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D E C I S I O N
of 6 October 1999

Case Number: T 0402/95 - 3.4.1

Application Number: 91302528.4

Publication Number: 0453102

IPC: G01R 33/54

Language of the proceedings: EN

Title of invention:
Magnetic resonance imaging methods and apparatus

Applicant:
Picker International, Inc.

Opponent:
-

Headword:
Magnetic resonance imaging/PICKER INTERNATIONAL

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step (no; application of a known algorithm for the purpose of making use of its known property; skilled person being a team of experts)"

Decisions cited:
T 0164/92, T 0222/86, T 0460/87, T 0424/90, T 0002/94

Catchword:
-

Case Number: T 0402/95 - 3.4.1

D E C I S I O N
of the Technical Board of Appeal 3.4.1
of 6 October 1999

Appellant: Picker International, Inc.
595 Miner Road
Highland Heights
Ohio 44143 (US)

Representative: Waters, Jeffrey
The General Electric Company, p.l.c.
GEC Patent Department
Waterhouse Lane
Chelmsford, Essex CM1 2QX (GB)

Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 19 December 1994 refusing European patent application No. 91 302 528.4 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: G. Davies
Members: H. K. Wolfrum
G. Assi

Summary of Facts and Submissions

I. European patent application No. 91 302 528.4 was refused by a decision of the examining division dated 19 December 1994, on the grounds of lack of inventive step of the claimed subject-matter, contrary to the requirements of Articles 52(1) and 56 EPC.

II. The applicant lodged an appeal against the decision on 17 February 1995 and paid the prescribed fee on 21 February 1995. A statement of grounds of appeal was filed on 18 April 1995. Together with this statement, the applicant submitted an affidavit by an expert in magnetic resonance (Prof. Haacke) as further evidence in support of its view on inventive step.

The appellant requested that the decision be cancelled and a patent granted on the basis of claims 1 to 16 filed on 18 March 1994 before the examining division. An auxiliary request for oral proceedings was made.

III. In a communication dated 16 June 1999, accompanying a summons to oral proceedings, the applicant was informed that the Board was inclined to share the examining division's view on inventive step (Articles 52(1) and 56 EPC). Reference was made *inter alia* to documents:

D4: The Bell System Technical Journal, vol. 48, no. 5, 1969, pages 1249 to 1292, New York, USA; L. R. Rabiner et al. : "The Chirp z-Transform Algorithm and Its Application";

D5: EP-A-0 299 070; and

D7: Proceedings of the Spie - The International Society for Optical Engineering, vol. 1153, 1989, USA, pages 400 to 411; A. V. Forman et al.: "An Implementation of the Two-Dimensional Discrete Fourier Transform on the Geometric Arithmetic Parallel Processor";

of which document D7 was cited from the Board's own knowledge.

IV. Oral proceedings were held on 6 October 1999.

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

- claims 1 to 16 filed in the oral proceedings, with an adapted description and the Figures filed on 15 April 1991 (main request); or

- claims 1 to 11 filed in the oral proceedings, with an adapted description and Figures 1a, 1b and 2 filed on 15 April 1991 (auxiliary request).

VI. Independent claims 1 and 14 of the main request read as follows:

"*1. A method of magnetic resonance imaging comprising the steps of:*

a) automatically determining a first dimension of a region of interest along a first phase encode direction;

b) *dividing the first dimension by a selected resolution in the first direction to determine a number of steps of a first phase encode gradient to be applied along the first direction;*

c) *collecting magnetic resonance data lines with each of the first direction phase encode gradient steps;*

d) *digitizing the magnetic resonance data lines; and,*

e) *Fourier transforming on the digitized data lines in at least two dimensions to generate a spatial image representation, the Fourier transforming step including using a discrete Fourier transform with respect to one of the dimensions having a number of digital data values which is not an integer power of two and wherein the step of using the discrete Fourier transform operates on the data with a CHIRP-Z-transform.*"

"*14. A magnetic resonance examination apparatus comprising: a means for generating a plurality of data lines which are phase encoded with each of N incremental phase encode gradient steps, where N is a plural integer that is not an integer power of two; a Fourier transform means (90) for operating on each data line with a first Fourier transform algorithm to generate Fourier transformed data lines and for operating on the Fourier transformed data lines with a second Fourier transform algorithm to distribute the Fourier transformed data lines over a transformed data* *array, one of the first and second Fourier transform being a discrete Fourier transform and wherein the discrete fourier transform is a CHIRP-Z-transform.*"

"Independent claims 1 and 9 of the auxiliary request are identical to claims 1 and 14 of the main request, respectively."

