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**D E C I S I O N**  
of 13 October 1994

**Case Number:** T 0249/92 - 3.4.2

**Application Number:** 8112855.8

**Publication Number:** 0114349

**IPC:** G01N 24/08, A61B 5/05

**Language of the proceedings:** EN

**Title of invention:**  
Nuclear magnetic resonance diagnostic apparatus

**Patentee:**  
KABUSHIKI KAISHA TOSHIBA

**Opponent:**  
N.V. Philips' Gloeilampenfabrieken

**Headword:**

**Relevant legal provisions:**  
EPC Art. 100(a), 54, 56

**Keyword:**  
"Opposition grounds under Article 100(a) - lack of patentability"

**Decisions cited:**

**Catchword:**



Case Number: T 0249/92 - 3.4.2

**D E C I S I O N**  
of the Technical Board of Appeal 3.4.2  
of 13 October 1994

**Appellant:**  
(Opponent)

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**Decision under appeal:**

Decision of the Opposition Division of the  
European Patent Office dated 17 December 1991,  
written decision posted on 8 January 1992  
rejecting the opposition filed against European  
patent No. 0 114 349 pursuant to Article 102(2)  
EPC.

**Composition of the Board:**

**Chairman:** E. Turrini  
**Members:** W. W. G. Hofmann  
J-C. Saisset

### Summary of Facts and Submissions

I. The Appellant (Opponent) lodged an appeal against the decision of the Opposition Division on the rejection of the opposition against the patent No. 0 114 349 (application No. 83 112 855.8).

Opposition was filed against the patent as a whole and based on Article 100(a) EPC.

The Opposition Division held that the grounds for opposition mentioned in Article 100(a) EPC did not prejudice the maintenance of the patent unamended, having regard, inter alia, to the following documents:

(D1) DE-A-2 928 551,

(D2) P. Mansfield and P.G. Morris, NMR Imaging in Biomedicine, Supplement 2, Advances in Magnetic Resonance, Academic Press, Inc., 1982, pages 80, 81, 102, 156 and 161, and

(D3) DE-A-3 202 368.

II. During appeal proceedings, the Board considered the following further documents:

(D1') GB-A-2 026 172 (& D1) and

(D3') GB-A-2 091 884 (& D3).

III. The Appellant requested that the decision under appeal be set aside and the patent revoked.

IV. The Respondent (Patentee) requested that the appeal be dismissed (**main request**) or, as auxiliary requests, that the decision under appeal be set aside and the patent be maintained with the following amended documents:

**first auxiliary request:**

**Claims:**

No.: 1 to 3 received during oral proceedings of 13 October 1994,

**Description:**

Columns: 1 to 9 of the patent specification, to be adapted to the new claims,

**Drawings:**

Sheets: 1/6 to 6/6 of the patent specification.

**second auxiliary request:**

**Claim:**

No.: 1 received during oral proceedings of 13 October 1994,

**Description:**

Columns: 1 to 9 of the patent specification, to be adapted to the new claim,

**Drawings:**

Sheets: 1/6 to 6/6 of the patent specification.

V. Due to a printing error, the text of Claim 1 as published in the patent specification EP-B1-0 114 349 does not correspond to that referred to in the decision to grant a patent, dated 30 December 1987 (see also the communication pursuant to Rule 51(4) EPC, dated 23 July 1987). Whereas the apparatus according to Claim 1 on

which the decision to grant a patent was based comprises inter alia " means (11) for temporarily storing the digital NMR signals and for improving the S/N ratio thereof ...", the corresponding text of the published Claim 1 reads "means (11) for temporarily storing the digital NMR signals and/or improving the S/N ratio thereof ...". The authentic text of the granted Claim 1 (and the one submitted or agreed to by the Respondent) is the text referred to in the decision to grant a patent. This **Claim 1**, to which the **main request** of the Respondent is directed, reads as follows:

