise recognize that this teaching in Bogdahn could be applied to both pairs of cooling rollers in KR '349. Thus, when KR '349 is combined with Bogdahn for the reasons discussed above in claim 1, the resulting method teaches the limitation of claim 4. EX1003, ¶ 0188.

The rotation of the rollers in Bogdahn is controlled by a motor as shown in Figure 2. EX1008, ¶ [0060] ("The rollers 18 are rotated by a motor 20.") Therefore, the combination of KR '349 and Bogdahn also teaches the limitation of claim 5. EX1003, ¶ 0189.

As Bogdahn describes controlling the rotation of rollers for controlling the speed and torque of reference roll 3 (which serves as a "setpoint torque" for the remaining draw-off rolls 4, 7, and 8) and that the angular velocity of at least one roll in a pair can be controlled and adjusted while idling the other roll. A POSITA would likewise recognize that Bogdahn would control the torque between rollers and in doing so optimize the relative torque between the rollers, including the same (100%)

or less (e.g., 50%). Thus, when KR ’349 is combined with Bogdahn for the reasons discussed above in claim 1, the resulting method teaches the limitation of claim 6. EX1003, ¶ 0190.

Thus, each of claims 4, 5, and 6 would be obvious to a POSITA over the combination of KR ’349 and Bogdahn. EX1003, ¶ 0191.

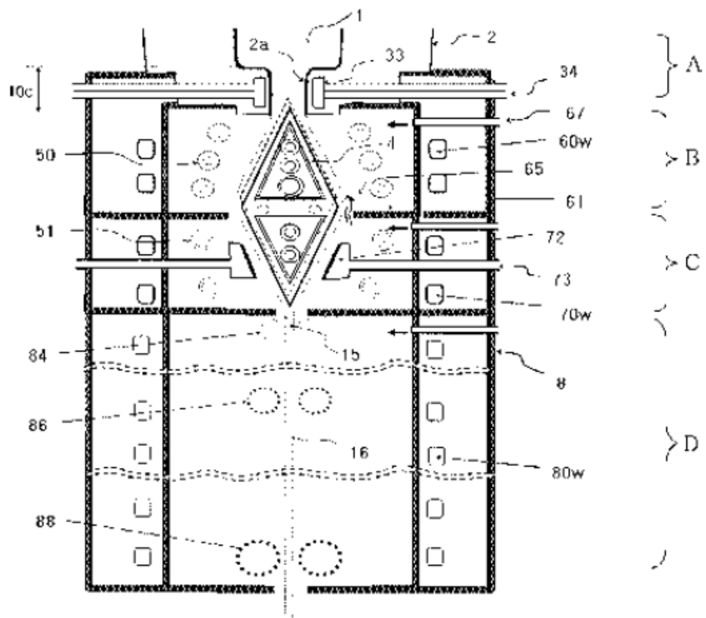
E. Independent Claim 7

There are several limitations in Claim 7 and each is addressed in turn.

Limitation 7[p], [a], [b]:

KR ’349 discloses an “apparatus for manufacturing sheet glass using the downdraw method.” EX1006, Title. Figure 1 of KR ’349 shows “a conceptual diagram of a downdraw method using a drawing control plate (resistance body) of a sheet glass manufacturing device using the downdraw method of the present invention.” *Id.*, page 2. Figure 2 below shows “the process in which molten glass is formed into sheet glass through four elaborate process steps . . . .” *Id.*, page 6; EX1003, ¶ 0192.

Figure 2



The diffusion section (D) in this Figure includes lower tension rollers 86 and 88 for pulling the sheet glass (14) downward. *Id.*, page 7. EX1003, ¶ 0193.

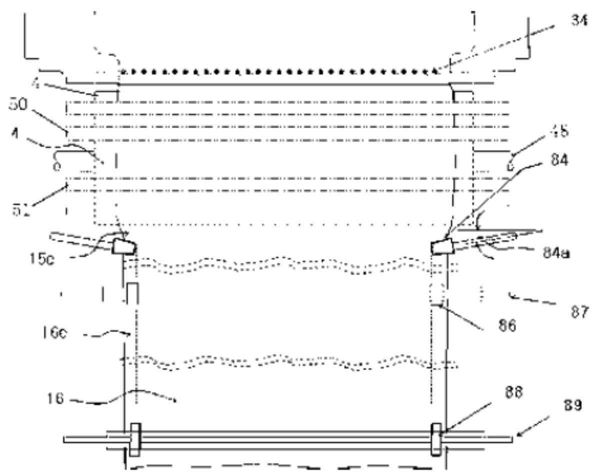
Accordingly, limitations 7[p]-[b] are disclosed in KR ’349. EX1003, ¶ 0194.

Limitation 7[c1], [c2], [c3] and [c4]:

In KR ’349, the “sheet glass (14) is pulled downward while being pulled taut to a more accurate size in the diffusion section (D).” EX1006, page 6. According to the specification, Japanese patents PTC/JP2000/04898 and 10-291826 teach methods of glass forming that include “applying mechanical tension in the width direction by installing rollers in multiple inclined positions.” *Id.*, page 3. EX1003, ¶ 0195.

