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D E C I S I O N
of 30 September 1998

Case Number: T 0974/94 - 3.4.1

Application Number: 90125862.4

Publication Number: 0444324

IPC: G01T 1/164

Language of the proceedings: EN

Title of invention:
Method for removing artifact and for correcting sensitivity of single photon emission computerized tomography and apparatus thereof

Applicant:
Kabushiki Kaisha Toshiba

Opponent:
-

Headword:
Spect image apparatus/KABUSHIKI KAISHA TOSHIBA

Relevant legal provisions:
EPC Art. 83, 56

Keyword:
"Inventive step (no: main, first auxiliary and third auxiliary request)"
"Sufficiency of disclosure (no: second auxiliary request)"

Decisions cited:
T 0694/92

Catchword:
-

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Case Number: T 0974/94 - 3.4.1

D E C I S I O N
of the Technical Board of Appeal 3.4.1
of 30 September 1998

Appellant: Kabushiki Kaisha Toshiba
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Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 29 July 1994 refusing European patent application No. 90 125 862.4 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: G. Davies
Members: H. K. Wolfrum
U. G. O. Himmler

Summary of Facts and Submissions

I. European patent application 90 125 862.4 is entitled "Method for removing artifact and for correcting sensitivity of single photon emission computerized tomography and apparatus thereof". The application was refused by a decision of the examining division dated 29 July 1994, on the grounds of lack of inventive step of the subject-matter of the independent claims 1 and 6 then on file having regard to document D1 and conventional practice in the technical field at issue, contrary to the requirements of Articles 52(1) and 56 EPC.

II. On 27 September 1994 the applicant lodged an appeal against the decision and paid the prescribed fee. A statement of grounds of appeal was filed on 29 November 1994.

Together with the statement of grounds a set of new claims 1 to 7 was filed, replacing the previous claims on which the contested decision was based. In addition, amended pages 1 to 3 of the description were filed.

The appellant requested

- the grant of a patent on the basis of the amended claims and description;

- oral proceedings in the event that the Board of Appeal could not agree that the subject-matter of claim 1 was patentable.

III. In a communication dated 19 June 1998, accompanying a summons to oral proceedings, the Board raised objections as to the introduction of subject-matter extending beyond the content of the application as filed (Article 123(2) EPC), as to lack of clarity (Article 84 EPC) and sufficiency of disclosure (Article 83 EPC).

Moreover, by making reference to documents:

D1: IEEE TRANSACTIONS ON NUCLEAR SCIENCE, vol. NS-32, No. 1, February 1985, pages 741-747;

D2: THE JOURNAL OF NUCLEAR MEDICINE, vol. 27, No. 6, June 1986, pages 810-819;

D3: THE JOURNAL OF NUCLEAR MEDICINE, vol. 25, No. 8, August 1984, pages 893-900; and

D4: PATENT ABSTRACTS OF JAPAN, vol. 12, No. 58, (P-669), 20 February 1988 & JP-A-62 203 077.

the Board saw no inventive step (Articles 52(1) and 56 EPC) involved in the claimed subject-matter. In introducing documents D2 to D4, the Board exercised its discretion under Article 114 (1) EPC.

IV. By a letter filed on 26 August 1998 the appellant filed a new set of claims 1 to 7, replacing the claims previously on file as a main request, and replacement pages 1 and 2 of the description.

As a first auxiliary request, the appellant suggested a claim 1 being a combination of claims 1 and 8 of the main request. Additionally the appellant suggested wording amendments to claim 1 as further auxiliary requests.

V. Oral proceedings were held on 30 September 1998.

In particular the issues of sufficiency of disclosure and inventive step were extensively discussed.

The appellant requested that the decision under appeal be set aside and that the patent be granted on the basis of

- **main request**: claims 1 to 8 filed on 26 August 1998; with pages 1 and 2 of the description filed on 26 August 1998, page 3 filed on 27 September 1994 and pages 4 to 21 as originally filed; and Figures 1/17 to 17/17 as originally filed;

- **first auxiliary request**: claim 1 filed in the oral proceedings, claims 2 to 8 and description as for the main request; Figures as originally filed;

- **second auxiliary request**: claims 1 to 7 filed in the oral proceedings; pages 1 and 3 to 21 of the description as for the main request, with amended page 2 filed in the oral proceedings; Figures as originally filed;

- **third auxiliary request**: claims 1 to 7 filed in the oral proceedings; description as for the main request; Figures as originally filed.

