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THE OCCURRENCE OF NEGATIVE BARKHAUSEN JUMPS IN THE PROCESS OF THE MAGNETIC AFTEREFFECT

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The occurrence of negative Barkhausen jumps (*B.j.*) during the process of the magnetization reversal of metal ferromagnetic samples was observed in a number of experimental works [1—3]. It has been shown that the participation of negative *B.j.* in the total number of the registered jumps is sensitive to the change of the sample temperature [4] and to the way in which the magnetization has been reversed [5]. Paper [6] gives an explanation of the origin of the negative *B.j.* as a consequence of the presence of the time-varying eddy currents appearing in the conducting medium of metal ferromagnets after the positive *B.j.* has been realized. This model has been the basis for a good qualitative explanation of the temperature dependence of the relative occurrence of negative *B.j.* and for an estimation of time intervals between the original positive and the succeeding negative jump. However, this time interval depends upon the distance between the points at which the original and the *B.j.* coupled with him originate. For distances comparable with the linear dimension of domains in polycrystalline samples we get for the above mentioned time interval values of about 10^{-6} s. With increasing distance this time interval increases rapidly and for distances of the order of mm its value is already about 10^{-3} s. But the intensity of the magnetic field of eddy currents has a very low value at such a distance from the original *B.j.* That is why the probability is very small that the field of the eddy currents at such a distance would reach the value of the critical field for the irreversible displacement of the local domain wall.

In addition to the above mentioned mechanism of the origin of the negative *B.j.* another mechanism is principally possible, i.e. the formation of negative jumps as a consequence of the local thermal fluctuation of the magnetization in the domains. The magnitude of these fluctuations is quantitatively characterized by the effective field of thermal fluctuations, which was introduced by Neél [7, 8]. This effective field reaches its maximal values in positive and in negative directions with the same probability, thus its average value is equal zero.

It is very difficult to determine the participation of these two mechanisms in the occurrence of negative jumps. Under normal conditions the density of the occurrence of the *B.j.* during the magnetization reversal of the sample is very high. This makes it very difficult to detect unambigously which of the preceding positive jumps is coupled with the particular negative *B.j.* and so determine their time separation. That was the

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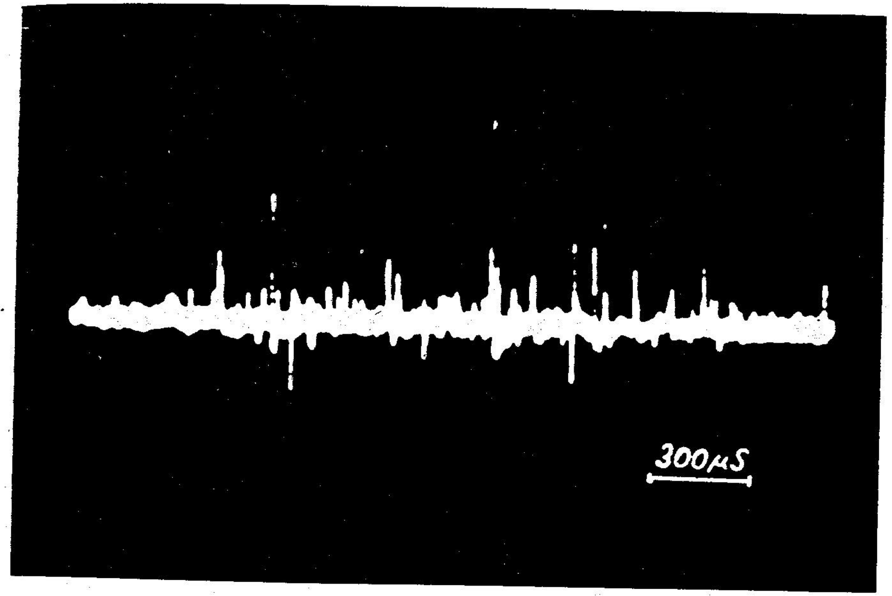

Fig. 1.

