THE CRYSTALLISATION OF METALS.[1]

THE crystalline characters of metals have been much less completely studied than those of non-metallic minerals and artificial salts, owing in large part to the infrequency of occurrence of regular and well-defined crystals amongst metals. Masses of metal are now known to be entirely crystalline, but special means are necessary in order to reveal their structure. In a few cases, notably that of bismuth, good results are obtained by pouring off the still liquid portion of a partly solidified mass of metal, when characteristic striated crystals of bismuth, recalling the Greek "key" pattern, result. Crystals are also obtained in relief on the surface of ingots cooled in contact with the air, tin, aluminium, and silver giving good results in this way. If the solidifying metal is spread out in a thin layer, the structure in relief may be developed in quite a remarkable degree, as when sheets of steel are dipped in molten zinc in the preparation of "galvanised" iron. The crystals (Fig. 1) closely resemble those of frost figures on glass. Crystals of steel up to 15 in. in length are occasionally found in the cavity or "pipe" of large ingots, and these have a characteristic form—that of closely packed, spiky branches arranged at right angles to a main stem.

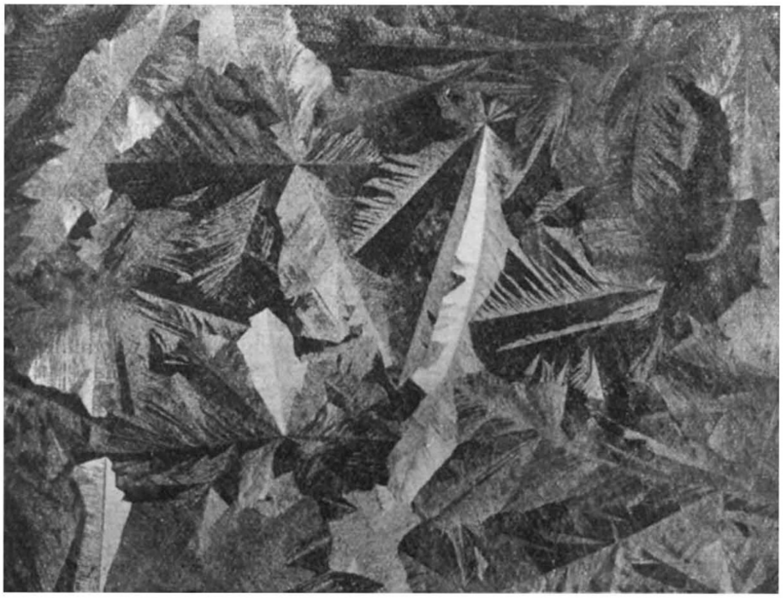

FIG. 1.—Surface of galvanised iron.

The internal dendritic structure of a solid mass of crystalline metal is most readily revealed in the case of an alloy. By suitable etching, the primary crystallites may be brought into contrast with the material subsequently deposited. The arrangement of the axes of such crystal skeletons is not readily followed by the examination of the usual plane sections, and a better representation of the arrangement of the parts in space is obtained by adopting the biological method of serial sections. A specimen is so ground as to present two accurately parallel faces, and is then placed, after etching, on the stage of the microscope in a special holder which permits the observer to bring the same area repeatedly before the objective. A suitable crystallite, having been selected, is photographed, and a thin layer is then removed from the surface by grinding and polishing. After again etching, the thickness is again measured, and a second photograph is taken. After several repetitions of this process the photographs, which represent plane parallel sections of the specimen, may be used for the reconstruction of the crystallite in plastic material. In the specimen of phosphor-copper shown to the Society, fourteen such layers were removed, the average thickness of each layer being 0·014 mm.

A marked feature of most metallic crystallites is the rounded termination of their axes. This rounding can only be attributed to the effects of surface tension at the moment of solidification. Intermetallic compounds are frequently less rounded, and less disposed to assume dendritic forms, than pure metals.

In the varied patterns of eutectic alloys it is sometimes difficult to recognise any relation to crystallisation, and it is evident that surface-tension plays an essential part. In the copper-antimony alloy shown in Fig. 2, however, it is seen that the minute antimony crystals of the eutectic are all in parallel orientation, and that the direction of their principal axes is the same as that of the neighbouring large crystallite. The violet copper antimonide forms a mere filling material, occupying the intervening spaces.

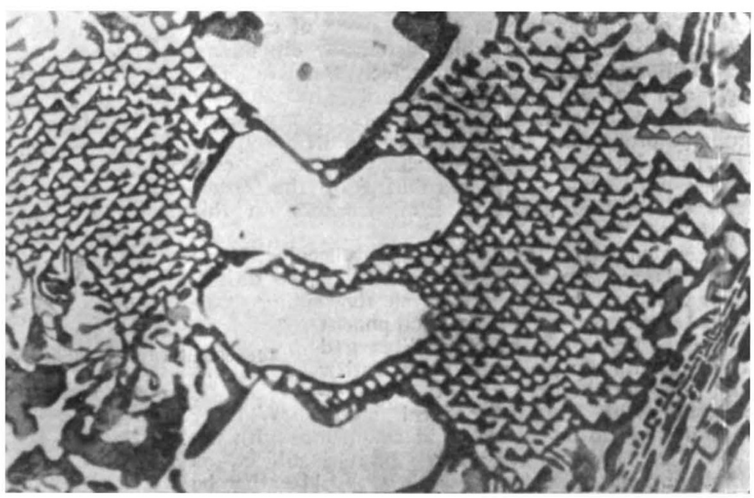

FIG. 2.—Eutectic of antimony and copper.

[1] Abstract of a paper read before the Royal Philosophical Society of Glasgow on November 29, 1911, by Dr. Cecil H. Desch.