VI. Independent claim 1 of the main request reads as follows:

"1. A single photon emission computerized tomographic (SPECT) image apparatus comprising:
data acquiring means (2) acquiring both first projection image data by receiving via a fan-beam collimator (7) first radiation emitted from a source (9) of reference radio isotopes (RI), and also second

projection image data by receiving via the fan-beam collimator (7), second radiation emitted from a radio isotope injected into a biological body under medical examination, with employment of a gamma camera, which is rotated around a center of rotation along with said collimator (7), relative to said body;
artifact removing means (5) processing said first projection image data to obtain first correction data ($1/U(x, y_0)$) based on the first projection data and sensitivity distribution data, and for correcting said second projection image data based upon said first correction data to obtain third projection data from which an artifact component caused by fluctuation in the character of the fan-beam collimator has been removed;
reconstructing means (3) for reconstructing a SPECT image of the biological body under medical examination based on said third projection image data and free from the artifact component,
wherein said reference radio isotopes (RI) source (9) is a flat radio isotope vessel (9) located near the center of rotation of the gamma camera (8) and at a distance parallel to the surface of said collimator (7)."

Independent claim 1 of the first auxiliary request reads:

"1. A single photon emission computerized tomographic (SPECT) image apparatus comprising:
data acquiring means (2) acquiring both first projection image data by receiving via a fan-beam collimator (7) first radiation emitted from a source (9) of reference radio isotopes (RI), and also second projection image data by receiving via the fan-beam collimator (7), second radiation emitted from a radio isotope injected into a biological body under medical examination, with employment of a gamma camera, which

is rotated around a center of rotation along with said collimator (7), relative to said body;
artifact removing means (5) for processing said first projection image data to obtain first correction data ($1/U(x, y_0)$) based on the first projection data and calculated sensitivity distribution data, and for correcting said second projection image data based upon said first correction data to obtain third projection data from which an artifact component caused by fluctuation in the character of the fan-beam collimator has been removed;
reconstructing means (3) for reconstructing a SPECT image of the biological body under medical examination based on said third projection image data and free from the artifact component,
wherein said reference radio isotopes (RI) source (9) is a plane vessel containing a plane radio isotope vessel unit (13) which constitutes a volume containing radio isotopes, and extends through the SPECT effective field, the vessel unit (13) having a constant thickness and being so thin that the absorption of gamma radiation within the vessel unit is negligible; the plane vessel unit (13) being arranged parallel to the surface of the collimator."

Independent claim 1 of the second auxiliary request is based on claim 1 of the first auxiliary request and additionally defines:

"sensitivity correcting means (6) for calculating a plurality of fourth projection image data by receiving, via the fan-beam collimator (7), radiation emitted from radio isotopes uniformly distributed within an effective field of said gamma camera (8), and correcting the obtained projection image data based upon the first correction data so as to obtain SPECT image data of the radio isotopes uniformly distributed within the effective field, for processing the SPECT

image data to produce second correction data, and for correcting said reconstructed SPECT image data of the biological body based upon the second correction data, whereby a sensitivity of said fan-beam collimator (7) is corrected in said reconstructed SPECT image data."

Independent claim 1 of the third auxiliary request is based on claim 1 of the main request and additionally defines that:

"said artifact removing means (5) obtains the first correction data ($1/U(x, y_o)$) based on value ($U(x, y_o)$) which is obtained by dividing the first projection data by the sensitivity distribution data."

VII. In support of its requests the appellant essentially relied on the following submissions:

1. Amendments (Article 123(2) EPC)

Claim 1 of the main request is based on original claim 8 in combination with features disclosed in particular on pages 12 and 14 of the description, further specifying the artifact removing means and the reference radio isotopes source.

Claim 1 of the first auxiliary request adds further features to the definition of the reference radio isotopes source as disclosed in the description.