Figure 3 of KR ’349 shown below is a simplified frontal schematic diagram of the apparatus in Figure 2:

Figure 3



EX1003, ¶ 0196-0197.

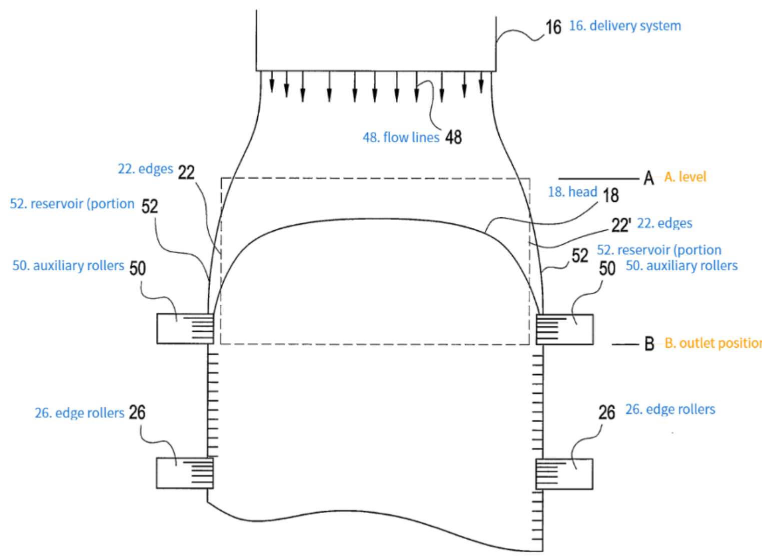
The teachings of an apparatus and a method of KR ’349, and the diffusion roller (84) and lower tension rollers (86 and 88) described in KR ’349 satisfy limitations 1[c1]-[c4]. EX1006, page 7. EX1003, ¶ 0198.

Limitation 7[c5]:

Fredholm discloses a process and device for manufacturing flat glass sheets. EX1009, Title, Abstract; EX1003, ¶ 0200.

Figure 8 of Fredholm shows a front view of one embodiment of the apparatus with specific descriptions of cantilevered auxiliary rollers, including a plurality of roller pairs that are positioned and configured to strategically to control tension, viscosity, and shear stress on the manufactured glass sheet. EX1009, ¶ [0054]; EX1003, ¶¶ 0200-0201.

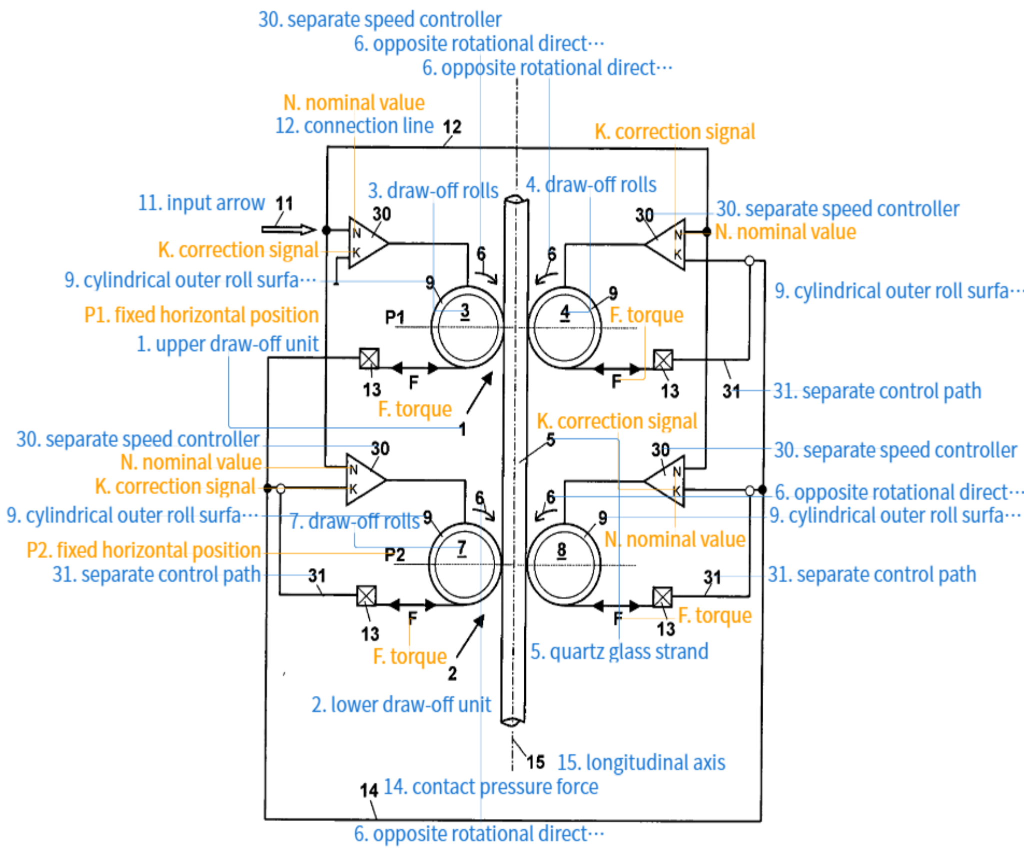
FIG. 8



Therefore, it would have been obvious to a POSITA to incorporate Fredholm's cantilevered auxiliary rollers in the method of KR '349, which are downtilted, to better control and improve the consistency of the tension in the glass sheet in the vertical and horizontal directions, which would predictably reduce warping during the manufacturing process. Accordingly, limitation 7[c5] is taught by KR '349 in view of Fredholm. EX1003, ¶ 0202.

