The Internal Physics of Metals.

The general discussion on the failure of metals under internal and prolonged stress, held on Wednesday, April 6, was of special interest for several reasons. In the first place, being arranged jointly by the Faraday Society, the Institution of Mechanical Engineers, the Iron and Steel Institute, the Institute of Metals, the Institute of Shipbuilders in Scotland, and the East Coast Institution of Engineers, it constituted a symposium which united the physicist, the metallurgist, and the engineer in the discussion of a problem which can be solved only by the co-operation of all three. The problem itself, also, is of no small interest, whether viewed from the practical point of view of the engineer who is concerned with the adequate safety and permanence of his works, or from the scientific point of view as a question of the internal physics of metals and of solids in general.

Briefly, we have first the long-known phenomenon miscalled "season-cracking" in brass. A cold-drawn rod or tube, or a spinning such as a cup, may appear to be perfectly sound and good when first made, but after a time, which may be a matter of hours or of years, it breaks, seemingly spontaneously. Such fracture we now know is the result of the prolonged operation of an internal stress which existed in the finished article as the result of undue deformations applied to the metal during manufacture, and this stress has in time proved sufficient to pull the constituent crystals apart. This is a type of fracture quite different from that which the same metal undergoes if broken in the ordinary way in a tensile test, when fracture occurs through the crystals themselves, and not through their junctions.

Until 1919 this phenomenon stood as an isolated, but important, fact in connection with brass, but then it was discovered that other metals, such as certain aluminium alloys, lead, and even steel, could undergo similar inter-crystalline fracture after the lapse of time if left, under suitable conditions, exposed to a sufficiently severe and continuously acting stress. In view of these discoveries Rosenhain and Archbutt put forward the suggestion that inter-crystalline fractures of this type arise as a consequence of the existence of an amorphous layer between adjacent metallic crystals; such a layer is regarded as consisting of a highly viscous, under-cooled liquid, and should, therefore, be subject to a minute amount of movement—either true viscous flow or visco-elastic displacement—under the action of long-continued stress. If, then, the form of the crystal boundaries is such as to favour easy relative displacement, inter-crystalline fracture will ultimately result, while if the boundaries between crystals are irregular or rough, displacement will soon be checked and no fracture occur. Rosenhain and Archbutt found that in their aluminium alloy they could produce at will a micro-structure with smooth boundaries in which failure under stress might occur within an hour, while in another condition the same material would resist failure for many years, and probably indefinitely. Similar results were obtained with lead, and in the case of steel also indications of a powerful effect arising from the nature of the crystal boundaries were found.

More recently Moore and his collaborators at Woolwich have shown that the selective action of certain chemical reagents, such as mercury salts and ammonia on inter-crystalline material, in the case of brass, plays a most important part in the process of "season-cracking"; indeed, they go so far as to say that, in brass at all events, such chemical action is essential to the occurrence of the phenomenon. In reply to this contention Rosenhain and Archbutt have recently shown that while even in their special alloy, in which the phenomena are most strictly analogous to those in brass, but more rapid, and therefore more readily studied, chemical action—in that case by air or water vapour, or both—also affects the process, yet it serves, not as the prime cause, but as an accelerator. Specimens of their alloy which fail, when left in the air, in a few hours, withstand the same stress for several days when kept in a high vacuum or in hydrogen; yet they ultimately fail even in the total absence of chemical action, and it is suggested that severely stressed brass will do so also, given time enough.

The main discussion, however, did not turn upon the relatively minor differences between the views of Moore and of Rosenhain, but rather upon the general question of the existence of the supposed inter-crystalline amorphous layer and its properties. Here it seems that some of the metallurgists who wished to dispose of this theory on *a priori* grounds—that the existence of such a layer in "highly crystalline" materials like metals was not possible—adopted a somewhat unintelligent and unscientific attitude. They cannot surely claim to have so intimate a knowledge of the behaviour of atoms during crystallisation as to entitle them to say that when two growing crystals approach each other the process of crystallisation *must* continue until the last layer of atoms is in some way forced to assume some orientation common to both the adjacent space-lattices. Nor can they dispute that a highly viscous liquid may behave as a hard and brittle quasi-solid under forces as ordinarily applied, *i.e.* at relatively rapid rates, and may yet undergo flow or visco-elastic displacements if sufficient time is allowed.

It is not, perhaps, possible to say that the actual existence of amorphous inter-crystalline layers in metals is proved, but it must be admitted that there is more than a strong *prima facie* case for the theory, and, further, that it serves to explain and unify a very large range of phenomena which otherwise lack explanation or correlation. The theory of an amorphous inter-crystalline layer must at least be regarded as an extremely helpful hypothesis which has been gaining steadily in strength from the accumulation of experimental evidence during the past ten years. Whether it will ever be possible to place it on a surer foundation it is difficult to predict, but our methods of studying the internal structure of matter have made such great progress in recent years that more is to be anticipated. Meanwhile, so far as inter-crystalline fracture under prolonged stress is concerned, it remains the only tangible explanation which was put forward during the discussion.

Mongolian Imbecility.

Dr. F. C. Cruikshank read a paper on March 22 at a meeting of the Royal Anthropological Institute entitled "The Ethnological Significance of Mongolian Imbecility." He pointed out that Robert Chambers eighty years ago directed attention to the occurrence in England of persons who in adult life are yet a "kind of children" and "of the Mongolian type." In 1866 Dr. Langdon Down definitely described a type of idiocy that he called Mongolian, and that has been recognised ever since by physicians. The homologies of these imbeciles have been discussed by medical men from various points of view, but it