Claim 1 of the second auxiliary request is in principle a combination of the features indicated in claims 1 and 5 of the first auxiliary request.

Claim 1 of the third auxiliary request combines claims 1 and 8 of the main request.

2. Sufficiency of disclosure (Article 83 EPC)

The present invention aims at an improved correction of errors in obtaining SPECT images with a fan-beam collimator/gamma camera data acquisition system. When acquiring data from a biological object with such systems, the data are flawed by geometrical imperfections of the collimator, as for instance variations in the thickness of collimator and fluctuations in the diameters of the collimator holes. These imperfections are the source of so-called "ring-shaped artifacts" in the measured data. In addition, the sensitivity of the collimator may deviate from a theoretically expected ideal distribution over the extension of the collimator.

In prior art SPECT image apparatuses data for correcting these errors were obtained by acquiring data from a three-dimensional reference source of radio isotopes. The correction data reflected the two types of errors in combination and, in addition, were not accurate because of the effects of scattering and absorption of gamma radiation within the three-dimensional reference source.

The present invention overcomes this deficiency by correcting the ring-shaped artifact in a first stage by means of artifact removing means, using a plane, thin reference source arranged at a distance parallel to the surface of the collimator. This first stage is separate from a subsequent stage of correcting sensitivity effects by means of sensitivity correcting means, by performing measurements which include a "distance" information, as explained on page 8, line 27 to page 9, line 5 of the description on file.

The originally-filed application documents provide a clear technical teaching for a separate correction of geometrical deficiencies of the collimator (i.e. the ring-shaped artifact) and of sensitivity effects. The documents teach a clear sequence of measures to be taken and define the corresponding apparatus features with which these measures can be put into practice.

As is evident from Figures 13, 14, 19 and 20 and the corresponding description as filed, the ring-shaped artifact is separately corrected by measuring the radiation emitted from the flat reference source. The acquired set of data (set "A") is normalized and set into relation with a calculated set of data (set "B") reflecting a theoretically expected ideal sensitivity distribution for the collimator. The inverse of the resulting set of data (set "U"), which reflects exclusively the ring-shaped artifact component in the acquired data, is stored as first correction data in a memory and used for correcting the ring-shaped artifact in data (data "I") acquired from a biological body under examination. From the corrected data an image of the body is reconstructed.

It is apparent in particular from page 8, line 27 to page 9, line 5 of the description, that the correction performed by the first correction data does not include a sensitivity correction. Moreover, the ring-shaped artifact included in the data "A" acquired from the flat reference source would not be depending on the distance between the

collimator and the reference source. Therefore, the artifact correction data obtained for a given distance would be effective for other distances, as they occur between different regions of the biological body and the collimator, as well.

The sensitivity correction, which is performed on the artifact-free reconstructed image data of the biological body, is based on radiation which is emitted from radio isotopes uniformly distributed within an effective field of the gamma camera and received via the fan-beam collimator, as is evident from original claim 3 and page 16, lines 14 to 21 of the description. As is further apparent from Figures 15, 18, 19 and 20 and the corresponding description, the radiation signals received as projection data from this second reference source are used to reconstruct image data (data "C"), the inverse of which is stored in another memory and forms second correction data used for the sensitivity correction.

This sensitivity correction data is corrected for the ring-shaped artifact and thus is not reintroducing this artifact when the sensitivity correction is performed, as would be evident from page 15, line 36 to page 16, line 13 of the originally-filed description.

3. Inventive step (Articles 52(1) and 56 EPC)

The invention as defined in claim 1 of the main request is not rendered obvious by the prior art. Even the closest prior art given by document D2 lacks any recognition of the problem associated with the two different sources of image errors: the ring-shaped artifact and the uneven sensitivity of the collimator/camera system.

Moreover, document D2 does not teach essential features of the claimed solution in that it does not perform a separate correction of the two errors and does not use a flat reference source as defined in claim 1 of the main request and required for the isolated correction of the ring-shaped artifact. As is apparent from pages 813 and 814 of D2 the reference sources are either point or line sources or cylindrical containers. Finally, D2 does not hint at artifact removing means capable of performing the respective data processing steps specified in claim 1.

