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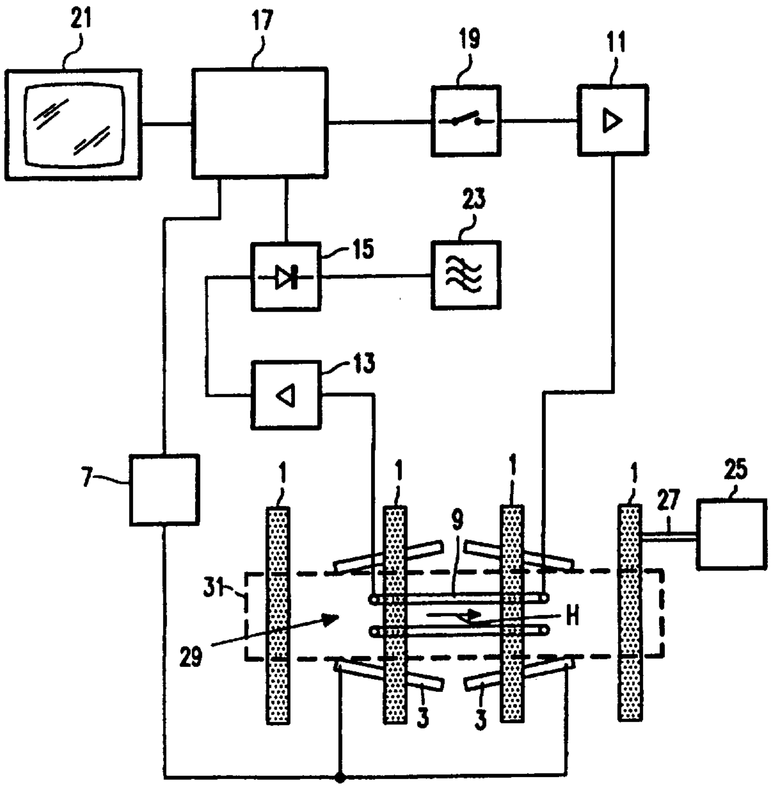
(54) Title: MAGNETIC RESONANCE EXAMINATION APPARATUS

(57) Abstract

The apparatus comprises an examination zone (29) for receiving an object (37) to be examined, a component (41) of an electrically non-conductive plastics material being located in the examination zone at least when the apparatus is in an operating condition. In order to reduce the visibility of this component (41) in MR experiments, the plastics material comprises an additive of a paramagnetic material.



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Magnetic resonance examination apparatus.

The invention relates to a magnetic resonance examination apparatus, comprising an examination zone for receiving an object to be examined, a component of an electrically non-conductive plastics material being located in the examination zone at least when the apparatus is in an operating condition. The invention also relates to a patient table for use in an apparatus of this kind.

An apparatus of this kind is known from US-A-5 416 413 (PHD 92 100). The known apparatus comprises a support for a coil system, the support being made of a non-conductive synthetic (plastics) material. When the apparatus is in operation, the support is located in an examination zone in which a strong, uniform magnetic field, gradient magnetic fields and an RF magnetic field are generated. Thus, the apparatus can be used e.g. for magnetic resonance (MR) imaging or spectroscopy of an object to be placed in the examination zone. It has been found that in some experiments plastics parts become visible or give artefacts in unknown and unpredictable locations in the images and spectra. Results of an investigation of this phenomenon have been published in Magnetic Resonance in Medicine, **13**, 498-503 (1990). From this publication it is clear that many materials which, from the point of view of dielectric properties and/or machinability, would be very suitable for manufacturing components to be used in the examination zone cannot be used because they become visible or give artefacts as mentioned above.

It is, therefore, an object of the invention to provide an apparatus of the kind set forth, which provides a greater freedom of choice of plastics materials for the manufacture of components than the known apparatus. The apparatus in accordance with the invention is characterized in that the plastics material comprises an additive of a paramagnetic material. The invention is based on the following insight: Many plastics materials comprise free protons that are detectable with MR. Adding a slight amount of a paramagnetic material will cause local disturbances in the magnetic field experienced by these free protons thereby substantially reducing the detectability of these protons.

