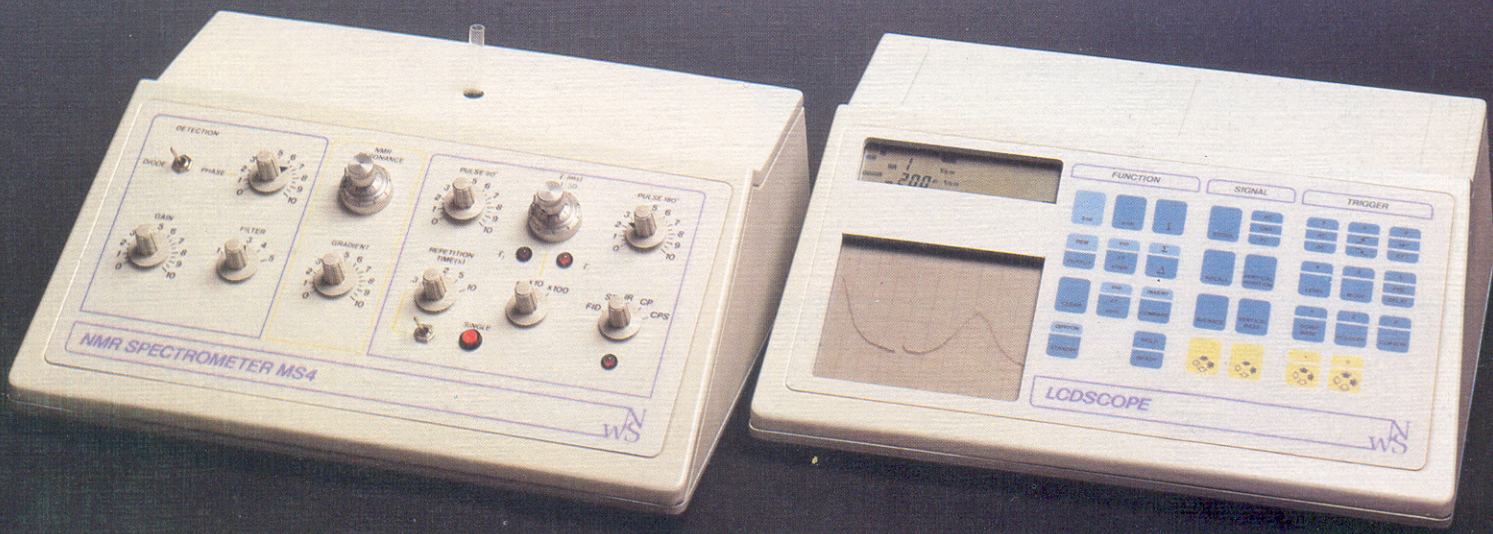
SMALL MR IMAGER AND NMR SPECTROMETER



NWS

Small MR Imager and NMR Spectrometer

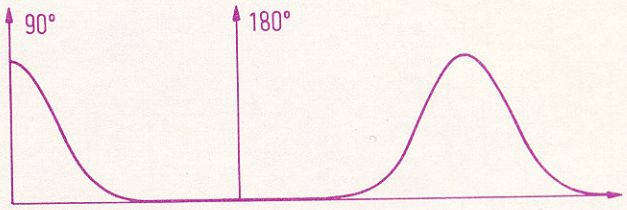
The small MR imager and NMR Spectrometer is a self-contained NMR system operating at 9 MHz. It includes a permanent magnet and a data acquisition system. It is designed to measure the nuclear magnetic resonance observables such as free induction decay (FID), spin-echo, spin-spin and spin-lattice relaxation times, self-diffusion coefficient and, in the first place, MR images of phantom objects.

The magnet has a built-in gradient coil system that can generate a linear magnetic field gradient along the z-component of the magnetic field. The data acquisition and processing system has all the characteristics of a digital oscilloscope. A microcomputer controls the operation and performs digital averaging of the signal amplitude, its Fourier transform, its integral and so on.

BASIC SPECTROSCOPIC OPERATIONS

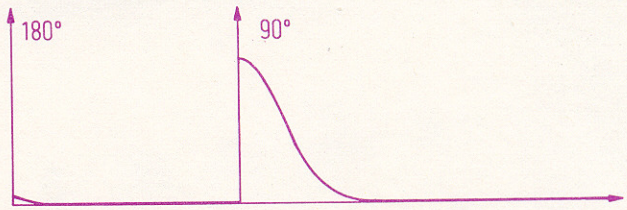
HAHN ECHO

Observation of proton spin-echo. Measurement of the echo amplitude and of the spin-spin relaxation time.