Document D3 refers to a completely different type of SPECT image apparatus as well as to a different process of image correction. As is apparent from page 894, right-hand column, the apparatus according to D3 does not have a fan-beam collimator but employs parallel-hole collimators. Moreover, as is apparent for instance from the abstract of this document, image and correction data are acquired from different pulse-height windows, respectively. In view of the substantial difference in the collimator structure and the different data correction technique, the reference made on page 895 of D3 to a sheet source as reference source of radio isotopes has to be regarded as a passing remark only. D3 does not give the skilled reader the slightest hint to isolate this incidental piece of information from its disclosed proper context and to apply it in an apparatus as known from D2.

Reasons for the Decision

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

2. *Amendments*

The subject-matter of the claims of the requests on file is, in principle, to be found in the originally-filed application documents. Therefore, for the purpose of this decision, the Board does not address the issue of Article 123(2) EPC.

3. *Inventive step (Articles 52(1) and 56 EPC)*

3.1 Main request

3.1.1 The closest prior art is represented by document D2 (see in particular the abstract; Figures 2 and 4; and the description on pages 810 to 815), from which a SPECT image apparatus is known having data acquiring means for acquiring first projection image data by receiving, via a fan-beam collimator, first radiation emitted from a source of reference radio isotopes, and also second projection image data by receiving, via the fan-beam collimator, second radiation emitted from a radio isotope incorporated within a body under examination (e.g. a "phantom"), with employment of a gamma camera, which is rotated around a center of rotation along with said collimator, relative to said body. The source of reference radio isotopes is given by a line source arranged at a distance parallel to the surface of the collimator. In one of the examples included in Figure 4A (i.e. that for a distance of 15 cm) the reference source is located at the center of rotation of the gamma camera, as is apparent from a

comparison with information provided in the second paragraph in the right hand column of page 810. It is further evident from Figure 4A of D2 in combination with equations (4) and (5) given on page 812 and the information provided by the chapters "Measurements of Physical Characteristics" and "Image Reconstruction and Attenuation Correction" on pages 813 and 814, that the apparatus according to D2 comprises means which remove artifacts from the data received from the body under examination by taking the theoretically expected ideal sensitivity distribution for the fan-beam collimator into account. These means, which further reconstruct SPECT images of the body from the corrected data, apparently consist of data processing means with associated memories for storing data, and thus are to be considered as being capable of performing data processing operations as defined for the artifact removing means and reconstructing means according to claim 1 under consideration.

Thus, as far as claim 1 under consideration defines the elements of a SPECT image apparatus and their mutual arrangement, its subject-matter differs from the apparatus known from D2 only in that the reference radio isotopes source is a flat radio isotope vessel.

3.1.2 The data obtained for a line reference source as shown in Figure 4A of document D2 and its relationship to theoretically expected data is in principle identical to the data obtained for a flat reference source according to the specific embodiment of Figure 13A of the present application.

For this reason, the Board cannot accept the appellant's submission that it is the choice of a flat reference source which would allow for a correction of an artifact component (a so-called "ring-shaped artifact") separate from sensitivity corrections.

Thus, contrary to the opinion expressed by the appellant, the objective problem associated with the choice of a flat reference source is not the quest for an improved quality of the correction of image data by a separate correction of the individual sources of errors and artifacts, but merely the desire to look for a suitable alternative to the reference source used according to D2.

In this context the Board notes that, according to page 1, line 36 to page 2, line 2 of the originally-filed application description, uneven or unbalanced sensitivity is the result of a low focusing precision of the fan-beam collimator (i.e. a misalignment in the inclination of the collimator holes). Thus an uneven sensitivity, within the meaning of the present application, is caused by geometrical imperfections of the collimator, as is the ring-shaped artifact. Therefore, the data obtained via one collimator from a one- or two-dimensional reference source (as the data "A" shown in Figure 13A of the application or the data shown in Figure 4A of D2) must inevitably reflect in combination all errors caused by the geometrical imperfections of this collimator so that the derived correction data not only correct for a ring-shaped artifact but for an uneven sensitivity as defined by the present application as well.