Limitation 7[d], [e] and [f]:

Bogdahn discloses a method and device for manufacturing cylindrical glass bodies. EX1008, Title. Figure 1 is "a diagram for controlling the torque of a draw-off device for performing the vertical drawing method" (*Id.*, ¶ [0047]). Bogdahn describes numerical features in the specification. *Id.*, ¶¶ [0053]-[0057]; EX1003, ¶ 0203.



Additionally, Bogdahn teaches that it is possible "to reduce or prevent gearing differences between the individual rolling bodies [and the resulting damage to the glass surface] by coordinating the torques." *Id.*, ¶¶ [0021], [0037]. A POSITA would understand that these benefits obtained through torque control can also be applied to flat glass production, and a POSITA would have been motivated to apply torque control to the flat glass manufacturing process of KR '349 for at least the same reason. As is clear from the descriptions cited above, Bogdahn teaches that the torques of rolls 4, 7, and 8 are set equal to the torque of the reference roll 3, which can be understood as the torque ratio of rolls 4, 7, and 8 to the reference roll being preset to 1. Thus, Bogdahn provides a basis for setting the torque ratio between rolls positioned vertically above and below to a preset value in the KR ’349 method. EX1003, ¶ 0205.

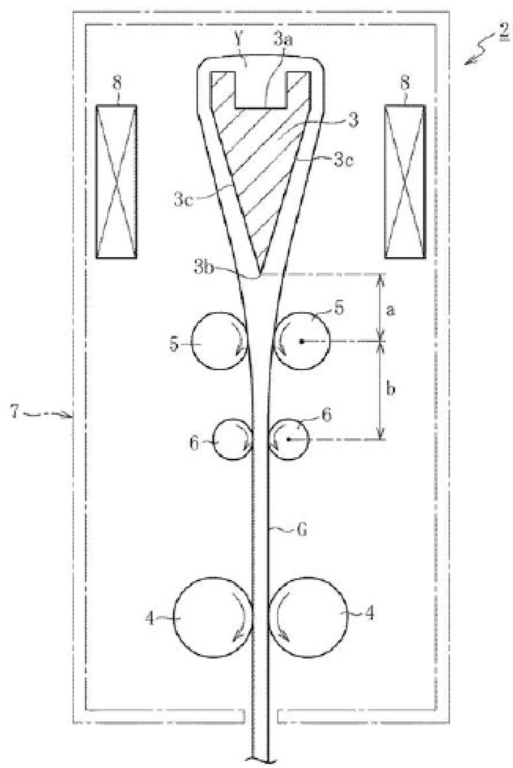
The differences between claim 7 and KR ’349 are: (1) monitoring and controlling the torque of each roll; and (2) the ratio of the torque of the short roll to the long roll is a preset value. KR ’349, which describes flat glass production, and Bogdahn, which describes cylindrical glass production, are both clearly glass manufacturing processes, but more importantly, both KR ’349 and Bogdahn provide teachings relevant for vertically stretching glass. Vertically stretching glass is a key aspect of manufacturing flat glass as well as cylindrical glass. Therefore, KR ’349 and Bogdahn would be understood by a POSITA to be closely related technical references in the same field and, as such, a POSITA would be motivated to use the teachings of Bogdahn to achieve the beneficial technical improvements obtained by torque control in the glass manufacturing process of KR ’349. EX1003, ¶ 0206.

Thus, limitations 7[d]-[f] are taught by the combination of KR ’349 and Bogdahn. EX1003, ¶ 0207.

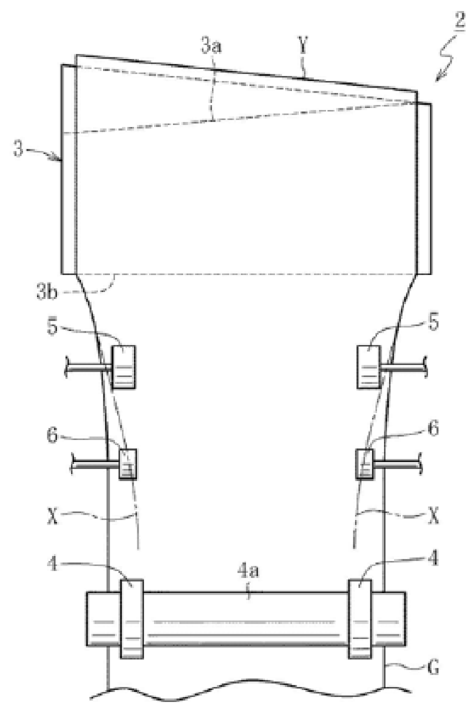
Limitation 7[g]:

JP ’027 discloses a method for manufacturing sheet glass that includes a wedge-shaped forming body 3 used to form sheet glass 1, which is then held and pulled between cooling rollers 5 and 6 and pulling rollers 4, as shown in Figures 2 and 3 below. EX1005, Abstract, ¶¶ [0042], [0043]; EX1003, ¶ 0208.

