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Current Effects in Ferromagnetic Wires

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Current Effects in Ferromagnetic Wires

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The Oersted effect explains the magnetic field surrounding a conductor carrying an electric current. In January 1957 Gale[1] reported that ferromagnetic wires carrying d.c. currents have their magnetizations changed and in addition to the current-field there is a change in the field set up by the re-orientation of the domains in the wire. The motion of the domains at the inception and interruption of a direct current in the wire can be shown by surrounding the wire sample with a search coil. The motion of the domains induces a voltage in the search coil similar to the Barkhausen effect, but in this case produced by the current in the sample itself. Figure one

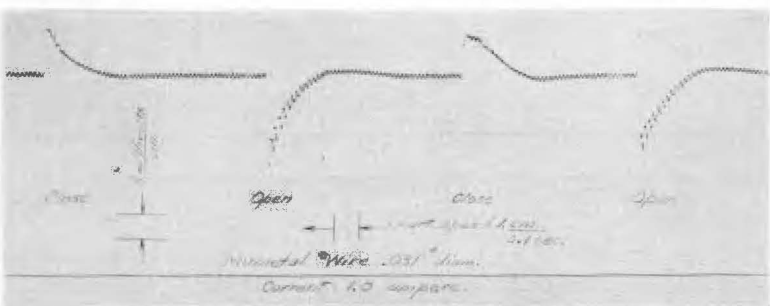

Figure 1.

shows a photograph of the flux change on the "make" and "break" recorded by means of a Sanborn recorder. The ripple is 60 cycle. Evidence indicates that these voltage changes are closely related to the magnetic properties of the sample and disappear at the Curie point. Alternating current sent through the wire sample induces continuous a.c. in the pick up, the wave form depending upon the shape of the hysteresis loop of the material. Figure two shows the alternating voltages picked up by the search coil surrounding a nickel wire on an oscilloscope, as a function of temperature.

In order to test the hypothesis that the electric current magnetizes the wire, tests of the internal friction losses and magnetostriction were undertaken by George Sullivan as a Senior Honors project. This paper reports the results on the internal friction losses.

Experimental

A torsion pendulum approximately 75 cm. long was constructed of No. 24 iron wire, and loaded so as to have a period of 2.36 seconds.

[1]1957 New York meeting of the American Association of Physics Teachers.

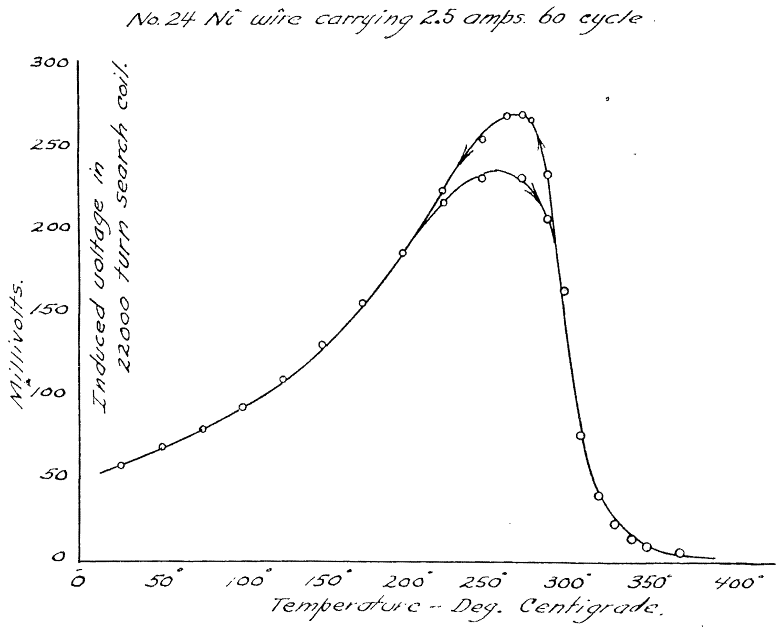

Figure 2.

The wire terminated in a mercury contact at the bottom so that electric currents could be sent through the wire. The whole assembly was mounted inside a box so as to eliminate effects of air currents. Air damping was assumed to be constant. The motion of the pendulum was followed by means of the usual lamp and scale, about one meter from the mirror. The suspended wire was also surrounded by a single layer solenoid so that known fields could be applied to the wire.

Internal Friction

It has been known for some time that a ferromagnetic wire has less energy loss in a magnetized state than in a demagnetized condition.[2] The internal friction losses were measured by the usual decrement method. Data was taken on amount of decay in a known period of time and the decrement Δ calculated as follows:

$$\Delta = \frac{(\log_e x_1 - \log_e x_2)\,T}{t_1 - t_2}$$

where x_1 = original amplitude = 10 and $t_1 - t_2$ = 840 sec. T is the period.