It has been found that good results are obtained if the amount of paramagnetic material in the plastics material is between 0.5% and 10% by weight. All paramagnetic materials are suitable but best results have been obtained with manganese and bismuth. Suitable plastics materials are the polymers, a good example being polyurethane which showed a considerable improvement when a paramagnetic material was added to it.

These and other aspects of the invention will be apparent from the embodiments described hereinafter.

Figure 1 shows a block diagram of an embodiment of a magnetic resonance examination apparatus in accordance with the invention,

Figure 2 shows a side elevation of the apparatus shown in Figure 1, and

Figure 3 shows a diagram illustrating the improvements obtained with the invention.

The MR apparatus which is diagrammatically shown in Figure 1 comprises a first magnet system 1 for generating a steady magnetic field H, a second magnet system 3 for generating magnetic gradient fields, and a power supply source 7 for the second magnet system 3. A radio frequency (RF) coil 9 serves to generate an RF magnetic alternating field; to this end, it is connected to an RF source 11. The RF coil 9 can also be used for detection of spin resonance signals generated by the RF transmitted field in an object to be examined (not shown); to this end, it is connected to an RF receiver device comprising a signal amplifier 13. The output of the signal amplifier 13 is connected to a detector circuit 15 which is connected to a central control device 17. The central control device 17 also controls a modulator 19 for the RF source 11, the power supply source 7 and a monitor 21 for display. An RF oscillator 23 controls the modulator 19 as well as the detector 15 processing the measurement signals. For cooling of the magnet coils of the first magnet system 1 there is provided a cooling device 25 comprising cooling ducts 27. The RF coil 9, arranged within the magnet systems 1 and 3, encloses a measurement space or examination zone 29 which is large enough to accommodate a patient to be examined, or a part of a patient to be examined, for example the head and the neck, in an apparatus for medical diagnostic measurements. Thus, a steady magnetic field H, gradient fields selecting object slices, and a spatially uniform RF alternating field can be generated within the examination zone 29. The RF coil 9 can combine the functions of transmitter coil and measuring coil. Alternatively, different coils can be used for the two functions, for example measuring coils in the form of surface coils. If desired, the coil 9 may be enclosed by an RF field shielding Faraday cage 31.

Figure 2 is a side elevation of the apparatus shown diagrammatically in Figure 1. The magnet systems 1 and 3 are located in a housing 33 that comprises a circular cylindrical bore 35 (shown in dotted lines) for receiving a patient 37. The patient 37 lies on a patient table 39, comprising a detachable table top 41 which is displaceable in a longitudinal direction (parallel to the cylinder axis of the bore 35) on a support 43. The table top with the patient lying on it can be slid into the bore 35. This construction is described in detail in US-A-5 014 968 (PHN 12.742). The table top 41 is made of an electrically non-conductive material, usually a plastics material. Further parts, for example a housing accommodating the RF coil 9 (Figure 1) and a head rest for supporting the head of the patient 37, may be located on the table top 41. These parts are not shown in Figure 2. An example of such parts is described in detail in US-A-5 285 150 (PHN 14.093). These parts too are usually made of a suitable plastics material.

An example of a plastics material that meets the requirements of machinability and dielectric properties is polyurethane. However, the cited article in Magnetic Resonance in Medicine **13,** 498-503 discloses that this material gives an unacceptably high MR signal for protons. It is believed that this is caused by the presence of free protons in the polyurethane. Components of this material are formed by simultaneously injecting, for example, a polyol and C-isocyanate in a mould. These two chemicals will form long intertwining strings.

```
C-isocyanate:   O=C=N~~~~~~~~~~N=C=O
Polyol:         HO~~~~~~C-O-C~~~~~~OH

                                                  H
                                                  |
Reaction:   ~~~~N=C=O + ~~~OH ==> ~~~~N-C-O~~~~
                                                    ||
                                                    O
```

In reactions like this one, not all the OH-groups will be gone after the reaction. The remaining OH-groups comprise 'free' protons which will be detectable with MR. They have T2 relaxation times in the order of 20 ms. It has been found that adding a slight amount of a paramagnetic material such as manganese or bismuth will cause local disturbances of the magnetic field at the location of the free protons, thereby causing a decrease of the T2*. This substantially reduces the detectability of these free protons.