[FIG. 2]



[FIG. 3]



JP ’027 further teaches setting the cooling rollers and pulling rollers to different speeds, that “the cooling roller circumferential speed A and the pulling roller circumferential speed B are set so that they differ sufficiently, specifically so that the ratio B/A is 3.5 or greater, making it possible to improve the productivity of thin, large sheet glass while minimizing warping. . .” and “. . . the ratio B/A is set to

20 or less. After full consideration of the matters described above, the lower limit of the ratio B/A is preferably 4, and the upper limit is preferably 15." *Id.* ¶ [0029]; EX1003, ¶ 0209.

Although JP '027 does not explicitly refer to the controlling the torque of the rollers, a POSITA would understand that circumferential speed is directly proportional to rotational speed, and that both circumferential speed and rotational speed are inversely related to torque in most cases (*e.g.*, assuming power is constant). That is, as circumferential or rotational speed increases, the available torque generally decreases, and vice versa. Therefore, a POSITA would know that torque can be controlled by adjusting the circumferential or rotational speed. EX1003, ¶ 0210.

Moreover, a POSITA with the understanding from Bogdahn of the benefits of torque control, as described above, would likewise be motivated to control the torque of at least one roller in each of the cooling roller pairs in the method of KR '349. And, because JP '027 discloses setting the cooling roller circumferential speed A and the pulling roller circumferential speed B so that the ratio of B/A is between 3.5 and 20 (*i.e.*, the cooling roller speed is a predetermined percentage of the pulling roller speed), a POSITA would have been motivated to control the torque of at least one roller in each of the cooling roller pairs to be a predetermined percentage of the torque of the pulling roller. EX1003, ¶ 0211.

Thus, limitation 7[g] is taught by the combination of KR ’349, Fredholm, Bogdahn, and JP ’027 and as all of the limitations of claim 7 are taught by these citations, Claim 7 would have been obvious. EX1003, ¶ 0212.

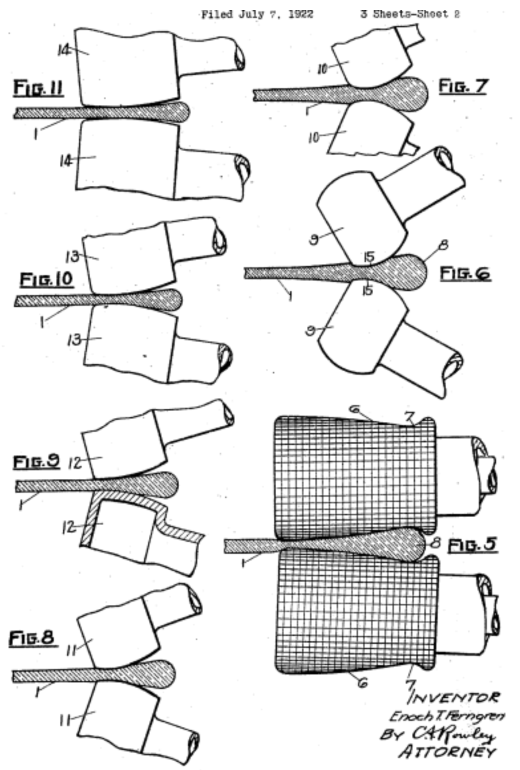
F. Dependent Claim 8

Bogdahn provides a detailed description of “speed and torque control” with respect to the rollers in the manufacture of cylindrical glass. EX1008 ¶¶ [0053]-[0057]; EX1003, ¶ 0213.

Thus, considering the combination of description in KR ’349 and Bogdahn, it would have been obvious to control, adjust angular velocities and torques of the rollers via the motors connected thereto as in claim 8. EX1003, ¶ 0214.

G. Dependent Claim 9

Ferngren describes successive pairs of rollers, pp. 3, line 104-pp. 4, line 3 and depicts in Drawing Sheet 2:



EX1003, ¶ 0215.

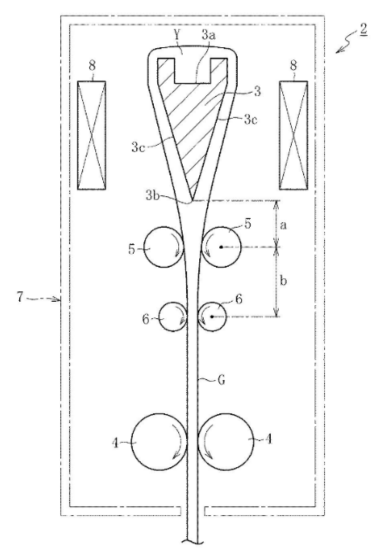
Ferngren also describes:

