75. A New Equilibrium Diagram for the System Fe-C.

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Two equilibrium diagrams, the single diagram and the double diagram, have been proposed for the system Fe-C and we can not as yet decide upon which is the correct one.

The single diagram is based upon the assumption that graphite never separates directly from molten iron, which was, however, recently experimentally disproved by different authors. I examined under a microscope many small ingots (10 mm. dia.) of ordinary pig iron cast into metal and sand moulds. In many cases, the periphery consisted of ledeburite, the next inner zone of graphite eutectic, and thence on approaching the center graphite becomes gradually coarser appearing, indeed, as flake graphite at the center. The single diagram (Fig. 1) claims that all the graphites are formed in the solid phase by decomposition of Fe_3C during cooling from 1150°C to about 1000°C . The difference in the cooling times required by the periphery and the adjacent portions will be within a few seconds and it is highly impossible for the decomposition to be completed followed by growth of graphite crystals in the solid phase in such a short space of time. Graphite must be formed directly from the melt on solidification.

The single diagram meets with a second difficulty as it represents (and many authors do) a metastable equilibrium. We want a stable equilibrium diagram for such an important alloy as Fe-C.

The double diagram (Fig. 2) claims that graphite may sometimes be formed directly from the melt, and so is freed from the former difficulty but it encounters more as following:

1) Two diagrams (stable and metastable) are drawn with an

Fig. 1.

Single diagram.

Fe- Fe_3C (metastable equilibrium).

interval less than 10°C and such a coupled diagram makes the matter difficult to understand. Several double diagrams have been proposed by different authors and we are actually left in a dilemma trying to select from them.

2) Two eutectic temperatures (austenite-cementite or ledeburite and austenite-graphite) are expected by the double diagram but many authors have been able to show only one in spite of their elaborate experiments.

Fig. 2.
Double diagram.
Fe-C (stable equilibrium).
dotted line.
Fe-Fe₃C (metastable equilibrium).
full line.

Fig. 3.
New diagram.
Fe-C (stable equilibrium, low
temperature).
Fe-Fe₃C (stable equilibrium,
high temperature).

3) The lower (metastable) lines of the double diagram express a supercooling. It is not reasonable to add a supercooling phenomenon in an equilibrium diagram. We have now about 400 binary equilibrium diagrams and only three of them, Cd-Sb, Cd-As, Fe-C, include supercooling. Supercooling in the systems Cd-Sb and Cd-As is abnormal. Ordinary supercooling is added only in the double diagram of the system Fe-C. We must have some important reason to justify the addition

of supercooling in the equilibrium diagram and the metastable equilibrium lines added should have been clearly proven by experiments. Nevertheless, neither conditions are really fulfilled. The double diagram includes the supercooling at the eutectic but not that at the eutectoid. The depression of A_1 (martensite formation) is never included. This, again, is a self-contradictory point of the double diagram.

The present author proposes a new equilibrium diagram as shown in Fig. 3. As the stable equilibrium lines are only drawn (omitting supercooling), this diagram is freed from all of the difficulties of the double diagram. Fe_3C is assumed to decompose on solidifying or on separating from austenite. Fig. 3 shows a stable equilibrium, eliminating the two difficulties of the single diagram. The lines DB, EBC, SE, PSK, and PQ are drawn heavy to show that Fe_3C decomposes here. Two series of lines in the double diagram are coincided in the new diagram.

The details will be published in the report of our institute.