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Abstract

Full Text

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PHYSICS

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ON THE EXISTENCE OF TWO INDEPENDENT MECHANISMS OF BARKHAUSEN JUMPS IN FERROMAGNETS

(Presented by Academician A. V. Shubnikov on February 7, 1967)

Numerous works have been devoted to the study of various parameters (duration, size, amplitude) of magnetization-reversal jumps, as well as to the distribution of jumps with respect to these parameters (see, for example, ([1–3])). According to the authors' data, the average duration of the jumps τ lies in the interval 5—15 μsec, while the average jump size ΔM (the change in magnetic moment corresponding to one jump) is 10^{-7}—10^{-6} CGSM units. At the same time, most authors take as the principal mechanism of a jump the abrupt motion of a 180° or 90° domain wall at some internal defect (inclusion, inhomogeneous stress) of the crystal.

In the present work we succeeded in detecting an independent group of anomalously long Barkhausen jumps, the durations τ and sizes ΔM of which exceed by more than two orders of magnitude the corresponding parameters of "ordinary" jumps. The investigations were carried out on an apparatus whose operating principle is described in ([4]); an essential addition to it is the pulse integrator described in ([5]). Wire specimens of silicon iron (0.8% Si), annealed in vacuum at 10^{-3} mm Hg at 1100°, were chosen as the material studied.

Fig. 1. Oscillogram of Barkhausen jumps

Figure 1 shows a photograph of a long-duration jump against the background of ordinary jumps, taken from the screen of an SI-4 oscilloscope. The sharp difference between the parameters of these jumps and the corresponding parameters of ordinary jumps makes it possible to conclude that the mechanism of their occurrence differs from the mechanism by which jumps of ordinary durations arise.

Fig. 2

Figure 2: Fig. 2

Fig. 3

Figure 3: Fig. 3

The distribution of jumps by duration that we obtained indirectly confirms this supposition. It turned out that anomalously long jumps constitute a separate group, producing on the distribution curve a second maximum corresponding to the most probable duration of these jumps, of the order of 1—2 msec.

Although anomalously long jumps account for only 5—10% of the total number, the contribution they make to the irreversible part of the magnetization caused by the entire Barkhausen effect proves to be of the same order as the contribution made by ordinary jumps. This is clearly seen in Fig. 2, where curves obtained with the aid of the integrator are presented for the dependence of the change in the total magnetic moment corresponding to Barkhausen jumps on their duration. On the differential curve

two maxima are clearly distinguished, corresponding to two different groups of jumps. The contributions made by both groups to the change in the total magnetic moment are of the same order. It is quite obvious that the mechanisms by which jumps with such sharply differing parameters arise must be different.

Analysis of theoretical calculations of the critical field, carried out by E. I. Kondorskii ([6]), Becker and Döring ([7]), shows that jump-like motion of individual interconnected 180° and 90° walls cannot be the cause of anomalously long jumps.

Fig. 2. Contribution of jumps of different durations to the irreversible process of remagnetization caused by the Barkhausen effect.
1 —integral, **2** —differential distribution.

Fig. 3. Distribution curves by durations of jumps caused by mechanical stresses, for different values of the maximum loads $\sigma_{\max}$:
1 —$\sigma_{\max} = 9$ kG/mm^2; **2** —5.6 kG/mm^2; **3** —3 kG/mm^2.

One of the possible reasons leading to such anomalously large jumps, in our view, may be the interconnected motion of 180° and 90° boundaries. Such interconnected motion leads to the fact that the more "mobile" 180° wall is impeded in its motion by the 90° wall associated with it, so that the 180° wall finds itself in a stressed state. At a certain value of the field this "coupling"breaks, and the 180° wall jumps into a new position that is energetically favorable for it*. An approximate calculation showed that, in order of magnitude of the remagnetized volume, such a jump corresponds to an anomalously long jump.

If the indicated mechanism actually takes place, then such a jump-like restruc-

turing of the structure and the jumps corresponding to this restructuring should be caused not only by a change in the magnetic field applied to the specimen, but also by other causes leading to a change in the domain structure, for example by mechanical stresses applied to the specimen.

In this connection we carried out a study of the Barkhausen effect caused by mechanical stresses, for the presence of anomalously long jumps. The measurements showed that in this case as well, along with the jumps studied earlier ([9]), anomalously long ones are also present. Figure 3 gives distribution curves of jumps by duration for the "mechanical" Barkhausen effect, on which two maxima are clearly visible.

Thus, it may be asserted that both in the Barkhausen effect caused by a change in the magnetic field and in the Barkhausen effect caused—

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* Jump-like motion of interconnected 180° and 90° walls was observed by the powder method in nickel by Haak and Yuman ([8]).

caused by mechanical stresses, there exist two independent groups of jumps with sharply different parameters and with different mechanisms of their occurrence.

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Note: Figure translations are in progress. See original paper for figures.