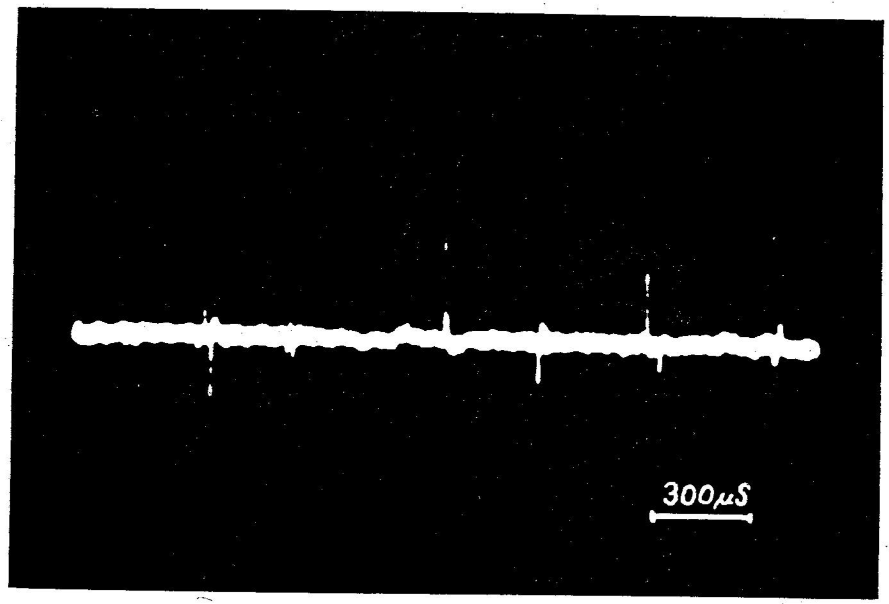

Fig. 2.

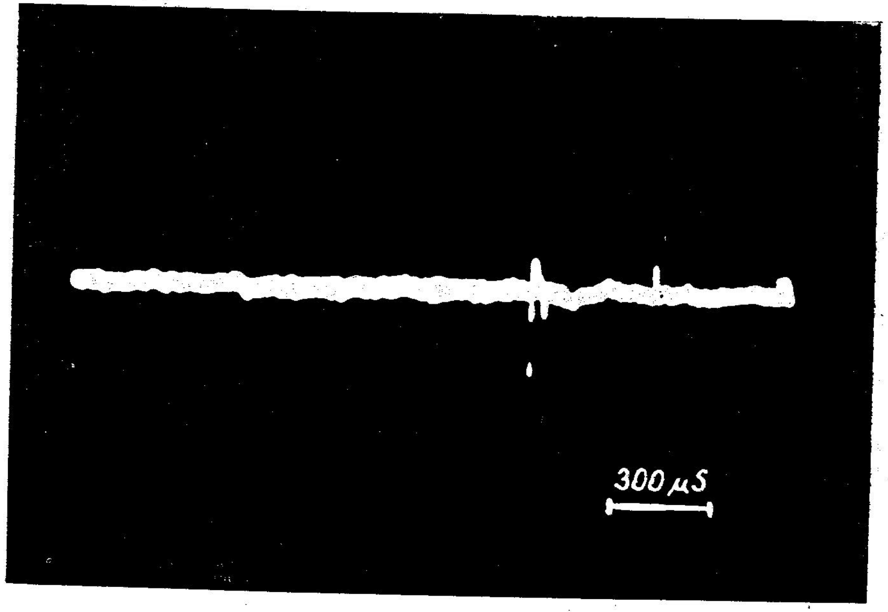

Fig. 3.

reason why we studied the occurrence of the negative $B.j.$ among the jumps in the process of the magnetic aftereffect, realized after a sudden change of the acting magnetic field. The density of the $B.j.$ is much lower in this case, which is advantageous for the purpose of our work.

The occurrence of the negative $B.j.$ in the process of the magnetic aftereffect was studied in such a way that we registered oscilloscopically $B.j.$ originating a certain time after the realization of the spring change of the acting magnetic field. For the sake of a good reproducibility of the initial conditions of the experiment we selected magnetic saturation as the initial state of the sample. The sample was magnetized from this state to the selected point of the hysteresis loop by a very rapid change of the magnetizing field. The change of the field was realized in less than 10^{-5} s. The oscilloscopic record of the studied phenomenon was photographed.

The results of our study are in Figs. 1, 2, 3, which show oscillograms of $B.j.$ in the process of the magnetic aftereffect, registered after the spring magnetization reversal of the wire sample PY 50 at room temperature. The spring change of the field was realized from the saturated state into the region of the coercive force of the used sample. Fig. 1 shows a part of the $B.j.$ registered 0.3 s after the spring change of the field. The occurrence density of the positive jumps is still high here, making it difficult to survey the recording. It is seen, however, that the time interval between positive and successive negative jump is in every case shorter than 50 μs. Fig. 2 shows the situation after 3 s. The recording is easier to survey, because the occurrence density is substantially lower. The time interval for the first pair of positive and negative jumps is about 50 μs, for the second pair 300 μs and for the third pair about 50 μs. Fig. 3 is the recording of the studied phenomenon in the 20th second after the sudden change of the field. It is seen that at least 1.4 ms before the appearance of the negative $B.j.$ recorded in this figure, no positive

jump has been registered. This indicates that this single negative jump originated with the greatest probability as a consequence of the random impulse of the thermal fluctuation field.

It can be concluded from the above that the mechanism described in [6] need not be the only mechanism of the origin of the negative $B.j.$ But the participation of negative jumps originating as a consequence of thermal fluctuations will be relatively low in the process of the magnetization reversal of metal samples, as it is shown by the results of the study of the temperature dependence of the occurrence of negative jumps. On the other hand, in the case of non-conducting samples it is the only possible way of how the negative $B.j.$ could originate. However, until now no negative jumps were observed in the process of the magnetization reversal of ferrite samples [9].

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