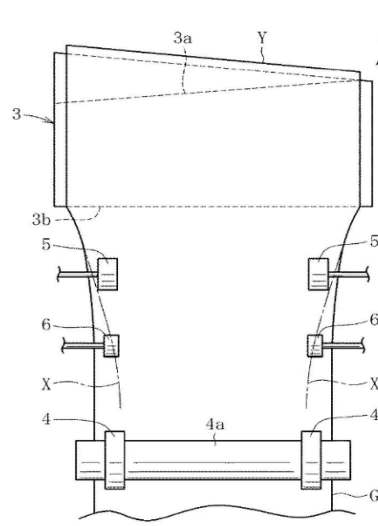
> As the width maintaining mechanisms at the two sides of the sheet are substantially duplicated, a description of one will suffice for both. Mounted (as hereinafter described) above the edge holding rolls 6, is a series of superposed pairs of edge-holding rolls which grip into the thickened edge 8 and hold the sheet substantially to its initial width. The apparatus here shown by way of example, employs six pairs of these rolls numbered 9, 10, 11, 12, 13 and 14, respectively. The first pair of rolls 9, (Fig. 6), bites into the thickened edge 8, forming groove 15, the thicker portion 8 back of the grooves acting as a wedge to prevent the sheet pulling out from between the rollers. The successive pairs of rollers 10 to 14, (Figs. 7 to 11), engage in the grooves 15, and function both to hold the sheet to width and at the same time to gradually flatten out the thickened edge 8, so that the sheet leaves the last pair of rollers 14 with the edges of substantially the same thickness as the sheet. This is desirable as it facilitates the subsequent bending of the sheet about the roller the handling of the sheet in the flattening and annealing

mechanism. This process of ironing out the thickened edges may be accomplished either by arranging the axes of the successive pair of rollers at successively decreasing angles to the plane of the sheet, or by varying the contour of the successive roller surfaces throughout the series. In the preferred form of the apparatus here shown both expedients are combined, as best illustrated in Figs. 6 to 11. These rollers act upon the sheet while it is passing through that zone wherein the sheet remains semi-plastic, and is still susceptible to the ironing or flattening process without danger of cracldng the sheet. As the sheet passes beyond the upper pair of rollers 14 its temperature condition and the internal stresses have been so modified that there, is little tendency for further contraction.

EX1007, col. 5, line 91 to col. 6, line 5; EX1003, ¶ 0216.

In addition, JP ’027 includes FIGs. 2 and 3:





JP ’027 further describes:

Also, the ratio of the peripheral speed of the cooling roller 5 to the peripheral speed of the tension roller 4 is set to 1:3.5 to 1:20, more preferably 1:4 to 1:15, and the peripheral speed of the auxiliary cooling roller 6 is set to , and is set to be less than 80%, more preferably less than 70%, of the peripheral speed of the tension roller 4 within the range of the peripheral speed of the cooling roller 5 or higher.

EX1005, ¶ [0046]; EX1003, ¶ 0217-0218.

The relative speed control of different rollers as is described in JP ‘027 includes the range of 0 to 10% defined in claim 9 of the ‘684 Patent and thus claim 9 would have been obvious. EX1003, ¶ 0219.

H. Dependent Claim 10

KR ’349 describes (emphasis added):

> Figure 3 shows the side structure of Figure 2 and is an example of a structure that includes a drawing device. In order to prevent the integrated sheet glass (15) that has passed through the resistor (4) from having a bead phenomenon in which the edges become thick and round due to the convergence phenomenon caused by surface tension at both ends (15e), a diffusion roller (84) is installed. **The diffusion roller (84) is configured to be moved up and down in height so that it can be pressed as close as possible to the bottom of the resistor (4) by forming the edges thinly. In addition, in order to compensate for the sheet expanding thinly during diffusion, it is installed with an angle (84a) tilted outward**, and the sheet glass in this area is not used as a product as surface-blemished glass (16e).
>
> EX1006, page 7; EX1003, ¶ 0220.

Thus, the provision of adjusting rollers in a downtilt position was known from KR ‘349 and claim 10 would have been obvious. EX1003, ¶ 0221.

I. Dependent Claim 11

Claim 11 is identical to claim 10, except that it refers to controlling and adjusting a downtilt position of the third and fourth stub roll pairs instead of the first and second stub roll pairs. Therefore, as discussed for Claim 10, KR ’349 describes adjusting rollers and doing so in a downtilt position was known and claim 11 would have been obvious. EX1003, ¶ 0222.

J. Dependent Claim 12

Ferngren describes the process step of "ironing out" the thickened edges of a glass sheet using a series of roller pairs positioned at successively decreasing angles relative to the glass surface: ". . .***This process of ironing out the thickened edges may be accomplished either by arranging the axes of the successive pair of rollers at successively decreasing angles to the plane of the sheet,*** or by varying the contour of the successive roller surfaces throughout the series. In the preferred form of the apparatus here shown both expedients are combined, as best illustrated in Figs. 6 to 11. These rollers act upon the sheet while it is passing through that zone wherein the sheet remains semi-plastic, and is still susceptible to the ironing or flattening process without danger of cracking the sheet. As the sheet passes beyond the upper pair of rollers 14 its temperature condition and the internal stresses have been so modified that there is little tendency for further contraction." EX1007, Col. 4, line 91 – Col. 5, line 5; FIGS. 6-11; EX1003, ¶ 0223.