3.1.3 The alternative of using a sheet reference source (and thus a flat source) for the purpose of acquiring correction data to compensate for a non-uniform detector response in a SPECT image apparatus is known from D3 (cf. pages 894 to 895, "data acquisition and reconstruction").

In the Board's opinion, the SPECT image apparatuses disclosed by documents D2 and D3 are so closely related that the skilled practitioner working with such apparatuses would have readily contemplated the use of a flat reference source as known from D3 as an alternative to the line reference source in the apparatus as known from D2.

3.1.4 Contrary to the opinion expressed by the appellant, fan-beam collimators, as used according to D2, and parallel-hole collimators, as used according to D3, are technically closely related types of collimators, which possess for instance spatial resolutions and relative geometric efficiencies of the same order of magnitude, as is evident from document D2 (cf. Figure 6 and the corresponding description on pages 815 and 816).

Moreover, the Board does not recognize any relevant difference between the SPECT image apparatuses according to D2 and D3 in the fact that according to D3 the gamma radiation is received in two different pulse-height windows. The proper choice of suitable pulse-height windows, according to the specific radio isotopes used in the reference source and the body under examination, is a matter of routine practice followed by the skilled person. Such a choice has to be made by the skilled person also when following the teaching provided by D2 as well as when operating an apparatus as defined by claim 1 under consideration. Apart from that it is noted that neither claim 1 of the main request nor any other claim on file comprises a limitation as to the choice of the radio isotopes or to the number and kind of respective pulse-height windows of the gamma camera.

3.2 First auxiliary request

3.2.1 Independent claim 1 of the first auxiliary request specifies in addition to claim 1 of the main request

(a) that the first correction data ($1/U(x, y_o)$) are based on "calculated" sensitivity distribution data, and

(b) that the flat reference source is a plane vessel containing a plane radio isotope vessel unit which constitutes a volume containing radio isotopes, and extends through the SPECT effective field, the vessel unit having a constant thickness and being so thin that the absorption of gamma radiation within the vessel unit is negligible.

3.2.2 In the Board's opinion, feature (a) would have been obvious from Figure 4A of document D2 showing in addition to the data acquired from the reference source the theoretically calculated sensitivity distribution for the fan-beam collimator.

Moreover, in the Board's opinion, feature (b) would have constituted a simple and straightforward design option for a practically useful vessel unit of a reference source because the skilled person would have known from document D3 about the use of a flat reference source of radio isotopes and from both documents D2 and D3 about the fact that such isotopes are normally diluted in water.

3.3 Third auxiliary request

Claim 1 of the third auxiliary request defines in addition to claim 1 of the main request the artifact removing means by a specific process for obtaining the

first correction data, the process consisting of the step of dividing the first projection data (acquired via the fan-beam collimator) by the (theoretically calculated)first projection data (acquired via the fan-beam collimator) by the (theoretically calculated) sensitivity distribution data.

In the Board's opinion, such a process would have been rendered obvious to the skilled person by Figure 4A of document D2, showing first projection data and comparing them with theoretical sensitivity distribution data calculated with the help of formulas. In this context, the Board notes that in particular equations (1), (4) and (5) given on pages 811 and 812 of document D2 correspond to equation (5) which is indicated on page 9 of the application description and is used, according to page 12, lines 21 to 23 of the description, for the calculation of the sensitivity distribution data "B".

3.4 For the foregoing reasons, in the Board's judgement, the subject-matter of claim 1 of the main request, as well as the subject-matter of the first and the third auxiliary requests do not involve an inventive step within the meaning of Article 56 EPC. These claims are therefore not allowable.

The corresponding dependent claims are not allowable insofar as they presuppose an allowable independent claim.

4. *Sufficiency of disclosure (Article 83 EPC)*

4.1 Article 83 EPC requires an invention to be disclosed in a manner sufficiently clear and complete for it to be carried out by a person skilled in the art.

For the purpose of Article 83 EPC the skilled person would have had to be in a position, at the priority date and on the basis of the description in the application in suit together with the knowledge provided by the prior art, to achieve the technical effect the invention seeks to contribute to the state of the art (see T 694/92, OJ EPO, 1997, 408).

