BESCHWERDEKAMMERN DES EUROPÄISCHEN PATENTAMTS

BOARDS OF APPEAL OF THE EUROPEAN PATENT OFFICE

CHAMBRES DE RECOURS DE L'OFFICE EUROPEEN DES BREVETS

Internal distribution code:
(A) [ ] Publication in OJ
(B) [ ] To Chairmen and Members
(C) [X] To Chairmen
(D) [ ] No distribution

D E C I S I O N
of 15 July 2004

Case Number: T 0225/00 - 3.4.1

Application Number: 96911251.5

Publication Number: 0813686

IPC: G01R 33/36

Language of the proceedings: EN

Title of invention:
Automatic tuning apparatus and method for substance detection using nuclear quadrupole resonance and nuclear magnetic resonance

Applicant:
Quantum Magnetics, Inc.

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 54, 56

Keyword:
"EPC Art. 56 - Inventive step - no"

Decisions cited:
-

Catchword:
-

Case Number: T 0225/00 - 3.4.1

D E C I S I O N
of the Technical Board of Appeal 3.4.1
of 15 July 2004

Appellant:	Quantum Magnetics, Inc. 7740 Kenamar Court San Diego CA 92121-2425 (US)
Representative:	Riebling, Peter, Dr.-Ing. Patentanwalt Postfach 31 60 D-88113 Lindau (DE)
Decision under appeal:	**Decision of the Examining Division of the European Patent Office posted 21 October 1999 refusing European application No. 96911251.5 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: G. Davies
Members: G. Assi
M. G. L. Rognoni

Summary of Facts and Submissions

I. The appellant (applicant) lodged an appeal, received on 17 December 1999, against the decision of the examining division, dispatched on 21 October 1999, refusing European patent application No. 96911251.5 (publication number 0 813 686). The fee for the appeal was paid on 17 December 1999. The statement setting out the grounds of appeal was received on 16 February 2000.

II. In the contested decision, the examining division held that the subject-matters of independent claims 1, 5, 8 and 9 according to the main request lacked an inventive step within the meaning of Article 56 EPC, having regard *inter alia* to the following documents:

(D1) L.G. Butler *et al.*, "*High-power radio frequency irradiation system with automatic tuning*", Rev. Sci. Instrum., Vol. 53(7), American Institute of Physics, July 1982, pages 984-988,

(D5) WO-A-92/19979,

(D6) US-A-5 024 229,

(D7) J.P. Hornak *et al.*, "*Phosphorus-31 NMR Spectroscopy Using a Loop-Gap Resonator*", J. Magn. Reson., Vol. 68, Academic Press Inc., 1986, pages 319-322.

III. In an official communication dispatched to the appellant with the summons to oral proceedings, the Board referred to the following additional prior art cited in the application as originally filed:

(D9) US-A-5 365 171.

IV. Oral proceedings were held on 15 July 2004.

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

Main request:

Claims:

Nos. 1-9 as filed with the statement of grounds of appeal of 14 February 2000 (the wording corresponds to that of the claims according to the main request considered in the decision under appeal),

Description:

Pages 1-5 and 5a as filed with a letter of 2 December 1998,

Pages 6-8, 10-12, 14 and 16 as originally filed,

Pages 9, 13 and 15 as filed with a letter of 11 March 1997,

Drawings:

Sheet 1/3 as filed with the letter of 11 March 1997,

Sheets 2/3 and 3/3 as originally filed,

First auxiliary request:

Claims:

Nos. 1-7 as filed with a facsimile of 30 January 2004,

Description and drawings:

See the main request,

Second auxiliary request:

Claims:

Nos. 1-9 as filed with the facsimile of 30 January 2004,

Description and drawings:

See the main request.

VI. The wording of claim 1 of the **main request** reads as follows:

"1. *An apparatus for detecting concealed explosives and narcotics to establish maximum power transfer efficiency at at least one selected predetermined frequency in nuclear quadrupole and nuclear magnetic resonant (NQR/NMR) detection systems when a specimen is inserted into the detection element of an NQR/NMR detection system in order to enable such detection systems to detect nuclear quadrupole or nuclear magnetic resonant frequencies of predetermined substances if present in the specimen, the predetermined substances having predetermined characteristic nuclear resonant frequencies, wherein nuclear resonant frequency is the frequency of nuclear precession due either to quadrupolar interaction with molecular electric field gradients (NQR) or to an applied static magnetic field (NMR), the apparatus comprising a sequence controller (21) having means for providing timing and programming pulses to said apparatus, a variable frequency RF source (23) to provide either continuous or pulsed RF excitation at a predetermined frequency,* ***characterised by****, for automatic tuning purposes, an array of fixed value capacitors (93) connected in said apparatus and selectively switchable into circuit with said RF coil, and a plurality of individually controllable switch means (94) for selectively connecting said capacitors into said RF coil circuit,*

