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**D E C I S I O N**  
**of 14 November 2002**

**Case Number:** T 0989/01 - 3.2.5

**Application Number:** 95102020.5

**Publication Number:** 0655333

**IPC:** B41J 2/045

**Language of the proceedings:** EN

**Title of invention:**  
Drop-on-demand ink-jet printing head

**Patentee:**  
SEIKO EPSON CORPORATION

**Opponent:**  
Océ-Technologies B.V.

**Headword:**  
-

**Relevant legal provisions:**  
EPC Art. 56

**Keyword:**  
"Inventive step: main request, first to fourth auxiliary request (no); fifth auxiliary request (yes)"

**Decisions cited:**  
T 0337/00

**Catchword:**  
-



Case Number: T 0989/01 - 3.2.5

**D E C I S I O N**  
of the Technical Board of Appeal 3.2.5  
of 14 November 2002

**Appellant:** Océ-Technologies B.V.  
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**Respondent:** SEIKO EPSON CORPORATION  
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**Representative:** DIEHL GLAESER HILTL & PARTNER  
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**Decision under appeal:** Interlocutory decision of the Opposition Division  
of the European Patent Office posted 3 July 2001  
concerning maintenance of European patent  
No. 0 655 333 in amended form.

**Composition of the Board:**

**Chairman:** W. Moser  
**Members:** H. M. Schram  
W. R. Zellhuber

## Summary of Facts and Submissions

- I. The appellant (opponent) lodged an appeal against the interlocutory decision of the Opposition Division maintaining the European patent No. 0 655 333 in amended form.

The Opposition Division held that the grounds of opposition based on Article 100(a) EPC (lack of novelty and inventive step) did not prejudice the maintenance of the patent in amended form.

- II. Oral proceedings were held before the Board of Appeal on 14 November 2002.

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

(ii) The respondent (patentee) requested as main request that the appeal be dismissed, or that the decision under appeal be set aside and the patent be maintained on the basis of the following documents filed on 11 October 2002:

(a) claims 1 to 13 as first auxiliary request;  
or

(b) claims 1 to 13 as second auxiliary request;  
or

(c) claims 1 to 11 as third auxiliary request;  
or

(d) claims 1 to 11 as fourth auxiliary request;

or on the basis of:

- (e) claims 1 to 10 submitted as fifth auxiliary request during oral proceedings.

III. The main request comprises three independent claims 1, 3 and 5, respectively, claim 1 of which reading as follows:

"1. A drop-on-demand ink-jet printing head, comprising: a base (44); a nozzle plate (43) defining a plurality of nozzle apertures (41, 42); an array of piezoelectric elements (45, 46) each arranged at predetermined intervals and having one end which is fixed onto said base (44) and the other free end which is confronted with said nozzle apertures (41, 42) of said nozzle plate (43); wherein a gap is formed between said nozzle apertures (41, 42) of said nozzle plate (43) and said free end of said piezoelectric elements for accumulating an ink therein, wherein electrical signals are applicable to each respective piezoelectric element through lines (47, 48) connected to said second collecting electrodes (27) of said respective piezoelectric elements at said one ends of said piezoelectric elements which are fixed onto said base (44); characterized in that said piezoelectric elements (45, 46) are formed by alternately stacking paste-like piezoelectric material and conductive material in the form of a layer, wherein one-side electrodes (24) are formed by said conductive material layers, said one-side electrodes (24) being exposed on a first surface of said lamination, and wherein other-side electrodes (22) are formed by said conductive material layers, said other-side electrodes (22) being exposed on a second surface of said lamination opposite to said

first surface; burning a lamination of said piezoelectric material and said conductive material to provide a piezoelectric plate (28), and cutting said piezoelectric plate into a plurality of piezoelectric elements with a predetermined width so that a lamination direction coincides with a main vibrating direction and a direction between said one fixed end and said other free end of said respective piezoelectric elements (45, 46), wherein a first collecting electrode (26) is formed on said first surface of said lamination for contacting said one-side electrodes (24), and wherein a second collecting electrode (27) is formed on said second surface of said lamination for contacting said other-side electrodes (22); wherein said first and second collecting electrodes (27, 26) are formed by coating corresponding surfaces of said piezoelectric plate (28) with a conductive paint."

Claim 1 of each of the first to fourth auxiliary requests corresponds in substance to claim 1 of the main request.