A POSITA would have been motivated to combine the teachings of combination of KR '349 (modified by Fredholm, Bogdahn, and JP '027) and Ferngren to arrive at the limitation in claim 12. Both references teach process steps that precipitate annealing of the glass sheet. Ferngren teaches that flattening out the edges of the glass sheet using pairs of successively angled rollers to achieve a uniform thickness "facilitates . . . the handling of the sheet in the flattening and annealing mechanism." EX1007, Col. 4, line 91 – Col. 5, line 5. A POSITA would have recognized the advantage of performing both steps—applying horizontal and vertical tension, and flattening out the edges of the glass—before the glass sheet is annealed. Thus, Ferngren teaches a known technique that would yield predictable results and lead to the method described in claim 12. EX1003, ¶ 0224.

Therefore, Claim 12 is taught by combination of KR '349, Fredholm, Bogdahn, JP '027 and further in view of Ferngren and would have been obvious. EX1003, ¶ 0225.

K. Dependent Claim 13 and 14

Figure 6 of Butts depicts a pull roll assembly with two rolls supported by four support arms that each incorporate a sensor (electrical strain gage module) for measuring torque:

> Referring to FIG. 6, there is a perspective view of a fifth embodiment of the pull roll assembly 140e in accordance with the present invention. The pull roll assembly 140e includes a first roll assembly 600 and a second roll assembly 602. The first roll assembly 600 includes two pulling roll support arms 604a and 604b that support a first roll 606 which is driven by a first drive/motor 605. Likewise, the second roll assembly 608 includes two pulling roll support arms 610a and 610b that support a second roll 612 which is driven by a second drive/motor 611. The pull roll assembly 140e also includes one or more sensors 614 (e.g., device 155) which in this embodiment are electrical strain gage modules 614. As shown, four electrical strain modules 614 extend across gaps 615 within the four pulling roll support arms 604a, 604b and 610a and 610b. It should be appreciated that not all but any number of the pulling roll support arms 604a, 604b, 610a and 610b can incorporate an electrical strain module 614. Moreover, it should be

> appreciated that the sensor 614 need not be an electrical strain gage module 614 but can be anyone of a variety of sensors that measures pressure, displacement, deflection or torque (for example).

EX1004, ¶ [0026]; EX1003, ¶ 0226.

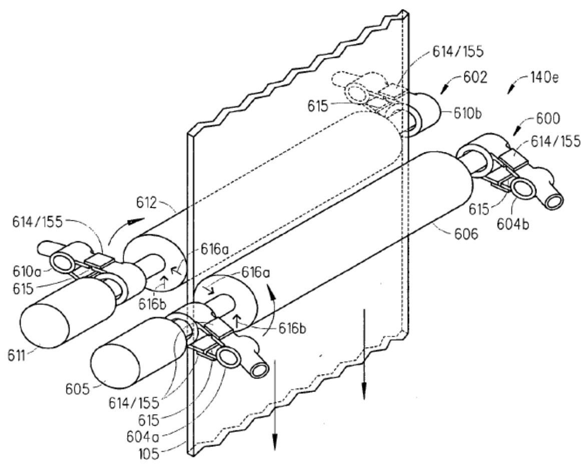


FIG. 6

The pulling forces exerted by the rolls on the glass sheet are converted into an electrical signal that is sent to a drive/motor that controls the rotational speed of the motors coupled to the rolls for maintaining the required pulling force on the glass sheet:

> The pulling roll support arms 604a, 604b, 610a and 610b that incorporate electrical strain modules 614 in effect are converted into "load cells". In particular, the pulling roll support arms 604a, 604b, 610a and 610b and electrical strain modules 614 enables pulling forces 616a and 616b (e.g., glass contact normal force 616a and required sheet pulling force 616b) exerted by the rolls 606 and 612 on the drawn glass sheet 105 to be precisely determined. The forces 616a and 616b measured by each electrical strain module 614 are converted into an electrical signal (e.g., 0-5 Vdc, 4-20 mA) that is sent to a computer (not shown) or the corresponding drive/motor 605 and 611. Upon receiving the electrical signal, the corresponding drive precisely controls the rotational speed of the motors 605 and 611 coupled to rolls 606 and 612

which enables one to maintain the required pulling force on the drawn glass sheet 105 even when the force supplied by the weight of the glass sheet 105 constantly changes. It should be appreciated that the electrical signals can be used in a wide variety of control schemes other than the one described above to help draw the glass sheet 105. Several different exemplary control schemes and uses of the electrical signals are described below:

Knowing the normal forces 616a and 616b could permit closed loop or open loop adjustment to the position of the arm weights (see arm weights 716 in FIG. 7B). This would lessen the formation of checks in the glass sheet 105 and reduce down time and equipment damage.

Knowing the pulling forces 616a and 616b exerted by the rolls 606 and 612 on the glass sheet 105 enables one to tract how these forces 616a and 616b change with time which can if necessary enable an early warning system to tell an operator that some critical process variables are changing and that he/she may need to take corrective action. The main process variables that could be adjusted include the temperatures in a lower muffle and in a flow control glass delivery tube 130 (see FIG. 1).

