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Letters to the Editor

THE TEMPERATURE DEPENDENCE OF THE RELATIVE PARTICIPATION OF NEGATIVE BARKHAUSEN JUMPS IN THE PROCESS OF MAGNETIZATION OF METAL FERROMAGNETS

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The existence of negative Barkhausen jumps (B. j.) in the process of magnetization of both polycrystalline and monocrystalline metal ferromagnets was experimentally confirmed in papers [1–3]. Paper [4] gives the interpretation of the origin of negative B. j. as a consequence of the influence of time – varying eddy currents, which appear in the metal ferromagnets after the realization of positive B. j. Such an interpretation of the origin of negative B. j. is supported by some experimental results, reported in [5] and [6]. With respect to the fact that some important parameters of ferromagnets (electrical conductivity, coercive force), which according to this interpretation of the origin of negative B. j. may affect their relative participation, are temperature dependent, it seems useful to study the temperature dependence of the relative participation of these elementary irreversible magnetization processes, especially down to low temperatures. This paper gives results of the experimental study of the temperature dependence of the relative participation of negative B. j. in the process of magnetization of polycrystalline metal ferromagnets in the temperature range of 77 K to 300 K.

Positive as well as negative B. j. occurring in the process of magnetization of given ferromagnets were registered by the apparatus described in [2]. The resolving time of this apparatus was 2.5×10^{-6} s. It registered all B. j. with the time separation between them equal to or greater than this time interval and connected with the change of the magnetic momentum during the jump of more than 1.6×10^{-6} units cgsm. Measurements were made on the polycrystalline samples of Fe, Co, Ni, PY 50 in the form of wires. All samples were annealed in a hydrogen atmosphere prior to measurements. During the investigation of the temperature dependence the sample was placed in a cryostat enabling continuous temperature control in the range of 77.4 K to 310 K. This cryostat is described in [7].

The obtained temperature dependence of the relative number of negative B. j. $n = N^-/N^+$ in the process of magnetization along the branch of a $B - H$ loop, i. e. the ratio of number of all recorded negative B. j. N^- to the number of all recorded positive

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B. j. N^+, is shown in Fig. 1. It is evident from this figure that for all samples there is an apparent change of the relative participation of negative B. j. with temperature in the process of magnetization from saturation in one direction to saturation in the opposite direction.

To obtain an idea about how the relative number of negative B. j. depends upon the coercitive force, we have measured this number for polycrystalline samples with various values of coercitive force in the process of magnetization along one branch of the $B - H$ loop at room temperature. The results of these measurements are shown in Fig. 2. As can be seen, with increasing value of the coercive force the relative number of negative B. j. decreases practically exponentially.

To interprete the dependences shown in Fig. 1 let us consider first how their course can be affected by the temperature dependence of the electrical conductivity of metal ferromagnets. As follows from [4] the temperature dependence of electrical conductivity does not affect the amplitude of the magnetic field of eddy currents, yet it affects the variation of this field with time. This can be seen from Fig. 3 showing the time dependence of the magnetic field of eddy currents at a distance of 10^{-3} cm from the point of jump,

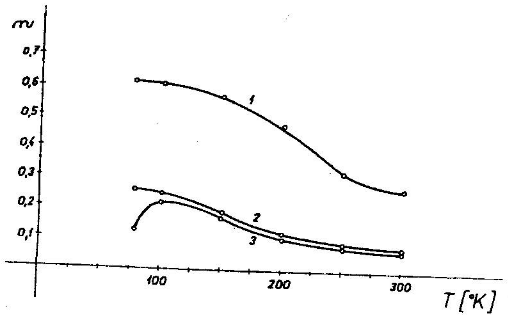

Fig. 1. The temperature dependence of the relative participation of negative Barkhausen jumps 1 — Fe; 2 — Ni; 3 — Co.