The fifth auxiliary request comprises two independent claims 1 and 2, which correspond to claims 5 and 7 of the main request. Claims 1 and 2 according to the fifth auxiliary request read as follows:

"1. A drop-on-demand ink-jet printing head, comprising: a base (44); a nozzle plate (43) defining a plurality of nozzle apertures (41, 42); an array of piezoelectric elements (45,46) each arranged at predetermined intervals and having one end which is fixed onto said base (44) and the other free end which is confronted with said nozzle apertures (41, 42) of said nozzle plate (43); wherein a gap is formed between said nozzle apertures (41,42) of said nozzle plate (43) and said

free end of said piezoelectric elements for accumulating an ink therein, characterized in that said piezoelectric elements (45,46) are formed by alternately stacking paste-like piezoelectric material and conductive material in the form a layer, wherein one-side electrodes (24) are formed by said conductive material layers, said one-side electrodes (24) being exposed on a first surface of said lamination, and wherein other-side electrodes (22) are formed by said conductive material layers, said other-side electrodes (22) being exposed on a second surface of said lamination opposite to said first surface; burning a lamination of said piezoelectric material and said conductive material to provide a piezoelectric plate (28), and cutting said piezoelectric plate into a plurality of piezoelectric elements with a predetermined width so that a lamination direction coincides with a main vibrating direction and a direction between said one fixed end and said other free end of said respective piezoelectric elements (45, 46), wherein a first collecting electrode (26) is formed on said first surface of said lamination for contacting said one-side electrodes (24) and wherein a second collecting electrode (27) is formed on said second surface of said lamination for contacting said other-side electrodes (22); and wherein said piezoelectric elements comprise inactive regions (12a, 12a') where said one-side electrodes (24) or said other-side electrodes (22) do not exist at a portion which is fixed onto said base."

"2. A drop-on-demand ink-jet printing head, comprising: a base (44); a nozzle plate (43) defining a plurality of nozzle apertures (41, 42); an array of piezoelectric elements (45, 46) each arranged at predetermined

intervals and having one end which is fixed onto said base (44) and the other free end which is confronted with said nozzle apertures (41, 42) of said nozzle plate (43); wherein a gap is formed between said nozzle apertures (41, 42) of said nozzle plate (43) and said free end of said piezoelectric elements for accumulating an ink therein, characterized in that said piezoelectric elements (45, 46) are formed by alternately stacking paste-like piezoelectric material and conductive material in the form a layer, burning a lamination of said piezoelectric material and said conductive material to provide a piezoelectric plate (28), and cutting said piezoelectric plate into a plurality of piezoelectric elements with a predetermined width so that a lamination direction coincides with a main vibrating direction and a direction between said one fixed end and said other free end of said respective piezoelectric elements (45, 46), wherein said piezoelectric plate is cut into a plurality of adjacent struts (146) and piezoelectric elements."

IV. The following documents have been referred to in the appeal proceedings:

D1: EP-A 0 402 171

D3: US-A 4 072 959

D4: JP-A 60-90770 (English translation)

D8: US-A 4 729 058

V. In the written procedure and during oral proceedings, the appellant argued essentially as follows:

Claim 1 of the main request and of the first to fourth auxiliary requests required that the lamination direction of the piezoelectric elements in the print head had to coincide with the main vibrating direction. Such a print head was shown in Figures 6 to 32 of the application as filed and the patent as granted. By way of contrast, the lamination direction of the piezoelectric elements in Figures 1 to 5 of the application as filed and the patent as granted was perpendicular to a main vibrating direction. The claim was an attempt to combine features taken from these distinct embodiments, contrary to Article 123(2) EPC. The claim was an obvious combination of documents D3, D4 and D8. The feature at the end of the claim that the electrodes were connected by a conductive paint was one of a number of ways of connecting electrodes all well-known to the skilled person, see e.g. document D8.

Document D3 showed the additional feature of independent claim 1 of the fifth auxiliary request that the portion of the piezoelectric elements that was fixed to the base was free of electrodes. The subject-matter of independent claim 2 of the fifth auxiliary request lacked novelty vis-à-vis document D1.

VI. In the written procedure and during oral proceedings, the respondent argued essentially as follows:

It was permissible to claim the laminate of piezoelectric material and conductive material as produced by the method shown in Figure 3 of the application as filed, since it was clear that the laminate shown in e.g. Figure 6 of the application as filed was produced by the same method. The subject-matter of claim 1 of the main request thus met the



requirements of Article 123(2) EPC. The subject-matter of claim 1 of the main request also involved an inventive step, since it was not obvious to use conductive paint to form a collecting electrode on a piezoelectric element. Document D8 was not relevant in this respect since it did not relate to a piezoelectric vibrator. Moreover, a combination of documents D3 and D4 would not lead to the invention, because one of the electrodes would be on the free end of the vibrator, not on the portion fixed to the base as required by claim 1. Also the subject-matter of claims 1 and 2 of the fifth auxiliary request involved an inventive step, since the additional features of these claims were not rendered obvious by the cited prior art.

