

Fig. 3 - Schematic: Ground Fault Interrupting Circuit Breaker (GFCI).

The International Electrotechnical Commission, Committee 23E and many national safety organizations like, for instance, the Underwriter's Laboratories in the U.S. (UL 943) and the VDE Organization in Germany (VDE Standard 0-64) have therefore adopted regulations for circuit breakers to protect people from the hazard of electrical shock. Devices built to these specifications should interrupt the current supply either at currents (ground faults) of 30mA maximum, preventing heart fibrillation, or at even lower currents of 6 - 15mA, the let go current preventing muscle cramps, see Fig. 3. Such devices are now used in large quantities worldwide. We report here on the differential transformer cores required for the operation of such devices.

5ma - 30mA Differential Current Transformers With Electronic Amplification.

As explained previously, GFCI's which interrupt the supply voltage at fault currents as low as 5mA, will allow an individual to either let go of the faulty equipment or will disconnect the device. Such GFCI's are therefore useful for the protection of people in or near the swimming pools, wet basements. They offer the best possible protection for people and are specified by UL 943 as well as in IEC Document 23E, Type AC.

These devices sense the fault current of 5mA or more with a small current transformer core whose output signal is detected by an integrated circuit when a fault current of predetermined value flows. The IC then provides power to a low carbon steel relay which trips the circuit breaker. The core, the IC and the relay can be kept very small so that the tripping package, as well as the mechanical breaker arrangement, can be packaged within the standard dimensions of a circuit breaker or supply current outlet box, see Fig. 4.

Since the current transformer for 5mA has only one primary turn, great demands have to be made on the core⁶. It has to be self shielding, ignoring erroneous signals from other current supply lines in the vicinity. It has to have the highest possible permeability which should not vary by much over the normal operating temperature range from -35°C to +70°C, nor

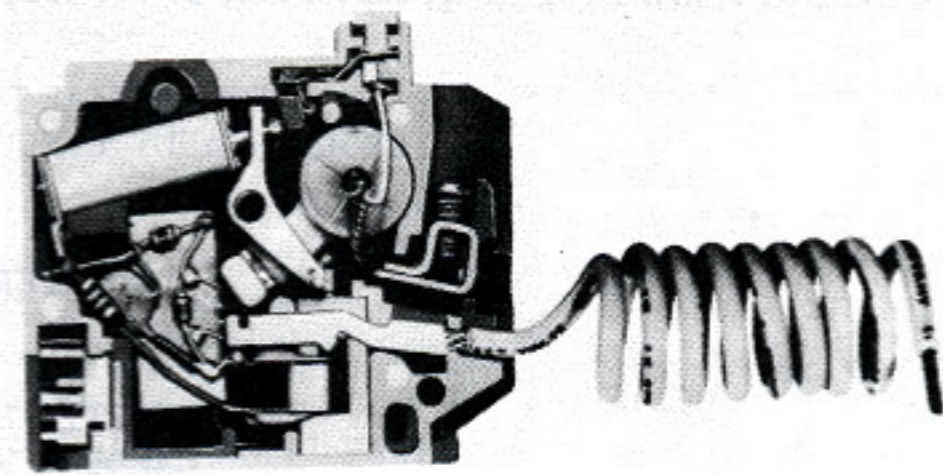


Fig. 4 - Ground Fault Interrupter, courtesy Bryant Electric, Westinghouse.