For testing purposes, a small production unit with a rectangular mould (25x15x1 cm) was put into service to produce test samples with a density similar to that of actual coil parts. In the supply bins the polyol was mixed with a predetermined amount of $MnSO_4(+1H_2O)$. Samples with different concentrations of Mn^+ were made, one of these samples (sample A) consisting of the basic material (polyurethane), another (sample B) consisting of the basic material and an additive of 5% (weight) $MnSO_4=1H_2O$ and a third sample (sample C) consisting of the basic material and 10% (weight) of the same additive. By chemical analysis of the samples, the concentrations of Mn^+ in samples B and C were determined to be about 1.5% and 6.6% by weight, respectively. The proton MR spectra of the samples were measured in an MR apparatus. The result is shown in the diagram of Figure 3.

The diagram shows the signal s obtained from each one of the samples A, B and C as a function of the frequency f. The curve marked D shows the signal obtained from the 'empty' MR apparatus (the apparatus without any sample) and the curve marked E shows the signal obtained from a sample of 10 ml H_2O as a reference. For the sake of clarity, the curves A, B, C and D have been shifted in the vertical direction to prevent them from overlapping. In reality, the curve C is, within the measuring accuracy coincident with the curve D. The peak of curve B is about three times as high of the peak of curve C and the peak of curve A is about six times as high as the peak of curve B. From this it is clear that the addition of a paramagnetic material to a plastics material significantly reduces the visibility in MR experiments of parts made from that material.

After these successful tests the addition of manganese to polyurethane was used in the normal production of under covers for head coils. Because $MnSO_4$ is available for laboratory use only (it is rather expensive), it was decided to use $MnCO_3$ which is available in bulk. Covers were made from polyurethane with this additive and chemical analysis of one of these covers showed the actual concentration of Mn^+ to be 0.67%. When the proton signal of these covers was measured in an MR apparatus, it turned out to be a factor 5 less than the signal from a standard cover from polyurethane without a paramagnetic additive. From these and other experiments it follows that good results are obtained when the amount of paramagnetic material in the plastics material is between 0.5% and 10% by weight.

CLAIMS:

1. A magnetic resonance examination apparatus, comprising an examination zone for receiving an object to be examined, a component of an electrically non-conductive plastics material being located in the examination zone at least when the apparatus is in an operating condition, **characterized in that** the plastics material comprises an additive of a paramagnetic material.

2. A magnetic resonance examination apparatus as claimed in Claim 1, **characterized in that** the amount of paramagnetic material in the plastics material is between 0.5% and 10% by weight.

3. A magnetic resonance apparatus as claimed in Claim 1 or 2, **characterized in that** the paramagnetic material is manganese or bismuth.

4. A magnetic resonance examination apparatus as claimed in any one of the preceding Claims, **characterized in that** the plastics material is a polymer.

5. A patient table for use in a magnetic resonance examination apparatus, the table comprising at least one part of an electrically non-conductive plastics material, **characterized in that** the plastics material comprises an additive of a paramagnetic material.

6. A patient table as claimed in Claim 5, **characterized in that** the amount of paramagnetic material in the plastics material is between 0.5% and 10% by weight.

7. A patient table as claimed in Claim 5 or 6, **characterized in that** the paramagnetic material is manganese os bismuth.

8. A patient table as claimed in any one of the Claims 5 through 7, **characterized in that** the plastics material is a polymer.