## **Reasons for the Decision**

### *Main request*

#### 1. *Admissibility of the amendments*

The following features of claim 1 have been added with respect to claim 1 as granted:

- (i) wherein electrical signals are applicable to each respective piezoelectric element through lines (47, 48) connected to said second collecting electrodes (27) of said respective piezoelectric elements at said one ends of said piezoelectric elements which are fixed onto said base (44)
- (ii) wherein one-side electrodes (24) are formed by said conductive material layers, said one-side

electrodes (24) being exposed on a first surface of said lamination, and wherein other-side electrodes (22) are formed by said conductive material layers, said other-side electrodes (22) being exposed on a second surface of said lamination opposite to said first surface

- (iii) wherein a first collecting electrode (26) is formed on said first surface of said lamination for contacting said one-side electrodes (24), and wherein a second collecting electrode (27) is formed on said second surface of said lamination for contacting said other-side electrodes (22)
- (iv) wherein said first and second collecting electrodes (26, 27) are formed by coating corresponding surfaces of said piezoelectric plate (28) with a conductive paint

A basis for these amendments in the application as filed (published version) is the following:  
feature (i): see Figure 6b; features (ii) and (iii): column 5, line 33, to column 6, line 9, and column 6, lines 26 to 33, and column 8, lines 48 to 53; feature (iv): column 6, lines 1 to 9.

The appellant has submitted that the method of producing the vibrators shown in Figure 3 of the application as filed pertained to the embodiments of the invention shown in Figures 1 to 5 of the application as filed, whereby the lamination direction *did not coincide* with a main vibrating direction as required by claim 1 and as shown in e.g. Figure 6 of the application as filed. The new claim was an

inadmissible attempt to claim a combination of features relating to two principally different embodiments.

The Board agrees with the appellant that Figures 1, 2, 4 and 5 of the application as filed merely illustrate the structure of a drop-on-demand printing head, which does not fall within the ambit of claim 1. Likewise, the piezoelectric vibrators mounted on a base as shown in Figures 3e and 3f of the application as filed do also not fall within the scope of claim 1. However, it is immediately evident for the person skilled in the art that the method of producing the piezoelectric vibrators as shown in Figures 3a to 3c is used to produce the vibrators shown in Figures 6 to 32 of the application as filed as well. This is also apparent from the passage in column 8, lines 48 to 53, of the application as filed (published version).

Hence, the Board is satisfied that the subject-matter of claim 1 is disclosed in the application as filed, cf. Article 123(2) EPC. The subject-matter of claim 1 is also clear and supported by the description of the patent in suit, cf. Article 84 EPC.

Since the above-mentioned features have been added, the scope of protection conferred by claim 1 is restricted with respect to claim 1 of the patent in suit as granted. Claim 1 thus meets the requirements of Article 123(3) EPC as well.

2. *Inventive step*

Document D4, which is considered to represent the closest prior art, discloses a drop-on-demand ink-jet printing head comprising a base (9), a nozzle plate (1)

defining a plurality of nozzle apertures (11), an array of piezoelectric elements (6) each arranged at predetermined intervals and having one end which is fixed onto said base (9) and the other free end which is confronted with the nozzle apertures (cf. page 1, section 3, first paragraph; page 5, lines 18 to 22 of the English translation, and Figures 1 and 2). The array is formed by cutting a piezoelectric plate into pieces. A gap (pressure chamber 2) is formed between said nozzle apertures (11) of said nozzle plate (1) and the free end of the piezoelectric elements, specifically between the nozzle plate and a vibration plate (3) for accumulating an ink therein.

In order to avoid the necessity of applying high voltages, document D4 further recommends (cf. Figure 3 and page 5, lines 23 to 34 of the English translation) to use a piezoelectric plate obtained by a lamination of a plurality of layers of piezoelectric material and a plurality of layers of conductive material (electrodes) stacked alternately in layers. Such a construction requires lower driving voltages which is mentioned as being particularly advantageous when driving a large number of nozzles.

In the Board's judgement, it was thus obvious to make the printing head shown in Figures 1 and 2 of document D4, which may comprise up to 2000 nozzles (cf. page 4, lines 20 to 22 of the English translation of document D4), by cutting a piezoelectric plate obtained by a lamination comprising layers of piezoelectric and conductive material. The conductive material layers form one-side electrodes (21) and other-side electrodes (22) on a first and second surface of the lamination, respectively. The lamination direction of the

piezoelectric elements thus formed coincides (cf. Figure 3) with a main vibrating direction and a direction between the fixed end and the free end of the piezoelectric elements.

