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D E C I S I O N
of 26 March 2003

Case Number: T 0491/01 - 3.3.5

Application Number: 93102994.6

Publication Number: 0567735

IPC: C03C 17/36

Language of the proceedings: EN

Title of invention:
High performance, durable, low emissivity glass and method of making same

Patentee:
GUARDIAN INDUSTRIES CORP.

Opponent:
SAINT-GOBAIN GLASS FRANCE

Headword:
Low-e Glass/GUARDIAN

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step (no)"

Decisions cited:
-

Catchword:
-

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Case Number: T 0491/01 - 3.3.5

D E C I S I O N
of the Technical Board of Appeal 3.3.5
of 26 March 2003

Appellant: (Opponent)
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Decision under appeal: **Interlocutory decision of the Opposition Division of the European Patent Office posted 7 March 2001 concerning maintenance of European patent No. 0 567 735 in amended form.**

Composition of the Board:

Chairman: R. K. Spangenberg
Members: M. M. Eberhard
J. H. Van Moer

Summary of Facts and Submissions

I. This appeal is from the interlocutory decision of the opposition division according to which European patent No. 0 567 735 in the amended form filed on 9 November 2000 meets the requirements of the Convention. The decision was based on the granted claims, as the main request, and on three sets of amended claims as auxiliary requests 1 to 3. Claim 1 as granted reads as follows:

"1. A sputter-coated glass article comprising a glass substrate having thereon, from the glass outwardly, a layer system comprising:
(a)- an undercoat layer of Si_3N_4,
(b)- a first layer of nickel or nickel alloy,
(c)- at least a layer of silver,
(d)- a second layer of nickel or nickel alloy, and
(e)- an overcoat layer of Si_3N_4;
characterised in that, when said glass substrate has a thickness of 2 mm - 6 mm, said layer is durable and said coated glass has a visible transmittance of at least 78%, a normal emissivity (E_n) of less than 0.12 and a hemispherical emissivity (E_h) of less than 0.16; said measurable characteristics being obtained by making said layer system such that, in combination:
- the thickness of the silver layer is greater than 7 nm, provided that when there are more than one silver layers, it is the total thickness of all the silver layers to be greater than 7 nm;
- the thickness of the Ni or Ni-alloy layers is less than 1 nm; and
- the thickness of the Si_3N_4 layers is equal to or greater than 32 nm for the undercoat and equal to or greater than 45 nm for the overcoat."

II. During the opposition proceedings the parties relied *inter alia* on the following documents:

D1: known Airco product referred to in the patent in suit

D2: EP-A-0 456 487

D6: Solar Energy Materials 19 (1989) 43-53

D10: FR-A-2 106 431

D13: Computer modelling from the respondent

The opposition division took the view that the subject-matter of claim 1 of each of the main request and auxiliary requests 1 and 2 lacked an inventive step over the disclosure of D2. It could be deduced from a comparison of the examples of D2 that a decrease of the thickness of the NiCr layers and an increase of the Ag layer thickness lowered the sheet resistance and increased the transmittance. The same behaviour could be deduced from the theoretical modelling in D13. Therefore both D2 and the said modelling pointed in the direction of the invention. The process according to the third auxiliary request was considered to involve an inventive step.

III. The appellant (proprietor of the patent) filed an auxiliary request with the statement of grounds of appeal as well as an experimental report "Exhibit 1" (hereinafter D14). Claim 1 of this request reads as follows:

"1. A sputter-coated glass article comprising a glass substrate having thereon, from the glass outwardly, a layer system comprising:

(a)- an undercoat layer of Si_3N_4,
(b)- a first layer of nickel or nickel alloy,
(c)- at least a layer of silver,
(d)- a second layer of nickel or nickel alloy, and
(e)- an overcoat layer of Si_3N_4;
characterised in that, when said glass substrate has a thickness of 2 mm - 6 mm, said layer is durable and said coated glass has a visible transmittance of at least 78%, a normal emissivity (E_n) of less than 0.12 and a hemispherical emissivity (E_h) of less than 0.16; said measurable characteristics being obtained by making said layer system such that, in combination:
- the thickness of the Si_3N_4 layers is equal to or greater than 32 nm for the undercoat and equal to or greater than 45 nm for the overcoat; and
wherein said layer system consists essentially of said five layers, said nickel or nickel alloys layers are less than 0.7 nm thick and the only one silver layer is equal to or greater than 9 nm thick."

