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Letters to the Editor

CONCERNING A SENSATIONAL EFFECT

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REPORTS have recently appeared in our popular journals, and also in the central press (the "Izvestiya"), about a new effect—the effect of a magnetic field on the properties of common water. It is stated that water passed through a constant magnetic field of a special geometric configuration acquires new properties. The operation is referred to as the magnetic treatment of water. In using the treated water one observes a decrease in the rate of formation of scale and in its amount on the walls of the boilers. In other words, in the process of boiling the relative role of the formation of vapor bubbles and sediment within the volume increases compared with the same effect on the walls. In the opinion of some persons this effect is connected with a considerable change in the structure of the water under the influence of the magnetic field.

I would like to request the editors of "Uspekhi Fizicheskikh Nauk" to bring some clarity to this problem; it is not a simple problem and may be incorrectly interpreted. The effect of a constant or low-frequency magnetic field on water, as on every other material medium, in a state of thermodynamic equilibrium is characterized quantitatively by the value of its magnetic susceptibility. The change of all the properties of water, its structure, surface tension, density, etc, in a magnetic field is in the final analysis determined by the magnetic susceptibility. This assertion is based on the most general ideas concerning systems in a state of thermodynamic equilibrium. All the properties of systems in equilibrium are completely determined by their function of state (partition function) Z. The magnetic susceptibility is by definition

$$\chi = \frac{kT}{v}\frac{1}{H}\frac{\partial \ln Z}{\partial H},$$

and is a quantitative measure of the change in the partition function on placing the system in a magnetic field of intensity H.

The change in the thermodynamic functions and of their derivatives for an arbitrary system is expressed in terms of χ. It follows thus from the general assumptions of statistical physics and thermodynamics that the changes of thermodynamic properties of systems with small values of the magnetic susceptibility in a magnetic field are relatively small.

An elementary estimate shows that in the case of water the effect of moderate magnetic fields, up to several tens of thousands of gauss, on its thermodynamic parameters is negligibly small.

Another general assumption is that when a system in equilibrium undergoes the action of some field, and the field is then turned off sufficiently slowly, the system returns to its initial state. The widely known exceptions to this rule, for instance in the case of adiabatic demagnetization, are connected with special properties of systems—the presence of slowly relaxing degrees of freedom. In the slow passage of water through a magnetic field, where the time of passage through the space between the magnetic poles is large compared with the characteristic times of the molecular oscillations, the water should on leaving the magnetic field have precisely the same properties as it had before the treatment. Therefore even those negligibly small changes in the properties which do appear in water under the effect of a magnetic field should disappear without trace. An experimental check of these assertions would be as fruitful as an experimental check of other assumptions of thermodynamics.

We would like to emphasize that the only assumption made—the assumption that at slow flow velocities the flowing water is in a state of equilibrium—can be considered valid. As regards the possible disturbance of the state of equilibrium by the magnetic field, it seems to us that it is quite impossible for some relaxation mechanism to exist in water which would be characterized by relaxation times on the order of seconds, in the course of which the water passes through the magnetic field in the process of treatment. It follows thus that there are no scientific reasons for considering the effect of the magnetic treatment of water as a homogeneous system to be real. There are in the literature no convincing experimental investigations of the treatment of sufficiently pure water, and as we have indicated, it is in our view not necessary to carry out such experiments.

The situation becomes less definite for the case of water containing impurities. We know at present very little about the nature of the formation of scale and the phenomena that govern the rate of formation of steam bubbles on the surface and within the volume. We must not a priori disregard the possibility of a strong effect of some, particularly ferromagnetic, impurities on this process. However, if such is the case, then the entire effect of the magnetic treatment must be studied from a totally different point of view—not as part of an investigation of a new physical phenomenon, but as a purely applied project. It would, for example, be useful to introduce into the water special impurities; one should study the nature of the impurities, etc.

However, it appears to me essential to emphasize also the fact that it seems very unlikely that a real effect of the magnetic treatment of water will be observed. The amounts of ferromagnetic impurities in water are generally very small. It is quite unclear how the magnetic field can affect even the ferromagnetic impurities under the conditions of the magnetic treatment. At the same time there are no reasons to expect that the ferromagnetic impurities play a special role in the processes of scale formation.

Experiments carried out under real conditions with water containing undetermined impurities, within a large volume, etc., are very complex. However, since a number of sources have stated that the magnetic-treatment effect may be of practical significance, suitable experiments should be carried out under real conditions with the requisite observance of all technological and methodological rules, correct statistical processing of the observations, and the required control of the quality of the water.

Translated by Z. Barnea