"An apparatus (100) for examining an object (1) by nuclear magnetic resonance comprising:  
means for applying uniformly to the object (1) a static magnetic field ( $H_0$ );  
means (4) for generating a signal which is used, on the one hand, as exciting pulses and, on the other hand, as a reference signal;  
signal transmitter/receiver means (2) through which the exciting pulses are applied in a plurality of examination periods so as to excite an imaginary cross-sectionally sliced portion of the object (1), and NMR signals are received from the excited sliced portion thereof;  
characterized by  
phase shift means (7) for shifting a phase of the reference signal by  $90^\circ$  so as to produce a  $90^\circ$ -shifted reference signal with respect to the phase of the reference signal;  
means (6A; 6B) for performing a quadrature detection of the NMR signal by utilizing both the  $90^\circ$ -shifted reference signal and the reference signal, so that a series of cos signal components (C1-1; C1-2; C1-3) of the quadrature-detected NMR signals and a series of the sin signal components (S1-1; S1-2; S1-3) thereof are produced respectively;

A/D converting means (10A; 10B) which converts the cos signal components (C1-1; C1-2; C1-3) and sin signal components (S1-1; S1-2; S1-3) of the quadrature-detected NMR signals into corresponding digital NMR signals respectively;

means (11) for temporarily storing the digital NMR signals and for improving the S/N ratio thereof by a summation comprised of cos signal components (C1-1; C1-2; C1-3) and/or sin signal components (S1-1; S1-2; S1-3) of the digital NMR signals, respectively; and means (12) for processing the quadrature-detected NMR signals, the S/N ratio of which is improved so as to obtain a tomographic image of the sliced portion of the object (1)."

Claims 2 to 4 according to the main request depend on Claim 1.

The wording of **Claim 1** according to the **first auxiliary request** reads as follows:

"An apparatus (100) for examining an object (1) by nuclear magnetic resonance comprising:  
means for applying uniformly to the object (1) a static magnetic field ( $H_0$ );  
means (4) for generating a signal which is used, on the one hand, as exciting pulses and, on the other hand, as a reference signal;  
signal transmitter/receiver means (2) through which the exciting pulses are applied in a plurality of examination periods so as to excite an imaginary cross-sectionally sliced portion of the object (1), and NMR signals are received from the excited sliced portion thereof;  
phase shift means (7) for shifting a phase of the reference signal by  $90^\circ$  so as to produce a  $90^\circ$ -shifted

reference signal with respect to the phase of the reference signal;

means (6A; 6B) for performing a quadrature detection of the NMR signal by utilizing both the 90°-shifted reference signal and the reference signal, so that a series of cos signal components (C1-1; C1-2; C1-3) of the quadrature-detected NMR signals and a series of the sin signal components (S1-1; S1-2; S1-3) thereof are produced respectively;

A/D converting means (10A; 10B) which converts the cos signal components (C1-1; C1-2; C1-3) and sin signal components (S1-1; S1-2; S1-3) of the quadrature-detected NMR signals into corresponding digital NMR signals respectively; characterized by

means (11) for temporarily storing the digital NMR signals and for improving the S/N ratio thereof by a summation comprised of cos signal components (C1-1; C1-2; C1-3) and/or sin signal components (S1-1; S1-2; S1-3) of the digital NMR signals, respectively; and means (12) for processing the quadrature-detected NMR signals, the S/N ratio of which is improved so as to obtain a tomographic image of the sliced portion of the object (1), wherein:

tuning means (3) is connected between the signal transmitter/receiver means (2) and the signal generating means (4) so as to derive the exciting pulses from the signal generating means (4);

the quadrature-detection means (6A; 6B) is constructed by two detector paths in conjunction with the A/D converting means (10A; 10B), one (6A; 10A) being for the series of the cos signal components (C1-1; C1-2; C1-3), and the other (6B; 10B) being for that of the sin signal components (S1-1; S1-2; S1-3); and

the S/N ratio improvement means (11) is operated in such a manner that at least one of the cos signal components (C1-1; C2-1; C3-1), or of the sin signal components (S1-1; S2-1; S3-1) of the quadrature-detected NMR signals

which were collected during one examination period as (read "is") summed with one of the cos signal components (C1-2; C2-2; C3-2), or of the sin signal components (S1-2; S2-2; S3-2) of the quadrature-detected NMR signals which were collected during a succeeding examination period, respectively."

