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**Datasheet for the decision  
of 25 September 2015**

**Case Number:** T 0889/12 - 3.3.05

**Application Number:** 07101906.1

**Publication Number:** 1790620

**IPC:** C03C3/093, C03C3/097

**Language of the proceedings:** EN

**Title of invention:**

Glass for Display Substrate

**Patent Proprietor:**

Nippon Electric Glass Co., Ltd.

**Opponent:**

Corning Incorporated

**Headword:**

**Relevant legal provisions:**

EPC Art. 123(2), 76(1), 83, 56

**Keyword:**

Amendments - added subject-matter (no)  
Divisional application - added subject-matter (no)  
Sufficiency of disclosure - (yes)  
Inventive step - (yes)

**Decisions cited:**

T 0409/91, T 0435/91, T 1511/07, T 0812/09

**Catchword:**



**Beschwerdekammern  
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Case Number: T 0889/12 - 3.3.05

**D E C I S I O N**  
**of Technical Board of Appeal 3.3.05**  
**of 25 September 2015**

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**Decision under appeal:** **Interlocutory decision of the Opposition  
Division of the European Patent Office posted on  
8 February 2012 concerning maintenance of the  
European Patent No. 1790620 in amended form.**

**Composition of the Board:**

**Chairman** H. Engl  
**Members:** G. Glod  
O. Loizou

## Summary of Facts and Submissions

I. The present appeal lies from the interlocutory decision of the opposition division to maintain the patent in suit on the basis of the claims of the second auxiliary request.

II. The documents cited during the opposition proceedings included the following:

- D1: WO-A-02 060 831
- D2: WO-A-00 325 28
- D3: WO-A-98 270 19
- D4: US 5 851 939
- D5: Corning<sup>®</sup> Eagle<sup>2000™</sup> AMLCD Glass Substrates  
Material Information, August 2002
- D6: Corning Code: 7059F Material Information, June  
1994
- D7: JP2003-192377
- D7a: English translation of D7
- D8: Corning<sup>®</sup> 1737 AMLCD Glass Substrates  
Material Information, August 2002
- D8a: Corning Code: 1737F Material Information,  
January 1999
- D8b: Optical transmission graph of page 5 of D8a  
magnified
- D10: US 6 329 310
- D11: US 6 867 158
- D12: Data on prior art glass compositions from  
Panasonic notebook computers

III. The **opponent** (hereinafter: **appellant**) filed an appeal against said decision and submitted grounds for the appeal. In addition the following documents were filed:

- D7b: Translation of D7

- D15: US 4 819 247  
D16: Lityushkin et al., *Science for Glass production*,  
Glass and Ceramics, Vol. 55, Nos 1-2, 1998,  
p. 36-38  
D17: GB-A-845 981

- IV. With its response to the notice of appeal, the **patent proprietor** (hereinafter: **respondent**) maintained as a main request the claims found allowable by the opposition division and filed six auxiliary requests.
- V. In its communication under Article 15(1) of the Rules of Procedure of the Boards of Appeal (RPBA), the Board expressed its preliminary non-binding opinion that the main request met the requirements of Articles 123(2), 76(1) and 83 EPC, but lacked an inventive step. Claim 1 of auxiliary requests 2, 4 and 6 appeared not to be directly and unambiguously derivable from the original application. Furthermore, none of the auxiliary requests was considered to be based on an inventive step.
- VI. By letter dated 17 August 2015, the respondent filed auxiliary requests 1 to 9.
- VII. Oral proceedings took place on 25 September 2015, during which the appellant, having withdrawn its main request, made auxiliary request 4 filed with the letter of 17 August 2015 its main request.

