LETTERS TO THE EDITOR

Prompt publication of brief reports of important discoveries in physics may be secured by addressing them to this department. Closing dates for this department are, for the first issue of the month, the twenty-eighth of the preceding month; for the second issue, the thirteenth of the month. The Board of Editors does not hold itself responsible for the opinions expressed by the correspondents.

On Inhomogeneities in the Magnetization of Ferromagnetic Materials

For some time work has been in progress on a method for detecting slight inhomogeneities in the magnetization of ferromagnetic materials and as a result of a good deal of experimenting the conclusion has been reached that qualitative observations are best made with small magnetized particles in suspension in a liquid. If such a suspension is allowed to settle on a magnetized surface, the pattern of the deposit reveals those points at which irregularities in the magnetic flux occur. The first successful attempts were made with finely divided iron obtained by sparking between iron electrodes under alcohol. This material was, however, very poor, and revealed only one pattern, namely, that obtained near saturation, as in Fig. 1, and that only with some uncertainty. Since starting this investigation Hámos and Thiessen[1] have published observations similar to those mentioned above.

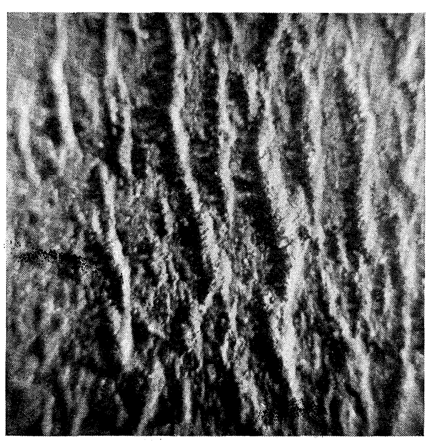

Fig. 1. Patterns obtained on an iron-silicon alloy in large fields. Magnification ×16.

[1] L. v. Hámos and P. A. Thiessen, Zeits. f. Physik **71,** 422 (1931).

The technique for observing inhomogeneities has, however, been carried considerably farther, and though the procedure may still be regarded as a crude first attempt, very pretty results have been obtained. The essential improvement results from using particles having a larger permanent moment. So far the best have been small Fe_2O_3 particles, and I am greatly indebted to Mr. L. McCulloch of these Laboratories for preparing the suspension with which the following results were obtained.

The first observations were made on crystals of iron and of an iron-silicon alloy having large grains. The samples had been ground and annealed. For large magnetizations the deposits found were like that shown in Fig. 1, the field being perpendicular to the striations. The markings do not show any relationship to the grain structure. For somewhat smaller magnetizations, however, various systems of evenly spaced straight parallel lines appear, as in Fig. 2, the lines being usually more or less perpendicular to the magnetization, but varying slightly in direction and spacing from grain to grain. As the sample is rotated in the field, the lines gradually disappear, and new sets of lines having a new orientation take their place. At very low magnetizations no detectable patterns have been found. Similar results have been observed on an iron-silicon alloy melted in H_2. Its surface was quite smooth and clean, and as free from strains as is possible in material having more than one grain.

Observations were made on the untouched surface of samples of nickel and cobalt melted in H_2 with similar results, except that in nickel a new aspect of the phenomenon manifested itself. Instead of showing single parallel lines of like intensity, the microscope revealed rather complicated patterns whose detail changed with the degree of magnetization. Three representative deposits are shown in Figs. 3 to 5. The last two differ only in intensity of magnetization. Many cases have been observed in which both the periodicity of the intensity and the spacing of the lines made various complex but regular patterns. There are indications that the regularity of the patterns depends on the homogeneity of the magnetization, and that inhomogeneous magnetization gives rise to several superimposed patterns.

Fig. 2. Pattern obtained on the same sample as that shown in Fig. 1, but at smaller magnetizations. The width of the lines is probably due to surface irregularities. Magnification ×47.

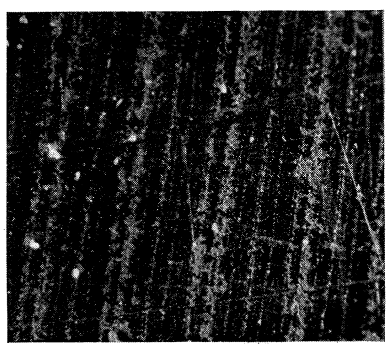

Fig. 3. Pattern obtained on a sample of nickel. Magnification ×47. On the original photograph some of the lines are distinctly seen to be double, while others are single.

As to the interpretation of these results, little can be said at present with any confidence. The periodicity of the patterns makes it convenient to describe them in terms of periodic functions. It is of some interest to observe that the energies J associated with the spin-spin interactions would give rise to a wave phenomenon of the observed order of magnitude if the usual relations $J=h\nu$, and $\lambda\nu=c$ are applicable. If z is the number of nearest neighbors that an atom has, then zJ is of the order of $2\ \theta K$, θ being the Curie temperature and K the Boltzmann constant. This gives for iron with $z=8$ and $\theta=1060°K$, and for nickel with $z=12$ and $\theta=630°K$, the following wave-lengths:

Fe	Ni
0.055 mm	0.14 mm

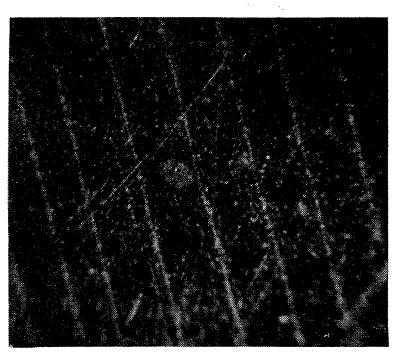

Fig. 4. The narrow lines are the deposit obtained on a crystal of nickel. Magnification ×16.