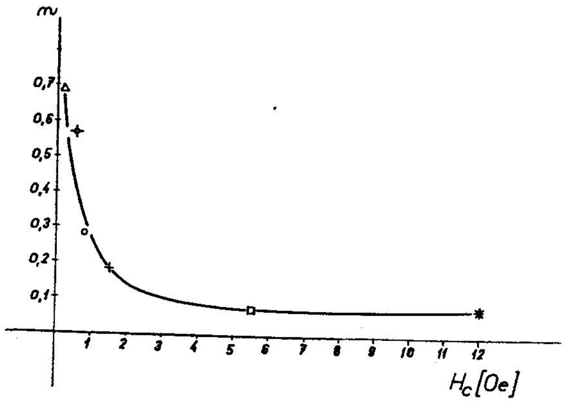

Fig. 2. The dependence of the relative participation of negative B. j. upon the coercive force (△ — PY 50; ⌖ — Ni 1; ○ — Fe; + — Ni 2; □ — Ni 3 (def.); * — Co).

which has caused these eddy currents, this being at temperatures of 78 K and 293 K respectively. Curves in Fig 3 were calculated according to [4]. It is evident from this figure that the time at which the magnetic field caused by eddy currents reaches its maximum, is at 78 K practically by one order longer than at a temperature of 293 K. Therefore it appears that with decreasing temperature the time separation between mutually coupled positive and negative B. j. becomes longer, which enables a more relative number of negative B. j. to be recorded with the measuring apparatus with the given resolving time.

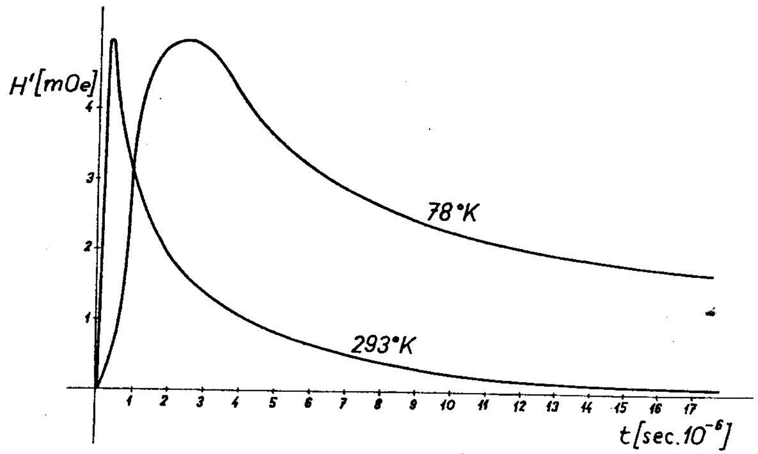

Fig. 3. Time dependence of the magnetic field of eddy currents at a distance of 10^{-3} cm from the point of jump at temperatures of 78 K and 293 K.

As the coercive force of the sample is the root-mean-square value of critical fields in a ferromagnet, obviously its temperature dependence will affect the number of negative B. j. when the sample temperature is changed. Information on the character of the temperature dependence of the coercive force of polycrystalline metal ferromagnets is given in papers [8] to [13]. According to them the coercive force of these ferromagnets increases when passing from room temperature down to liquid nitrogen temperature, this increase being quite marked in some materials. If we considered only the effect of the coercive force increase with decreasing temperature, it would lead to the decreasing relative number of negative B. j. in the given magnetization process (see also Fig. 2).

It is evident from what was said above that two tendencies of opposite character are influencing the course of the temperature dependence $n = n(T)$ as recorded with the measuring apparatus. They act simultaneously and the experimentally measured dependences shown in Fig. 1 indicate that in the used Fe and Ni samples there dominates in the whole covered temperature range much or less the tendency which increases the relative number of negative B. j. There is a similar tendency in the case of a Co sample in the temperature range from 300 K to 100 K. However, the measured n for this sample at the temperature of 77.4 K is much less than that at 100 K. Below 100 K thus the tendency begins to dominate, which results in the decrease of the relative number of negative B. j.

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