IV. In reply to a communication from the board asking for the document illustrating the Standard Airco system referred to in the patent in suit, the respondent (opponent) filed extracts (hereinafter D15) from the US file relating to US patent US-A-5 584 902.

V. Oral proceedings took place on 26 March 2003. The appellant requested that the decision under appeal be set aside and that the patent be maintained as granted, or in the alternative, on the basis of the set of claims according to the auxiliary request filed with the statement of grounds of appeal. He also requested to maintain the patent in the amended form accepted by the opposition division as a further auxiliary request. The respondent requested that the appeal be dismissed.

VI. The appellant's arguments concerning the issue of inventive step can be summarised as follows:

D1 did not form part of the prior art. Thus, D2 represented the closest prior art. The technical problem was to provide a coating system which simultaneously showed the durability of the known pyrolytic coatings, exhibited optimal solar management characteristics and was easy to obtain with a high productivity. The gist of the invention did not reside merely in making the silver layer thicker and the nichrome layer thinner but also in varying the thickness of the silicon nitride layers within critical ranges which depended on the thicknesses chosen for the silver and nichrome layers. This was confirmed by D13 and D14. When comparing Examples 1 and 2 of D2 the opposition division wrongly took into consideration only three layers. A correct analysis based on all five layers showed that the examples of D2 involved considerably thicker silicon nitride layers than in the examples of the patent in suit and that the layer systems of D13 were not equivalent to those of D2 because of the thinner silicon nitride layers. D2 gave only generic information about the layer thicknesses but did not refer to the claimed specific layer system. According to D2 the nichrome layer only provided adhesion of the silver layer and both D2 and D10 taught that the thin precoat layer had no effect on the optical properties of the silver layer. D2 disclosed a trend regarding the thickness of the silver and nichrome layers but did not suggest that the transmittance would be improved by simultaneously changing the thickness of the silicon nitride layers. The skilled person would not have tried to change the thickness of all five layers, in particular of the dielectric layers, in order to achieve the results of the invention. The theoretical modelling did not change the situation since the thicknesses of the layers have

to be input in the computer to obtain the transmittance values and there was a very great number of possible permutations. The behaviour of a five-layer interference filter was unpredictable as shown by the experimental report D14 in which only the thickness of the dielectric layer was decreased. In claim 1 of the auxiliary request, the thicknesses for the silver layer and nichrome layers were far away from the preferred ranges disclosed in D2. The skilled person would not have tried values lying outside the said preferred ranges.

VII. The respondent presented the following arguments:

The subject-matter of claim 1 as granted lacked novelty. The ranges disclosed in D2 for the transmittance, electrical sheet resistance and layers thickness overlapped with the claimed ranges and the criteria for a selection invention were not met. Starting from D2 as the closest prior art, the problem to be solved was to maintain a sufficient optical performance while improving the energetic properties, ie the emissivity, of the layer stack. According to D2 the optical and electrical properties of the film could be varied by changing the thicknesses of the layers. The skilled person was aware of the fact that the thickness of the silver layer had to be increased in order to improve the emissivity. Furthermore, a comparison of Examples 1 and 2 of D2 showed that by increasing the silver layer thickness by only 0.5 nm the sheet resistance considerably dropped. Therefore he would have tried to further increase the thickness of the silver layer in order to decrease the emissivity. He would have expected the thicker silver layer to decrease the visible light transmittance; however D2 further disclosed that this negative effect could be compensated for by decreasing the thickness of the nichrome layers. According to D2 and D10 a thickness

of 0.5 nm for the precoat layer was sufficient to avoid agglomeration of the silver particles. It was common general knowledge that the dielectric layers had an influence on the transmittance and this was also derivable from D2. The skilled person would thus have tried to vary the thickness of the dielectric layers within the ranges disclosed in D2. The durability being excellent in the examples of D2, he would not have expected it to become unsatisfactory when decreasing the thickness of the overcoat layer within the said ranges. In view of the teaching of D2 the selections of thicknesses were only routine optimisations which could be conducted using computer modelling means such as the software Filmstar which was available in 1991.