Traditionally it was virtually impossible to measure the average viscosity of the glass sheet 105 as it was being stretched. The present invention solves this problem since the pulling forces 616a and 616b are inversely related to the average viscosity of the glass sheet 105. As such, the electrical signals associated with the pulling forces 616a and 616b can enable the closed loop control of a variety of critical variables (e.g., temperature in the delivery tube 130 shown in FIG. 1) in the manufacturing process of the glass sheet 105.

Because the rolls 606 and 612 generally pull on the edges of the glass sheet 105, the forces measured by the transducers 155 and the load cells (see load cell 714a in FIG. 7B) could be balanced thru thermal control. This could be very beneficial to the draw operation and could be implemented using a closed loop control process.

Id., ¶¶ [0027]-[0031]; EX1003, ¶ 0227.

Angular velocity generally refers to how fast an object rotates around an axis. Butts discloses that upon receiving an electrical signal from the electrical strain module, "the corresponding drive precisely ***controls the rotational speed of the motors 605 and 611 coupled to rolls 606 and 612*** which enables one to maintain the required pulling force on the drawn glass sheet 105 . . . ." *Id.*, ¶ [0027] (emphasis added). Butts also teaches that "the electrical signals can be used in a wide variety of control schemes other than the one described above to help draw the glass sheet 105." *Id.* A POSITA would understand that one such control scheme would involve controlling and adjusting the angular velocity of at least one roll in a pair while idling the other roll. Accordingly, the limitation of claim 13 is disclosed in Butts. Therefore, when the process described in KR '349 incorporates the torque control disclosed in Butts to improve the manufacture of glass sheets for the reasons discussed above in claim 7, a POSITA would understand that the resulting combination teaches claim 13. EX1003, ¶ 0228.

Moreover, because the drive in Butts "precisely controls the rotational speed of the ***motors 605 and 611*** coupled to rolls 606 and 612" (*Id.*, ¶ [0027], emphasis added), the combination of KR '349 and Butts also teaches the limitation of claim 14. EX1003, ¶ 0229.

Thus, claims 13 and 14 are taught by KR '349, Fredholm, Bogdahn, JP '027 and further in view of and Butts and would have been obvious. EX1003, ¶ 0230.

XI. CONCLUSION

For the reasons set forth above, petitioner respectfully requests that a trial be instituted. Claims 1-14 should be cancelled.

Respectfully Submitted,

/Daniel J. Pereira/

Daniel J. Pereira (Reg. No. 45,518)

<u>CERTIFICATE OF WORD COUNT</u>

Pursuant to 37 C.F.R. §42.24(d), Petitioner certifies that this Petition includes 13,521 words, as measured by Microsoft Word®, exclusive of the table of contents, mandatory notices under §42.8, certificates of service, word count, and exhibits.

CERTIFICATE OF SERVICE (37 C.F.R. § 42.6(e)(1))

The undersigned hereby certifies that the above document was served on June 11, 2025, by filing this document through the Patent Trial and Appeal Board P-TACTS System, as well as delivering a copy via express mail upon the following attorneys of record for the Patent Owner and Petitioner:

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Corning, NY 14831

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Respectfully submitted,

Dated: June 11, 2025

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APPENDIX A – CLAIM LISTING

U.S. Patent No. 8,627,684

Claim/Claim Element	Limitation(s)
1[p]	A method for manufacturing a glass sheet, said method comprising the steps of:
1[a]	melting batch materials and forming the glass sheet;
1[b]	delivering the glass sheet to a pull roll apparatus;
1[c1]	drawing the glass sheet and creating a cross-tension in the glass sheet using the pull roll apparatus which comprises:
1[c2]	(i) a cantilevered vertically downtilted first stub roll pair for drawing a first edge portion of the glass sheet out away from a center of the glass sheet;
1[c3]	(ii) a cantilevered vertically downtilted second stub roll pair for, at a location transversely opposite the first stub roll pair, drawing a second edge portion of the glass sheet out away from the center of the glass sheet, thereby creating a cross-tension in the glass sheet between the first stub roll pair and the second stub roll pair;

Claim/Claim Element	**Limitation(s)**
1[c4]	(iii) a pull roll pair disposed below the first and second stub roll pairs for drawing the first edge portion and the opposing second edge portion of the glass sheet and creating a vertical draw tension on the glass sheet between the pull roll pair and the first and second stub roll pairs;
1[d]	monitoring the torque of at least one of the pull rolls in the pull roll pair;
1[e]	monitoring the torque of at least one of the stub rolls in the first stub roll pair and at least one of the stub rolls in the second stub roll pair;
1[f]	controlling the torque of at least one of the pull rolls in the pull roll pair;
1[g]	controlling the torque of at least one of the stub rolls in the first stub roll pair and the torque of at least one of the stub rolls in the second stub roll pair to be a predetermined percentage of the torque of the at least one pull roll.
2	The method of claim 1, further comprising the step of controlling and adjusting a downtilt position of said first stub roll pair and said second stub roll pair.