a single turn RF coil made of a single sheet (34) of highly conductive material shaped and configured to define a cavity of predetermined volume therewithin and to receive the specimen within the cavity defined by said coil, the RF signals from said RF source generally *corresponding to the nuclear resonant frequency of a predetermined substance, are transmitted within said cavity and are uniformly applied to the specimen within said RF coil cavity, thereby generating a uniform field within said cavity, said RF coil also functioning as the pickup coil for the NQR/NMR signals from the specimen and providing an output signal, said fixed value capacitors (93) being connected in parallel with said RF coil; and*

means (36) for measuring the power transfer efficiency of said RF coil at the predetermined nuclear resonant frequency;

said sequence controller controlling the selective switching of said fixed value capacitors into and out of circuit with said RF coil pursuant to power transfer efficiency measurements from said measuring means to establish and maintain maximum power transfer efficiency of said RF coil with the specimen therewithin at the predetermined nuclear resonant frequency."

The wording of claim 1 of the **first auxiliary request** differs from that of claim 1 according to the main request by the insertion of the following feature after "*means (36) for measuring the power transfer efficiency of said RF coil at the predetermined nuclear resonant frequency,"*:
"wherein said means for measuring power transfer efficiency of said RF coil comprises means for measuring the amount of power transferred directly to said RF coil from said RF source, and measuring the amount of power reflected back into said coil;".

The wording of claim 1 of the **second auxiliary request** corresponds to that of claim 1 according to the main request with the following additional feature at the end of the claim:
“means for reducing the effect of acoustic ringing by operating the automatic tuning system at a frequency outside the range of the sample frequency, either before or after the main sample detect sequence, using a standard or modified RF pulse sequence, and displaying or presenting the corresponding output signal.”

Reasons for the Decision

1. The appeal is admissible.

2. *Claim 1 according to the main request*

2.1 Closest prior art

In the examining division's view, document D5 represented the closest prior art. The appellant agreed with this choice and the Board has no reason to take another view.

Document D5 relates to a method and an apparatus for detecting specific substances, in particular explosives and drugs, in specimens such as luggage, freight and postal packages (see page 1, lines 3 to 10; page 5, lines 33 to 35). The detection relies both on nuclear magnetic resonance (NMR) and nuclear quadrupole resonance (NQR). Figure 4 shows an apparatus comprising a first RF coil (33) tuned for NMR detection and a second RF coil (33a) tuned for NQR detection, the RF coils being solenoidal according to an example (see page 12, lines 31 to 34) and being connected to a respective variable frequency RF source. The specimens to be tested are placed within or passed through a cavity defined by the RF coils (see page 13, lines 1 to 3). The RF coils also act as pickup coils for the NMR/NQR signals emitted by the specimens. A RF monitor circuit (43) monitors the applied RF irradiation while a reflectance monitor (37) measures the reflected RF signals. Both the RF monitor circuit and the reflectance monitor are used to confirm that suitable tuning and matching conditions are maintained and to detect if any ferromagnetic or conducting materials in the specimens are causing a detuning of the RF coils to such an extent that it could adversely affect the detection process (see from page 13, line 14 to page 14, line 2). A sequence controller (42) controls the overall detecting operation by providing timing and programming pulses to the various circuits.

Although not explicitly disclosed, the Board regards as implicit in document D5 that the solenoidal RF coils are made of a highly conductive material and that the RF signals are uniformly applied to the specimen within the cavity, since both features are immediately apparent to a person skilled in the art reading the document.

2.2 Novel features

The appellant agrees that the subject-matter of claim 1 differs from the disclosure of document D5 essentially by the following features:

(i) the RF coil is a single turn RF coil made of a single sheet,

(ii) an array of fixed value capacitors connected in parallel with the RF coil and selectively switchable into and out of circuit with the RF coil by means of a plurality of individually controllable switch means,

(iii) means for measuring the power transfer efficiency, the sequence controller controlling the selective switching of the fixed value capacitors into and out of circuit with the RF coil to establish and maintain maximum power transfer efficiency at the predetermined nuclear resonance frequency with the specimen located in the RF coil.