Claim 1 of this **main request** reads as follows:

"1. A method for producing a glass for a display substrate comprising the steps of:  
- preparing a glass raw materials mixed so that the glass having a  $SiO_2-Al_2O_3-B_2O_3-RO$  (RO is at least one

*of MgO, CaO, BaO, SrO and ZnO) based composition, a density of 2.5 g/cm<sup>3</sup> or less, an average thermal coefficient of 25 to 36x10<sup>-7</sup>/°C in a temperature range of 30 to 380°C, and a strain point of 640°C or higher is obtained;*

*- electrically melting the glass raw materials in a melting furnace constructed of a high zirconia refractory; and*

*- refining, homogenizing and forming the glass melt to produce the glass in which a ZrO<sub>2</sub> content is not less than 0.01% and less than 0.4% as expressed in % by mass;*

*- wherein the glass raw materials are mixed so that an alkali content of the resultant glass is 0.02 to 0.2%, and a Na<sub>2</sub>O content of the resultant glass is 0.02 to 0.2% as expressed in % by mass."*

VIII. The arguments of the **appellant** can be summarised as follows:

Articles 76(1) EPC and 123(2) EPC

The subject-matter of claim 1 was not directly and unambiguously derivable from the original application and the parent application. The ranges present in claim 1 for alkali and Na<sub>2</sub>O resulted from a choice from several lists.

Article 83 EPC

The disclosure of the patent was insufficient, contrary to Article 83 EPC, because none of the examples fell within the scope of the claims and the claims did not contain all the features necessary to define the invention. The skilled person had to carry out a research exercise to determine how to achieve the

effects that were purportedly associated with the claimed invention.

There was no guidance in the description how to modify the compositions of the examples to achieve the required thermal coefficient (CTE) values. The skilled person was thus faced with an undue burden.

There was no evidence that the glass produced by the process was suitable as a glass for a display substrate. In addition, the appellant's own calculations had shown that a glass having an average thermal coefficient of  $25/^\circ\text{C}$  had a very high melting temperature, so that a glass suitable as a glass for a display substrate could not be obtained by electrically melting in a furnace constructed of a high zirconia refractory. This was also confirmed by example 14 of D7.

Article 56 EPC

D7 represented the closest prior art, as it related to alkali-free glasses suitable for use as a display substrate and also described the use of a zirconia refractory furnace and the effects of zirconia content of the glass on devitrification (D7b, page 7).

Although the glasses of D7 were termed "alkali-free", this did not exclude the presence of alkali metals as impurities. In fact, the alkali metal content of the glasses disclosed in D7 was 0.05 mass-% or less, preferably 0.02 mass-%, or more preferably 0.01 mass-% or less. These ranges overlapped with the alkali metal content in accordance with claim 1 of the main request (0.02 to 0.2 mass-%). This was also in line with disclosures made in D1 to D6, D8 and D10 to D12 that

showed that "alkali-free" did not mean absolutely alkali-free.

Samples 1 to 3, 5, 6 and 8 of D7 all had compositions and physical properties falling within the claimed ranges.

The difference between D7 and claim 1 was the use of a high zirconia refractory furnace and the use of electric melting.

The relationship between devitrification (howsoever caused) and the  $ZrO_2$  content was clearly taught by D7, as was the preferred  $ZrO_2$  content of between 0 and 0.5 wt% (see examples). Therefore, the patent proprietor could not rely on any effects based on a relationship between  $ZrO_2$  content within the range claimed and the consequences on devitrification in glass to support inventive step. Samples 1 and 5 of the patent contained 0.4%  $ZrO_2$ , and devitrification was observed. It was not credible that a glass containing 0.39  $ZrO_2$  that fell within the scope claimed did not show any devitrification any more. In addition, samples 2 to 4 and 6 to 8 showing no devitrification contained at least 0.03 wt% alkali, so that there was no proof that already at 0.02 wt% of alkali no devitrification was present.

The alkali-metal was not the only parameter that varied between the different examples of the opposed patent, such that the purported effects relied upon could not unambiguously be solely related to the presence of alkali-metal in the claimed ranges. The examples did not support the presence of the alleged effect across the whole scope of the claims. Furthermore, all the examples of the opposed patent were outside the scope



of the claims, with respect to the average thermal coefficient.