Claim/Claim Element	**Limitation(s)**
3	The method of claim 1, wherein said drawing step further comprising a step of positioning each of the stub rolls to have a desired splay angle which is a horizontal angle that a corresponding roll face is positioned relative to a major surface of the glass sheet.
4	The method of claim 1, wherein said controlling the torque of at least one of the stub rolls in the first stub roll pair and in at least one of the stub rolls in the second stub roll pair step further comprising controlling and adjusting angular velocities of at least one of the stub rolls in each of the first and second stub roll pairs while idling the other one of the stub rolls in each of the first and second stub roll pairs.
5	The method of claim 1, wherein said controlling the torque of at least one of the pull rolls step further comprising controlling and adjusting an angular velocity of motors operatively connected to the stub rolls of said first and second stub roll pairs.

Claim/Claim Element	Limitation(s)
6	The method of claim 1, wherein the step of controlling the torque of the stub rolls comprises controlling the torque of the at least one of the stub rolls in the first stub roll pair and the torque of the at least one of the stub rolls in the second stub roll pair to be 50% to 100% of the torque of the at least one pull roll.
7[p]	A method for manufacturing a glass sheet, said method comprising the steps of:
7[a]	melting batch materials and forming the glass sheet;
7[b]	delivering the glass sheet to a pull roll apparatus;
7[c1]	drawing the glass sheet and creating a cross-tension in the glass sheet using the pull roll apparatus which comprises:
7[c2]	(i) a cantilevered vertically downtilted first stub roll pair for drawing a first edge portion of the glass sheet out away from a center of the glass sheet;

Claim/Claim Element	Limitation(s)
7[c3]	(ii) a cantilevered vertically downtilted second stub roll pair for, at a location transversely opposite the first stub roll pair, drawing a second edge portion of the glass sheet out away from the center of the glass sheet, thereby creating a cross-tension in the glass sheet between the first stub roll pair and the second stub roll pair;
7[c4]	(iii) a cantilevered vertically downtilted third stub roll pair disposed below said first stub roll pair, for drawing the first edge portion of the glass sheet out away from the center of the glass sheet;
7[c5]	(iv) a cantilevered vertically downtilted fourth stub roll pair, disposed below said second stub roll pair at a location transversely opposite the third stub roll pair, for drawing the second edge portion of the glass sheet out away from the center of the glass sheet, thereby creating a cross-tension in the glass sheet between the third stub roll pair and the fourth stub roll pair;
7[d]	monitoring the torque of at least one of the stub rolls in the first stub roll pair and at least one of the stub rolls in the second stub roll pair;

Claim/Claim Element	**Limitation(s)**
7[e]	monitoring the torque at least one of the stub rolls in the third stub roll pair and at least one of the stub rolls in the fourth stub roll pair;
7[f]	controlling the torque of at least one of the stub rolls in the third stub roll pair and at least one of the stub rolls in the fourth stub roll pair;
7[g]	controlling the torque of the at least one of the stub rolls in the first stub roll pair and at least one in the stub rolls of second stub roll pair to be a predetermined percentage of the torque of at least one of the stub rolls in the third stub roll pair and at least one of the stub rolls in the fourth stub roll pair.
8	The method of claim 7, wherein the step of controlling step the torques of the stub rolls further comprising the steps of controlling and adjusting angular velocities of master motors operatively connected to at least one of the stub rolls in the third stub roll pair and at least one of the stub rolls in the fourth stub roll and also controlling and adjusting torques of slave motors operatively connected to at least one of the stub rolls in the first stub roll pair and at least one in the stub rolls of second stub roll pair.

Claim/Claim Element	Limitation(s)
9	The method of claim 7, wherein the step of controlling the torque the at least one of the stub rolls in the first stub roll pair and at least one of the stub rolls in the second stub roll pair comprises controlling the torque of at least one of the stub rolls in the first stub roll pair and the torque of at least one in the stub rolls to be 0% to 10% of the torque of the at least one of the stub rolls of third stub roll pair and at least one of the stub rolls of fourth stub roll.
10	The method of claim 7, further comprising the step of controlling and adjusting a downtilt position of said first stub roll pair and said second stub roll pair.
11	The method of claim 10, further comprising the step of controlling and adjusting a downtilt position of said third stub roll pair and said fourth stub roll pair.
12	The method of claim 7, wherein said drawing step further comprising positioning each of the stub rolls to have a desired splay angle which is a horizontal angle that a corresponding roll face is positioned relative to a major surface of the glass sheet.

Claim/Claim Element	**Limitation(s)**
13	The method of claim 7, wherein the controlling the torque of the at least one of the stub rolls in the first stub roll pair and in the second stub roll pair step further comprising controlling and adjusting angular velocities of the at least one of the stub rolls in each of said first and second stub roll pairs while idling the other one of the stub rolls in each of said first and second stub roll pairs.
14	The method of claim 7, wherein the controlling the torque of the at least one of the stub rolls in the third stub roll pair and at least one of the stub rolls in the fourth stub roll pair step further comprising controlling and adjusting an angular velocity of motors operatively connected to the at least one of the stub rolls in the third stub roll pair and at least one of the stub rolls in the fourth stub roll pair.