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Evaluation of Magnetic Materials for Static Inverters and Converters

The design of lightweight, highly efficient static inverters and converters has been seriously hampered by the lack of suitable data on the behavior of commonly used materials when excited with square wave power.

A program was conducted to study materials for use in these static inverters and converters. This program included a literature survey of conductor materials, and a series of tests on magnetic alloys.

Tests were performed with square wave excitation to evaluate two thicknesses of available types of core materials to determine the CCFR (Constant Current Flux Reset) properties at room temperature at 400 to 3200 Hz, AC (400 to 3200 Hz) and DC magnetic properties at -55°C , room temperature and 250°C , degradation of magnetic properties resulting from normal factory processing, and the effects of high vacuum at 250°C for 1000 hours.

The tests made with square wave excitation were the first comprehensive compilation of data using a square wave form of voltage instead of a sinusoidal wave form of voltage. The formation of a square wave requires the use of the odd harmonic powers 1, 3, 5, 7, 9, 11, etc. The test equipment was designed to measure through the 15th harmonic to provide the utmost in accuracy.

The materials evaluated were:

- 1) Square hysteresis loop 4% Mo-79% Ni-17% Fe alloy.
- 2) Grain oriented 50% Ni-50% Fe alloy.
- 3) Magnetic field annealed 49% Co-2% V-49% Fe alloy.
- 4) Doubly grain oriented silicon steel both with and without magnetic field anneal.
- 5) Singly grain-oriented silicon steel.

Table 1. Potential Application of Materials

Application	Material					
	4% Mo-79% Ni-17% Fe	50% Ni-50% Fe	Magnetic Field Annealed 49% Co-2% V-49% Fe	Singly Grain Oriented Silicon Steel	Doubly Grain Oriented Silicon Steel	Stress Relief Anneal Doubly Grain Oriented Silicon Steel Magnetic Field Anneal
Power Transformers			•	•	•	•
Specialty Type Transformers	•	•	•	•	•	•
Current Transformers	•	•	•	•	•	•
Pulse Transformers	•	•	•	•	•	•
Reactors (Inductors)			•	•	•	•
Saturable Reactors	•	•	•	•	•	•
Magnetic Amplifiers	•	•	•	•	•	•
Flux Counters	•	•				
Transducers	•	•	•	•	•	•
Time Delays	•	•				
Bi-Stable Switching Devices	•	•				
Saturating Switching Devices	•	•				

Test results follow:

- 1) The grain oriented 50% Ni-50% Fe toroid had the optimum combination of overall magnetic properties for core applications.
- 2) The magnetic field annealed doubly grain oriented silicon steel had the second most generally useful properties.

(continued overleaf)

3) The square hysteresis loop 4% Mo-79% Ni-17% Fe toroid was best suited for core applications requiring high gain.

4) The magnetic field annealed 49% Co-2% V-49% Fe toroid was best for those applications requiring a high saturation.

5) The singly grain-oriented silicon steel toroid was a suitable substitute for the stress relief annealed doubly grain-oriented silicon steel.

The test results and data should enable a designer using square wave excitation to select suitable materials to minimize losses when operating at various induction levels and frequencies.

Potential uses of the materials are shown in Table I.

Notes:

1. Documentation is available from:
Clearinghouse for Federal Scientific
and Technical Information
Springfield, Virginia 22151
Price \$3.00
Reference: TSP69-10306

2. Technical questions may be directed to:
Technology Utilization Officer
Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135
Reference: B69-10306

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No patent action is contemplated by NASA.

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