As was evident from D15, the relationship between the resistivity of a refractory and temperature was well known in the field of melting glass, as was the concept of resulting refractory corrosion and appearance of refractory components in a glass melt. This was also in line with D17, which even taught to include alkali metal at quantities in the range of 0.01 to 0.025% by weight to increase the conductivity of borosilicate glass melts in order to suppress electric energy dissipation through the zirconia refractory (page 2, lines 26 and 27).

Using a gas furnace for glasses with melting temperatures of the order of 1600°C was the exception rather than the rule (see D16 on borosilicate glasses). There was no prejudice in the art against the use of electric melting.

According to the appellant, the technical problem objectively solved by the patent in suit consisted in providing an alternative method of making an "alkali-free" glass suitable for a display substrate that was resistant to devitrification.

The claimed solution was obvious in view of D7, because it employed a conventional furnace, conventionally melting the glass, to provide a glass with a known composition, having conventional quantities of alkali metal and  $ZrO_2$ .

The use of electric melting in zirconia refractory furnaces was entirely conventional and known from D15, D16 and D17.

IX. The arguments of the **respondent** can be summarised as follows:

Articles 76(1) and 123(2) EPC

The ranges present in claim 1 were unambiguously derivable from the passages of the original application and the parent application that corresponded to paragraph 39 of the patent.

Article 83 EPC

Paragraphs 64 to 72 and 78 to 88 provided enough guidance to carry out the invention. Furthermore, the CTE values of the examples, which were outside the claimed range, were not correct. It had been explained in the declaration by T. Takaya, dated 12 December 2011, that the CTE figures should read  $32 \times 10^{-7}/^{\circ}\text{C}$  instead of  $38 \times 10^{-7}/^{\circ}\text{C}$ . In any event, the examples provided sufficient information for the skilled person to use the given compositions as a starting point for working the invention.

There was no proof that the process could not be carried out at the lower end of the CTE range claimed. Example 14 of D7 was outside the scope of claim 1.

Article 56 EPC

D7 disclosed neither that the alkali content of the glass should be within the range of 0.02 to 0.2 % by mass nor that electric melting in a high zirconia refractory furnace was used.

Although electric melting in a zirconia refractory

furnace was known in the art, the skilled person would not have employed it when producing an alkali-free glass for a display substrate which had a high volume resistivity, because the current would flow through the refractory, erode the zirconia and contaminate the molten glass batch. Zirconia in the glass was known to lead to devitrification. D15 to D17 did not refer to alkali-free glasses. For instance, the glasses of D17 contained 4.5% by weight of Na<sub>2</sub>O. Such glasses possessed a high electric conductivity. Therefore, D15 to D17 were not applicable to alkali-free glasses with low electrical conductivity.

D16 taught that the addition of chloride and the elimination of water improved the electrical conductivity of the liquid glass, and as a result the erosion amount of ZrO<sub>2</sub> in a high zirconia refractory was reduced.

For these reasons, before the present invention, it was considered that there were only two options for the melting of an alkali-free glass, namely the method of using an enlarged gas furnace or electric melting using an alumina system refractory. When melting an alkali-free glass by electric melting, a person skilled in the art looking at D7b would have avoided using high zirconia refractory and would have used an alumina system refractory as usual.

The effects of the alkali metal oxides were clearly demonstrated in the opposed patent. There was no proof that improved devitrification was not obtained with 0.02 % by mass of alkali.

The effect of alkali metal oxides was demonstrated clearly by comparing examples 1 and 2, since the effect

of alkali metal oxides was greater than the influence of the chloride content and the  $\beta$ -OH value. The examples showed that an increase in alkali metal content caused a reduction in zirconia.

D7 taught to reduce the alkali and the zirconium content as much as possible.