Reasons for the Decision

1. The appeal is admissible.

Main request

2. The appellant argued that the document which is implicitly referred to in the patent in suit in connection with the Standard Airco product (see in particular page 3, lines 15 to 21) was a confidential document not available to the public before the priority date of the patent in suit as confirmed by D15. This confidential document had only been distributed to the licensees of Airco Corporation, and thus to Guardian Industries Corporation (proprietor of the patent in suit). The only document available to the public before the priority date and describing the Airco Standard layer system was D2. The Airco product

presented as known in the patent in suit (see page 3, line 24) exhibited a visible transmittance of 76%, which was too low for a satisfactory commercial product. This product was thus not a commercial product put on the market before the priority date.

The board observes that D15 makes reference to confidential information from Airco Corporation (see Annexes III and V of D15) which was provided to the US examiner. The redacted version of the confidential document, namely Annex IV of D15, was made available to the public after the priority date of the patent in suit. In view of document D15 which confirms the existence of confidential information concerning the Airco Coating Technology, Super-E III, the board sees no reasons not to accept the appellant's arguments that the Airco product ("Standard Airco" or STD) and the Airco technology referred to in the patent in suit, in particular on page 3, lines 15 to 28 and page 6, lines 27 to 38, were not available to the public before the priority date. This was not disputed by the respondent at the oral proceedings. Therefore, document D1 based on this product and technology cannot be considered as forming part of the prior art.

3. The respondent disputed at the oral proceedings that the subject-matter of claim 1 as granted was novel over the disclosure of D2. The board is satisfied that D2 does not disclose a coated glass article having the combination of characteristics stated in claim 1, in particular the combination of **both** the emissivity and visible light transmittance values, and thus, that the coated article of claim 1 is new with respect to D2. Detailed considerations in this respect are not

necessary taking into account that granted claim 1 is not allowable because of lack of inventive step of its subject-matter (see reasons given hereinafter). The product of granted claim 1 also meets the requirement of novelty with respect to the other cited documents.

4. D2 represents the closest prior art. It discloses a sputter-coated durable low-emissivity thin film interference filter comprising a glass substrate, and from the glass outwardly, a layer system comprising the following layers:

- a layer of a dielectric material, preferably silicon nitride, having a thickness of 30 to 90 nm, more preferably 40 to 60 nm;

- a first precoat layer of a metal or an alloy with a thickness ranging from 0.5 to 2 nm, more preferably 0.8 to 1.2 nm, the preferred material for this precoat layer being a nickel-chromium alloy;

- a metal layer deposited onto the precoat layer, preferably a silver layer, the thickness of the metal layer ranging from 4 to 15 nm, more preferably from 5.5 to 8.5 nm;

- a second precoat layer deposited onto the metal layer which can be formed from the same material and in the same thickness as the first precoat layer;

- an additional dielectric layer formed of the same material and of the same thickness as the first dielectric layer, though the preferred thickness range is between 57.5 and 86 nm.

The visible light transmittance and the electrical sheet resistance of the interference filters disclosed in D2 can range from 10 to 80% and from 3.0 to 30 ohm/square respectively (see claims 1 to 8; page 2, lines 1 to 2 and 39 to 41; page 3, lines 5 to 35, lines 49 to 52 and 56; page 5, Table 1; Figure 2). The interference filter exemplified on page 5 has the following layer structure on a soda line glass: Si_3N_4 49 nm/NiCr 0.8 nm/Ag 7.5 nm/NiCr 0.8 nm/Si_3N_4 72 nm. It exhibits a visible light transmittance of 75.96% and an electrical sheet resistance of 14.7 to 15.3 ohm/square.

