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NMR IMAGING EXPERIMENT IN EARTH'S MAGNETIC FIELD

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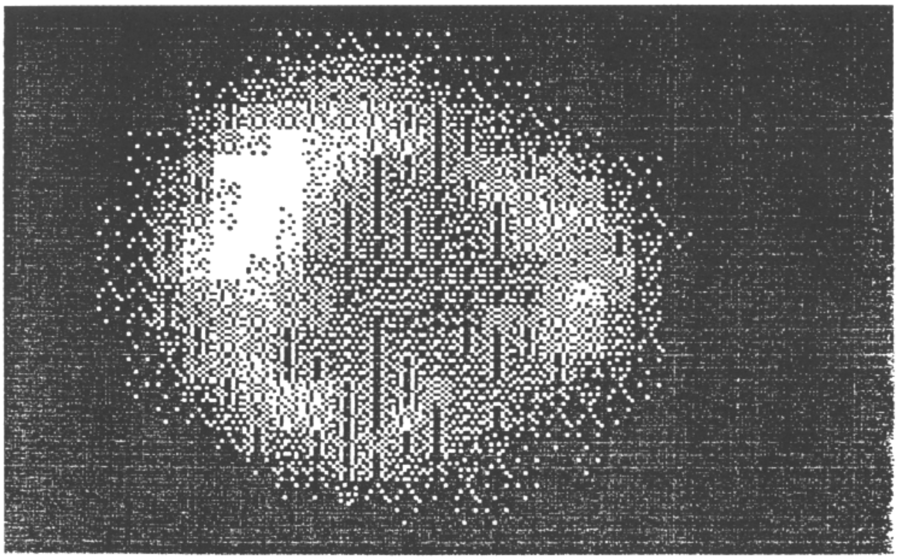
ABSTRACT

The most important and very expensive part of the magnetic resonance imaging setup is the magnet which is capable of generating a constant and highly homogeneous magnetic field. Here the new MR imaging technique without the magnet is proposed. Instead of the magnet it uses the earth's magnetic field. The results of the preliminary experiments make possible to reconstruct the NMR images of fantoms without using any radiofrequency shieilding.

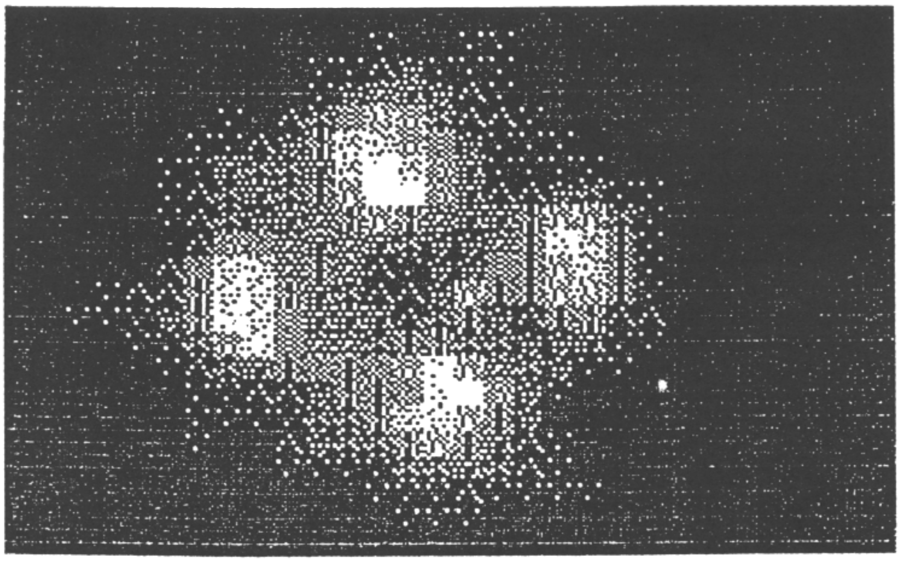
Magnetic resonance technology is emerging rapidly from the realm of research and experimentation and is becoming an imaging modality with clinical utility. To interrogate the sample, NMR imaging techniques employ the extensive, three-dimensional magnetic field created by the large magnet. The generation of the required magnetic field has become "not only a technological challenge but also a decisive economic factor" in the MR imaging system development. In order to avoid the expenses and the difficulties related to the installment of a large magnet an attempt is made to employ the earth's magnetic field for NMR imaging. Its stability and homogeneity are within the required range.

The most sensitive NMR technique at low field is the Varian-Packard method (1) at which the transverse magnetization is not created by the rf pulse, but by the spin prepolarization in the direction perpedicular to the earth's magnetic field. Usually it is achieved by the magnetic field generated by the same coils which are also used to detect the spin free precession by induction. In this way the initial magnetization is not determined by the magnitude of the earth's magnetic field but by the value and the duration of the prepolarizing magnetic field. Thus, the expected low sensitivity is mostly due to low free precession frequency in the earth's magnetic field. At NMR in the low field the receiving coils might have few hundred times more turns than the coils in the high field and therefore it has higher detectivity. Therefore it is expected that the NMR sensitivity in the earth's magnetic field is not much lower than that in the high magnetic field, when the method of Varian-Packard is used.

Preliminary experimental demonstration of NMR imaging by the earth's magnetic field (MRIE) has been persormed on the home made setup using the Varian-Packard method. The construction scheme of the experiment is similar to that descibed in (3), except that at the field switching the polarizing field decays like a damping oscillator with the time constant of 3 ms. The sample is prepolarized in the field of 30 mT generated by solenoidal coils with 300 turns, and the same coils are used to detect spin free precession in the earth field. At this stage, the experiment has been performed without any radiofrequency shielding. Only, the coils system — the receiving coils together with the gradient coils — has been placed ten meters outside the building in order to reduce the magnetic disturbances caused by electrical installations. In spite of this, the noise generated by the external perturbances has been three orders of magnitude above the inherited noise of electronic setup.



The cross sectional view of the pumpkin by NMR imaging in the teresterial field. Its diameter is 20 cm.



NMR imaging of four tube.s Each of them contains 1 cm* of the water.

The induced NMR signal was conducted from the receiving coils by the coaxial cable to the amplifiers and digitizer in the building.

Only two gradient coils have been used. The first one is the reversed Helmholtz coil with the field parallel to the polarizing field with the gradient about 0.2 mT/cm. This field is swiched off simultaneously with the polarizing field but in the adiabatic manner i. e. with much longer time constant. In this way just the polarization in the thin slice of the sample around the zero point of the gradient is preserved. This is the selective prepolarization (11). The second gradient field is also generated by the reversed Helmholtz coils but with the field parallel to the earth magnetic field. It is used for encoding the information about the spin spatial distribution in the free induction decay. The free precession signal from different orientations of the samples in the magnetic field gradient has ben taken and the magnetic resonance images in the earth magnetic field (MRIE) of fantoms have been obtained using the projection reconstruction technique (6) (figure 1 and 2).

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MRIE of four tubes each of them containing 1 cm^3 of water.

The cross sectional view of the pumpkin by MRIE. Its diameter is 17 cm.