It is clear from Figure 3 of document D4 that first and second collecting electrodes are formed on the first and second surfaces of the lamination for contacting the one-side electrodes (21) and other-side electrodes (22), respectively. These collecting electrodes extend on the top and bottom surfaces of a piezoelectric element (20) and are denoted by the reference numerals 10 and 8, respectively. On page 5, lines 28 to 34 of the English translation of document D4, it is mentioned that an electric field is applied on the piezoelectric elements, although the electrical lines themselves are not shown in Figure 3.

The subject-matter of claim 1 thus goes beyond the disclosure of document D4 in that

- the lamination of the piezoelectric material and the conductive material is burned to provide a piezoelectric plate, and in that
- electrical signals are applicable to each piezoelectric element through lines connected to the second collecting electrodes of said respective piezoelectric elements at the ends of the piezoelectric elements that are fixed onto the base, and in that
- the first and second collecting electrodes are formed by coating corresponding surfaces of said piezoelectric plate with a conductive paint.

The first difference concerns the manufacturing of the lamination of piezoelectric and conductive material. Document D4 is silent about the process of manufacturing the lamination. However, burning or firing a lamination of a paste-like piezoelectric material and a conductive material was well-known in the art before the priority date of the patent in suit. This has not been disputed by the respondent, so that there is no need for further substantiation of this matter (see also T 337/00 of 19 March 2002, point 3 of the Reasons, concerning European patent No. 0 443 628, which originated from the application 91 102 760.5 of which the application that matured in the patent in suit is a divisional).

The second distinguishing feature concerns the problem of applying electrical signals to each piezoelectric element. No positive contribution to inventive step can be seen in connecting the power lines to the electrodes at the ends of the piezoelectric elements that are fixed to the base, since this represents just one form of connection a person skilled in the art takes into consideration.

The third distinguishing feature concerns the making of collecting electrodes. It was also well-known in the art before the priority date of the patent in suit to use conductive paint to form electrodes, see e.g. document D8, column 5, lines 21 to 26. In this document a ceramic capacitor is formed (see column 2, lines 60 to 68) by stacking layers of ceramic material each having a conductive coating or electrode formed on one surface thereof. Conductive surfaces are then formed on two opposite edges of the sintered ceramic stack to join together all the electrodes extending to the

respective edges. For this purpose silver paint may be used.

The respondent did not contest that the use of conductive paint to form collecting electrodes was known in the art *per se*, but argued that it was not obvious to use this method for forming electrodes on a piezoelectric element, since these elements vibrate when an electric field is applied. This argument is not convincing, since the person skilled in the art had a reasonable expectation of success in view of the fact that the amplitude and frequency of the vibration were predictable.

Therefore, the subject-matter of claim 1 does not involve an inventive step within the meaning of Article 56 EPC, and, consequently, the main request of the respondent is not allowable.

3. Claim 1 of each of the four auxiliary requests filed on 11 October 2002 is identical to claim 1 of the main request, apart from the interchange of the words "said" and "a" before the expression "second collecting".

It follows that for the reasons given under point 2 above none of these requests is allowable either.

#### *Fifth auxiliary request*

4. *Admissibility of the amendments*

Claim 1 of the fifth auxiliary request contains, apart from the aforementioned features (ii) and (iii) (cf. point 1 *supra*), the additional feature with respect to claim 1 as granted: "and wherein said piezoelectric

elements comprise inactive regions (12a, 12a') where said one-side electrodes (24) or said other-side electrodes (22) do not exist at a portion which is fixed onto said base". This feature is disclosed in column 6, lines 37 to 41, and Figures 6a, 6b, 9, 11, 22a, 23a and 26 of the application as filed (published version). The Board is satisfied that the combination of features of claim 1 is disclosed as a whole in the application as filed.

Claim 2 of the fifth auxiliary request contains the additional feature with respect to claim 1 as granted: "wherein said piezoelectric plate is cut into a plurality of adjacent struts (146) and piezoelectric elements". This feature is disclosed in Figures 19 and 20 and in column 12, lines 16 to 24 of the application as filed (published version). The Board is satisfied that the combination of features of claim 2 is disclosed as a whole in the application as filed.

The subject-matter of claims 1 and 2 is also clear and supported by the description of the patent in suit. The scope of protection conferred by claim 1 and claim 2 has been restricted with respect to claim 1 as granted. Dependent claims 3 to 10 correspond to claims 2 to 9 as granted; the reference sign for the support member in claims 7 and 8 as granted has now been deleted in the corresponding claims 8 and 9, and the reference signs in claim 9 as granted have now been corrected in the corresponding claim 10.