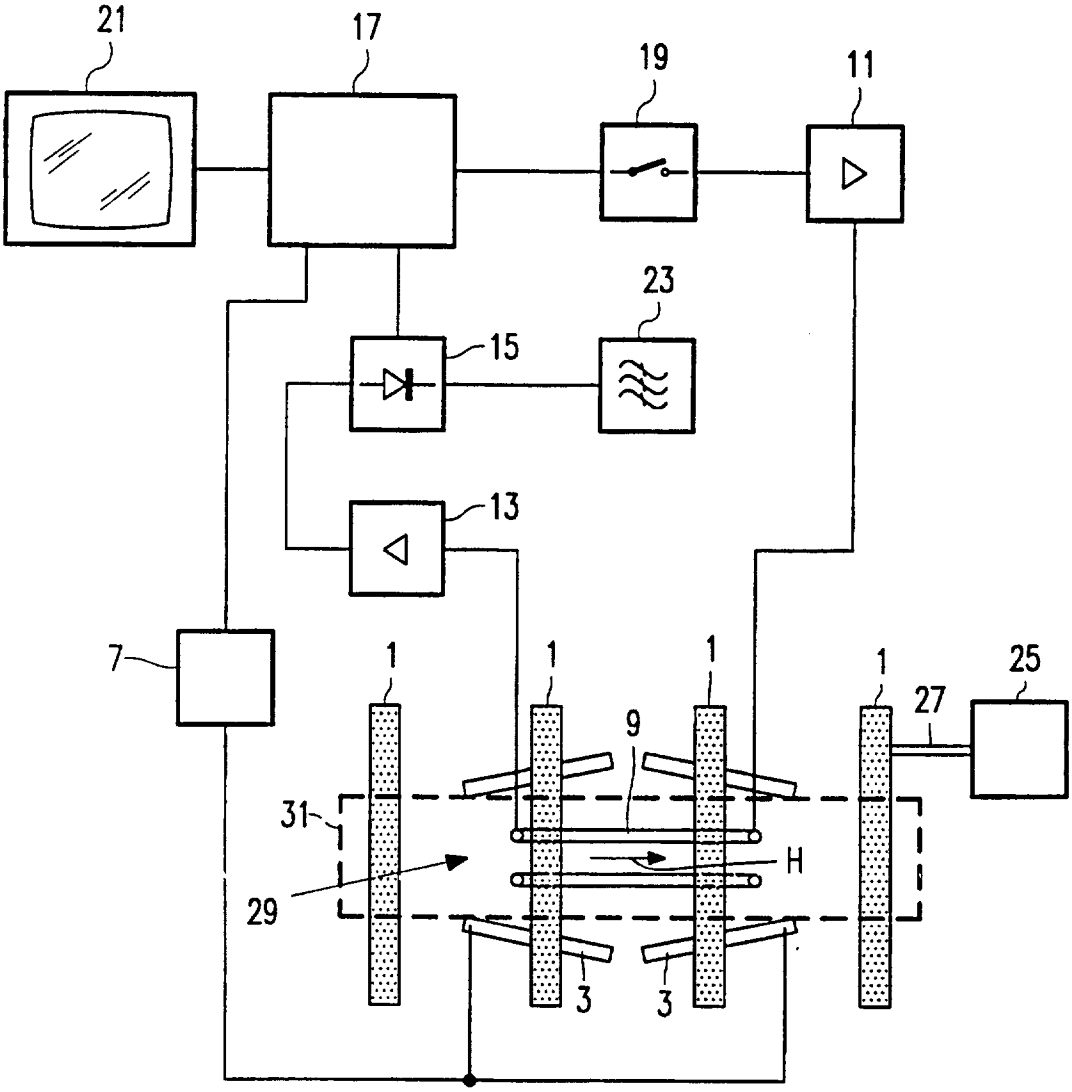

FIG. 1

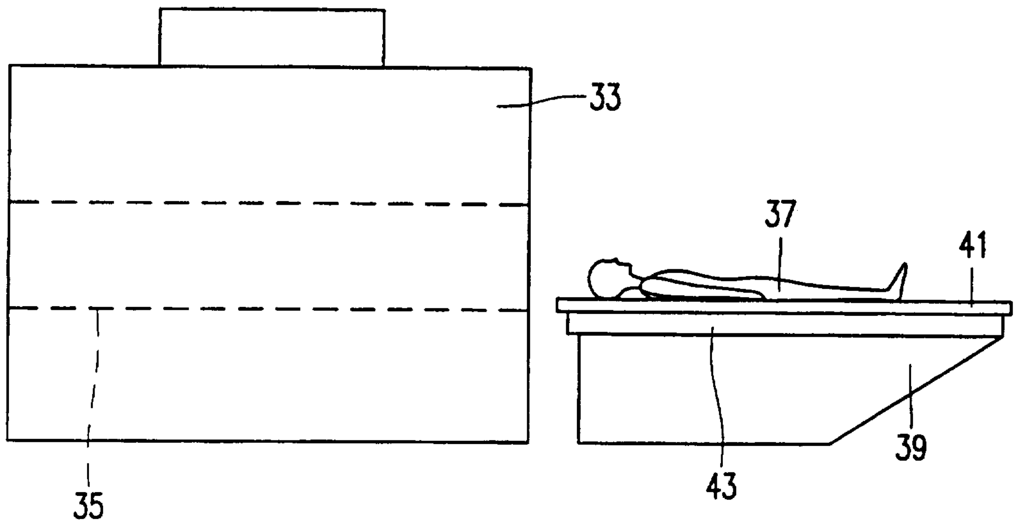

FIG. 2

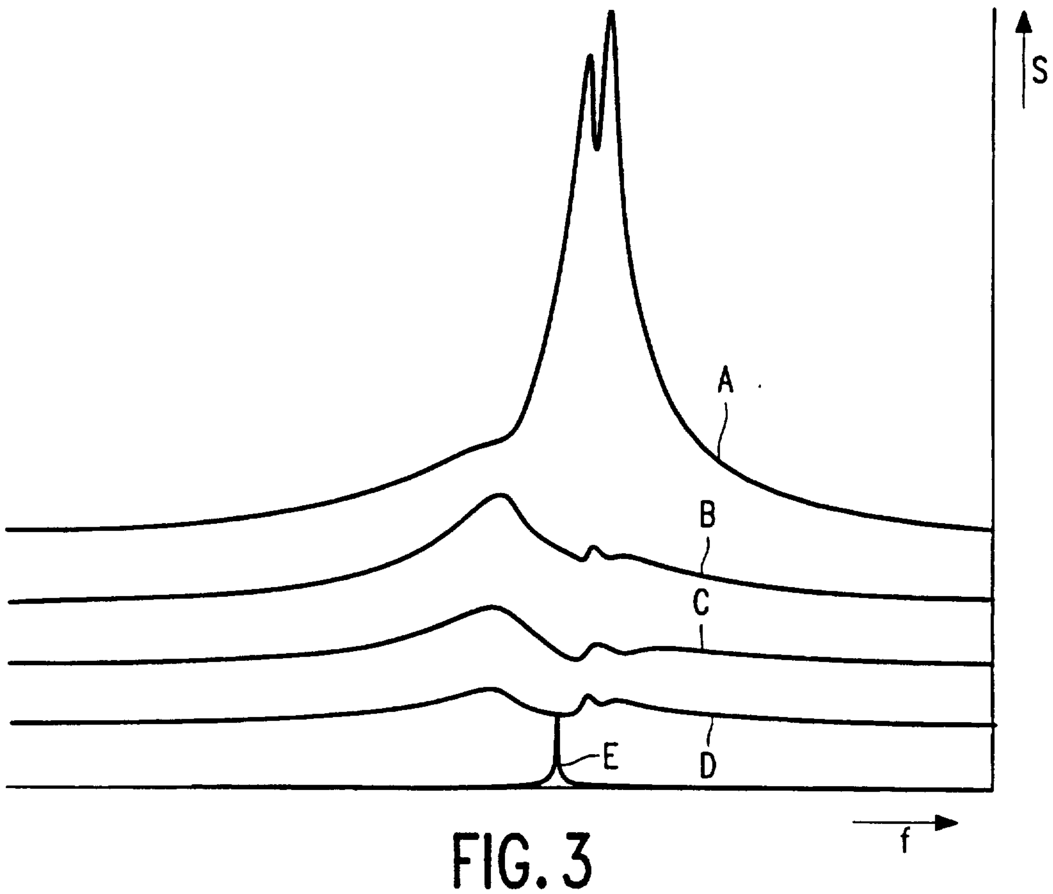

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB 97/00681

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: A61B 5/055, A61B 6/04, G01R 33/20
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: A61B, G01R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5361765 A (D.J.HERLIHY ET AL), 8 November 1994 (08.11.94), column 5, line 32 - line 42, abstract --	1-8
A	US 5111541 A (K.E.WAGNER), 12 May 1992 (12.05.92), see the whole document --	1-8
A	US 5007425 A (D.VANEK ET AL), 16 April 1991 (16.04.91), column 3, line 24 - line 28, abstract --	1-8

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4688278 A (J.VAN M.ASPERT), 25 August 1987 (25.08.87), column 2, line 46 - line 62, abstract --	1-8
A	US 5427116 A (M.NOONE), 27 June 1995 (27.06.95), column 2, line 10 - line 68; column 3, line 1 - line 13, abstract -- --------	1-8