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Bezeichnung der Erfindung: Electron emission regulator for an X-ray tube filament
Title of invention:
Titre de l'invention :

Klassifikation / Classification / Classement : H 05 G 1'34

ENTSCHEIDUNG / DECISION

vom / of / du 21 May 1987

Anmelder / Applicant / Demandeur :

Patentinhaber / Proprietor of the patent / Titulaire du brevet : General Electric Company (Respondent)

Einsprechender / Opponent / Opposant : Siemens Aktiengesellschaft (Appellant)

Stichwort / Headword / Référence : X-ray tube filament regulator/General Electric

EPÜ / EPC / CBE Art. 56

Kennwort / Keyword / Mot clé : "Inventive step (yes)"

Leitsatz / Headnote / Sommaire

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Case Number : T 188/86

D E C I S I O N
of the Technical Board of Appeal 3.4.1
of 21 May 1987

Appellant : (Opponent)
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Representative :

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Decision under appeal :
Decision of Opposition Division ofthe European Patent Office dated 21 May 1986 rejecting the opposition filed against European patent No. 0 043 060 pursuant to Article 102(2) EPC.

Composition of the Board :

Chairman : K. Lederer
Member : H. Reich
Member : W. Moser

Summary of Facts and Submissions

I. European patent No. 0 043 060 was granted on 15 February 1984 on the basis of four claims, pursuant to European patent application No. 81 104 758.8. filed on 20 June 1981. Independent Claim 1 reads as follows:

1. a) X-ray apparatus including an X-ray tube having a filament and an anode, a filament transformer having a primary winding and a secondary winding across which the filament is connected, a high voltage transformer having a primary winding and a secondary winding connected for applying a high voltage between said anode and filament during an X-ray exposure, said last named secondary winding providing a loop circuit through which tube current between the anode and filament flows,

b) a circuit for controlling the emission capability of said filament before and during an X-ray exposure to thereby regulate said tube current during an exposure comprising:

c) a voltage regulator having input means for being supplied from a voltage source and output means for applying alternating voltage to the primary winding of said filament transformer and means for controlling said regulator,

d) means for sensing the root mean square (RMS) value of the voltage applied to said primary winding continuously during pre-exposure and exposure intervals and means responsive to the sensed voltage by producing a first dc voltage signal proportional to said sensed voltage,

e) means for producing a second dc voltage signal proportional to the current desired through said secondary winding and said filament for preheating said X-ray tube filament during the pre-exposure interval,

f) means for producing a voltage signal proportional to the high voltage which is to be applied between said X-ray tube anode and filament during an exposure and means for producing a third dc voltage signal corresponding with the last named voltage signal,

g) summing means having input and output means,

h) a circuit including a first switching device that is in a conductive state during a pre-exposure interval for applying said first, second and third voltage signals to the input means of said summing means, said summing means being operative to produce a signal to which said means for regulating responds by regulating said voltage source and, hence, the voltage applied to said filament transformer primary winding,

i) means for producing a signal representative of the magnitude of the tube current desired in said loop circuit and between said anode and filament during an exposure and for producing a signal representative of the magnitude of the tube current that is flowing after high voltage is applied to initiate an exposure, means for producing an output signal representative of the difference between said signal magnitudes,

j) a circuit including a second switching device that is in a nonconducting state during said pre-exposure interval, said circuit being connected for applying said output signal to the input means of said summing means for it to provide the signal to which said regulating means responds by regulating said filament transformer voltage, and

k) means responsive to current flow through said X-ray tube by switching said first switching device to a nonconductive state and said second switching device to a conductive state.

(The segmentation of a,b,...,k has been introduced for convenience by the Board).

II. The grant of said European patent was opposed on the ground of lack of inventive step. In support of this ground the Opponent cited the following new documents:

1. DE-A-S 27 559 VIIIC/21g
2. DE-A-2 422 844
3. US-A-3 766 391
4. DE-A-2 407 041
5. DE-A-2 102 686 (not submitted in due time)

III. By a decision dispatched 21 May 1986 the opposition was rejected on the basis of the following reasoning:
It would imply an inventive step for a skilled person to select the various circuit means claimed in Claim 1 from the multitude of circuits known from different cited documents without any further hint and to combine them to the claimed apparatus, having regard to its complexity.

IV. On 30 May 1986 the Opponent lodged an appeal against this decision, simultaneously paying the appeal fee and filing

a Statement of Grounds. The Appellant (Opponent) requested that the decision under appeal be set aside and the patent be revoked. He maintained his view that the subject-matter of Claim 1 would result from an obvious combination of above-defined claim features a), b), e) known from document (2) with claim feature c) known from document (5), claim feature d) known from documents (2), (4) or (5) respectively and claim features f) to k) known from document (1). Said view was supported by the following two arguments:

i) Claim feature d) would implicitly be known per se from document (2) because the heating filament of an X-ray tube represents an ohmic load, wherein the root mean square (RMS) value of the filament current is proportional to the RMS value of the filament voltage,

ii) the fact that claim feature d) is per se known from document (4) would clearly follow from lamps 11 and 12 connected in series with resistor 10.