VII. The appellant's submissions in support of its requests may be summarized as follows:

The invention was to be seen in the recognition that for a magnetic resonance imaging (MRI) method an image of an object of arbitrary dimensions could be obtained in a fast and efficient manner with isotropic resolution in all dimensions and free of artifacts by abandoning the established concept of using a conventional fast Fourier transformation (FFT) algorithm for the calculation of image data and by replacing it with a specific algorithm, the CHIRP-Z-transform (CZT). The conventional FFT algorithm required that for an object to be imaged a set of data values had to be obtained which, in each dimension, was equal to a power of two. For a human body, having differing extensions in different directions, this condition could only be met if either data values were collected from areas outside the body or if additional zeros were added in a dimension the size of which happened not to be an integer power of two. The conventional method followed for the latter alternative was explained in document US-A-4 748 411 (cited as D2 in the examination procedure). In the specific example given in D2, a data matrix was obtained, one dimension of which was not equal to a power of two. In order to accommodate a FFT, an interpolation by adding zeros was performed (although not explicitly mentioned) to meet the power of two requirement. A "stretching" of the image representation in that dimension resulted. To remove the distortion due to the stretching, an inverse zoom was finally performed on the image representation.

The prior art given by document D5, although silent as regards the details of the Fourier transform to be performed, comprised the same teaching as D2. Putting the teaching of D5 into practice, the skilled person had not had any incentive to use any algorithm other than the conventional FFT, in particular in view of the fact that all specific examples of D5 concerned data matrices meeting the power of two requirement. Moreover, the skilled person in the field of MRI, not being an expert in the signal processing art, would have brought an MRI data matrix into a form meeting the power of two requirement and would not have expected any solution from the field of mathematical algorithms. In particular, he could not have foreseen that the CZT algorithm, although not matching the speed of the FFT, resulted in time savings, improved image quality and the elimination of artifacts.

Documents D4 and D7 concerned the processing of signals containing spectroscopic information and did not relate to MRI. D4, in particular, was published long before the emergence of MRI.

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 amendments made to the independent claims of both requests define more clearly the fact that the CZT is applied to the processing of spatially encoded MRI data. They are based on information disclosed on originally-filed page 14, second paragraph, in combination with page 9, second paragraph. The Board is thus satisfied that the amendments comply with the requirements of Article 123(2) EPC.

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

3.1 The closest prior art is represented by document D5 (cf. in particular claim 1; page 3, second paragraph, to page 5, first line; and Figures 3 and 4 with the corresponding description), which discloses a MRI method designed to obtain a preselected isotropic pixel resolution in images from an object having different extensions in different directions. The data to be Fourier transformed in two dimensions is collected in the form of a matrix, the dimensions N and M of which match the horizontal and vertical extensions of the object under study and are only required to be positive integers. Contrary to the appellant's submission, the Board is of the opinion that a skilled reader would have gathered from D5 that by preselecting a desired isotropic resolution the resulting dimensions N and M would normally not become equal to a power of two. The power of two examples to be found in D5 (cf. page 3, second paragraph, to page 4, first paragraph) exclusively relate to prior art which is sought to be improved by the teaching of D5.

Thus, in working with the method known from D5, a data matrix is to be transformed which in practice does not meet the power of two requirement for FFT, as is the case in the present application.
Hence, the subject-matter of claim 1 of both requests differs from the teaching of D5 only in the choice of the Fourier transformation algorithm being a CHIRP-Z-transform.

3.2 The Board sees the objective problem associated with this difference in the task of finding a Fourier transformation algorithm capable of handling data matrices having dimensions which are not an integer power of two. In fact, no specific information is given in D5 as to how the necessary two-dimensional Fourier transformation for generating a spatial image representation is to be performed. The recognition of this problem cannot be considered to possess inventive merit because it is a normal task for the skilled person.

