Ferromagnetic Domain Observation

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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.

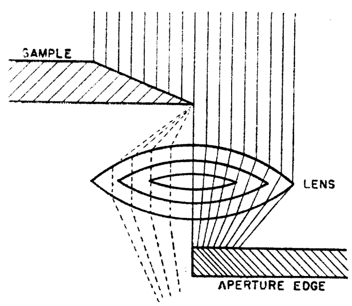

FIG. 1. Arrangement of the sample and of the optical system.

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

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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 width of the ring-shaped zone. If, neglecting the effect (b), one calculates the values of S and α giving the best resolution for a given luminosity (product of the solid angle ω by the area of the source) one finds that the optimum conditions are $\alpha=40°\ 25'$, and $S/D=11.4(\Delta\alpha)^2=0.172\omega^2$ ($\Delta\alpha$ in radians, ω in steradians). The inverse resolution is then given by $\Delta p/p=0.156\omega^2$ (so that, approximately, $S/D=\Delta p/p$). Under these conditions, $\frac{4}{5}$ of the Δp are produced by the width of the source and $\frac{1}{5}$ by the residual spherical aberration. The radius of the ring focus is $0.544D$ and the distance of its plane from the source is $1.63D$.

The relative importance of the neglected (b) effect may be roughly evaluated by saying that its contribution to the width of the ring-shaped zone (if the first limiting diaphragm is at the point of maximum distance of the rays from the axis) is about $0.17\omega^2$ of the total width—e.g., for $\Delta\alpha=2°$ (that is a solid angle $\omega=0.572$, more than 4.5 times that of Witcher) this contribution is only 1.4 percent.

It would seem that a spectrometer made on such a design and having the same resolving power as that of Witcher should have a luminosity more than 7 times greater.

[1] C. M. Witcher, Phys. Rev. **60**, 32 (1941).
[2] S. Frankel, Phys. Rev. **73**, 804 (1948).

Measurements of Radio Frequency Resistance of a Piece of Columbium Nitride through the Transition

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THE purpose of this investigation was to ascertain the relationship between DC resistance and RF resistance of columbium nitride through the transition from a normal state to a superconducting state. The DC resistance has been measured accurately by potentiometer methods, but the actual RF resistance has not been ascertained up to now.

The first method of approach to measure the RF resistance was to build an oscillating circuit including the strip of columbium nitride under test and measure the decay time of oscillations once built up in the tank circuit. If then the resistance of the CbN changes abruptly over the transition range, one would expect a correspondingly large change in the losses of the circuit and hence in its ringing time. This method, however, had to be abandoned because it was found that at low temperatures the losses in the condenser of the tank circuit change in an unpredictable fashion and overshadow the change in CbN resistance.

Accordingly the following method has been used to determine the RF resistance of CbN over the transition range. The Q of a coil with and without the strip of CbN in series was measured both above and below the transition temperature of the CbN. Assuming all the losses in the circuit to be series losses, the difference between the measurements with and without the CbN gives them the additional resistance introduced by the CbN at the frequency considered. Within the limits of experimental error the RF resistance of the CbN strip was found to be exactly equal to the DC resistance measured at the same temperatures. This holds true at frequencies of from 600 to 1000 kc.

This result was to be expected because of the relatively large ohmic resistance per cm length of CbN above the transition. For such a high value of resistance the skin effect is essentially negligible. The apparatus as used was not delicate enough to measure the differences in resistance when the strip of CbN is almost completely superconducting. Theoretical computations, however, have indicated that a change in resistance can be expected when the d.c. resistance of the strip falls down to approximately 10^{-2} ohm or below. However, the absolute magnitude of the difference is too small to be noticeable, if curves of resistance *vs.* temperature are plotted for varying frequencies up to 1 mc. It can thus be assumed, that, for all practical purposes, the DC and RF transition curves of the CbN are identical.

Variation of Penetrating Showers with Altitude

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PRELIMINARY results have been obtained from an experiment designed to determine the dependence on altitude of penetrating showers. The equipment used as a detector of these showers is similar in principle to the various arrangements used in recent experiments of Broadbent and Janossy,[1] and Jason and George.[2,3] Five trays of Geiger-Mueller counters are arranged as shown in the accompanying figure (Fig. 1); each counter has an active length of ten inches, and is one inch in diameter. There is a thickness of four inches of lead over tray A, between trays A and B, and between trays B and C, and a thickness of three inches on the sides of trays D. The eight counters in trays D are effectively connected in parallel, while fast addition circuits are used in the other trays to select coincident discharges of two or more counters in each tray.

The events recorded can be represented by the following symbols: $A_1B_1C_1$, $A_1B_1C_1D_1$, $A_2B_2C_2$, $A_2B_2C_1$, $A_1B_2C_2$, $A_2B_2C_2D_1$, $A_1B_2C_2D_1$, where, for example, $A\alpha B\beta\cdots$ indicates a simultaneous discharge of α or more counters in tray A, β or more counters in tray B, and so on.

The equipment was operated on the ground at Lexington, Massachusetts (altitude: 300 ft.) and in a B-29 airplane flying at altitudes of 15,000, 20,000, 25,000, and 30,000 feet; all measurements were taken at a geomagnetic latitude of about 53°. The rates of coincidences of the types $A_1B_1C_1D_1$, $A_2B_2C_2$, $A_2B_2C_1$, and $A_1B_2C_2$ are plotted as a function of atmospheric depth in g cm^{-2}; the standard deviations have been indicated wherever they exceed 5 percent.