V. The Respondent (Patentee) requested that the appeal should be dismissed and the patent be maintained unamended. His arguments can be summarized as follows:

An assessment of inventive step should take into account the problem underlying the subject-matter of Claim 1 as indicated in col. 2 of the impugned patent. An inventive merit could already be seen in finding out that the increasing sensitivity of the aging filament is the reason for disadvantageous over-exposures at very short exposure intervals appearing in a prior art apparatus with a pre-exposure control circuit which stabilizes the filament current at a constant set value. In the apparatus known from (2) at pre-exposure intervals the filament current

is sensed and adjusted and not the filament **voltage**. Sensing a preset maximum RMS value of the filament voltage in order to avoid filament burn-out as known from (4) does not render obvious to deviate from said known pre-exposure filament **current** control and to replace it by a filament **voltage** control.

Reasons for the Decision

1. The appeal complies with Articles 106 to 108 and Rule 64 EPC and is therefore admissible.

2. There is no objection to the current version of the claims as far as Article 123(2) EPC is concerned since they are adequately supported by the original disclosure.

3. The subject-matter of Claim 1 is novel. No prior art document describes an X-ray apparatus with a circuit for controlling the emission capability of the tube filament before an X-ray exposure comprising means for sensing the RMS value of the voltage applied to the primary winding of a filament transformer (above-defined claim feature d)).

3.1 In the X-ray apparatus known from document (1) (not comprising claim features: c, d, f, h, j, k) a current regulator instead of a voltage regulator (c) is used for filament control. The pre-exposure control is based on only a comparison between the set and the actual value of the heating **current** and comprises no means for producing a voltage signal proportional to the sensed RMS-value of the actual heating voltage (d), no means for producing a voltage signal proportional to the high voltage (f), no first switching device for applying the sum of three voltages to the input of the summing means (h) and no second switching means for applying the difference signal

between desired and flowing current to the summing means (j). Switching to exposure control using the actual value of the tube current is effected by means 12 which are not responsive to the tube current flow (k).

3.2 Document (2) describes an X-ray apparatus (not comprising claim features: c, d, h, i, j, k) with a filament current control circuit, which uses for pre-exposure and exposure intervals summing means, which compare the output signal of a proportional-plus-integral (PI) control unit with the actual and the set RMS value of the filament current. During pre-exposure intervals the PI signal is kept at a constant value and during exposure intervals it is varied according to the deviation between the set and the actual value of the tube voltage in order to stabilize it.

3.3 The summing means of the filament current control circuit in document (3) (not comprising claim features: d, e, h, i, j, k) compare the RMS value of the actual filament current during pre-exposure intervals with a voltage signal proportional to the tube voltage and the set value of the tube current and during exposure intervals additionally with the actual value of the tube current.

3.4 Document (4) describes no circuit for controlling the emission capacity of the tube filament and adjusting it during pre-exposure and exposure intervals but an overload protection means, which de-energizes the filament whenever the RMS value of the actual filament voltage surpasses a preset maximum. Thus only claim features a and d are disclosed.

3.5 Document (5) has been filed after the 9 month period provided for by Article 99 EPC. Having carefully studied this document in accordance with Article 114(1) EPC, the Board has come to the conclusion that taking into account

this document would not lead to a different judgement on novelty or inventive step than without it. Therefore, this document may be disregarded, according to Article 114(2) EPC, as not submitted in due time and, thus, does not need to be discussed further.

3.6 From US-A-4 072 865 (document (6)) cited in the description of the impugned patent there is known an X-ray apparatus (not comprising claim features: d, h, j) which differs from that defined by the wording of Claim 1 in that the known first dc voltage, which is proportional to the actual value of the filament **current** would have to be replaced by a dc voltage proportional to the RMS value of the filament **voltage** in order to correspond to claim feature d), and in that known summing means 22 would have to be shifted from the input to the output of known switching circuit 18 in order to arrive at first and second switching devices as defined by the wording of claimed features h) and j).

3.7 The remaining documents cited in the description of the impugned patent or the European Search Report do not come closer to the subject-matter of Claim 1 than document (6) and need not be discussed for this reason.

4. The question now to be considered is whether the apparatus according to Claim 1 involves an inventive step.

4.1 The Board is satisfied that - as also stated in the description of the impugned patent, column 2, lines 10 to 44 - an objective formulation of the technical problem refers to an improvement of a prior art X-ray apparatus with filament control means wherein during pre-exposure intervals the controlled condition is to keep the filament heating current at a constant value. Such an apparatus is for instance known from document (1), (2) or (6). The

objective technical problem faced therefore was to avoid in such a prior art X-ray apparatus with constant current control at pre-exposure intervals over-exposures appearing at very short exposure intervals.

It is evident that a skilled person would observe said over-exposures when using such a known apparatus. For this reason no contribution to inventive step is to be found in the recognition of the technical problem. The Board takes the view that a skilled person can be expected to find out the technical reason of the observed over-exposure by normal routine work. This means that a skilled person is regarded to be able to find out that the increasing resistivity of the aging filament and the constant current control during pre-exposure intervals cause higher filament temperatures than required for the set value of tube current during exposure intervals and that a thermal lag during the subsequent cooling down of the filament allows a known control circuit for exposure intervals to restrict the tube current to its set value only after a certain exposure time.