X. Requests

The appellant (opponent) requested that the decision under appeal be set aside and the patent be revoked.

The respondent (patent proprietor) requested that the patent be maintained in amended form on the basis of the claims of the main request, filed as auxiliary request 4 with letter dated 17 August 2015, or in the alternative, on the basis of one of auxiliary requests 5 to 7, also filed with letter dated 17 August 2015.

## Reasons for the Decision

1. Articles 123(2) and 76(1) EPC
  - 1.1 Claim 1 of the main request is based on claims 11 and 14 and on page 5, lines 25 and 37 of the parent application EP-A-1 593 657. Claims 2 to 5 correspond to claims 12, 13, 15 and 16, respectively, of the parent application.
  - 1.2 Claim 1 is based on claim 8 and on page 5, lines 14 and 26 of the application as filed (EP-A-1 790 620). Claims 2 to 5 correspond to claims 9 to 12 of the application as filed.
  - 1.3 In the parent application (paragraph 41), ranges are disclosed for the alkali content and for the amount of  $\text{Na}_2\text{O}$ , so that there is no creation of a range in the present case. In addition, all the end values present in claim 1 are disclosed as possible end values of the specific ranges in the parent application.

Claim 1 has been restricted by narrowing the alkali range present in claim 11 of the parent application (0.01 to 0.2) due to an increase of the lower end value towards the specific samples disclosed in the patent. In addition, it was further specified that  $\text{Na}_2\text{O}$  needs to be present by providing a range that covers the samples in accordance with the invention disclosed in the patent.

The combination of the lower end value (0.02) with the upper end value (0.2) is not a creation of a new range, since the skilled person recognises from the original application that all lower and upper end values

disclosed for Na<sub>2</sub>O are equally possible as long as they fall within the broader definition of the alkali content (page 5, lines 36 to 38). It is understood by the skilled person from the parent application that Na<sub>2</sub>O is the preferred alkali component, since it is indicated "*it is preferable that the amount of Na<sub>2</sub>O, among the alkali component, is the largest*" (page 5, lines 35 and 36), which is also in line with the examples. This understanding is translated into claim 1 by specifying that Na<sub>2</sub>O needs to be present.

The inclusion of the range for Na<sub>2</sub>O in claim 1 does **not** lead to a combination from **two independent lists**, since the first limitation with respect to alkali (0.02 to 0.2) is only further specified by indicating which type of alkali needs to be present. The range of Na<sub>2</sub>O is linked to the range of alkali and cannot be considered as independent. Rather it is a specification of the feature "alkali".

In that respect, the present case differs from T 1511/07 (reasons 2.1), wherein an individual, narrow sub-range obtained by selecting explicitly disclosed borderline values defining several (sub-) ranges was combined with another individual range emerging from a second list of ranges and **relating to a different feature**, which was considered not to be disclosed in the application as filed in the absence of a clear pointer to such a combination.

The case also differs from T 812/09 (reasons 3.1), wherein a selection of **four different groups** of features having different preferential rankings in the original application was not allowed because an explicit combination of these features could not be

found anywhere in the original application documents.

Furthermore the limitation included in claim 1 does **not** lead to an **individualisation** of a specific alkali composition, but is only the restriction of the degree of generality as compared with the parent application.

Consequently, the subject-matter of the claims is directly and unambiguously derivable from the parent application.

1.4 The same conclusion applies to the derivability from the application as filed, since the description of the parent application and the application as filed are identical in the passage relating to the amounts of alkali (see parent application, paragraph 41 vs. application as filed, paragraph 39).

1.5 The requirements of Articles 123(2) and 76(1) EPC are fulfilled.

2. Article 83 EPC

2.1 Article 83 EPC stipulates that the application shall disclose the invention in a manner sufficiently clear and complete for it to be carried out by a person skilled in the art.

