were removed by scrubbing and scraping and the resultant powder examined by X-ray diffraction. The main constituent was a hydrated iron oxide as commonly found on the surface of rusty steel. There was also some silica present which could be accounted for if some of the particles adhering to the surface were sand grains.

Hardness of Samples

Hardness measurements made on the samples gave values of from 134 to 142, average 138 VPN (74 Rockwell B) for the magnetic material and 306 to 387, average 355 VPN (Rockwell C 36) for the non-magnetic metal. These values are consistent with the microstructures of the specimens.

Metallographic Examination

Samples of the metals from the two layers were polished mechanically and etched to show up their microstructures.

Non-Magnetic Metal

Figure 1 is an optical micrograph of the non-magnetic material. The microstructure is similar to that of cast Hadfield's manganese steel, consisting of equiaxed grains of austenite. At the grain boundaries are large irregularly shaped particles known as the "massive" form of iron-manganese carbide, $(Fe,Mn)_3C$. There are also needle-like particles of this carbide within the grains and at grain boundaries. In manganese steels the carbides are formed by precipitation on cooling of the cast steel. Their presence gives rise to intergranular fracture on impact, which is the way in which the steel fractured on being hit with a sledge hammer. In manganese steel used for high impact resistance, formation of the carbides is suppressed by quenching the steel from a temperature of about 1000°C (1832°F).

In some of the grains at the outside surfaces of the specimen there are fine parallel lines (Figure 2) typical of the twins formed when austenitic manganese steel is subjected to impact. These could be accounted for by the sledge hammer blows or general handling of the piece because no twins were found in the interior of the sample more than a few grain diameters from the outside surfaces. This, and the fact that the grains themselves were not deformed, indicate that the overall specimen had not been subjected to heavy deformation such as mechanical working and was still in the cast condition.

In the sample were very many inclusions of manganese sulphide and many gas holes, showing the metal to be of poor quality that might be expected of residues cast without care.