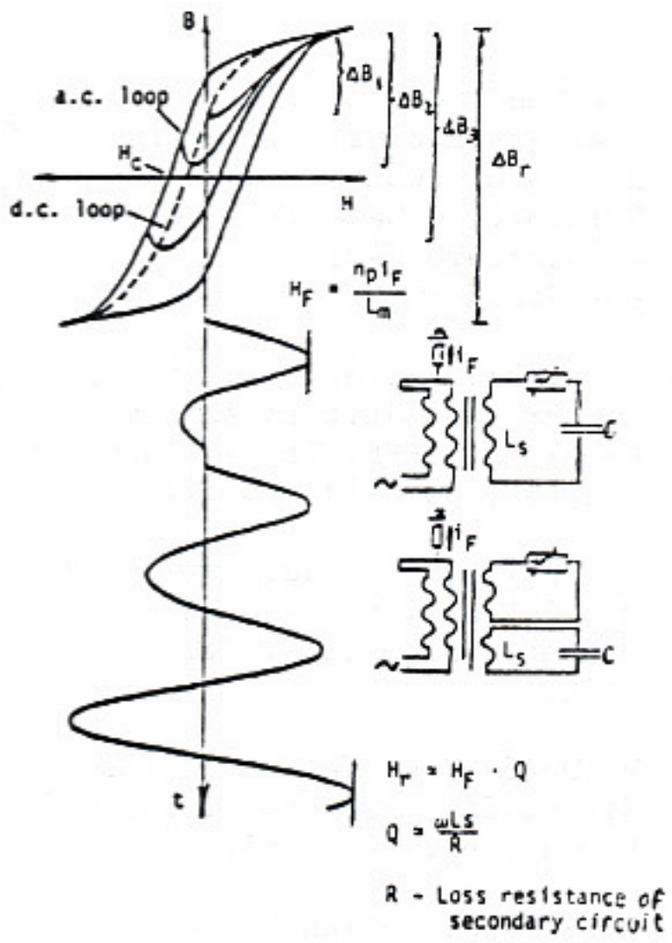

Fig. 12 - Magnetization of a round loop GFCI core by half wave fault currents.

The magnetization cycle of a transformer core excited by half wave fault currents iF in a resonant circuit is shown in Fig. 12. The first pulse current iF charges the resonant capacitor C through the induced voltage ΔB. Without capacitor the core would remain at Br at the end of the pulse and the magnetization would change from the ac Br to the dc Br. The stored current charge in the capacitor discharges after the pulse and demagnetizes the core to the ΔB_2 remanence. After 3 or 4 pulses the core will be in complete resonance and provide the power to trip the relay. Resonance occurs in less than 200ms so that the device safely removes the electrical shock hazard. Cores for such devices need to have a low remanence and a low coercive force Hc so that the initial charge to the capacitor can be made.

Supermalloy tape cores made of .08mm tape are generally used. Several methods are available[10]. First, by fast cooling the Supermalloy type cores from the high temperature anneal of 1180°C an order-disorder structure can be produced in the alloy which will lead to a round loop, see Fig. 13. Unfortunately, such cores do change their characteristics with temperature. At +60°C the loop is more square and at -20°C, the coercive force is much higher so that the trip level of a GFCI using such cores can vary significantly. Second, by heat treating cores in an axial field - perpendicular to the direction of magnetization a uniaxial magnetic anisotropy can be introduced which rounds the hysteresis loop as shown in Fig. 13. Such cores have very stable pulse permeabilities over temperature and the loop can be flat to a large degree. The heat treatment required is elaborate, must be precise and is relatively expensive because of the labor involved.