The established jurisprudence of the boards of appeal considers that the requirements of sufficiency of disclosure are met if the invention as defined in the independent claims can be carried out by a person skilled in the art, using his common general knowledge, in the whole scope of the claim without undue burden. (e.g. T 409/91, Reasons 3.5; T 435/91, Reasons 2.2 and 2.2.1).

In order to make a case of insufficiency of disclosure, it is necessary to identify gaps in information resulting either from limitations in the teaching or from a lack of guidance in general.

The question then to be answered is whether the skilled person with his common general knowledge can remedy any such defects, or whether the consequences of the information gaps result in an undue number of experiments to be performed.

- 2.2 In the present case, the patent contains several examples illustrating a method according to claim 1. The thermal expansion coefficients (CTE) given in Tables 2 and 3 is  $38 \times 10^{-7}/^{\circ}\text{C}$ , which falls outside the range given in claim 1 ( $25$  to  $36 \times 10^{-7}/^{\circ}\text{C}$ ). However, the respondent had filed before the opposition division (15 December 2011) a declaration in lieu of an oath that these values are incorrect and that they should read " $32 \times 10^{-7}/^{\circ}\text{C}$ " instead of " $38 \times 10^{-7}/^{\circ}\text{C}$ ". This was not contested by the appellant and there is nothing to prove that this declaration was not true.

The erroneous indication of the thermal expansion coefficient (CTE) would not be immediately recognised by the skilled reader when reading the patent, so it could be argued that there was a gap in information. Nevertheless, when trying to put the invention into practice the skilled person would start from the examples given in the patent. When reworking the examples in line with the information provided in paragraphs 79 to 89, the skilled person would realise that the CTE values given in the table must be erroneous. Therefore, he would recognise that, when reworking examples 2 to 4 and 6 to 8 as shown in Tables



2 and 3, he would effectively be executing a method falling within the scope of claim 1.

2.3 It is specified in the patent that the object of the invention is to provide a glass for a display substrate which has a low density, low expansion and a high strain point, and hardly causes devitrification at forming, even when electrically melted in a melting furnace constructed of a high zirconia refractory (paragraph 21). Examples 2 to 4 and 6 to 8 illustrate how such glasses can be obtained. In view of the similarity of the glasses with the glasses disclosed in D7 that are suitable for a display substrate, and in view of the lack of evidence to the contrary, it is accepted that said glasses are also suitable for a display substrate.

2.4 The examples of the patent disclose glasses that have a CTE of  $32 \times 10^{-7}/^{\circ}\text{C}$ . It was questioned whether glasses having a CTE of  $25 \times 10^{-7}/^{\circ}\text{C}$  and having the other properties defined in claim 1 were obtainable by electric melting in a melting furnace constructed of a high zirconia refractory. Example 14 of D7 shows that a glass having a CTE of  $22 \times 10^{-7}/^{\circ}\text{C}$  has a very high melting point ( $1945^{\circ}\text{C}$ ).

However, the CTE value of this glass is well below the lower limit of the range ( $25 \times 10^{-7}/^{\circ}\text{C}$ ) present in claim 1. It may be accepted that a glass having a CTE of  $25 \times 10^{-7}/^{\circ}\text{C}$  has a melting point higher than the samples shown in the patent, but neither the exact value nor the composition of such a glass can be deduced from example 14 of D7.

The patent teaches that the thermal expansion coefficient of the glass can be influenced by the

amount of SiO<sub>2</sub> (page 7, lines 15 to 17), CaO (page 7, lines 18 to 21), BaO and SrO (page 7, lines 24, 25, 30 and 31). The appellant has not provided any evidence in the form of data that show that this teaching is not sufficient and that the process according to claim 1 does not permit to obtain glass having a CTE of  $25 \times 10^{-7}/^{\circ}\text{C}$  that is suitable for a display substrate. The objection is thus based on speculation and is not corroborated by facts.

Therefore, the Board has no reason to doubt that the invention can be carried out over the whole scope of the claim.