Summarizing, the claims meet the requirements of Articles 84, 123(2) and 123(3) EPC.

5. *Novelty*



The subject-matter of claims 1 and 2 is novel, since none of the cited prior art documents discloses a drop-on-demand ink-jet printing head with all the features of claims 1 and 2, respectively. In particular, the feature of claim 1 that the piezoelectric elements comprise inactive regions where electrodes do not exist at the portion fixed onto the base, is not disclosed in any of the cited documents belonging to the state of the art. Likewise, the feature of claim 2 that the piezoelectric plate is cut into a plurality of adjacent struts and piezoelectric elements is not disclosed in any of the cited documents pertaining to the state of the art under Article 54(2) EPC.

The appellant has submitted that document D1, which is a prior art document under Article 54(3) and (4) EPC, was novelty destroying for the subject-matter of claim 2. However, this document fails to disclose a drop-on-demand ink-jet printing head having a base and a nozzle plate.

It follows that the subject-matter of claims 1 and 2 is novel within the meaning of Article 54 EPC.

6. *Inventive step*

A printing head comprising an array of piezoelectric elements having one end which is fixed onto the base, which elements comprise inactive regions where one-side electrodes or other-side electrodes do not exist at the portion fixed to the base (see claim 1) is neither known from nor suggested by the cited prior art. These inactive regions reduce the mechanical stress between the piezoelectric elements and the base. By choosing the length of the inactive regions to be a quarter of

the vibration wavelength, elastic waves produced by the piezoelectric elements are reflected on the surface of the base while their phases are reversed by reciprocal passage through the inactive regions, thereby contributing to the ink drop generation, cf. description of the patent in suit, column 8, lines 32 to 49.

The appellant has argued that Figure 7 of document D3 showed a comb-like arrangement of piezoelectric elements, where electrodes did not exist in a part of the comb.

Document D3, cf. Figure 7, concerns a printing head comprising a comb-like array of piezoelectric elements. The piezoelectric elements (teeth 14) comprise contact areas which are connected to printed lines 17 placed on the comb base 16 via connecting lines 18, cf. column 3, lines 29 to 34. The horizontal line, drawn just below the black dot indicating the end point of the connecting line 18 at the bottom part of the teeth depicted in Figure 7, may be construed as indicating that the contact area on the teeth 14 ends just before the comb base. However, the description of document D3 is silent about that constellation, and it does not suggest providing any inactive regions.

Moreover, document D3 does not concern a printing head comprising a lamination of alternately stacked layers of piezoelectric and conductive material. The array of piezoelectric elements shown in Figure 7, therefore, does not comprise one-side and other-side electrodes connected to respective collecting electrodes as defined in claim 1.

Therefore, document D3 does not suggest a printing head comprising piezoelectric elements formed by a lamination comprising one-side and other-side electrodes wherein inactive regions are provided in that the one-side or the other-side electrode does not exist in the respective part of the piezoelectric element.

Consequently, the subject-matter of independent claim 1 involves an inventive step.

Independent claim 2 relates to a printing head, whereby the array of piezoelectric elements is formed by cutting a piezoelectric plate into a plurality of adjacent struts and piezoelectric elements. Such a printing head is also neither known from nor suggested by the cited prior art. By using struts the distance between the nozzle plate and each of the piezoelectric elements can be controlled, and dynamic pressure can be prevented from propagating between adjacent piezoelectric elements, cf. description of the patent in suit, column 11, lines 5 to 10.

By forming the struts and the piezoelectric elements from one plate, the struts and the array of piezoelectric elements are formed in one process. Moreover, the step of attaching the strut members to the base plate is eliminated.

Consequently, the subject-matter of independent claim 2 also involves an inventive step.

The subject-matter of claims 3 to 10, which are appendant to the claims 1 and/or 2, similarly involves an inventive step.

Therefore, the request of the respondent that the patent be maintained in amended form on the basis of the documents filed as fifth auxiliary request is allowable.

## **Order**

### **For these reasons it is decided that:**

1. The decision under appeal is set aside.
2. The case is remitted to the first instance with the order to maintain the patent on the basis of the following documents:
  - (a) claims 1 to 10 filed as fifth auxiliary request during oral proceedings; and
  - (b) description: page 2 submitted during oral proceedings, and pages 3 to 9, columns 15 and 16, lines 1 to 22, as granted;
  - (c) drawings, pages 12 to 29, as granted.

The Registrar:

The Chairman:

M. Dainese

W. Moser