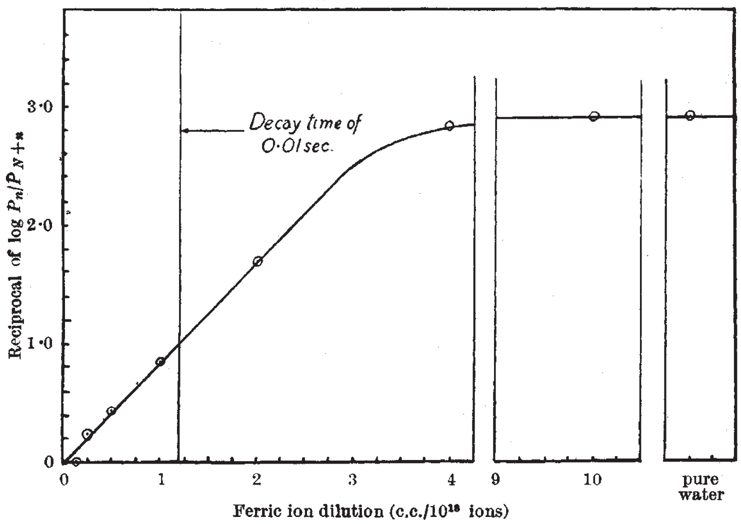

Fig. 2. Variation of 'wiggle's' decay with ferric ion dilution

$\sim 1/\gamma \Delta H$. This has proved a limitation in the measurement of transverse relaxation times $T_2 \gg 10^{-3}$ sec., as for such measurements a magnetic field inhomogeneity of $\lesssim 0\cdot003$ gauss is required; and, hitherto, this requirement has not been satisfied. Torrey[3] has proposed and used a method in which long relaxation times T_2 can be studied in the presence of an inhomogeneous magnetic field. The observation of his phenomenon depends on maintaining the magnetic field at resonance, and is quite unrelated to the 'wiggles' experiments.

The purpose of this note is to report another experiment from which it appears that relaxation times can be measured in the presence of an inhomogeneous field. By using this new method, it is possible also to detect changes of magnetic field of 1 in 10^6, and possibly of as little as 1 in 10^8 or 10^9.

A magnetic field of 1,060 gauss was modulated at 50 c./s. by an amplitude of ~ 10 gauss. Samples of water with ferric ammonium sulphate added were chosen, and the solution made very weak so that the relaxation times T_2 should be $\gtrsim 0\cdot01$ sec. The radio-frequency coil was about 1 cm. diameter and 1·1 cm. long. By suitable adjustments of the radio-frequency magnetic field ($2H_1$), and the rate of sweep through resonance, signals as shown in Fig. 1 were obtained. This shape is explained, as with ordinary wiggles, by assuming that the magnetic moments are left spinning after resonance is passed. The precessional motion continues, the signal passing outside the band-width of the receiver (100 kc./s.), and reappearing, still precessing, on the return of the magnetic field sweep. The wiggles on both halves of the sweep are visible for about 2 gauss from resonance, the continuous change in amplitude being due to the receiver band-width. During one half-period of the sweep, the amplitude has been reduced by some damping process which is independent of the inhomogeneity of the magnetic field.

Assuming that the relaxation times T_1 and T_2 are inversely proportional to the concentration of the ferric ion in the region under discussion (10^{18} Fe^{+++}/c.c.), then it is found that for a wide range of ferric ion concentrations, the damping of the oscillations is proportional to T_1 and/or T_2. This is demonstrated in Fig. 2, where (P_n/P_{N+n}) is the ratio of the amplitudes on the outgoing sweep to those on the return sweep, at the same magnetic field. For very weak concentrations and pure water, the decay reaches a limit (of about 25 per cent), probably governed by some other inhomogeneity not yet understood (cf. Torrey[3]). That the effect observed is independent of the inhomogeneity is demonstrated by distorting the field. Although the signal can be reduced in size by a factor of 10, the ratio (P_n/P_{N+n}) remains unchanged to within the experimental error of $\pm$ 10 per cent.

The magnetic moments cannot be precessing completely freely all the time, as the decay is also dependent on the radio-frequency magnetic field $2H_1$, and on the rate of change of magnetic field. For sufficiently small values of $2H_1$ ($\sim 10^{-3}$ gauss), the ratio (P_n/P_{N+n}) increases with H_1 until a broad maximum is reached with $2H_1 \sim 10^{-2}$ gauss. The maximum is reached for larger values of H_1 when the rate of change of field is greater, but all maximum values of (P_n/P_{N+n}) are roughly equal. A final property of the effect is that the time taken to obtain a signal appears to be $\sim T_1$. If the magnetic field is suddenly changed a little, the effect disappears, reappearing in a time $t \sim T_1$. Very small abrupt changes in the magnetic field cause the pattern on the return stroke to break up and re-arrange itself. In fact, field changes of 1 in 10^6 can be detected in this way. The average rate of precession is about 4·5 Mc./s., so that during 0·01 sec. the magnetic moments have spun 45,000 times. Thus a field-change of 1 in 10^6 would bring about, after 0·01 sec., a phase change in the spinning magnetic moments of $\approx 15°$ relative to the constant exciting radio-frequency. The fact that such a change is observed, together with the time of recovery being $\sim T_1$, seems to imply that the spinning is only loosely held in coherence in some way by the radio-frequency. If field-strengths of 10,000 gauss are used, and if relaxation times T_2 of ~ 1 sec. exist, as is suspected, then this mechanism could possibly be used to detect field changes of as little as 1 in 10^9.

It seems that in this particular case there is not yet an explanation of why the decay is independent of the main field inhomogeneity. Torrey's theory does not help in understanding cases where the magnetic field departs from resonance by more than H_1, whereas the effect occurs for departures from resonance of as much as 200 H_1.

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Feb. 27.

[1] Bloembergen, Purcell and Pound, *Phys. Rev.*, 73, 679 (1948).
[2] Jacobsohn, B. A., and Wangsness, R. K., *Phys. Rev.*, 73, 942 (1948)
[3] Torrey, H. C., *Phys. Rev.*, 76, 1059 (1949).

Dr. Gooden was unable to read the proofs of this letter before his return to Australia, where he has since died. We are uncertain as to the correctness of the "decay time of 0·01 sec." in Fig. 2, but feel that this does not detract from the general information contained in the communication.

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