The requirements of Article 83 EPC are fulfilled.

### 3. Article 56 EPC

#### 3.1 Invention

The invention concerns a method for producing a glass for a substrate that is used in a flat substrate display such as a liquid crystal display and an electroluminescent display (paragraph 1).

#### 3.2 Closest prior art

D7 is considered to be the closest prior art, since it also relates to a glass that is suitable as a glass substrate material for a flat display, which glass has a similar composition as the glass produced by the method of claim 1 of this request (D7: claims 1 to 3).

The glass according to D7 has a density of not more than  $2.5 \text{ g/cm}^3$ , a thermal expansion coefficient of 25 to  $40 \times 10^{-7}/^{\circ}\text{C}$  and a strain point of not less than  $630^{\circ}\text{C}$

(paragraph 73). In addition, D7 discloses that the glass essentially contains no arsenic oxide ( $\text{As}_2\text{O}_3$  or  $\text{As}_2\text{O}_5$ ) or alkali metal oxides, contains 0.005 to 0.4 wt% of  $\text{SnO}_2$  and 8 to 13.5 wt% of alkaline earth metal oxides ( $\text{MgO}$ ,  $\text{CaO}$ ,  $\text{SrO}$ ,  $\text{BaO}$ ) and has the following composition: 50-70 wt%  $\text{SiO}_2$ , 10-19 wt%  $\text{Al}_2\text{O}_3$ , 5-15 wt%  $\text{B}_2\text{O}_3$ , 0-3 wt%  $\text{MgO}$ , 0-12 wt%  $\text{CaO}$ , 0-6 wt%  $\text{SrO}$ , 0-5 wt%  $\text{BaO}$ , 0-2 wt%  $\text{ZnO}$ , 0-1 wt%  $\text{ZrO}_2$ , 0-5 wt%  $\text{TiO}_2$ , 0-5 wt%  $\text{P}_2\text{O}_5$ , 0-5 wt%  $\text{Sb}_2\text{O}_3$  (D7: paragraph 29). It is specified that, preferably, the glass should contain 0.01 to 0.5 wt% of  $\text{ZrO}_2$  (paragraph 30). "Containing essentially no" means that alkali metal oxides must be kept to not more than 0.05 wt%, preferably not more than 0.02 wt%, and more preferably not more than 0.01 wt% (paragraph 52).

The raw materials were placed in a platinum crucible and melted at 1600°C for 24 hours (paragraph 61).

The ranges of density, thermal expansion coefficient, strain point and  $\text{ZrO}_2$  disclosed in D7 overlap with the ranges given in claim 1.

However, it is not directly and unambiguously derivable from D7 that the alkali content of the glass is 0.02 to 0.2% wt%. It is disclosed that most preferably the alkali content should be not more than 0.01% (paragraph 52), which means that it is unambiguous that the glass according to D7 has an alkali content of [0-0.01] wt%. 0.02 wt% is disclosed as a preferred option, but not as the most preferred, which means that in some cases the alkali content may be up to 0.02%, but not in all cases. Therefore, it cannot be argued that the glass of D7 unambiguously comprises from [0-0.02] wt% of alkali.

### 3.3 Problem to be solved

The problem underlying the patent in suit is to provide a process for preparing glass that causes hardly any devitrification (paragraph 21).

### 3.4 Solution

As a solution to this problem, a process according to claim 1 is proposed, characterised in that the raw materials of the glass are electrically melted in a melting furnace constructed of a high zirconia refractory and the glass resulting from the process has an alkali content of 0.02 to 0.2% and a Na<sub>2</sub>O content of of 0.02 to 0.2% wt%.

