Alpha-Gamma Transformation in Iron-Carbon Alloys

THERE are many indications that the gamma modification of iron-carbon alloys, existing above the temperatures indicated by the lines GS and SE in the iron-carbon diagram[1], should be regarded as heterogeneous and not homogeneous as heretofore.

Experiments based on microscopic and X-ray analysis of quenched hypo- and hyper-eutectoid alloys have provided evidence of the existence of three distinct austenitic pseudo-phases, which may be called γG, γS and γE to correspond to the composition given by points G, S and E, namely, nil, 0·8882 per cent and 1·7764 per cent carbon[2]

In carbon-free iron the austenite is γG only. In hypo-eutectoid steels the austenite grains are of γS composition intersected with plates and needles of γG austenite, the amount of which increases as the composition approaches that of point G. In hyper-eutectoid steels the austenite is γS intersected with plates and needles of γE austenite, the latter increasing in quantity as the composition approaches that of point E.

The composition of all three austenitic pseudo-phases, γG, γS and γE, is stable and corresponds to pure, face-centred cubic iron, one carbon atom associated with six face-centred cubic iron unit cells (24 iron atoms), and one carbon atom associated with three face-centred cubic iron unit cells (12 iron atoms) respectively. When quenched, γG austenite produces ferrite, γS austenite produces martensite, and γE austenite produces retained austenite.

Experiments with various iron-carbon alloys quenched in various ways tend to show that the amounts of ferrite, martensite and retained austenite obtained in the quenched specimen are independent of the quenching-rate so long as a certain critical rate (not determined) is exceeded.

A more detailed discussion of some of the questions which emerge from the above hypothesis will be published in due course.

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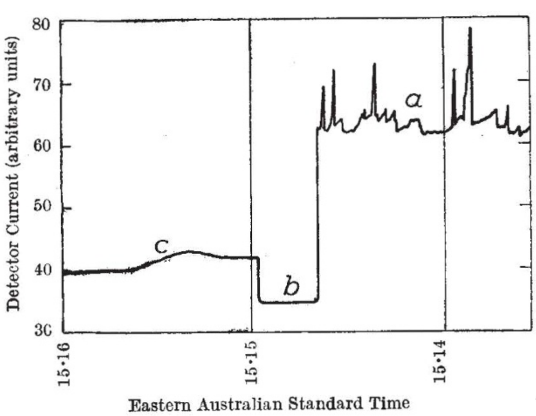
[1] Desch, C. H., "Metallography" (London: Longmans, Green, 1944).
[2] Wrazej, W. J., *J. Iron and Steel Inst.*, No. II, p. 189P (1945).

Polarization of Solar Radio-frequency Emissions

THE recent experimental proof[1] that the sun emits energy on radio frequencies was followed by evidence[2] that the amount of such energy can increase markedly during the passage of important sunspots across the solar disk. Such sunspots are invariably associated with strong magnetic fields, the influence of which almost certainly extends into the upper chromosphere and inner corona. Considerations of optical depth indicate that the observed emissions cannot come from below these levels, so that they must arise in regions where the electron collision frequency is much less than the (radio) wave-frequency, and where the latter is probably of the same order of magnitude as the gyromagnetic frequency He/m. Under these conditions we should expect to find evidence of the magnetic field in the production of gyratory effects at the source of the emissions, and/or in differential absorption of right-handed and left-handed components of polarization during transmission through the corona.

An opportunity occurred of testing this hypothesis during the passage of a large sunspot group across the solar disk in the last week of July 1946. The observations were made on a frequency of 200 Mc./s. with an aerial system which was so disposed as to receive circularly polarized radiation of one sense only (right- or left-handed). This was achieved by the use of four Yagi aerial arrays, of which one set of two was disposed perpendicularly to the other set. In addition, one set was displaced by a quarter of a wave-length from the other, in the line of sight. It is not difficult to show that the output voltage from such a system is zero for circularly polarized radiation of one sense and has the full value appropriate to the field strength for the other sense. It is easy to change the sense of the polarization accepted by changing the sense of the quarter wave displacement.