4.1 Starting from this closest prior art, and in particular from the product exemplified on page 5 of D2, the problem underlying the claimed product can be seen in the provision of a coated glass article useful as architectural glass, which exhibits a durability at least approaching that of pyrolytic coatings while having improved optical properties and infrared energy reflecting characteristics, in particular improved visible light transmittance and emissivity.

It is proposed to solve this problem by the coated glass article as defined in claim 1, which differs from the interference filter of D2 in particular by the combination of a visible light transmittance of at least 78% with a normal emissivity E_n of less than 0.12 and a hemispherical emissivity E_h of less than 0.16. In view of the statement about the durability on page 7, lines 2 to 5, of the patent in suit and of the emissivity and transmittance values reported in the examples, it is credible in the absence of evidence to the contrary that the technical problem stated above has actually been solved by the claimed product.

4.2 The appellant argued that the coated glass article according to the patent in suit had the additional advantage of being easy to produce with high productivity. It can be inferred from the patent in suit that this advantage is achieved when specific atmospheres are used in the different zones during the sputtering process (see page 5, lines 29 to 50). Granted claim 1 is however not limited to products manufactured under these particular operating conditions. Therefore this advantage cannot be taken into consideration for the assessment of the inventive step of the product defined in claim 1.

4.3 According to the appellant the emissivity and transmittance values stated in claim 1 may be achieved by changing the thicknesses of all five layers of the interference film disclosed in D2 and these values established upper limits to the thickness of the silicon nitride and silver layers as well as lower limits to the thickness of the nichrome layers. The board observes that the relative thicknesses of the different layers, which the appellant considers as very important, are not given in the examples of the patent in suit. They can also not be inferred from the voltages, amperages and powers of the coating apparatus disclosed in the examples. The appellant was not in a position to provide further information concerning the specific combination of layer thicknesses produced in the examples. According to the appellant, this would have involved a too expensive reproduction of the examples of the patent in suit. Consequently inventive step has to be assessed without knowledge of the said upper and lower limits for the thicknesses of the layers.

4.4 According to D2, it is possible to vary the optical and electrical characteristics of the interference filter by variations on the materials and thicknesses for each

layer thereof. By such variations the visible light transmittance can range from 10 to 80% and the electrical sheet resistance from 3.0 to 30 ohm/square (see page 2, lines 45 to 46; page 3, lines 49 to 52). It was general knowledge before the priority date of the patent in suit that the emissivity of a low emissivity coating of the type dielectric/noble metal/dielectric is correlated to the electrical sheet resistance, the sheet resistance being an indication of how well the layer reflects infrared energy (see D6, page 45; and patent in suit, page 2, lines 49 to 53). As indicated in the decision under appeal and not disputed by the appellant, it was also well-known that the thickness of the silver layer determines the electrical sheet resistance. As pointed out by the respondent and not contested by the appellant, it can be inferred from a comparison of the two examples of D2 that by slightly increasing the thickness of the silver layer and simultaneously decreasing the thickness of both NiCr layers while maintaining the thickness of the two dielectric layers at about the same level, the sheet resistance of the interference filter is decreased and the transmittance is increased, and thus both the emissivity and the visible light transmittance of the interference filter are improved. In view of these results the skilled person confronted with the problem stated above would have contemplated making experiments in the shown direction, ie further increasing the thickness of the silver layer and decreasing the thickness of the NiCr layers in Example 1 of D2. Although he was aware of the fact that a slight increase of the silver layer thickness with the view to further improving emissivity would possibly have led to a decrease of the visible light transmittance, he would not have been deterred from making experiments since, in view of the trend shown in Examples 1 and 2 of D2, he would have expected a further decrease of the thickness of the NiCr layers to

increase the transmittance. Thus starting from the layer system of Example 1 of D2, the skilled person would have tried to stepwise increase the silver layer thickness and decrease the NiCr-layers thickness while remaining within the thickness ranges recommended in D2 (see point 4 above). These experiments represent routine experimentation lying within the competence of the skilled person.