4.2 The Appellant's line of argumentation in point IV above leads to consider the following two items:

4.2.1 Would it be obvious to arrive at an apparatus with claim features a) to c) and e) to k) by combining features which are per se known from various prior art documents, and

4.2.2 would it be obvious to further apply in such an apparatus claim feature d), which the Appellant regards to be per se known from document (2) or (4) respectively?

4.3 Item 4.2.2 is regarded to be the crucial point in an assessment of inventive step, because in the Board's view claim feature d) forms the essential characteristic of the

Respondent's solution of the technical problem stated in point 4.1. The question of an inventive step underlying the subject-matter of Claim 1 reduces thus to the point of finding out whether it is obvious for a skilled person to replace in an apparatus with claim features a) to c) and e) to k) means for sensing the actual value of the filament heating **current** by RMS value-sensing means of the filament **voltage** in order to avoid said over-exposures. In the Board's view this replacement was not obvious for the following reasons:

4.3.1 In document (4), the only document in which a sensor producing a dc voltage signal proportional to the actual RMS value of the filament voltage is disclosed, this sensor is not part of a circuit for controlling the electron emission from the filament but part of means to protect the filament against overload. For this divergent purpose said known dc voltage signal is supplied to the input of a trigger circuit, which at a preset maximum value of the known signal de-energizes the filament. There is no hint in the prior art to use a dc voltage proportional to the RMS value of the actual filament voltage within control means adjusting operating parameters of an X-ray tube. The input voltage of a de-energizing trigger circuit does not incite a skilled person to input the same voltage together with a second dc voltage signal, which is proportional to the filament current desired for preheating the filament during the pre-exposure interval, and a third dc voltage, which is proportional to the tube voltage during the exposure interval, into summing means, the output of which is used to regulate the filament voltage during pre-exposure intervals.

Moreover, a skilled person is not regarded to be able to foresee, that in a prior art X-ray apparatus with constant

current control at pre-exposure intervals a replacement of means, which produce a dc voltage signal proportional to the actual filament current, by means, which produce a dc voltage signal proportional to the RMS value of the actual filament voltage, will allow to avoid said known over-exposures. Such a replacement would change the controlled condition during pre-exposure intervals from keeping the filament current constant to keeping the filament voltage constant. There is no hint in the prior art that - although at constant voltage the increasing resistivity of the aging filament during pre-exposure intervals causes lower filament temperatures than required for the set value of the tube current during exposure intervals - a known tube current control circuit for exposure intervals is able to increase the tube current to its set value right away at the starting point of the exposure interval without any thermal lag in heating up the filament.

4.3.2 With regard to the control system known from document (2) the Board cannot follow the Appellant's view, that the sensing means for the RMS value of the actual tube current used therein should be regarded as an implicit disclosure of sensing means for the RMS value of the actual filament voltage; see point IV(i) above. Such an interpretation would above all necessarily require that the actually sensed value of the filament current always allows to deduce therefrom unambiguously the exact value of the filament voltage, i.e. that an exact linear proportionality between current and voltage and with that a constant resistivity of the filament is guaranteed in the whole working range. However, the resistivity of filaments changes with temperature and age. Moreover, the filament current means in the apparatus known from document (2) are part of control system adjusting the filament current to a value which is - via the resulting tube current -finally compared with the set value of the

tube voltage, so that the known controlled condition is to keep the tube voltage constant. This fact would prevent a skilled person from recognizing in the current sensing means described in document (2) any necessity for sensing the RMS value of the filament voltage or even to recognize therein a means which allows to prevent said over-exposures.

4.3.3 For the reasons set out in points 4.3.1 and 4.3.2 above, the Board regards it also not obvious to replace in the apparatus known from document (6) - see also point 3.6 above - known means 20 producing a first dc voltage, which is proportional to the actual value of the filament current by means producing a first dc voltage, which is proportional to the actual RMS value of the filament voltage.

4.4 In view of the above given findings that the incorporation of feature d in a device already comprising features a-c and e-k of Claim 1 is not obvious, it is not necessary to examine if, possibly, even such combination of features (without d) would be obvious or not.

However, it should be noted, that contrary to the Appellant's view stated in point IV above, the Board is satisfied, that in document (1) there is no disclosure of claim features f, h, j and k for the reasons set out in point 3.1 above.

5. The Board's view therefore is that the subject-matter of Claim 1 would not have been obvious at the priority date from all the documents relied on in the pending proceedings or those cited in the patent specification.

Consequently, the subject-matter of Claim 1 involves an inventive step within the meaning of Article 56 EPC. The claim can therefore be maintained.

The dependent Claims 2 to 4 concern particular embodiments of the apparatus according to Claim 1 and can likewise be maintained.

Order

For these reasons, it is decided that:

The appeal against the decision of the Opposition Division is dismissed.

The Registrar: The Chairman:

J. Rückerl K. Lederer