3.3 Following the case law of the boards of appeal of the EPO according to decisions T 164/92 OJ EPO 1995, 305, T 222/86, T 460/87, T 99/89, T 424/90, and T 2/94 (cf. Case Law of the Boards of Appeal of the European Patent Office, third edition, 1998 page 119), the skilled person in MRI is to be regarded as a team of experts comprising a physicist responsible for devising the experimental conditions to collect the magnetic resonance data and an expert in digital signal processing to provide algorithms for calculating image representations from this data. Thus, the physicist is supposed to ask the signal processing practitioner for the availability of algorithms suitable for the treatment of the collected data.

In the present case, when applying the method according to D5, selecting an isotropic resolution in all dimensions and determining the field of view according to the size of the object to be imaged so as to avoid the collection of data from areas outside the object, the MRI specialist would be aware of the fact that the "normal" FFT could not be applied to the collected data unless the numbers N and M of data values in the respective dimensions were equal to a power of two. In the Board's opinion, this situation is distinguished from that according to D2 where an image representation in the shorter dimension is stretched to that of the longer dimension (and later inversely zoomed) so as to obtain a squared data matrix meeting the power of two requirement. The teaching of D5 does not include any indication as to a stretching and inverse zooming of image representations along body dimensions, nor is there any need for such operations.

3.4 Alternative algorithms to the FFT were known before the priority date of the present application in the field of digital signal processing. Specifically, the CHIRP-Z-transform algorithm was known from document D4 (cf. pages 1249, 1251 and 1252; and in particular equations (4) to (7); as well as the end of Chapter I, top of page 1254) to possess exactly the desired property of handling data matrices with arbitrary numbers of data values in each dimension. Moreover, it was known from document D7 (cf. in particular pages 400, 401 and 410) that the CHIRP-Z-transform was an efficient image signal processing algorithm allowing for real-time data processing and being suitable for texture analysis, i.e. for operation of spatially encoded information. According to D7, the CHIRP-Z-transform was specifically chosen over other algorithms because of its capacity to operate on arbitrary data array sizes.

For these reasons, applying the CHIRP-Z-transform algorithm (known from each of D4 and D7 to constitute a digital signal processing algorithm being specifically adapted to handle data matrices of arbitrary dimensions) in order to perform the required Fourier transformation in the MRI method according to D5 where such data matrices occur is to be considered as a non-inventive application of a known algorithm for the purpose of making use of its known property.

In this context, the Board notes that the present application introduces some confusion as regards the terminology concerning Fourier transformation of MRI data. Since all data to be Fourier transformed is collected in the form of a matrix of discrete elements, any Fourier transform operating on this data is a discrete Fourier transform (DFT, which is basically defined by equation (6) given in document D4), whereas the fast Fourier transform (FFT) as well as the CHIRP-Z-transform (CZT) are alternative algorithms to compute the DFT.

3.5 As regards the alleged advantage of the claimed method in terms of time savings, the Board notes that this advantage is not related to the choice of the CZT but is rather a consequence of the restriction of the field of view to the size of the object to be imaged, as is for instance apparent from the application specification on originally-filed page 7, second paragraph.

As regards improved image quality and elimination of artifacts (cf. original page 7, third paragraph) obtainable by the claimed method, these advantages are, according to the appellant, the consequence of abandoning the step of zero filling a data matrix to meet the power of two requirement for FFT. Since it has been shown that the skilled person had no reason to employ such zero filling when following the teaching of D5, these advantages cannot support inventive step either.

3.6 For the foregoing reasons, the skilled person did not have to exercise inventive skill in order to arrive at the subject-matter of claim 1 of the main request as well as claim 1 of the auxiliary request.

The same considerations apply *mutatis mutandis* to independent claim 14 of the main request and claim 9 of the auxiliary request because both claims define a magnetic resonance examination apparatus exclusively by means suitable for carrying out the method steps as defined in claim 1 of the respective request.

In consequence, in the Board's judgement, the subject-matter of independent claims 1 and 14 of the main request, as well as that of claims 1 and 9 of the auxiliary request does 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 in so far as they presuppose an allowable independent claim.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

M. Beer G. Davies