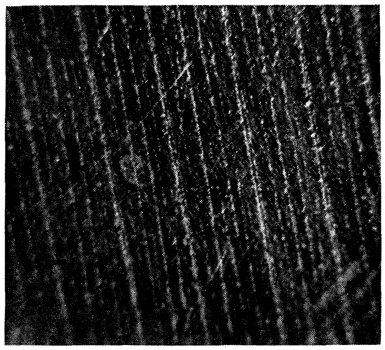

Fig. 5. Pattern obtained on the same grain as that shown in Fig. 4, but at a slightly higher magnetization. Magnification ×16.

In all figures the magnetic field is in this → direction.

In addition, the work of Wolf[2] indicates that iron is a comparatively homogeneous material in which almost all the atoms are in the same state, whereas nickel is made up of two states in the ratio of 3 : 1. In a qualitative way, therefore, if standing waves of some sort, such as Bloch's spin-waves for instance, are associated with magnetization, one would expect them to be more simple in a uniform material like iron than in a material like nickel in which at least three values of J are present.

A more detailed report will appear shortly in this journal.

F. Bitter

Research Laboratories,
Westinghouse Elec. and Mfg. Co.,
East Pittsburgh, Pa.

[2] A. Wolf, Zeits. f. Physik, **70**, 519 (1931).

The Absolute Values of the Mobilities of Gaseous Ions

The necessity of establishing the absolute values of the mobilities of gaseous ions under conditions of high purity and exact control of experimental conditions has long been recognized. The marked effect of extremely minute traces of impurities on the observed mobilities, as well as the unknown complications introduced in those methods which employ gauzes, air streams of possible turbulence and volumes of ionization vaguely defined make it imperative that a method be employed which is free from all these objections. Prior to the development by Tydall and Grindley (Proc. Roy. Soc. **A110,** 341, 1926) of a mobility method of considerable resolving power, the only method for studying ion mobilities free from experimental uncertainties was that employing ultraviolet light for the production of negative ions. By use of this method Loeb has obtained 2.21 as the absolute value of the mobility of the negative ion in air. The method of Tyndall and Grindley, however, permits ions of both signs to be studied, is free from all the objections mentioned above, and can be adapted to studies where high gaseous purity is maintained. It is, therefore, being employed in these measurements of the absolute mobilities of ions in pure gases.

In the experiments which are at present being carried out, the ionization is produced by intense, hard x-rays from a Coolidge tube under a potential of 80 kv pure D.C. The ionization chamber is of glass, with all metal parts reduced as far as possible in dimensions. The whole may be baked out under vacuum before filling with the gas to be studied which has been passed through a carefully constructed purifying train. A slight adaptation made in the potential cycle applied to the plates of the ionization chamber permits the study of positive ions in gases where free electrons exist.

Under these conditions of purity, the absolute values of the mobility of the positive and negative ions in air have been determined and found to be the same as those obtained by Loeb, Tyndall and Grindley. At normal temperature and pressure, the values obtained are 2.21 cm/sec. per volt/cm for the negative ion and 1.60 cm/sec. per volt/cm for the positive ion, the average age of the ions being 0.05 seconds.

A study of the mobility of the positive ion in hydrogen is of particular interest in view of the results of Loeb (Phys. Rev. **38,** 549, 1931). For Na^+ ions of extremely short age (10^{-5} seconds) he has found an initial mobility of 17.5, which after 10^{-4} seconds, changes abruptly to a value of 13.5. A subsequent change reduces the mobility to 8.4 at which value it becomes independent of the age of the ion. The correctness of these observations, as well as a slight refinement of the absolute values obtained, is most interestingly obtained from experiments made under the conditions described above. A typical curve showing the existence of two distinct classes of ions in hydrogen is shown in Fig. 1. The age of the

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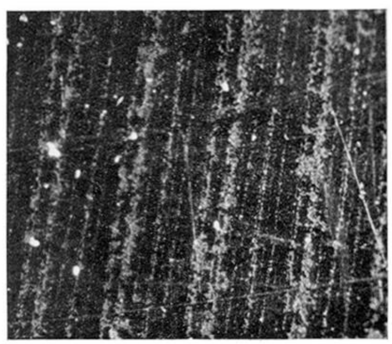

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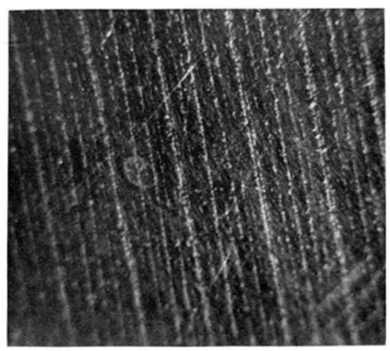

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In all figures the magnetic field is in this → direction.