MEASUREMENT OF THE NOISE OF CYCLIC REMAGNETIZATION OF FERROMAGNETIC SUBSTANCES AT LOW TEMPERATURES

N. N. KOLACHEVSKIĬ

Moscow Physico-Technical Institute

Submitted to JETP editor August 19, 1959

J. Exptl. Theoret. Phys. (U.S.S.R.) **36**, 401-403 (February, 1959)

We present the result of measurements of the noise due to cyclic remagnetization of ferromagnetic cores at temperatures between 2° and 300°K. No dependence of the noise on the temperature was detected.

INTRODUCTION

THE fact that the reversal of magnetization of ferromagnetic specimens is not repetitive from cycle to cycle leads to the appearance of a dc component in the spectrum of the emf's induced in an indicator coil wound on the remagnetized core.[1] This may be caused by thermal flucations in the parameters that determine the position of the boundary between the domains.[2*] Owing to these flucations, the instants at which the voltage pulses are produced by. the jump-like changes in the magnetic moment of the specimen upon its remagnetization (the Barkhausen effect) and also the time behavior of these pulses, may differ from cycle to cycle. However, such an explanation of the phenomenon should lead to a temperature dependence of the noise of cyclic remagnetization.

It was indicated in reference 5 that, in the temperature interval from 90°K (liquid nitrogen) to the corresponding Curie points, many ferromagnetic specimens (such as permalloy or nickel) display no variation whatever of the noise on the temperature, except for the variation caused by the temperature dependence of the average change in the magnetic moment in the Barkhausen effect.

To change substantially the influence of the thermal flucations on the remagnetization processes, we have measured the noise due to cyclic remagnetization at a temperature of 2°K (liquid helium, which boils at 24 mm Hg).

EXPERIMENTAL SETUP

The noise-measuring circuit is shown in Fig. 1. The spectrum analyzer measures the rms noise voltage at 1 to 200 kcs in a bandwidth of 15 cycles.

*The possibility of such fluctuations is indicated also in references 3 and 4.

Two indicator coils, 50 turns each, are wound on the specimens subject to remagnetization. These coils are connected in opposition to cancel the discrete components of the spectrum. Since the noise is incoherent, the noise power in these coils is additive. The solenoid with the specimen and the indicator coils is placed in a Dewar vessel with liquid helium.

In addition to measuring the cyclic remagnetization noise, we determined the average of the voltage pulses, corresponding to the average change in the magnetic moment in each elementary remagnetization event, occuring when the specimen is subjected to quasi-static remagnetization, and the voltage from the indicator coils was fed to an oscillograph. The time behavior (waveform) of the voltage pulses was also observed.

The specimens used were plates of single-crystal silicon iron (3%), the anisotropy and electric-resistivity constant of which have a low temperature dependence at low temperatures. The plates were cut out by the electric-spark method parallel to the [1 0 0] axis, with subsequent annealing in vacuo. The dimensions of the specimens were 32 × 0.65 × 0.3 mm. Two identical specimens were used under each indicator coil. The magnetization was effected with a common solenoid, 80 mm long and 30 mm in diameter, which produced a maximum field of 40 oersteds.

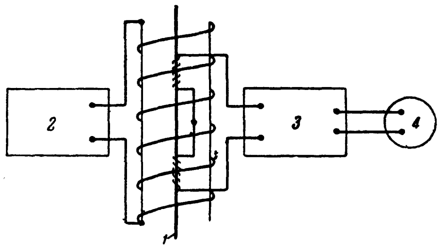

FIG. 1. Diagram of the experiment; 1) specimen, 2) generator ZG-10, 3) spectrum analyzer, 4) galvanometer.

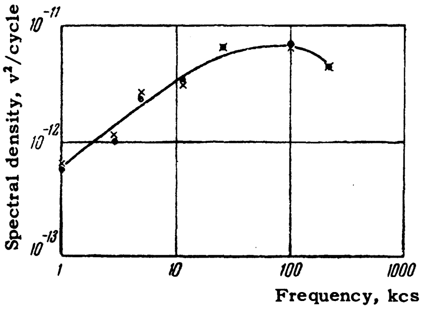

FIG. 2. Noise spectrum for a single-crystal specimen of silicon iron; × – 2°K, • – 300°K.

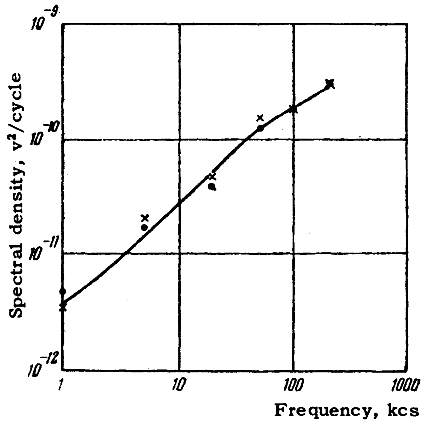

FIG. 3. Noise spectrum for polycrystalline specimen of silicon iron. Average grain dimension 5 mm; × – 2°K, • – 300°K.

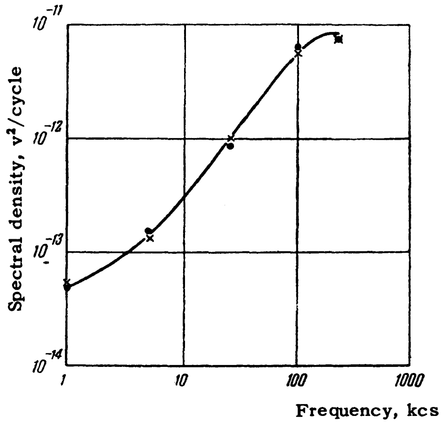

FIG. 4. Noise spectrum for a specimen of unannealed 78% permalloy; × – 2°K, • – 300°K.

To check our results we made analogous measurements on specimens of polycrystalline textured silicon steel, cut in the form of strips 0.3 mm thick, and on unannealed permalloy wire 0.2 mm in diameter. The length of the specimen was determined by the dimensions of the solenoid.

MEASUREMENT RESULTS

Figures 2, 3, and 4 give the cyclic-remagnetization noise spectra at room temperature and at 2°K. The value of the remagnetizing field was chosen such as to saturate the specimen (40 oersteds for all specimens). The frequency of the remagnetizing field was 2 kcs in all cases. As can be seen from the curves, the results of the measurements at room temperature and at the temperature of liquid helium are the same for all specimens. An observation of the oscillograms of the remagnetization pulses and a measurement of their average area also showed no differences in these temperatures. The average volume of the remagnetized region, corresponding to the average value of the voltage pulse, was on the order of 10^{-11} cm^3 for silicon steel and 10^{-10} cm^3 for permalloy.

The results obtained give grounds for concluding that the cyclic remagnetization noise is not due to thermal fluctuations.

[1] A. A. Grachev, Dokl. Akad. Nauk SSSR **71**, 269 (1950).

[2] G. S. Gorelik, Izv. Akad. Nauk SSSR, Ser. Fiz. **14**, 174 (1950).

[3] L. Neel, J. phys. et radium, **11** 49 (1950).

[4] L. Neel, J. phys. et radium **12**, 339 (1951).

[5] N. N. Kolachevskiĭ, Сб. тр. МФТИ (Coll. of Papers, Moscow Physico-technical Inst.) No. 2, (1958).

Translated by J. G. Adashko
69