4.5 Relying upon the theoretical computer modelling D13 filed by the respondent, the appellant argued that doing so the skilled person would not have arrived at a product having both the emissivity and transmittance values stated in claim 1, since the thickness of the silicon nitride layers had also to be decreased in Example 1 of D2 in order to achieve the desired high transmittance. Although the examples of the patent in suit do not disclose the thicknesses of the various layers and thus cannot support the appellant's arguments, the board can accept them in favour of the appellant in view of the computer modelling D13 (see serie B) and of the most preferred thicknesses stated in the patent in suit for the thickness of the silicon nitride layers (see page 5, lines 11 to 14, about 40 to 42.4 nm for the undercoat and 54 to 57.5 nm for the overcoat).

The board is not convinced by the appellant's arguments that the skilled person would not have tried to vary the thickness of the dielectric layers within the ranges disclosed in D2 if the visible light transmittance was still too low after increase of the silver layer thickness and decrease of the CrNi-layers thickness. It was well-known before the priority date that the dielectric layers in this kind of interference filter act as anti-reflection layers. It was therefore obvious to the skilled person that a variation of the thickness of the silicon nitride layers would have an

influence on the visible light transmittance and that, as a result of the change of the thickness of the other layers, the thickness of the dielectric layers might have to be adapted thereto. Therefore the skilled person, knowing from D2 that a visible light transmittance of up to 80% can be obtained with the interference filter of D2 by varying the materials and the thicknesses of each layer of the interference filter, would have contemplated varying also the thickness of the dielectric layers within the ranges disclosed in D2. As, on the one hand, the overcoat layer thickness in Example 1 of D2 is relatively high and, on the other hand, ranges of 30 to 90 nm preferably 57.5 to 86 nm are given on page 3 of D2 for this thickness, the skilled person would not have expected a reduction thereof to values close to the lower limit of the preferred range to adversely affect the durability of the interference filter to a great extent.

4.6 Concerning the appellant's arguments that D2 gave only generic information about the layer thicknesses without referring to the claimed specific layer system, the board observes the following. The thickness ranges disclosed on page 3, lines 5 to 35, of D2 indeed concern the dielectric layers, the precoat layers and the metal layer; however in each paragraph dealing with one of these layers, a preferred material is indicated, namely silicon nitride for the dielectric layer, a nickel-chromium alloy for the precoat layer and silver for the metal layer. These are also the materials used in the examples. Therefore, the skilled person would understand that the given ranges also apply to the specific layer system silicon nitride/nickel-chromium alloy/silver/nickel-chromium alloy/silicon nitride.

4.7 The appellant argued that according to both D2 and D10 the thin metal precoat had no effect on the optical properties of the silver layer or interference filter, thus suggesting that the skilled person would have no reason to decrease its thickness in order to solve the existing technical problem. What D2 in fact teaches is that the precoat layer is preferably maintained as thin as possible so that it will have very little, if any, adverse effect upon the optical characteristics of the substrate, subsequent metal layer or interference filter. Precoat layers with thicknesses ranging from approximately 0.5 to 2 nm are said to be satisfactory (see page 3, lines 10 to 13 and 20 to 21). An **adverse** effect on the optical properties of the filter should be avoided. It cannot be inferred therefrom that a decrease of the NiCr layer thickness from 0.8 nm in Example 1 of D2 to a value still within the said range would have no effect on the visible light transmittance and the comparison of the two examples of D2 suggests the contrary. Regarding D10, it is indeed stated that the precoat layer is preferably as thin as possible so that it has little or no effect on the optical characteristics of the substrate, silver layer or interference filter (see page 3, lines 15 to 18 and 33 to 35). However this statement is not consistent with the teaching of D10 that the precoat layer acts on the optical properties of the silver layer and causes the silver layer to behave as if it were an homogeneous metal foil: see page 4, lines 19 to 20; page 3, lines 35 to 36.