According to the claim, features (ii) and (iii) are for automatic tuning purposes.

2.3 Technical effect and definition of the problem

The general problem defined in the description of the application as filed is to provide a practical method and apparatus for improved bulk detection of substances using NMR and NQR under less than optimum conditions (see page 3, line 29 to page 4, line 1), for instance in applications such as explosive and drug detection in airline luggage or post items.

In the decision under appeal the examining division argued that feature (i), on the one hand, and features (ii) and (iii), on the other hand, independently achieved different technical effects and therefore contributed to the solution of different partial problems.

2.3.1 Feature (i)

The application as originally filed is silent on the benefits of having a single turn RF coil made of a single sheet apart from the fact that the thickness of the single sheet ensures "*a minimal amount of resistance to the flow of current when the coil is energised with RF*" (see page 9, lines 1 to 2). The thickness of the conductive sheet, however, is not claimed. Moreover, it can reasonably be assumed that the solenoidal coils of document D5 are also characterized by a low resistance to the current flow. Thus, the said advantage cannot be taken into consideration as a basis for defining the technical effect achieved by feature (i).

According to the appellant (see the grounds of appeal, page 6, last paragraph), the provision of a single turn RF coil made of a single sheet "*ensures a homogeneous field throughout the sample to be investigated*" and, due to the narrow band and high Q properties of the coil, "*improved accuracy of detection in combination with the automatic tuning apparatus*".

The Board has no reason to doubt this assertion, the mentioned properties being well-known in the art in connection with the kind of RF coil claimed (see, for instance, documents D6 and D7).

2.3.2 Features (ii) and (iii)

Features (ii) and (iii) describe how the automatic (re)tuning of the RF coil is achieved. The individually switchable capacitors allow the apparatus to automatically tune the RF coil, thereby maximising the detection sensitivity of NQR and NMR signals, in particular where large conductive materials or materials having a high dielectric constant are present inside the RF coil or where temperature variations or mechanical movement of the RF coil cause a detuning (see page 3, lines 8 to 27 of the application as originally filed).

2.3.3 Aggregation of features

Feature (i) as well as features (ii) and (iii) contribute to the achievement of the solution of the general problem of improving bulk detection under less than optimum conditions. In the present case, however, for the assessment of the inventive step the question must be considered whether a functional interaction between the features would entail that a synergistic effect is achieved going beyond the sum of the individual effects. The Board denies this, just as the examining division also does. Whereas feature (i) provides a coil having good properties for bulk detection, features (ii) and (iii) assure a rapid and accurate retuning of the coil. There is no specific functional interaction between the coil and the automatic tuning means, which would not be also present with another type of coil or with another automatic tuning means.

For these reasons, the Board regards feature (i) and features (ii) and (iii) as forming an aggregation of features, rather than a combination, and as solving different partial problems. In accordance with the established case law of the boards of appeal, in such a case it must be examined whether each of these two sets of features, taken singly, was obviously derivable from the prior art when starting from the closest prior art (see Case Law of the Boards of Appeal of the EPO, 4th Edition, 2001, No. I.D.6.4).

2.4 Obviousness of feature (i)

Document D6 describes a single-turn loop-gap solenoidal resonator for NMR imaging, which comprises a single sheet of a highly conductive material as specified in claim 1 of the application in suit. The resonator has the shape of a cylinder with a longitudinal gap, along which capacitors, including a variable one, are arranged for tuning purposes and for providing a homogeneous RF field within the cavity (see Figures 1 to 14; column 1, lines 54 to 63; column 5, lines 13 to 22). The document is silent as to how the variable capacitor is adjusted.

Document D7 also discloses a loop-gap resonator having a similar structure. According to the Abstract, the loop-gap resonator provides a simple and convenient alternative for large volume probes in NMR spectroscopy. Furthermore, it is easy to construct and to tune, has a high Q ensuring efficient detection and RF delivery to the specimen under investigation and generates a very uniform RF field (see page 319, first paragraph).

The Board thus agrees with the examining division that the skilled person, being aware of the advantages offered by the known loop-gap resonator in applications where uniform RF fields are required, such as NMR and NQR detection or spectroscopy, would use such a resonator in the apparatus of document D5 in order to obtain the same advantages.

For the above reasons, the Board agrees with the examining division that feature (i) does not contribute to inventive step.