This presupposes that the definitions provided by the claims, when interpreted in the light of the description, have a clear and unambiguous meaning and that the technical measures disclosed by the application documents as a whole lead the skilled person in a straightforward manner to a successful solution of the technical problem without undue burden and without the application of inventive skill.

4.2 In the present case, claim 1 of the second auxiliary request as well as dependent claims 5 of the main, the first and the third auxiliary request define a SPECT image apparatus having sensitivity correcting means in addition to and distinguished from artifact removing means.

On page 2, line 27 to page 3, line 3 of the originally-filed description it is stated that, due to the fact that the correction methods performed by prior art SPECT image apparatuses carry out the correction for the ring-shaped artifact and the sensitivity simultaneously, "both the sensitivity correction for the SPECT system (especially fan-beam collimator) and ring-shaped artifact elimination may not be precisely executed because the resultant SPECT image data still contains unevenness caused by scattering phenomenon of

the gamma ray". Consequently, as stated on page 3, lines 7 to 13 of the description, the invention "has an object to provide a novel ... apparatus ... capable of separately eliminating the ring-shaped artifact caused by a fan-beam collimator and of correcting an uneven sensitivity mainly caused by this collimator".

The importance, which the correction of the sensitivity of the fan-beam collimator in addition to and separate from the correction of the ring-shaped artifact component has for the invention, is confirmed throughout the description (cf. for instance page 6, lines 1 to 5; page 10, line 30 to page 11, line 1; page 11, lines 18 to 28; page 14, line 32 to page 15, line 5; page 18, line 18 to page 19, line 9; and page 21, lines 5 to 12).

4.3 The definition provided by claim 1 of the second auxiliary request and the technical information provided by the disclosure of the application documents give rise to a variety of questions:

4.3.1 It is not unambiguously clear what exactly is defined by the terms **sensitivity** and **sensitivity correction**.

From the statements "Also, if the fan-beam collimator owns low focusing precision, uneven or unbalanced sensitivity occurs. Further if machining precision of the collimator is lowered, a ring-shaped artifact may happen to occur in a SPECT image. Both of the uneven sensitivity and ring-shaped artifact are superimposed on the sensitivity profile curve.", given on page 1, line 36 to page 2, line 6 of the original description, as well as from page 8, lines 25 to 26; page 10, lines 33 to 34; page 11, lines 26 to 27; page 15, lines 4 to 5; page 16, lines 4 to 5 and 10 to 11; and page 19, lines 4 to 5 of the description, it is evident that "unbalanced" or "uneven sensitivity" is attributed

to the fan-beam collimator and is due to a geometrical imperfection of the collimator (more specifically, an error in the focussing precision of the collimator holes), as is the ring-shaped artifact or "artifact component" (which arises from non-uniformities of the collimator thickness and the diameters of the holes).

In the Board's opinion, data acquired by a given fan-beam collimator would reflect all structural imperfections inherent to this collimator. There is no technical reason recognizable why such data would include the effect of only one type of geometric imperfection (as the ring-shaped artifact) but would not be influenced by another type of geometric imperfection present in the same collimator.

Thus, as already pointed out in paragraph 3.1.2 above, any data (as for instance the data "a" shown in Figure 13A of the application or those shown by Figure 4A of document D2) which are obtained by a given collimator from a reference source must inevitably comprise the effects of all types of geometrical imperfections present in the collimator. In consequence, when interpreting the term "uneven sensitivity" as referring to a geometrical imperfection of the collimator, as it is done in the cited disclosure, the effect thereof must be included in the "first correction data" obtained by the artifact removing means as defined in claim 1, as is the effect of the "artifact component", so that the sensitivity is necessarily corrected at the same time and with the same first correction data used for correcting the ring-shaped artifact.

This finding, however, is in apparent contradiction to the claim for a separate correction of the (ring-shaped) artifact component and the sensitivity as defined in claim 1 under consideration and likewise repeatedly asserted throughout the description.

Neither the application documents on file nor the available prior art provide any information which would allow the skilled person to resolve this ambiguity in the meaning of the term "sensitivity" so that the skilled person has no clue of what exactly would be corrected by the additional step of "sensitivity correction" defined in claim 1.

