Ferromagnetism in Austenite

It is generally known that above 910°C iron is in the γ phase, consisting of a face-centered cubic lattice, while below this temperature it is in the α phase, which is body-centered cubic. Ferromagnetism can be detected only below 790°C so that γ-iron, or austenite as it is often called, is not ferromagnetic. Addition of alloying elements can lower considerably the temperature of the phase transformation, even below room temperature as in the case of austenitic stainless steel. But no matter how much this transformation may be lowered, it has always been found that the iron or steel remains nonferromagnetic as long as it is austenitic. For this reason the generally accepted viewpoint has been that the absence of ferromagnetism in austenite is one of its characteristic properties.

We have recently discovered that a steel containing 1.97 percent Ni, 0.86 Cr, 0.35 Mo and 0.28 C, is quite definitely ferromagnetic while in the austenitic condition and is thus an exception to the rule. The variation of magnetic intensity with temperature both on heating and on cooling in hydrogen is shown in Fig. 1. The measurements were made at 450 oersteds on a long rod so that the values shown are practically saturation values. On cooling the steel from 900°C at the rate of 6°C per minute, ferromagnetism first appeared at 750°C. The magnetic intensity at first increased rapidly and then leveled off around 600°C. That the steel was still austenitic was proved by dilatometric work on a sample cut from the same rod. It is well known that the $\gamma \rightarrow \alpha$ transformation in a rod is always accompanied by a very marked linear expansion. In the steel under discussion this break in the dilatometer curve started at 520°C and ended at 340°C, and it is the $\gamma \rightarrow \alpha$ transformation corresponding to this break that accounts for the sudden rise of the magnetic curve at 520°C.

Corroborating evidence that the steel was still austenitic above 520°C was found by microscopic examination of a sample quenched in water from 550°C. The structure was martensitic, showing that the steel could not have transformed previous to quenching. The cooling rate of 6°C per minute was great enough to prevent the transformation to ferrite and pearlite at 700°C or so. Unfortunately, it was impossible to prevent the transformation at 520°C so that we could not extend the study of magnetic austenite to room temperature.

It may be pointed out that the association of ferromagnetism with a face-centered lattice is nothing unusual since nickel and the iron-nickel alloys containing more than 30 percent Ni are ferromagnetic. But below 30 percent Ni, only the α phase alloys are ferromagnetic and the γ ones are not. The steel we have discussed falls in the low nickel group, for which the occurrence of ferromagnetism in austenite has not been previously reported. The composition range in which austenite can be ferromagnetic is quite narrow, as found by experiments on similar alloys.

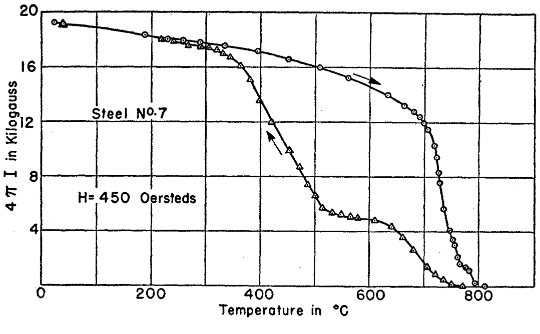

FIG. 1.

Complete details of this work will appear in the *Transactions of the American Society for Metals.*

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He^3 in Helium

We have used the 60″ cyclotron[1] as a mass spectrograph to show that He^3 is one of the stable isotopic constituents of ordinary helium. When the cyclotron was filled with helium, a linear amplifier chamber placed in the path of the ion beam was paralyzed at two values of the magnetic field, corresponding to the production of 8-Mev protons and 32-Mev alpha-particles. At a field midway between these two values, the amplifier showed the presence of a smaller, but quite definite, beam whose range was determined as 54 cm of air. He^{3++} is the only ion which satisfies the three criteria of e/m, v, and R measured in this way. Further weight is given to this view by the observation that this beam did not appear when the tank was evacuated, or filled with deuterium.

It was not possible to produce a steady beam of 24-Mev "light alpha-particles," because the cyclotron was "shimmed" for normal alphas and was therefore out of adjustment at lower fields. But it was possible to produce pulses of ions by lowering the magnetic field rapidly and letting the induced currents in the pole pieces increase the central magnetic field. We plan to shim the 37″ cyclotron for light alphas in the near future, to attempt to use the beam for disintegration experiments. The necessary intensity may be obtained by isotopic concentration or production of He^3 in the D−D reaction.

Because of the shimming differences noted above, it is impossible to measure the relative abundance of the helium isotopes; but the orders of magnitudes of the two beams may be of interest. There were approximately 10^{12} alpha-particles per sec. in the He^4 beam, and of the order of 10^3 per sec. in the He^3 beam. We looked for a beam at the He^5 magnetic field setting, but did not observe any effects.

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[1] E. O. Lawrence, L. W. Alvarez, W. M. Brobeck, D. Cooksey, D. R. Corson, E. M. McMillan, W. W. Salisbury and R. L. Thornton, Phys. Rev. **56**, 124 (1939).