2.5 Obviousness of features (ii) and (iii)

The apparatus shown in Figure 4 of document D5 detects a detuning of the RF coil from the forward and reflected RF waves. It is clear that where a detuned condition is detected, the resonant circuit must be retuned at the selected frequency if NMR or NQR detection is to be performed with good sensitivity. Since document D5 provides little indication as to how retuning should be achieved, the skilled person would look for solutions in the prior art and consider document D1, as the examining division also states.

In particular, this document describes a high-power RF irradiation system for detecting NQR transitions of light nuclei, for example ^{17}O. The system comprises a solenoidal RF coil in resonance with an array of capacitors which are individually switched in and out of circuit with the RF coil through relays, each of which can be activated by a logic signal from the computer or by a front panel switch. By opening switches 1-9 and closing switch 10, an array of fixed value capacitors is provided in parallel with the RF coil. Such an array of capacitors with their switches is identical to that shown on Figure 2 of the present application.

It is acknowledged that document D1 does not deal with the problem of tuning an RF coil which has been detuned by the specimen under examination. Nor does it present the tuning as a result of maximising power transfer efficiency, *ie* minimising the reflected RF power. However, the question to be considered is whether the circuit consisting in the parallel arrangement of fixed value capacitors according to D1 would permit automatic tuning of a loop-gap resonator in an apparatus according to D5. The Board concurs with the examining division that it would. Indeed, according to D6 (see Figures 13 and 14), the electrical circuit for coupling RF electromagnetic energy with a loop-gap resonator includes an inductor defined by the conductive single sheet and a capacitor defined by the gap, the capacitor being variable for frequency tuning of the resonator (see D6, column 7, lines 45 to 49). It would thus be obvious to use an array of capacitors in order to increase the tuning range. The selective switching of the capacitors would then be under the control of the circuit (42) (see D5, Figure 4), optimal tuning and matching conditions being detected by the RF monitor circuit (43) and the reflectance monitor (37). Moreover, although document D5 does not reveal which parameter of the RF signals is measured, it is obvious that the intended purpose would be achieved by measuring, for example, the signal amplitude or the power by standard procedures.

For the above reasons, the Board agrees with the examining division that features (ii), (iii) do not contribute to inventive step.

2.6 In conclusion, the subject-matter of claim 1 according the main request does not involve an inventive step (Article 56 EPC), having regard to the combination of document D5, which is considered as the starting point, with document D6 (or D7) for the aspect of bulk detection (feature (i)) and with document D1 for the further aspect of retuning the RF coil (features (ii) and (iii)).

The main request, therefore, is not allowable.

3. *Claim 1 according to the first auxiliary request*

3.1 Claim 1 according to the first auxiliary request essentially differs from its counterpart according to the main request in that it specifies that the RF power transfer efficiency is measured from the power of the forward and reflected RF waves.

As already stated with regard to the main request, document D5 (see page 13, lines 13 to 18 and from page 13, line 30 to page 14, line 2) teaches that a detuning of the RF coil is detected from measurements of the forward and reflected RF irradiations. This implies that in a tuned circuit the forward RF signal is maximised and the reflected RF signal minimised. Since the choice of the power as the physical quantity to be measured is obvious to the skilled person wishing to measure the forward and reflected RF signals, the new feature added to claim 1 cannot contribute to inventive step. It rather defines, in an explicit way, implicit and obvious features pertaining to the *“means (36) for measuring the power transfer efficiency”* recited by claim 1 of the main request.

3.2 In conclusion, the subject-matter of claim 1 according to the first auxiliary request does not involve an inventive step.
The first auxiliary request, therefore, is not allowable.

4. *Claim 1 according to the second auxiliary request*

4.1 Claim 1 according to the second auxiliary request differs from claim 1 according to the main request by the additional features concerning the acoustic ringing.

Acoustic ringing constitutes a further partial problem which is solved by the claimed apparatus. Its solution is not functionally related to the kind of RF coil used or the tuning system so that it can be dealt with *per se*. The problem, as well as its solution as claimed, are well-known in the prior art, for instance from document D9 (see column 9, lines 5 to 20). Thus, the Board does not regard as inventive the implementation of this known solution in the apparatus according to document D5, in which the procedure for reducing acoustic ringing will be carried out by suitable means in the control circuit (42) (see Figure 4).

4.2 In conclusion, the subject-matter of claim 1 according to the second auxiliary request does not involve an inventive step.

The second auxiliary request, therefore, is not allowable.

Order

For these reasons, it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

D. Sauter G. Davies