estimate, but should it prove to be so it would immediately reduce our time-scale and relieve us of the necessity of entering upon speculations such as those touched on above.

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On the Hardness of Manganese Steel.

NOTWITHSTANDING its extraordinary importance, the discovery of the 13 per cent. manganese steel, made by Sir Robert Hadfield more than forty years ago, has scarcely been elucidated regarding its most striking point, namely, the extremely high resistance to wear and tear, or the fact that the non-magnetic manganese steel, while comparatively soft in itself, offers an enormous resistance to a working tool.

It is natural to assume that this resistance is to be explained in the following way:[1] The state of the iron in the manganese steel being that of the non-ferromagnetic γ-iron, stable at high temperature but unstable at ordinary temperatures, a mechanical stress is likely to cause the transformation into the ferromagnetic α-state, stable at low temperature. This is in conformity with a general law of physical chemistry, exemplified by the well-known case of mercury iodide: the yellow modification, persisting at ordinary temperature in an unstable condition, is transformed by mechanical stress into the red modification, stable at low temperature. In other words: the high resistance is explained by the assumption that mechanical work transforms the relatively soft Mn- austenite (γ-Fe) into martensite (α-Fe), known to be extremely hard. From this view, if correct, it follows that mechanical work will at least partly transform the non-magnetic manganese steel into the ferromagnetic α-condition.

Some time ago the correctness of this conclusion was tested at this Institute by Dr. A. Westgren on a specimen, sent by Sir Robert Hadfield, of manganese steel which had been subjected to a tensile test.

On X-ray analysis, however, no lines characteristic for α-Fe could be detected even in the contracted part of the specimen. In view of this negative result, the following experiment, lately performed, seems to be of interest.

A small steel magnet needle (about $3 \times 0{\cdot}5 \times 0{\cdot}1$ mm.) was fastened to one end of a thin silica fibre, so as to be suspended in a vertical position. On approaching the sharp corner, or edge, of a Hadfield manganese (Era) steel specimen, it was not possible to obtain any sensible attraction of the needle—in conformity with its non-ferromagnetic character. On the other hand, a small drilling of the same steel (say $1{\cdot}2 \times 0{\cdot}4 \times 0{\cdot}1$ mm.) fixed at the end of a glass capillary, when brought near the needle, revealed a considerable attraction, or repulsion, proving the *drilling to be plainly ferromagnetic*, and this even permanently. The objection being possible that the ferromagnetism might be caused by steel particles given off by the drill used, metallic shavings were obtained by using sharp quartz edges, and also a slow rotating alundum disc; in both cases the shavings were found to be distinctly ferromagnetic.

Since it had been established in this way that the shavings have the magnetic characteristics of martensite, they were submitted to X-ray analysis by Dr. Westgren. However, no lines of the α-state could be detected. The reason probably lies in the fact that the α-lines are sharp only for a comparatively pure α-iron lattice, and rather blurred for the α-solid solutions; if in addition the α-portions occurring are few in number and very small, the analysis method developed as yet, is not sensitive enough to detect them. It may be considered as established that the difficulty in working non-magnetic manganese steel, is due, at least partly, to its partial transformation into martensite.

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[1] C. Benedicks, "Hadfield's undersökningar över specialstål," *Teknisk Tidskrift*, Bergsvet, 1923, p. 25.

A Stroboscopic Method of Determining Surface Tension of Liquids.

OF the various methods of determining surface tension of liquids, the method of ripples is free from all surface influences. Lord Rayleigh, Dorsey, Grünmach, Kalähne and others have determined the surface tension of water by this method. Grünmach applied the same method in determining the surface tension of some of the molten metals; but the main difficulty was that of observing the ripples properly to measure the wave lengths exactly, and the accurate estimation of the vibration frequency of the exciting fork. Unless the stroboscopic arrangement is perfect, there is always an uncertainty in the determination

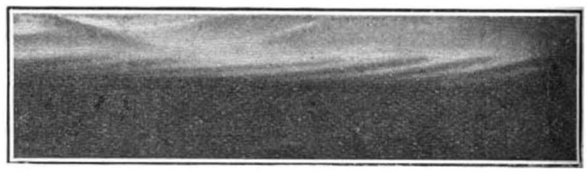

FIG. 1.

of λ accurately, and as λ^3 is to be taken in the calculation, a slight variation in the value of λ affects the final value.

We have, however, devised a method by which the stroboscopic arrangement is completely satisfactory. By fixing a fine edge to the prong of the exciting fork, and observing the reflection of this edge on the surface of the liquid at Brewster's angle (for water it is 53° 6′) fine teeth appear on the reflected image of the fine edge. These teeth remain absolutely stationary so long as the vibrations of the fork remain constant. The tips of the teeth are extremely sharp and stand a good deal of magnification (Fig. 1). The measurements of λ, therefore, could be made accurately. The excitation is produced by a fine needle soldered to one end of this edge, the needle dipping only about 0·25 mm. below the liquid surface. The ripples are scarcely visible on the surface.

The result given by this simple apparatus is satisfactory, namely, 74·1 in the case of clean distilled water. The vibrations of the tuning-fork are also recorded along with a standardised seconds pendulum, so that the frequency can be ascertained with great accuracy up to the second place of decimals. A slight touch of grease at once increases λ considerably, as has been pointed out by Lord Rayleigh.

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