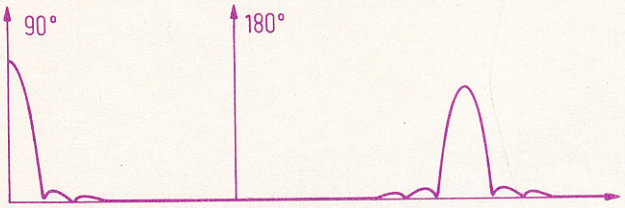
T_1 MEASUREMENT

The inversion recovery pulse sequence for measurement of the spin-lattice relaxation time.



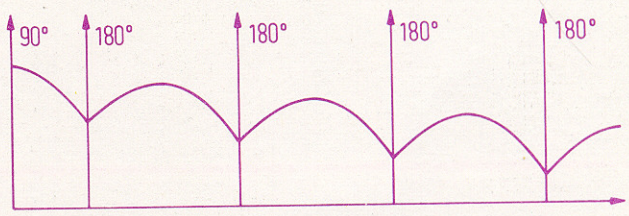
DIFFUSION MEASUREMENT

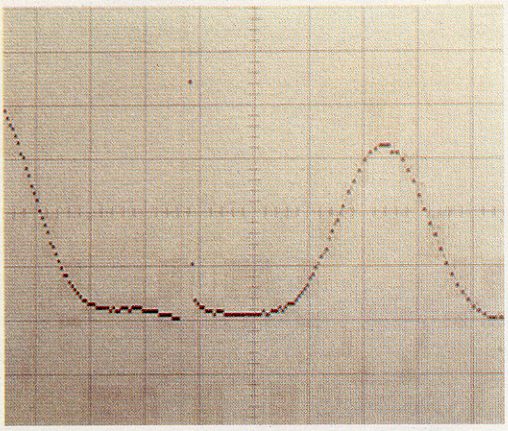
The observation of proton spin-echo in a magnetic field gradient. This gives the self-diffusion coefficient.



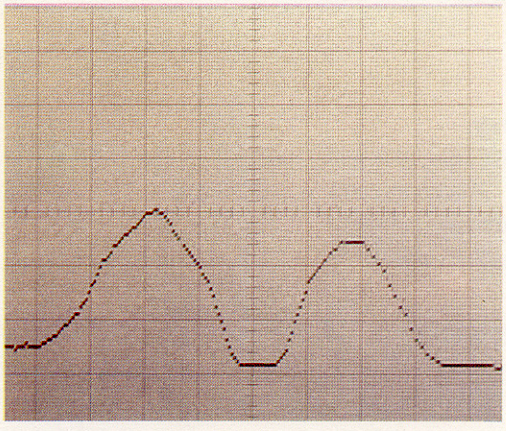
T_2 MEASUREMENT

The Carr Purcell pulse sequence for measurement of the spin-spin relaxation time.





A typical NMR signal such as the Hahn echo of water protons displayed on the LCD screen is shown on the right. The free induction decay appearing first is brought about by the first 90° r.f. pulse. The 180° pulse which reverses the coherence loss and thus enables the formation of Hahn echo, is shown as three dots half way between the free induction decay and the echo.



The fast Fourier Transform (FFT) allows for the reconstruction of the NMR absorption line-width from the free induction decay signal. The figure on the right shows two NMR absorption lines obtained by a Fourier transform of the phantom object consisting of two capillary tubes filled with water in a linear magnetic field gradient.