Independent **Claim 2** according to the **first auxiliary request** differs from Claim 1 in that in the last but one paragraph the references to (C1-1; C1-2; C1-3) and (S1-1; S1-2; S1-3) are replaced by (C1-1; C2-1; C3-1) and (S1-1; S2-1; S3-1) and the last paragraph is replaced by the text:

"the S/N ratio improvement means (11) is operated in such a manner that at least two cos signal components (C1-2, C2-2; C1-3, C2-3; C1-1, C2-1), or two sin signal components (S1-1, S2-1; S1-2, S2-2; S1-3, S2-3) of the quadrature-detected NMR signals which were collected during one examination period are summed, respectively".

Independent **Claim 3** according to the **first auxiliary request** differs from Claim 2 in that the last paragraph is replaced by:

"the S/N ratio improvement means (11) is operated in such a manner that the symmetrical part of one waveform portion (C2-1-f) of one of the cos signal portions (C2-1; C2-2; C2-3) is summed with the other waveform portion (C2-1-r) of the same cos signal, or the symmetrical part of one waveform portion (S2-1-f) of one of the sin signal portions (S2-1; S2-2; S2-3) is summed in a predetermined manner with the other waveform (S2-1-r) portion of the same sin signal respectively".

The wording of the single **Claim 1** according to the **second auxiliary request** is identical to that of Claim 1 of the first auxiliary request.

VI. The Appellant essentially argued as follows:

From D1 (or D1') quadrature detection of an NMR signal as well as signal averaging are known. For the skilled person signal averaging implies a summation - which, in D1, is performed on the components of the signal - and an improvement of the S/N ratio.

D3 (or D3') also discloses averaging of NMR signals from a plurality of measurements to improve the S/N ratio.

VII. The Respondent essentially argued as follows:

None of the prior art documents cited discloses improving the S/N ratio of the NMR signal by summing the cos components and/or the sin components of the digital signal.

In particular, according to D1 (or D1'), averaging of signals obtained from successive sequences is performed. This averaging, however, is made over a series of square roots, each one of which contains the sum of the squared sine component and the squared cosine component of the signal.

D2 merely discloses the averaging of signals from successive cycles in order to improve the S/N ratio. However, it fails to teach that the sin and cos components are detected in order to average them independently.

D3 (or D3') does not disclose or even suggest a method in which the sin and cos signal components are independently averaged.

## Reasons for the Decision

### 1. Main request

#### 1.1 Claim 1

##### 1.1.1 Novelty

In correspondence with Claim 1, D3' (see, in particular, Figure 1 and page 5, line 51 to page 6, line 11 of the description) discloses an apparatus for examining an object by nuclear magnetic resonance (NMR) comprising, inter alia, the following features:

- means 2 for applying uniformly to the object a static magnetic field (see page 4, lines 5 to 9),
- means 13 for generating a signal which is used, on the one hand, as exciting pulse (see the transmitter system 13-15-16-17-3 in Figure 1 and on page 5, lines 51 to 56) and, on the other hand, as reference signal (see the system 13-21 and page 5, lines 58 to 62),
- signal transmitter/receiver means 3 through which the exciting pulses are applied in a plurality of examination periods so as to excite an imaginary cross-sectionally sliced portion of the object, NMR signals being received from the said excited sliced portion (see page 4, lines 15 to 24 and 47 to 61, page 5, lines 56 to 58),
- phase shift means 21, 22 for shifting a phase of the reference signal by  $90^\circ$  so as to produce a  $90^\circ$ -

