ORIGIN OF DEFECTS IN COPPER CONDUCTORS

MR. J. E. DEERING contributes a useful article on the origin of defects in copper conductors to the *Electrical Review* of October 3. When hard drawing became a common practice, copper wire became a practical substitute for galvanized iron wire for overhead telegraph and telephone lines. The effect of the process was to raise the tensile strength of copper from 6·5 tons to 20 tons per square inch, which is almost equal to that of wrought iron, whilst its resistance is only about one-sixth. The effect of the cold drawing of copper is to make its resistivity only about 3 per cent higher than that of standard annealed copper.

Most contracts for the supply of copper wire quote the British Standards Institution specification, which states that the wire shall be approximately circular in section, smooth, uniform in quality, pliable, free from scale, inequalities, 'spills', 'splits' and other defects. Mr. Deering states that representatives of purchasing firms engaged upon the inspection of copper wire may be able to detect physical defects and yet are often unable to detect their origin. The following consideration of the different stages of manufacture will greatly facilitate the tracing of the causes of shortcomings.

During its passage through a succession of rolls after it has been ejected at white heat from the furnace, a copper billet, initially measuring 6 ft. by 4 in. by 3½ in. and weighing 250 lb., increases in length as its cross-section diminishes. It emerges from the rolls at a greater linear speed than that at which it entered, for it not only takes up the speed of the rolls, but is also squeezed forward by an amount corresponding to the reduction in cross-sectional area. Rapid operation is necessary, as it prevents too great a difference in temperature of the metal from one end to the other, causing sometimes 1½ per cent variation in the tensile strength of the wire.

To ensure a reasonable temperature throughout the rod before being drawn into wire, it is 'roughly annealed' by heating at 1200° F. and quenching with water. It is then pickled in dilute sulphuric acid to remove mill scale. During the rolling, the shape of the cross-section is varied from pass to pass, for if the section were circular throughout fins would be produced ; these would be bent over in the next pass to form 'cold shuts', which might be below the surface for a distance, and possibly remain throughout the complete process. A combination of shapes—squares, ovals and rounds—is therefore used, and this kneads the copper, rendering it homogeneous and ductile.

The next stage is the breaking down of the rod by pulling it through a dieplate with 12–18 holes. The dies are usually of steel, but for copper cast iron is sometimes used. For drawing long lengths of the wire, diamond dies are occasionally employed. Each hole has two zones—a short tapered one and a bell-mouth leading up to the approach. The walls of the latter must be quite clear of the entering wire, which might otherwise cause the metal of the die to be drawn forward and piled up in the throat.

A departure in circularity in section may occur during wire-drawing, if the wire has slipped on the drum of the coiling block, resulting in a 'flat' on the surface through rubbing. Lack of smoothness is sometimes due to the same cause. Non-uniform quality is traceable to impurities in the ore itself. Absorption of gases giving rise to blowholes when the ore is being smelted into billets may also occur. If during rolling a rod crowds a pass and issues with fins, these may become laid into the rod and show up as 'spills' on the surface. These are eliminated by 'scalping'.

The origin of 'splits' occurs in the smelting stage. If a fresh supply of metal is poured into a ladle which already contains a small amount of molten metal, the two will not mix or weld together. The seam or seal so formed will remain throughout the rod or wire being rolled and covered in later stages, so that it may appear on the surface at odd intervals. Two interesting photomicrographs are shown of a high-conductivity copper rod and of a section of the same rod after it has been made into hard-drawn wire.

BELGIAN EARTHQUAKE OF JUNE 11, 1938

THIS earthquake has been studied by O. Somville, chief of the Belgian Seismological Service (*Annales de l'Observatoire Royal de Belgique*, Série 3, 2 ; 1939). On June 11, 1938, at midday by the public clocks near the epicentre, an earthquake was felt in Belgium, North France, Holland, North-West Germany, Luxembourg and South-East England.

The shock reached intensity VII on Sieberg's modification of the Mercalli-Cancani Scale in central Belgium where it was strongest, and displaced tiles as far away as Herne Bay in England. The earthquake was the most intense of approximately 140 experienced in Belgium since the year 1086. At the Belgian Observatory at Uccle the Wiechert mechanical instruments were thrown completely out of gear, though the long-period Galitzin instruments with galvanometric registration gave the distance as between 50 and 60 kilometres from Uccle and suggested that the epicentre was to the north-west. This latter proved incorrect, as the epicentre by later calculations turned out to be between Audenarde and Renaix, almost west of Uccle. On a basis of 3,570 communications, isoseists were drawn using Sieberg's modification of the Mercalli-Cancani Scale, and two maps showing the