Ferromagnetic Domain Observation

L. Marton
National Bureau of Standards, Washington, D. C.
April 13, 1948

THE visual representation of ferromagnetic domains on the surface of magnetized materials is usually done by means of ferromagnetic colloids. The patterns produced by spreading such colloids give valuable information about the "shape" and distribution of the domains. A few years ago an attempt was made[1] to use the electron microscope for the observation of the orientation of the colloidal particles in the patterns formed on the domains and to gain added knowledge of the distribution of the fringe field. At that time, because of pressure of other work, the attempt was abandoned, and only now has it been resumed by using an entirely different approach.

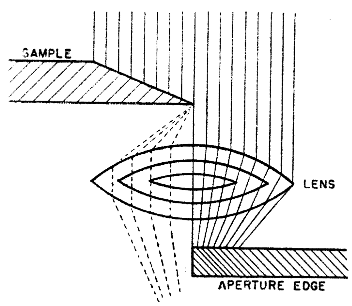

FIG. 1. Arrangement of the sample and of the optical system.

Experiments have been carried out for the observation of the fringe field from ferromagnetic domains by using the electron optical "Schlieren" effect, the description of which appears elsewhere.[2] For this purpose a thin laminar material, like steel shimstock, provided with a fine feather edge, or razor blades were used. After magnetizing to saturation the samples parallel to the edge, they were inserted in an electron microscope at the normal position for the specimens, and first a bright-field image was observed at a magnification of about 6000 diameters. After proper focusing of the bright-field image, the objective lens was slightly misaligned in order to bring in one edge of the objective aperture parallel to the observed edge but in the opposite direction (see Fig. 1). In this manner the direct rays are intercepted by the objective aperture and only the scattered or deflected electrons can reach the final image plane.

Figure 2 shows a typical observation of this kind. The bright line corresponds to a dark-field image produced by the scattered electrons on the edge. This line, however, is not continuous but is interrupted at irregular intervals. Whenever the line is interrupted, close observation shows a washed-out pattern at right angles to the edge. The spacing of this washed-out pattern is on the average equal to a few tenths of a micron. It is reasonable to assume that this pattern is produced by the fringe field of individual ferromagnetic domains and by the fringe field created on grain boundaries. Such a pattern is produced only if the edge is thin enough so that on the average we have no more than one domain in the direction of the electron beam (at right angles to the plane of the sample).

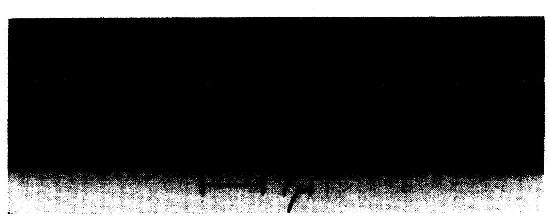

FIG. 2. "Schlieren" effect on magnetized steel edge.

To gather further evidence a similar observation was repeated with the objective aperture at an angle to the observed edge of the sample. In this case part of the image is dark-field and part of it shows a bright-field image of the magnetized edge. When overexposing the bright-field part of the image, a washed-out pattern at right angles to the edge corresponding to that of the dark-field image can be observed also in the bright-field image.

The collaboration of Mr. Max Swerdlow in taking the micrographs is gratefully acknowledged.

[1] L. Marton, Phys. Rev. **65**, 353 (1944).
[2] L. Marton, J. App. Phys. (to be published).

Optimum Conditions for a Beta-Ray Solenoid Spectrometer

E. Persico
Université Laval, Québec, Canada
April 30, 1948

IN any beta-ray spectrometer a compromise must be made, as is well known, between the resolving power and the luminosity. A theoretical investigation of the optimum conditions obtainable with a magnetic lens spectrometer of the solenoid type, with uniform field and a baffle system utilizing ring focus (which eliminates the main part of the spherical aberration[1]), has given the following results.

Let us put $D=2p/(He)$ (p = momentum of the electrons, H = intensity of the field, e = electronic charge in e.m.u.) and suppose that the baffle system admits the rays leaving the center of the source at an angle $\alpha\pm\Delta\alpha$ with the field. For a *point source*, one finds that the value of α giving the best resolution for a given luminosity (i.e. a given solid angle ω) is $\alpha=42°\ 20'$. Then the inverse resolving power is $\Delta p/p=0.032\omega^2$ (in good agreement with the approximate evaluation given by Frankel[2] for $30°<\alpha<60°$).

However, a case of greater practical importance is that of a source of low specific activity, so that its dimensions cannot be made negligible. Supposing the source to be a disk of diameter S perpendicular to the field, it limits the resolution in two ways: (a) because the rays leaving the source with a given α cross the plane of the final slit in a ring-shaped zone of width S; (b) because the rays coming from excentrical points of the source cover a wider interval of α than those coming from the center, which results (owing to the spherical aberration) in a supplementary

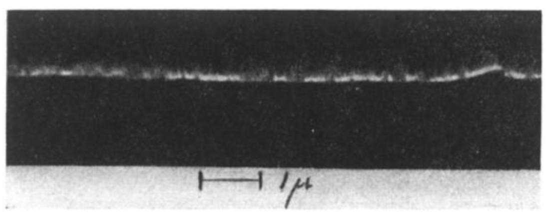

FIG. 2. "Schlieren" effect on magnetized steel edge.