- shifted reference signal with respect to the phase of the reference signal (see page 5, lines 58 to 62),
- means 19, 20 for performing a quadrature detection of the NMR signal by utilizing both the 90°-shifted reference signal and the reference signal (see page 5, lines 56 to 62), so that a series of cos signal components of the quadrature-detected NMR signals and a series of sin signals components thereof are produced respectively (this is the necessary consequence of the quadrature detection - see the outputs of the detectors 19 and 20 in Figure 1),
  - A/D converting means 25, 26 which converts the cos signal components and sin signal components of the quadrature-detected NMR signals into corresponding digital NMR signals respectively (see page 5, line 62 to page 6, line 2),
  - means for temporarily storing the digital NMR signals (these means consist in the memory of the computer 12, which is undoubtedly present and necessary for the calculations mentioned on page 5, lines 3 to 38, even though it is not explicitly mentioned), and
  - means 12 for processing the quadrature-detected NMR signals so as to obtain a tomographic image of the sliced portion of the object (see Figure 1 and page 6, lines 39 to 55).

According to D3', in deriving an image, a series of operations is performed, whereby for each operation there is used either a single exciting pulse or a sequence of pulses recurring at intervals greater than the spin-lattice relaxation time  $T_1$  (see page 4, lines 47 to 61, page 5, lines 18 to 24). Greater efficiency in respect of data collection is achieved if, for each operation, there is used a sequence of pulses

regularly recurring at intervals which are short compared with the spin-spin relaxation time  $T_2$ , for the protons in the sample. During a period immediately following each pulse, the "detected signals", which are to be understood as "detected signal components", are sampled at a regular series of epochs (see page 5, lines 24 to 30, and the two detection channels 20-24-26 and 19-23-25 in Figure 1). In cases where more than one pulse is used for each operation, the first stage of the processing, taking place in the computer 12, involves addition of the sampled values epoch by epoch for each operation, an average value for each epoch for each operation being so achieved (see page 6, lines 1 to 5). The fact that in this way a set of pairs of numbers is obtained, the numbers of each pair respectively corresponding to the two detection channels (see page 6, lines 6 and 7), unambiguously indicates that the summed sampled values are those of the cos and sin components. Moreover, in the further processing, the numbers of each pair are treated as the real and the imaginary parts of a complex number  $S_{mn}$  representing the digital signal reconstructed from the components (see page 6, lines 6 to 11). It is thus clear that, contrary to the argument of the Respondent, the apparatus according to D3' also comprises means for summing the cos signal components and the sin signal components of the digital NMR signals, respectively.

The purpose of this averaging operation is to improve the S/N ratio of the detected NMR signals. This fact is well-known to the skilled person and, thus, forms part of the implicit disclosure of D3'.

Therefore, having regard to D3', the subject-matter of Claim 1 according to the main request is not novel in the sense of Article 54 EPC.

The same conclusion can be drawn with regard to D3, which belongs to the patent family of D3'.

1.2 Since Claim 1 according to the main request lacks novelty, it is not necessary to examine dependent Claims 2 to 4.

1.3 Consequently, the main request is not allowable.

2. *First auxiliary request*

2.1 Claim 1

2.1.1 Novelty

Claim 1 according to the first auxiliary request results from the combination of Claims 1 and 2 of the main request. Therefore, for the reasons given in paragraph 1.1.1 above, all the features corresponding to the said Claim 1 of the main request, i.e. those arranged before "wherein", are already known from D3'.

This document also discloses the further feature that the quadrature-detection means 19, 20 together with the A/D converting means 25, 26 constitute two detector paths 19-23-25 and 20-24-26, one being for the series of the cos signal components, and the other being for that of the sin signal components.

The apparatus according to Claim 1 is, therefore, distinguished from that known from D3' by the following features:

- (i) it comprises tuning means connected between the signal transmitter/receiver means and the signal generating means so as to derive the exciting pulses from the signal generating means, and

- (ii) the S/N ratio improvement means is operated in such a manner that at least one of the cos signal components, or of the sin signal components of the quadrature-detected NMR signals which were collected during one examination period is summed with one of the cos signal components, or of the sin signal components of the quadrature-detected NMR signals which were collected during a succeeding examination period, respectively.