Observations were made with this system on July 26, when a large northern group of sunspots was approaching the solar meridian. It



SOLAR NOISE RECEIVED AT CANBERRA, JULY 26, 1946
(*a*) Circular right-handed polarization, (*b*) aerials directed away from sun, (*c*) circular left-handed polarization.

was found that the right-handed circularly polarized power received was some seven times greater than that received when the system accepted only left-handed circularly polarized radiation. A portion of the record obtained at this time is shown herewith. It will be noticed also that there is an absence of sudden short bursts on the left-handed system. Three days later, when this spot group had crossed the meridian, these conditions were reversed, five times more power being then received on the left-handed than on the right-handed system.

It would appear, therefore, that the magnetic field of sunspots, and probably the inclination of this field to the line of sight, profoundly affect the radiations observed. For this spot group the main field was inclined towards the earth before crossing, and away from the earth after crossing, the solar meridian. Making a solar application of Appleton's magneto-ionic theory of the ionosphere, we may say that our results correspond, in both cases, to the 'extraordinary' ray being stronger than the 'ordinary'.

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[1] Southworth, *J. Franklin Inst.*, **239**, 285 (1945).
[2] Pawsey, Payne, Scott and McReady, *Nature*, **157**, 158 (1946).

A Theorem in Statistical Mechanics

STATISTICAL mechanics considers any particular body at given temperature T as a member of a canonical ensemble, that is, the probability of finding it with energy E is given by

$$P \propto \Omega \exp -E/kT,$$

where Ω is the multiplicity of the level E of this body. We can take it that, for the body under test, P is a maximum with regard to any parameter n so that

$$\frac{\partial \log P}{\partial n} = 0 = \frac{\partial \log \Omega}{\partial n} - \frac{1}{kT}\frac{\partial E}{\partial n}.$$

The use of this relation

$$\frac{\partial \log \Omega}{\partial n} = \frac{1}{kT}\frac{\partial E}{\partial n} \qquad (1)$$

appears to simplify appreciably the treatment of some problems in statistical mechanics. I have not, however, been able to find it mentioned anywhere in the known treatises on the subject.

For example, let a monatomic crystal be given with n holes (Schottky defects). Let each hole contribute an energy ε so that $\partial E/\partial n = \varepsilon$. The multiplicity associated with n holes comes to $(N+n)!/N!\,n!$, where N is the number of atoms in the crystal. The relation (1) yields at once $n = N \exp - \varepsilon/kT$. Expressions for combined Schottky and Frenkel defects are derived in the same way. A second example of the application of (1) is provided by the order-disorder transformation of alloys in the Bragg–Williams approximation. For β brass, for example (following substantially the terminology of Fowler and Guggenheim), an order parameter s is introduced so that for a crystal consisting of $N/2$ each of copper and zinc atoms, the number of zinc atoms occupying zinc sites and also the number of copper atoms occupying copper sites is given by $(1 + s)N/4$, and the number of zinc atoms occupying copper sites and also the number of copper atoms occupying zinc sites is given by $(1-s)N/4$. It is readily seen that the number of states for a given s comes to

$$\Omega = \left[\frac{(N/2)!}{\{(1+s)N/4\}!\,\{(1-s)N/4\}!}\right]^2 \qquad (2)$$

Associating an energy $-2\chi_{ZnCu}/z$, $-2\chi_{ZnZn}/z$, $-2\chi_{CuCu}/z$ with each link ZnCu, ZnZn, CuCu, where z is the number of nearest neighbours to each atom, and noting that the probable number of these links is given by $(1+s^2)Nz/4$, $(1-s^2)Nz/8$, $(1-s^2)Nz/8$, we can write down the energy associated with the value s of the order parameter

$$E = -\frac{N}{2}\Big(\{1+s^2\}\chi_{ZnCu} + \tfrac{1}{2}\{1-s^2\}\{\chi_{CuCu}+\chi_{ZnZn}\}\Big). \quad (3)$$

Hence,

$$\frac{\partial \log \Omega}{\partial s} = \frac{N}{2}\log\left(\frac{1-s}{1+s}\right)$$

and

$$\frac{\partial E}{\partial s} = -\frac{sNw}{2}, \text{ with } w = 2\chi_{CuZn} - \chi_{CuCu} - \chi_{ZnZn}$$

The relation (1) then leads at once to the basic equation

$$\log\frac{1+s}{1-s} = \frac{sw}{kT} \qquad (4$$

without the use of any more of the apparatus of thermodynamics or statistical mechanics.

It should be mentioned that the relation (1) follows also from the frequently used identification $S = k \log \Omega$ by minimizing the free energy $F = E - TS$, but there the conceptual implications are far less obvious than its connexion with the canonical ensemble.

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