The appellant refers in this context in particular to the description on page 8, line 27 to page 9, line 5 as evidence that the first correction data does not include a sensitivity correction.

In the Board's opinion this citation, which reads: "As represented in Fig. 7 (meaning probably Figure 10) , in accordance with a projection distribution P(Θ) of the radio isotope along a direction of 1-1', since the radio isotope has been distributed between "1" and "1'", the projection data is acquired according to the sensitivity/resolution characteristics of this position. Any information on the length or the like of the distribution 1-1' cannot be obtained from the thus acquired projection data, so that the sensitivity correction cannot be performed. As a consequence, since the sensitivity correction may not be executed unless the distribution position has been judged, it may be recognized that the above-described sensitivity correction should be performed on the reconstructed SPECT image.", does not provide unambiguous technical information and thus is not suited to clarify the issue. The ambiguity is at least in part due to the use of expressions, like "distribution 1-1'" or

"distribution position", which have no technically recognizable meaning. Moreover it is not understandable which technical relationship would exist between the sensitivity of the fan-beam collimator and a distribution of radio isotopes.

4.3.2 It is not unambiguously clear what exactly is corrected by the "artifact removing means".

It is apparent from a comparison with the prior art given in particular by Figure 4A of document D2 that the effect caused by the geometrical imperfections of the fan-beam collimator strongly depends on the distance "b" between the collimator and the reference source of radio isotopes. Thus, the absolute values for the first correction data obtained by artifact removing means, as defined in claim 1 under consideration and disclosed by Figures 13 and 14 of the application, would significantly differ for different distances "b", so that the correction based upon a single set of first correction data obtained for a specific distance "b", as indicated by the term "correct distance" given in line 2 of page 14 and by the expression "acquired under the known distance "b"" given in lines 21 to 22 of page 15, leads only to an exact correction of image data originating from a specific plane within the body under examination, which plane corresponds to the location of the plane reference source at said distance "b".

In this respect, the original disclosure does not provide any indication as to under which circumstances first correction data determined from a plane reference source arranged at one specific distance from the

surface of the collimator could possibly result in a satisfying correction of image data corresponding to other regions of an extended body which regions would be located significantly apart from the location of the reference source.

The assertion made by the appellant that the ring-shaped artifact included in the data "a" acquired from the plane reference source would not be depending on the distance between the collimator and the reference source and that, therefore, the artifact correction data obtained for a given distance would be effective for other distances, as they would occur between different regions of the biological body and the collimator, as well, cannot be accepted in the light of the technical evidence provided by document D2.

The aforementioned ambiguity in the artifact removing process raises in turn serious doubts as to the nature and structure of the artifact removing means and as to what exactly would be corrected by the two separate sets of correction data defined in claim 1 under consideration.

4.3.3 Apart from the question discussed under 4.3.1 above what exactly would be corrected by the "sensitivity correction" as defined in claim 1, it is even not clear from the whole content of the application documents, how and by which means such a correction would be performed.

(1) First of all, it is unclear what would form the source of radio isotopes from which the radiation data is received which is then processed to produce the second correction data.

The appellant submits that this source would be a second reference source of radio isotopes which are uniformly distributed throughout the effective field of the gamma camera.

This submission, however, has no support in the definition provided by claim 1 under consideration nor in the application documents as filed:

According to originally-filed claims 3 and 12, the radiation received by the sensitivity correcting means is "emitted from radio isotopes uniformly distributed within an effective field of said gamma camera so as to obtain SPECT image data of the radio isotopes uniformly distributed within the effective field".

The description of Figure 15 on page 16, lines 14 to 21 refers to the steps of acquiring ""n" pieces ... of projection data" and of calculating, based upon the fan-beam projection data, "a SPECT image: C(x,y) of the radio isotope which has been uniformly distributed within the effective field". The corresponding flow chart of Figure 15 defines the steps "S-20":"acquire n pieces of projection data in case that radio isotopes are uniformly distributed within the effective field" and "S-21":"calculate SPECT image C(x,y) of RI uniformly distributed in effective field".