### 3.5 Success of the solution

Samples 2 to 4 and 6 to 8 of the patent show that the addition of 0.03 to 0.077 wt% of alkali (Na<sub>2</sub>O + K<sub>2</sub>O + Li<sub>2</sub>O) to the raw materials of the glass limits the amount of ZrO<sub>2</sub> eroded from the ZrO<sub>2</sub> electrocast refractory during electric melting. As a consequence devitrification does not occur. However, the presence of only 0.0065 wt% (sample 1) and 0.0076 wt% (sample 5) of alkali in the raw materials did not allow to limit the erosion of ZrO<sub>2</sub> such that no devitrification occurred.

When comparing samples 1 and 5 with samples 2 to 4 and 6 to 8, it is apparent that not only the amount of alkali is different, but also the amount of Cl<sub>2</sub> and the β-OH value. Samples 1 and 5 have the highest amount of Cl<sub>2</sub> and the lowest β-OH value. According to D16, the electric conductivity of the borosilicate glass is

improved when chlorine compounds are added to the glass and compounds containing water of hydration are eliminated (page 37, left column, lines 21 to 25). Since the improvement of the electric conductivity of the glass is expected to lead to less erosion of the refractory (patent: page 5, lines 15 to 18), samples 1 and 5 should lead to less erosion when considering the amount of  $\text{Cl}_2$  and the  $\beta\text{-OH}$  value. Still samples 1 and 5 have the highest erosion, which has to be linked to the lower amount of alkali.

Therefore, it is accepted that the problem is solved for the method producing samples 2 to 4 and 6 to 8 of the patent.

The ranges present in claim 1 are broader than the ranges present in the samples of the patent. In particular, the  $\text{ZrO}_2$  content can vary between 0.01 wt% to less than 0.4 wt%, while the amount of alkali can be from 0.02 to 0.2 wt%. It might be questioned that a glass containing less than 0.4%  $\text{ZrO}_2$  and encompassed by claim 1 shows no devitrification, while a glass containing 0.4%  $\text{ZrO}_2$ , such as samples 1 and 5 of the patent, shows devitrification and whether the results obtained for 0.03 wt% alkali also apply to the lower end value of 0.02 wt% present in claim 1. However, there is no evidence in the form of experimental data to justify such doubts and to suggest that an improvement in the devitrification property was not obtained over the whole scope claimed.

In the absence of such data, the board accepts that the problem is solved over the whole range claimed.

There is no need to reformulate the problem.

### 3.6 Obviousness

D7 teaches that furnaces of zirconia refractory can be used for preparing the glass and that zirconia can erode from such refractories. If the amount of  $ZrO_2$  increases,  $SnO_2$  present in the glass becomes very susceptible to devitrification. To suppress devitrification of  $SnO_2$  due to the  $ZrO_2$ ,  $ZrO_2$  should be 0.5 wt% or less and the amount of alkaline-earth metal oxides should be limited (paragraph 46). In addition, D7 indicates that the glass must be essentially free of alkali oxides to avoid deterioration in film characteristics of the glass (paragraph 9). This means that the amount of alkali metal oxides should be as low as possible (paragraph 52). D7 is completely silent about electric melting. D7 itself does not teach towards the solution of the problem.

Like D7, D1 to D4, D10 and D11 also relate to alkali free glass and are also silent about electric melting.

D5, D6, D8 and D8a all relate to glasses suitable for a display substrate comprising very low amounts of alkali, but there is no information provided concerning the process of production.

D12 discloses a glass containing 0.03 wt% of  $Na_2O$  and having a CTE of  $38 \times 10^{-7}/^{\circ}C$ . The method of production is not disclosed.

D15 teaches that the glass melt receptacle must be constructed of a durable refractory which is less conductive to electric current than the molten glass (column 1, lines 36 to 38). Attempts to avoid the declining electrical resistivity problem of refractory at high melt temperatures have involved building the

furnace from highly resistive refractories such as zircon or zirconia (column 2, lines 12 to 15). The skilled person learns from D15 that electric melting of glass is possible with a melting furnace of high zirconia refractory. However, D15 does not relate to glasses containing essentially no alkali, and does not teach to keep the amount of alkali in the range of 0.02 to 0.2 wt.-% to limit erosion of the refractory and thus reduce devitrification. Rather, D15 alerts the skilled person that there could be problems when using electric melting.

