where B_0 is the initial magnetic induction in front of the shock and B is the final magnetic induction behind the shock. If the external applied field is constant and the demagnetizing field is zero, using

$$B = H_e + 4\pi M \tag{4}$$

along with the conservation of mass jump condition

$$(D-u)\rho = D\rho_0 \tag{5}$$

yields

$$\delta\Phi = bD[4\pi(M\rho_0/\rho - M_0) + (\rho_0/\rho - 1)H_e]\delta t. \tag{6}$$

M_0 is the initial magnetization per unit initial volume and M is the final magnetization per unit final volume. Since

$$u = D(1-\rho_0/\rho) \tag{7}$$

from Eq. (5) and $M\rho_0/\rho$ is the final magnetization per unit initial volume, the rate of flux change becomes

$$d\Phi/dt = 4\pi bD\Delta M - buH_e. \tag{8}$$

The first term is the flux change due to the reduction in magnetization. The second term is the flux change due to the motion of the front surface of the pickup coil in the manner of a magnetic velocity gauge. In the present work the second term was quite small compared to the first. With Eq. (8), the demagnetization can be related to the recorded emf through Faraday's law.

The only significant complication encountered in using this analysis to reduce the demagnetization data was created by lateral relief waves in the platelets of YIG. The stretching of the relieved material increased the induced anisotropy effect in this region. A correction of this relief wave problem was necessary.

V. DISCUSSION

The present work for which the experimental technique was designed did not test the limits of its capabilities. The maximum fields obtained were about 1 kG. This requires a maximum current of about 35–40 A with an initial capacitor voltage of 750 V. The system is capable of carrying 150 A maximum current with only 10° to 15° temperature rise in the solenoid windings. This is substantially below the softening point of epoxy (~80°C). The technique is easily capable of producing pulsed fields up to 5 kG. The magnetic forces involved are still small compared to the strength of the materials used.

Switching the high voltage becomes a problem. For this work, a maximum voltage of 750 V was easily switched with a single silicon controlled rectifier (SCR). SCR's with blocking voltage capabilities higher than 1000 V become increasingly expensive. However, series operations of SCR's allow switching of voltages up to 3 or 4 kV.[11] For higher voltage, a spark gap technique should be used.

Since most impact studies are carried out in evacuated chambers, electrical breakdown and discharge is a potential difficulty. Care must be used in selection of cables and tank connectors for carrying the high voltages. All electrical circuitry within the chamber should be potted in insulating epoxy.

In the present work, maximum shock pressures in the solenoid and specimen were on the order of 45 kilobars. The survival time of the solenoid was about 15 to 20 μsec while that of the pickup coil was about 2 μsec. This was substantially more time than was required to perform the measurement. Survival would become a problem with increasing stress.

Although this technique was invented for investigation of shock induced anisotropy in yttrium iron garnet, it is potentially capable and sensitive enough for impact study of other magnetic and magnetostructural properties. The following possible application is suggested. Volume dependence of magnetic properties such as ferromagnetic or ferrimagnetic exchange integrals has usually been studied by hydrostatic techniques. This becomes increasingly cumbersome with increasing pressure. Shock wave techniques represent a highly sensitive means for investigating pressure dependent magnetic properties. This is because of the extremely high strain rates obtained and, therefore, extremely high flux rates expected. Unfortunately observation of this effect in homogeneous ferromagnetic material is prohibited by the much larger shock induced anisotropy effect. A possible method for circumventing the shock induced anisotropy effect would be to introduce the magnetic material, in powder form, into a low yield matrix such as Lucite or epoxy.[12] For properly chosen powder size, nearly hydrostatic conditions would obtain in the magnetic particles within a reasonable time behind the shock front. With a steady state stress profile in the magnetic composite, the analysis in the last section would provide the change in magnetization. The sensitivity of the technique is on the order of 1 V/G. This sensitivity should be more than sufficient for measuring expected demagnetization in many magnetic materials.

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