The cited information thus consistently refers to radio isotopes "uniformly distributed within" the effective field of the gamma camera.

The Board notes in this respect that the disclosed definition does not necessarily mean that the radio isotopes have to be distributed **throughout all** of the effective field (as long as their

distribution is **uniform** and **within** the effective field). Therefore, the conditions set by the original disclosure for obtaining the second correction data could be met for instance by the plane reference source used for obtaining the first correction data as long as this source is located within the effective field and has a uniform distribution of radio isotopes throughout its plane.

In view of the fact that no further information is available as to the reference source of radio isotopes from which the second correction data is derived, the skilled reader of the application documents as filed cannot know the true nature and exact extension of the required reference source. Nor would the skilled person obtain the missing information from the prior art to which a procedure of obtaining different sets of correction data from various reference sources is unknown. Without such knowledge, however, it is impossible to derive well-defined correction data in a reproducible manner.

(2) Secondly, it is unclear whether projection data have to be measured in one direction (i.e. in a single direction, as indicated by Figure 18) or have to be acquired from a plurality of projections (as indicated by Figure 15) in order to calculate therefrom image data (data "C") from which second correction data are obtained.

In the latter case no information is disclosed as to how the data from the plurality of projections would have to be combined in order to obtain the calculated image data "C (x,y)".

It is not plausible that correction data obtained according to the two alternatives would be identical. This raises further doubts as to what would be the correct second correction data.

(3) Finally, it is not conceivable why the projection data acquired by the sensitivity correcting means, using the same fan-beam collimator as employed by the artifact removing means, would not be influenced by the ring-shaped artifact.

By referring specifically to page 15, line 36 to page 16, line 3 of the description, the appellant submits that the second correction data is corrected for the ring-shaped artifact so that this artifact is not reintroduced into the image data when the sensitivity correction is performed.

This submission is, however, not supported by the content of this citation, which reads: "As previously stated, based upon the projection image data from which the ring-shaped artifact component has been removed, a SPECT image is reconstructed in the image reconstruction unit 3 shown in Fig. 4. In the sensitivity correction unit 6 for correcting the sensitivity of the fan-shaped collimator 7, sensitivity correction data is formed by utilizing the reconstructed SPECT image data in accordance with a process operation as defined in a flowchart represented in Fig. 15, and thereafter stored into a sensitivity correction table memory (not shown in detail). Subsequently, the sensitivity mainly caused by the collimator 7 is corrected based upon the sensitivity correction data stored in the sensitivity correction table memory in accordance with a flowchart shown in Fig. 16.", nor by the rest of the application documents.

In this citation a clear distinction is made between the "projection image data" from which the ring-shaped artifact component has been removed and which concerns data obtained from the **body under examination**, as is evident from the reference to the reconstruction unit 3, and, on the other hand, the "reconstructed SPECT image data" from which the sensitivity correction data is derived and which expressly concerns data obtained with a process operation as defined in the flowchart of Figure 15 and thus originating from radio isotopes uniformly distributed in the camera's effective field. There is not the slightest indication in the originally-filed application documents that the latter data would be corrected for any artifact component.

4.4 In summary, in view of the aforementioned inconsistencies and the lack in the originally-filed application documents of essential technical information as to the nature and effects of the disclosed correction procedures, the skilled person would have to carry out complex investigations in order to explore the technical possibilities for correction and to complete the missing information. Such activities, however, would clearly require more than a reasonable amount of experimentation and would even require the application of inventive skill. Therefore, the Board has come to the conclusion that the application documents as a whole, even when interpreted in the light of the background of the teaching provided by the relevant prior art, do not enable the skilled person to devise in a straightforward manner a SPECT imaging apparatus which would reliably achieve an improvement in the correction of imaging errors over a correction as is obvious from documents D2 and D3. In

particular, the original disclosure is not considered to enable the skilled person to successfully devise those elements of the apparatus which distinguish the subject-matter of claim 1 of the second auxiliary request from that of the independent claims of the other requests on file.

In consequence, the second auxiliary request does not meet the provisions of Article 83 EPC.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

M. Beer G. Davies