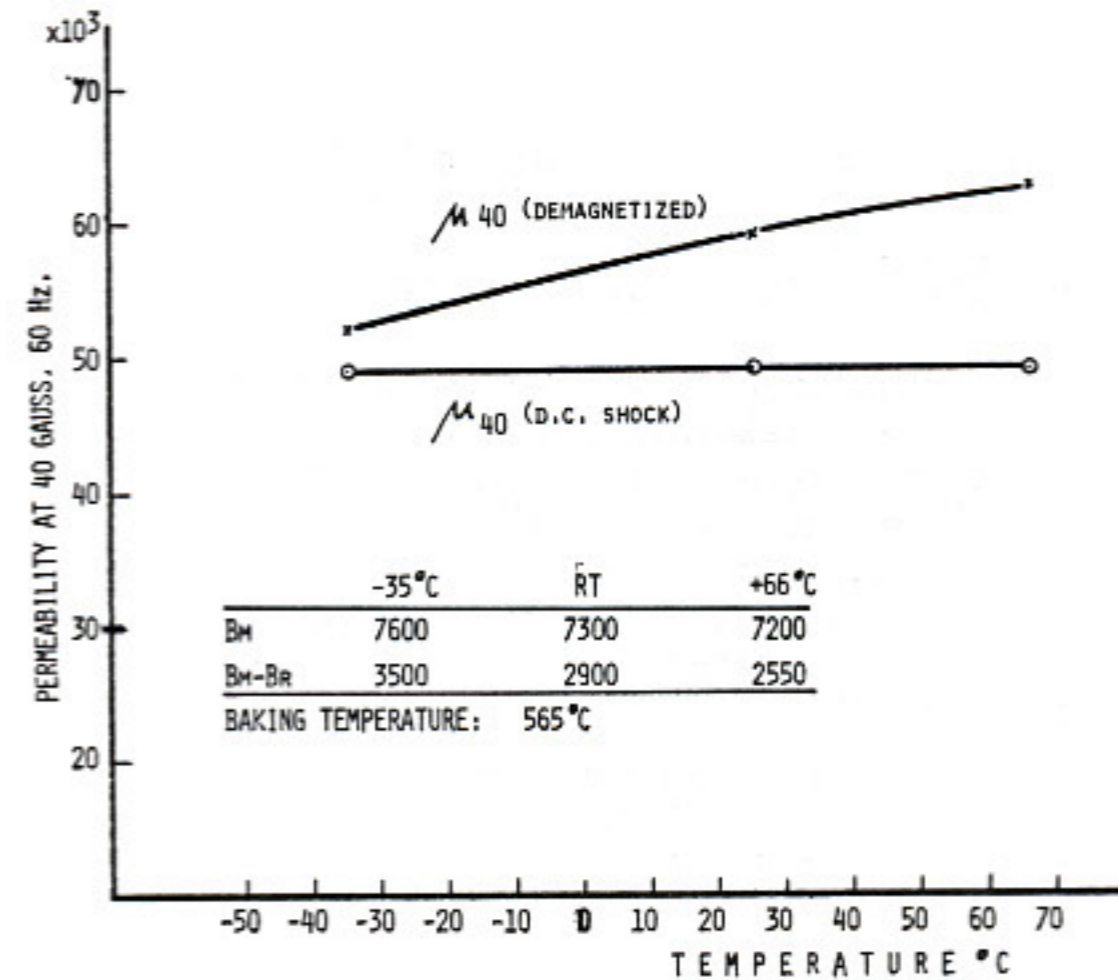


Fig. 6 - Typical permeability of Supermalloy rings with stabilized permeability for optimum performance in GFCI's, $\mu (T)$ for $-35^{\circ}\text{C} < T < +70^{\circ}\text{C}$.

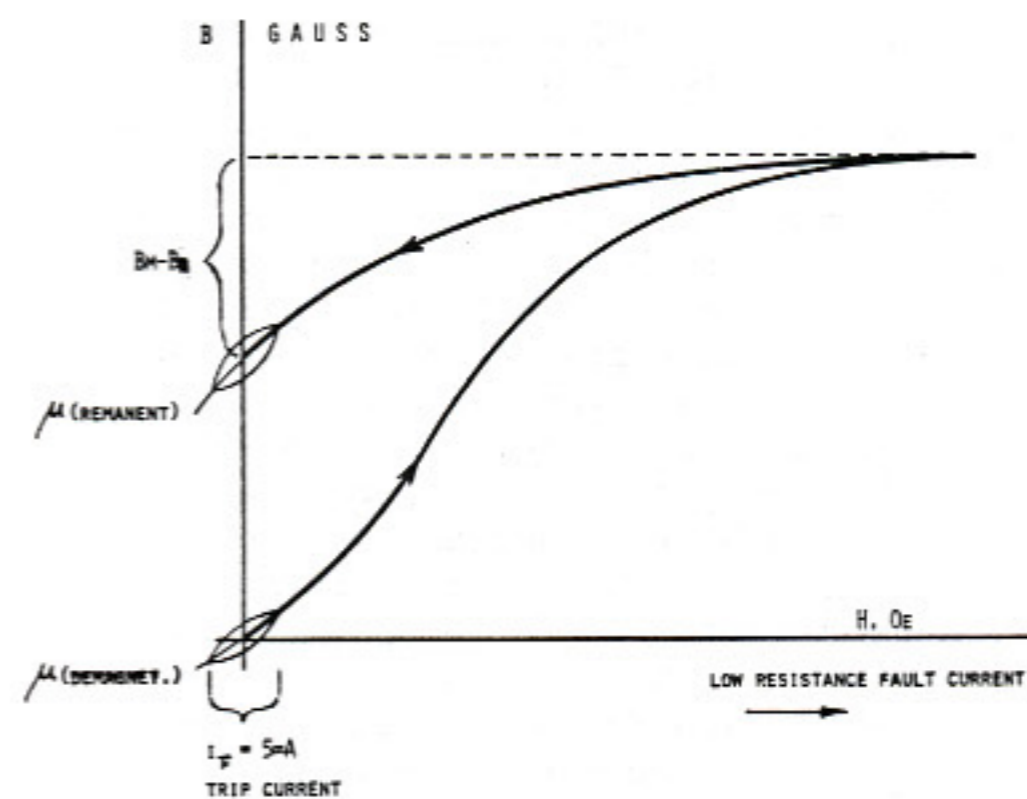


Fig. 5 - Permeability of differential transformer in the demagnetized state and after a low resistance fault.

should the permeability change much between the demagnetized state and the remanent state into which the core could be put by a low resistance fault (direct ground fault), see Fig. 5 and Fig. 6.