Specific and Latent Heats of Iron and Steel.

IN previous letters to NATURE (April 19 and September 20) I gave the results of some experiments on the rate of contraction of heated iron and steel wires, partly commercial steels, and partly of steels formed by heating nearly pure iron in graphite for periods lasting from one to five hours. It was found that even the five hours' heating in graphite did not complete, or even nearly complete, the conversion of iron into steel. A similar and more recent series of trials has now been carried out in which the graphite was replaced by wood-charcoal, from which it appears that the action of the latter is far more rapid than graphite, so much so, indeed, that a wire heated in charcoal for a single minute gives a cooling curve notably different from that of the pure iron.

Some of the results are shown in the accompanying diagram (Fig. 1), where the curves refer to nearly pure iron (4 parts in 10,000 of carbon) and to the same iron after remaining in wood-charcoal at a cherry-red heat for two and a half, five, ten, and twenty minutes, one hour, three hours, and four hours respectively. The greater part of the variation of form occurs in the first half-hour's heating, and the difference between the three-hour and four-hour curves is comparatively small.

In all cases the cooling curves well above and well below the critical temperature (*i.e.* from melting point down to about 800° C. and from 400° C. down to ordinary temperatures) are identical, but the presence of carbon prolongs the time required for the metal to change from the high to the low temperature state.

While this change is proceeding, latent heat is being evolved; and whether the wire rises in temperature and expands (showing what has been called "recalescence") during this process depends on whether the rate of evolution of heat exceeds, or falls short of, the rate at which heat is being lost by radiation and convection.

It has been shown, by experiments previously described in NATURE, that the coefficient of thermal expansion for iron and steel undergoes no discontinuous change at any temperature to which the metal was subjected. Assuming for the present purpose that the coefficient is constant, it will be seen, since the loss of temperature in cooling is proportional to the excess of temperature above the surrounding space, and since also the time taken to cool through a given number of degrees is proportional to the specific heat, that therefore the area contained between the cooling curves and the axis (*i.e.* extension in terms of time) is proportional to the total quantity of heat yielded in the cooling process.

Thus, from the results exhibited in Fig. 1, it appears that:

(1) The greater the carbon content of the metal, the longer is the time required to complete the change from the high to the low temperature state, and the lower is the temperature at which the conversion ends.

(2) The greater the carbon content, the less is the total heat necessary to raise the metal from ordinary temperature to anything above 400° C.

(3) The effective specific heat changes continuously while the change of state is in progress, but the change is more and more rapid as the carbon content diminishes, becoming probably instantaneous, or nearly so, for pure iron.

(4) The terminal specific heats (namely, from above 850° and below 400° C.) are very nearly in the ratio of one to three.

All the phenomena presented in the tempering of steel are connected with the change of state, and it seems likely that useful information might be derived from records of the contraction which occurs in cooling if made under standard conditions.

It is worth notice that in all the experiments I have made, a small permanent increase of length has

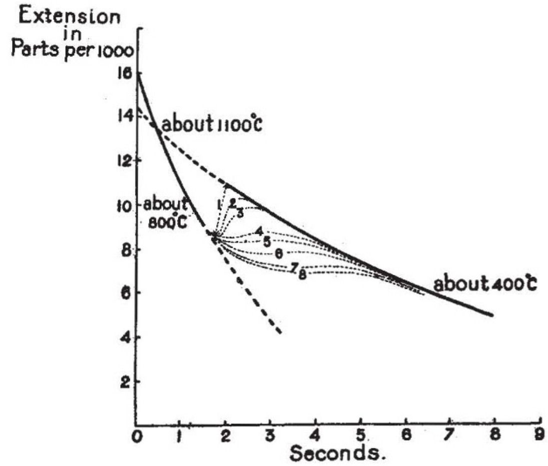

FIG. 1.—Curves showing the contraction of iron and steel wires after heating (by an electric current) in an atmosphere of nitrogen. The iron was produced by the reaction between iron sesquioxide and aluminium. Analysis showed that the metal contained about 4 parts of carbon in 10,000. A small ingot of this iron was drawn into wire of 0·02 in. diameter, and lengths of this wire were heated to a cherry red in wood-charcoal for times specified below. The ordinates of the curves give the extension of the wires at the times indicated by the abscissæ. Approximate temperatures are indicated.

Curve.	Time of heating in charcoal.
1	0 minutes.
2	2½ ,,
3	5 ,,
4	10 ,,
5	20 ,,
6	60 ,,
7	180 ,,
8	240 ,,

occurred at each successive heating when the iron was nearly pure, but that when the carbon content reaches a certain limit this change vanishes, and is replaced by a small permanent contraction when that limit is exceeded.

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An Endotrophic Fungus in the Coniferæ.

IN a communication to NATURE of December 13, Prof. F. J. Lewis directs attention to the discovery of intercellular mycelium in the shoot tissues of *Picea canadensis* and other conifers, and also in roots and shoots of *Ledum palustre* and *Vaccinium Vitis-idæi*. Referring to the two last-named species, Prof. Lewis writes: "an examination of the root and stem of *Ledum palustre* and *Vaccinium Vitis-idæa* from this district has been made, and an endotropic [?endotrophic] fungus has been found similar to that described by Rayner (*Annals of Botany*, 1915) in European material."

The fact that endotrophic mycorrhiza occurs in the *roots* of these plants has long been known and calls for no comment. A full account of the mycorrhiza of *V. corymbosum* was given by Coville in 1911 for American material.

In the paper cited by Prof. Lewis, the present writer described the wide distribution of mycelium throughout the shoot tissues of Calluna and recorded the fact of ovarial infection—implying a like distribution of the fungus—in *Ledum palustre* and *Vaccinium*