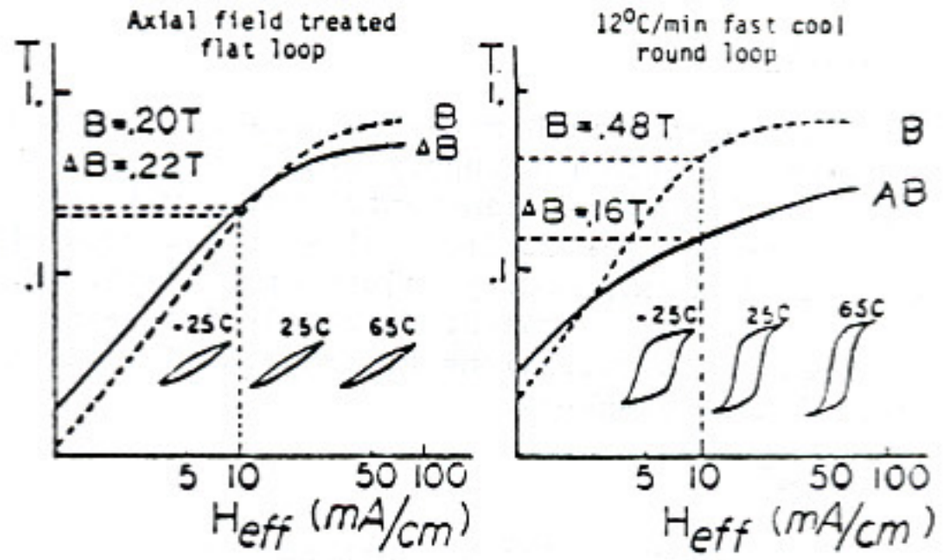

Fig. 13 - B-H curves for rounded Supermalloy, axial field treated and fast cooled.
— half wave, ---- sinusoidal magnetization

Third, by winding two or three layers of $MgO-Al_2O_3$ coated tape simultaneously, a controlled airgap can be introduced to the magnetic circuit which leans the loop, as shown in Fig. 14. The axial magnetic field treatment, as well as the multilayer winding, are covered by patents.

Such cores with sufficiently low remanent hysteresis loops can be used to build circuit breakers which trip safely under pure ac, as well as, under pulsed current conditions.

Other GFCI Cores.

Other GFCI devices which will disconnect ac pulsed dc, as well as pure dc power supply lines at 30mA, can be built using square loop cores of very thin gauge Supermalloy which oscillate at 5KHz to 10KHz. The fault current is superposed on the oscillating current and changes the required 5KHz magnetizing field. This is sensed by an IC and used to trip a relay.

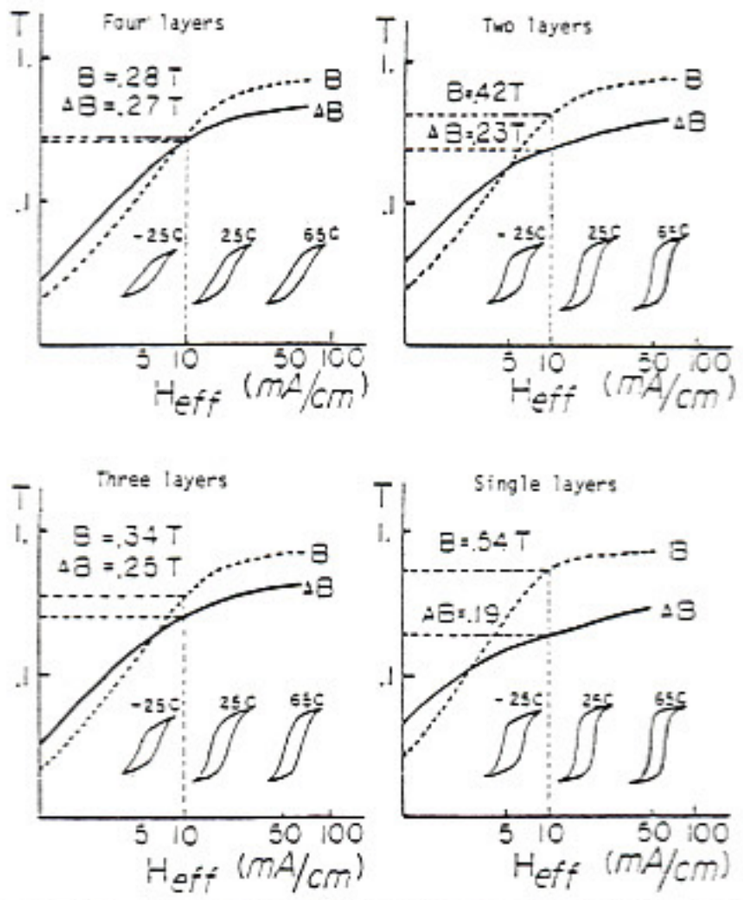

Fig. 14 - B-H curves and hysteresis loops for single and multi layer wound cores.
___ half wave, ---- sine wave.