With direct current flowing in the wire sample, the data shown in Figure 3 were obtained. The off-center is interpreted to be due

[2]Seitz, Frederick, *The Physics of Metal.* New York, McGraw-Hill, 1943, p. 302.

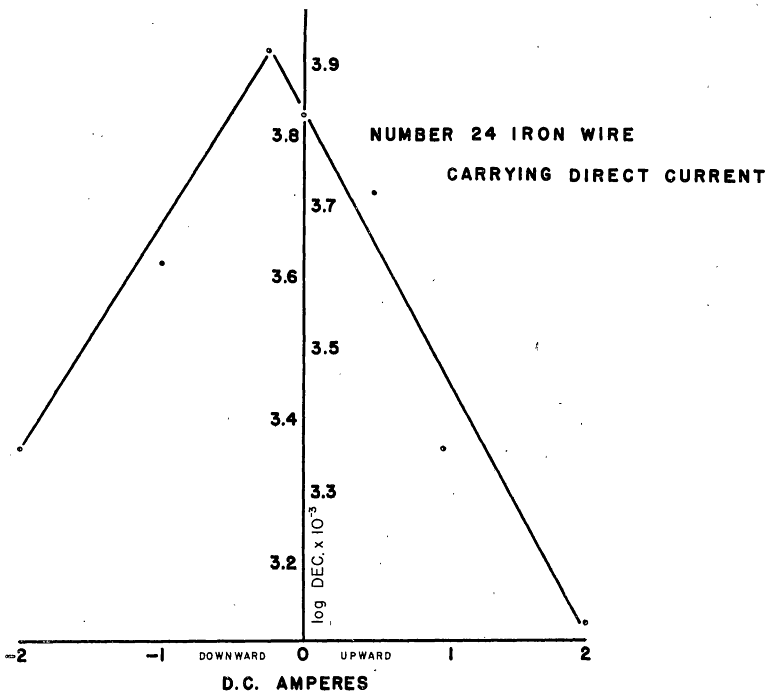

Figure 3.

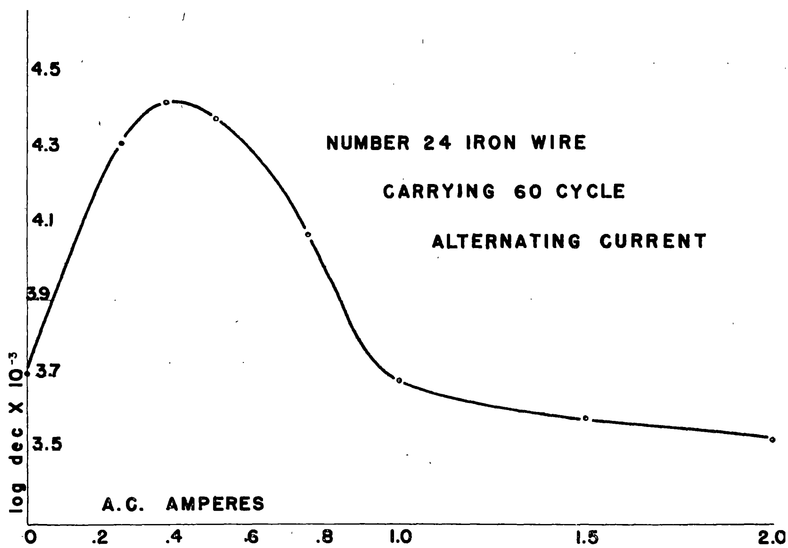

Figure 4.

to the fact that the wire is suspended in the vertical component of the earth's field, and electric currents in either direction reduced the decrement.

Alternating Current

In an attempt to make sure that the changes just mentioned were not due to temperature changes, alternating currents were tried both in the sample and in the solenoid. Rather surprising results were obtained in both cases.

Figure 4 shows the effects obtained by sending 60 cycle a.c. through the wire sample. The increase in the decrement for low currents is difficult to interpret. The maximum resembles a resonance peak and should be studied using different frequencies.

The wire was magnetized by a 60 cycle field from the solenoid. In this case it was observed that the amplitude of the pendulum not only decayed at a slower rate but that a.c. fields of 15 to 20 oersteds the amplitude actually increased and the decrement hence became negative. This seems to be a resonance phenomena whereby the suspension absorbs energy from the system.

It is hoped that the present studies will help in a better understanding of the nature of conduction and of magnetization.

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