Many eutectics take the form of masses presenting the appearance of single crystals, until found under a sufficiently high magnification to possess a duplex structure. Such masses have been termed by Benedicks "colonies," and are well seen in Swedish white pig iron. Fig. 3 represents portions of three such colonies in phosphor-copper, from which it is seen that each colony is in reality a spherulitic intergrowth of two constituents.

It may be said that the study of the formation and structure of crystallites and eutectics begins where geometrical crystallography leaves off. The labours of crystallographers have succeeded in bringing the geometrical branch of their science to a condition of remarkable perfection, but far less progress has been made in other departments of the study of crystals. For example, the causes which determine differences of crystalline habit are very imperfectly known. The beauty and diversity of form of natural minerals owes as much to differences of habit as to crystalline symmetry proper, but the former condition has, probably from its seemingly capricious character, contrasting with the severe regularity of the latter, attracted far less attention from workers on this subject.

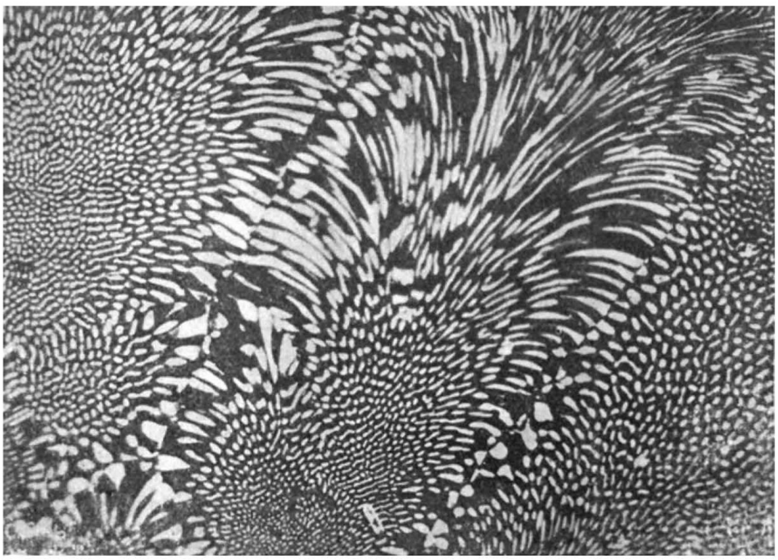

FIG. 3.—Eutectic colonies in phosphor copper.

It is evident, also, that a complete molecular theory of crystals must take into account the conditions which influence habit as well as the simple geometrical arrangement of the component particles. The study of crystallites and eutectics naturally connects itself rather with this obscure branch of the subject than with the geometrical study. Whether crystallites are to be regarded, in accordance with the views of some who have written on the subject, as embryonic crystals or whether they should rather be considered as crystals thwarted in their development by external conditions, their relation to normal crystals is an interesting one, whilst their importance as elements in the structure of metals affords ample justification for their study. The progress of metallography shows us how greatly the purely scientific study of such questions of molecular arrangement may influence technical practice, and the increasing stringency of the demands made on technical metals and alloys calls for a minute investigation of the relations between the crystalline structure and the physical and mechanical properties. The question has therefore both a theoretical and a practical importance, in addition to the fascination possessed by all problems bearing on the form of natural objects, whether organic or inorganic, the study of which constitutes morphology in the widest sense of the word.

SINHALESE IRON AND STEEL OF ANCIENT ORIGIN.[1]

IN this paper some interesting specimens of ancient Sinhalese iron were described. These consist of a chisel from Sigiriya, dating back to the fifth century A.D., a nail from Sigiriya of about the fifth century A.D., and a native billhook, or "Ketta."

From the results of the examination of these specimens it would appear certain that more than a thousand years ago there prevailed a knowledge of the metallurgy of iron. That a knowledge of hardening the cutting edges of tools was possessed is shown by the ancient chisel, which would appear to have its edges cemented and carburised. It would also seem that the crucible process of manufacturing steel has been known in the East for a long period, and that our modern belief that this process originated in Europe is probably not correct. This Indian industry is now almost extinct, owing to the fact that steel can be imported from Europe more cheaply than it can be manufactured locally.

Reference was made to the collection of ancient specimens of iron and steel (1200 to 1800 years old) in the Colombo Museum, which is probably the most complete of its kind in the world, that is, with regard to ancient iron.

Bearing upon this subject of Indian metallurgical knowledge, two papers were mentioned on Indian steel contributed by Mr. J. M. Heath to the Royal

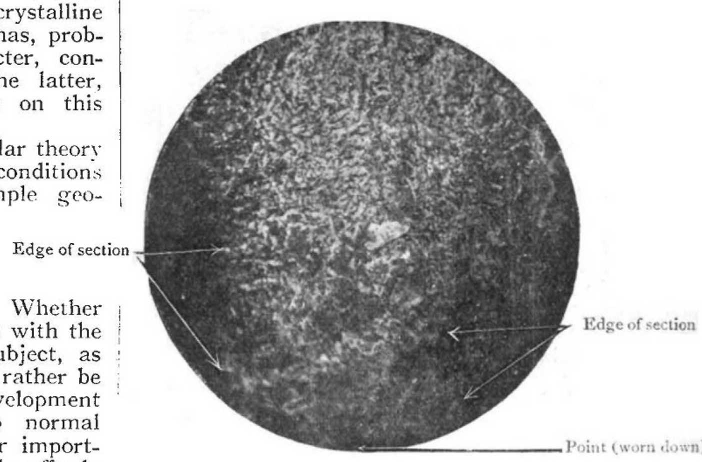

FIG. 1.—Chisel, from point. Longitudinal section. Magnified 80 diameters.

[1] Abstract of a paper read before the Iron and Steel Institute by Sir Robert Hadfield, F.R.S.