D16 discloses that the electric melting of borosilicate glass is better than melting in gas furnaces. However, D16 does not disclose glasses containing essentially no alkali and does not teach what to do to prevent erosion of the refractory at melting temperatures around 1600°C.

When trying to find a solution to the posed problem, the most relevant document is D17. It provides a method of melting or refining glass, wherein the walls of the furnace have a lesser specific electrical conductivity than the layers of glass adjacent thereto, under conditions in which the glass is maintained by the current at a temperature of about 1500°C, preferably 1600°C or higher (page 1, lines 59 to 74). It further teaches that the specific electric conductivity of the glass relative to that of the furnace may be increased by adding to the glass a salt or compound of an alkali metal, which will dissociate electrolytically of such composition and in such quantity as not to impair the useful properties of the glass produced by the method. This salt may be a salt of lithium, sodium or potassium; sodium chloride and lithium carbonate are preferred, and the quantity added preferably lies in

the range of 0.01% to 0.25% by weight (page 2, lines 13 to 27). As examples of refractory materials zirconia, alumina, silica and sillimanite are given (page 2, lines 109 to 116).

The composition used for making the borosilicate glass contains 77% sand, 2.6% alumina hydrate, 7% boric acid, 12% dehydrated borax and 1.4% nitrate of soda (sic) (page 3, lines 24 to 29). To this composition a salt or compound of an alkali metal, such as sodium chloride or lithium carbonate, is added in an amount in the range of 0.01% to 0.25% by weight to increase the electric conductivity of the glass (page 3, lines 30 to 37). Borax has the chemical formula  $\text{Na}_2\text{B}_4\text{O}_7$ , while nitrate of soda is  $\text{NaNO}_3$ . This means that this composition already contains sodium in an amount well above 1% (3%) prior to the addition of a small amount of 0.01% to 0.25% of a further alkali compound.

Starting from D7, the skilled person learns from D17 that electric melting of the raw materials is a possible option in glass production. D7 teaches that the refractory can erode, so that zirconia would enter the glass melt in case of zirconia refractory. This could lead to devitrification if the zirconia concentrations are too high. In view of the stated problem of providing a process for preparing glass that hardly causes devitrification, the skilled person would not choose a melting furnace constructed of high zirconia refractory, since he would want to avoid devitrification in the alkali-free glasses. He would instead opt for the alumina and silica disclosed in addition to zirconia in D17.

Although zirconia is a possible material that is mentioned in D15 and D17, and D7 teaches that a limited



amount (not more than 0.5 wt%) is acceptable, there is no teaching in D15 or D17 on how it can be ensured that erosion of zirconia is limited in an alkali-free glass. The teaching of D17 to add alkali to increase the electric conductivity of the glass applies to a glass already containing well above 1% of sodium, as illustrated in the example. In addition, this teaching is contrary to D7, which suggests limiting the amount of alkali as much as possible to prevent film forming. So a skilled person having a choice between several refractory materials would not choose zirconia in order to solve the problem posed.

Consequently, the prior art fails to teach or suggest a method of electrically melting glasses having improved devitrification properties due to the addition of 0.02 to 0.2% alkali in a melting furnace constructed of a high zirconia refractory.

The requirements of Article 56 EPC are met.

The main request is allowable and there is no need to discuss the lower ranked requests.

## Order

### For these reasons it is decided that:

1. The decision under appeal is set aside.
2. The case is remitted to the department of first instance with the order to maintain the patent in amended form on the basis of claims 1 to 5 of the main request, filed as auxiliary request 4 with letter dated 17 August 2015, and a description to be adapted thereto.

The Registrar:

The Chairman:



C. Vodz

H. Engl

Decision electronically authenticated