MAGNETIC RESONANCE IMAGING

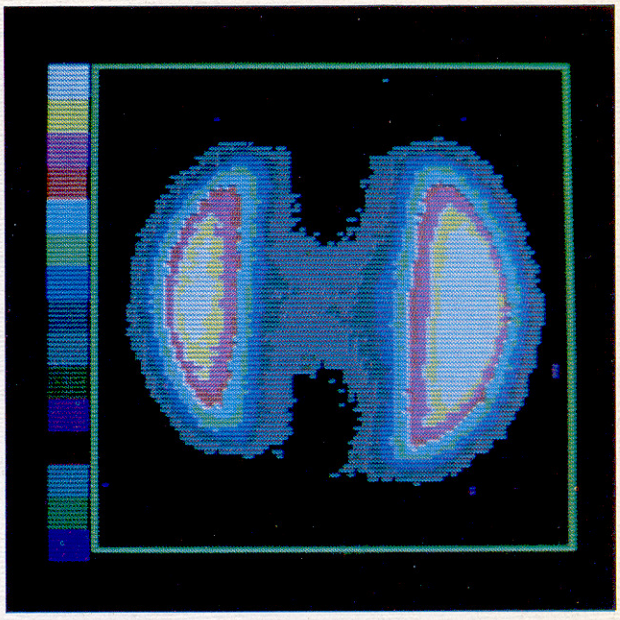
In a magnetic field with precisely known magnetic field gradient added, the precession frequencies of proton spins from a phantom may be considerably different. The precession frequency thus contains information on the position of spins in the magnetic field. The observed NMR free induction decay time signal shows the characteristic beating due to the interference between the signals with different precession frequencies from different parts of the phantom object.

In Small MR Imager the Fourier analysis resolves the time signal (beats) into frequency spectra which characterize the spacial positions of spins within the phantom sample.

After Fourier transforms of the phantom free induction decay (measured at 32 different orientations of the phantom with respect to the static magnetic field gradient), the x-z cross section of the phantom sample is calculated in the IBM PC computer using the standard back-projection reconstruction technique. The resulting MR image is shown on the picture above and on the next page.

SPECIFICATIONS*

Frequency	9 MHz
Magnetic field: strength	0.21 T
homogeneity	10^{-6} T/cm
Magnetic field gradient	0 to 2 × 10^{-4} T/cm
Sample dimensions	outer diameter 8 mm, length 10 mm
Pulse sequences	$\pi/2$; $\pi/2 - \tau - \pi$ Hahn echo; $\pi - \tau - \pi/2$ inversion recovery; Carr-Purcell sequence
R.f. phase channels	0°, 90° phase shifted with respect to the reference
R.f. transmitter power	$\pi/2$ r.f. pulse is about 10^{-3} T
Receiver recovery time	100 μs*
Detection	phase sensitive and diode
Signal to noise	100*
Gain variation	two orders of magnitude
Sampling frequency	variable in steps 1-2-5-10 from 2 MHz to 0.04 Hz
A/D resolution	0.5%
Data memory	512 or 2048 bytes
Display	LCD matrix 200 × 120
External computer interface	RS 232 C



IBM PC XT/AT compatible
IBM PC communication and data processing software is included
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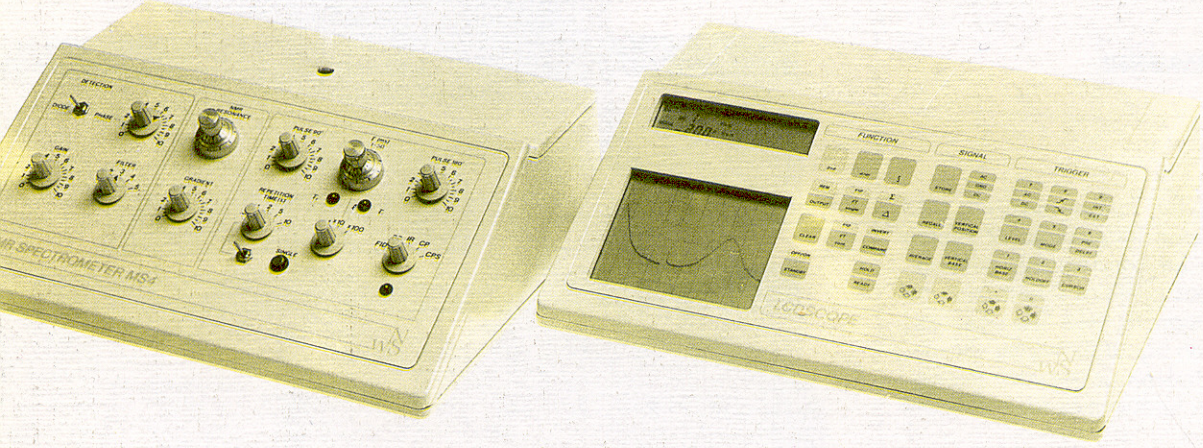
* The above characteristics are due to the improvements in R&D subject to change without notice.



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