4.8 Although the board can concur with the appellant that five-layer interference filters are relatively complicated structures, it does not follow therefrom that the effect of any variation of the layers thickness on the optical and solar control properties is totally unpredictable. The appellant pointed out in

connection with D14 that the thickness of the overcoat and undercoat layers had to be kept within critical ranges whose amplitude and limits were dependent on the thickness chosen for the silver and NiCr layers. This does not show that the optical and solar control properties are totally unpredictable, it confirms that although a trend is shown in D2 as regards the effect of a variation of the thickness of the silver and NiCr layers, experiments have to be made to verify the disclosed trend and to determine the most appropriate thickness of the dielectric layers leading to the desired high visible transmittance.

4.9 As indicated by the appellant a great number of combinations are possible with a five-layer system. However, as D2 discloses not only thickness ranges for each of the layers but also which direction to follow as regards the thickness of the silver and NiCr layers in order to improve both the emissivity and the visible light transmittance, the number of alternatives is then reduced. Furthermore the existence of a great number of combinations does not necessarily mean that the solution to the existing problem can be arrived at only with inventive skill. This is especially true in this technical field where computer modelling makes it possible to perform a pre-selection. It was not disputed by the appellant at the oral proceedings that the software Filmstar was available to the public before the priority date. Although the appellant disputed the reliability of such theoretical modelling, it relied itself on D13 to support its arguments that the emissivity and transmittance values stated in claim 1 could only be achieved by changing the thickness of all layers in Example 1 of D2.

5. It follows from the above that the subject-matter of granted claim 1 in the alternative involving a five-layer system does not fulfil the requirement of inventive step set out in Articles 52(1) and 56 EPC. Therefore the main request must fail in its entirety.

Auxiliary request

6. Claim 1 of the auxiliary request differs from the five-layer system of granted claim 1 in that the nickel or nickel-alloy layers are < 0.7 nm thick and the silver layer thickness is ≥ 9 nm (instead of < 1 nm and > 7 nm respectively in granted claim 1).

The preceding considerations of the board in connection with the inventive step of the coated glass according to granted claim 1 apply likewise to claim 1 of the auxiliary request.

The appellant's additional arguments that the thicknesses of the silver and nichrome layers were far away from the preferred range disclosed in D2 and that the skilled person would not have tried values lying outside these preferred ranges are not convincing. The thickness of the silver layer in D2 can range from approximately 4 to 15 nm, preferably approximately 5.5 to 8.5 nm. The claimed value of 9 nm is therefore relatively close to the upper limit of the preferred range disclosed in D2, and thus, this is a thickness the skilled person would try in order to achieve a greater improvement of the emissivity values. Concerning the thickness of the NiCr layers, the skilled person confronted with the problem stated above would, in view of the trend shown in the examples of D2, have decreased the thickness of the NiCr-layers in Example 1 of D2 to values < 0.8 nm in order to increase the visible light transmittance which is adversely affected by an increase of the silver layer

thickness (see point 4.4 above). The thickness <0.7 nm still lies well within the range of 0.5 to 2 nm stated in D2 and it is closer to the lower limit of the preferred range (0.8 to 1.2 nm) than to the lower limit of the broader range. The skilled person would have assumed that by decreasing the thickness of the NiCr-layers to a value lower than the preferred range, the mechanical durability might not be as excellent as in the examples of D2 since the precoat layer acts as a glue or nucleation layer that promotes adhesion between the dielectric and the silver layer (see D2, page 2, lines 37 to 38 and page 3, lines 18 to 19). However he would not have been led away from making experiments with a thickness of the NiCr-layers < 0,7 nm if his objective was to improve the emissivity and visible transmittance properties while accepting a slight decrease of the mechanical durability. The board observes that neither the patent in suit nor the file contains durability data showing that the durability of a coated glass comprising precoat layers with a thickness < 0.7 nm is the same as in the examples of D2.

For the preceding reasons, the board cannot follow the appellant's arguments that the subject-matter of claim 1 of this request involves an inventive step. As claim 1 is not allowable for lack of inventive step, the auxiliary request must fail irrespective of whether or not the seven-layer system according to independent claim 2 meets the requirements of the EPC.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

U. Bultmann R. Spangenberg

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