Therefore, having regard to D3', the subject-matter of Claim 1 according to the first auxiliary request is novel in the sense of Article 54 EPC.

The same conclusion can be drawn with regard to D3 which belongs to the patent family of D3'.

#### 2.1.2 Inventive step

As mentioned above, D3' teaches that, in cases where more than one pulse is used for each operation, the first stage of the processing consists in the addition of the sampled values - for each detection channel - epoch by epoch for each operation, so as to obtain an average value for each epoch for each operation (see page 6, lines 1 to 5). That this signal averaging serves to improve the S/N ratio, is well-known to the skilled person (see also, in this respect, D2, paragraph 4.4.1.2. on page 102).

Starting from the apparatus known from D3', which is considered as the closest prior art document, the problem to be solved could not be that mentioned in column 3, lines 26 to 30, of the patent in suit, consisting in improving the S/N ratio of the NMR signal, because, as is shown above, this result is already

achieved in D3' by the signal averaging at least in the cases in which each operation comprises a series of pulses. Thus, the problem is rather seen in the provision of another way of performing the said signal averaging. No contribution to inventive step can be perceived in the statement of this problem, per se.

The stated problem is solved by the feature (ii) mentioned above. As to the feature (i), it does not appear to contribute to the solution of the stated problem and, in itself, it represents a commonly used measure - generally well-known to the skilled person - for selecting an electromagnetic signal from the electromagnetic waves generated by generating means. It is evident that the electromagnetic waves are to be tuned in order to adapt the signal to a specific frequency and to a specific nucleus in the object.

According to D3', signal averaging - which serves improving the S/N ratio - is obtained by addition of the sampled values epoch by epoch for each operation, a set of pairs of numbers being obtained, the numbers of each pair respectively corresponding to the two detection channels and being treated as the real and the imaginary parts of a complex number  $S_{mn}$  representing the digital signal reconstructed from the components (see paragraph 1.1.1 above). This means that, for each operation comprising a sequence of pulses, each value of the NMR signal component sampled - in one detection channel - at a given epoch is added to the values, sampled at the corresponding epoch, of the other components obtained during the **same operation**.

Performing the addition with components from succeeding examination periods according to the above-mentioned feature (ii), therefore, appears to be a simple alternative to the solution known from D3', which

alternative the skilled person would consider without needing inventive ingenuity. Repeating the same experiment a number of times and averaging the results is the usual way in technics to improve precision of measurement. A hint at this way of proceeding is, moreover, given by document D2 (see paragraph 4.4.1.2.), according to which the phase sensitive detected nuclear signal is sampled for a discrete number of intervals during each SSFP (steady-state free precession) cycle and signals from **successive cycles** are cumulated, i.e. added, in order to improve the S/N ratio by this averaging.

It is thus obvious for the skilled person, starting from the apparatus of D3', to modify the way of averaging the signal in accordance with the feature (ii) mentioned above.

Therefore, the subject-matter of Claim 1 according to the first auxiliary request lacks an inventive step (Article 56 EPC).

The same conclusion can be drawn starting from D3 which belongs to the patent family of D3'.

2.2. Since Claim 1 according to the first auxiliary request lacks an inventive step, it is not necessary to examine the other independent Claims 2 and 3.

2.3 Thus, the first auxiliary request is not allowable.

3. *Second auxiliary request*

The wording of the single Claim 1 according to the second auxiliary request is identical to that of Claim 1 of the first auxiliary request.

Therefore, the second auxiliary request is also not allowable.

4. The grounds for opposition mentioned in Article 100(a) EPC thus prejudice the maintenance of the patent according to the various requests. The patent is, consequently, revoked.

#### Order

For these reasons it is decided that:

1. The decision under appeal is set aside.
2. The patent is revoked.

The Registrar:

The Chairman:

P. Martorana

E. Turrini