

before reduction can occur contact between the charcoal and oxide is essential. Unfortunately these oxides do not float to the surface and, therefore, the necessary contact is not obtained. It will naturally be stated that a layer of charcoal or the top will prevent the admission of air and thereby maintain a reducing atmosphere. To a certain extent this will be the case, that it is not completely so can be readily proved by simple trial.

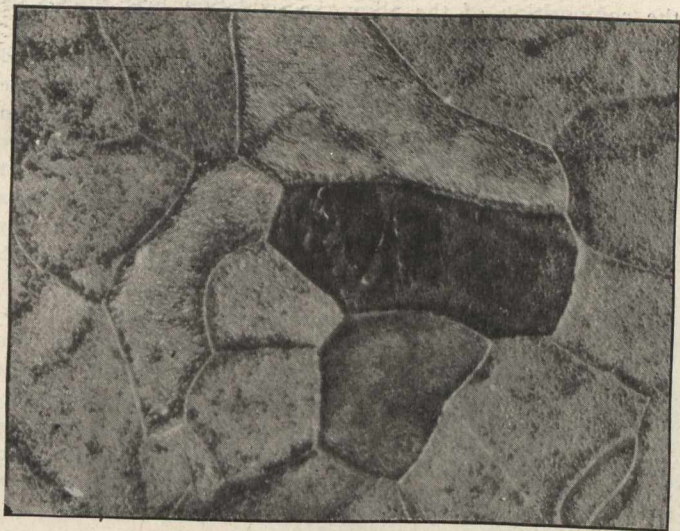


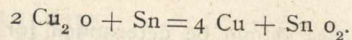
Fig. 1.—Pure Copper.
X. 58.

Commercial copper of the type used in the production of alloys always contains more or less oxygen in the form of oxide; in melting further quantities of oxide are formed before the copper is liquefied, but on liquefaction the amount formed is determined by the melting atmosphere and the effectiveness of the charcoal covering. Given a strongly reducing atmosphere during the whole period of melting and a crucible initially exhausted of oxygen then oxide free copper castings result. Such ideal conditions are, however, not attainable in practice, during parts of the melting period an oxidizing atmosphere will ensue and until the ingots of copper settle down into a liquid mass the covering of charcoal will not be effective.

Unlike charcoal, which only gives superficial contact, deoxidizing agents, such as zinc, phosphorus, silicon, or manganese, when added to molten copper by permeating the whole mass effectually seize oxygen and form oxides which readily float to the surface.

In practice many copper castings are produced by melting under charcoal, and just before drawing the crucible adding some 2% of zinc—the greater portion of which is oxidized and castings of fairly high purity result. The most familiar deoxidizing agent is phosphorus added in the form of phosphor-copper. An addition of $\frac{1}{2}$ pound phosphor copper to 50 pounds of copper would give a theoretical phosphorus content of 0.15%. The actual amount of phosphorus remaining will, of course, depend on the oxygen present; a phosphorus loss of 50% is, however, a safe estimate and this would, therefore, yield a phosphorus content in the copper of 0.075%. Manganese and silicon have very similar effects to that of phosphorus, and like phosphorus are more conveniently added in cupro form. In the production of German silver, the nickel, which enters largely into the composition, should always be deoxidized by manganese.

From the foregoing it is evident that with an alloy of copper and zinc, owing to the presence of zinc, copper will not take up or unite with oxygen. Further in the presence of these two metals there is always a preferential oxidation of zinc, which is readily evidenced by the fumes of zinc oxide given off. With a copper tin alloy the case is entirely different. Tin, like copper, will unite with oxygen to form an oxide, which is retained by the metal. A feature of note lies in the fact that metallic tin will reduce copper oxide but the oxide of tin is retained by the alloy. This reduction may be expressed as follows:—



Here again charcoal will only reduce the oxide of tin when in contact and owing to the fact that the oxide does not float, that contact does not occur.

Copper tin alloys have comparatively little industrial application, but the triple alloys, copper, tin and zinc are very largely used. As a rule the content of zinc varies from 2 to 6%, and with this metal present, oxidation of copper or tin will not occur.

As the majority of alloys contain zinc the loss of this metal is of some moment. As shown this loss is due to combination with the oxygen present, and further sources of loss are found in the volatile character of zinc at the alloying temperature. The total loss will, therefore, be greater when making an alloy, i.e., adding zinc to molten copper than when remelting an alloy, further it will vary according to conditions of melting, etc. As an example one case may be quoted in yellow brass, 70% copper, and 30% zinc was made over a long period of time by charging the foregoing quantities. As a matter of fact the cold castings contained 76% copper and 24% zinc, the castings thus containing an excess of the costly metal copper and a deficiency of the less costly metal zinc.

The author's experiments clearly show that the zinc loss is determined by the highest temperature reached and is entirely independent of the amount present. The following examples illustrate this point,—

Alloy.	Highest Temperature.	Actual content of zinc in the castings.	Percentage loss of zinc.
Gun Metal	1173° C	1.8%	27.7
Red Brass	1308° C	10.2%	28.6
Yellow Brass	1182° C	26.0%	26.1
Muntz Metal	1038° C	40.5%	19.0

The alloy containing the most zinc gives the least loss, but a glance down the temperature column will explain this. From other experiments evidence is offered to show that had the foregoing alloys been heated to one uniform temperature the loss in each case would have been identical.

Whilst casting a series of moulds from a crucible of yellow brass noxious fumes of zinc oxide are constantly emitted, and from this it would almost appear that the con-

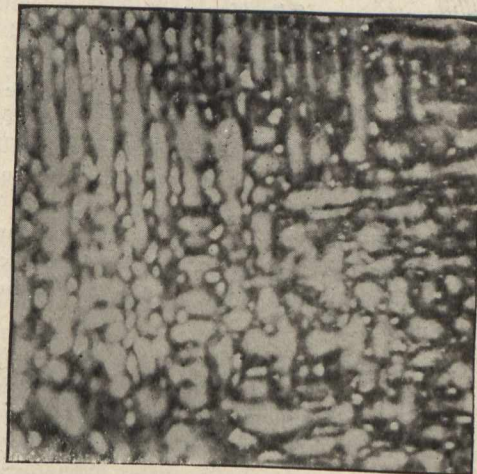


Fig 2.—Oxygenated Copper.
X. 58.

tent of metallic zinc would be steadily lessened. In other words the first casting poured would be higher in zinc than the last one. Such is, however, not the case, and a wide series of tests has clearly shown that the loss takes place entirely on heating, and the amount is determined by the highest temperature reached. As the fumes are emitted from the alloy as it stands in a crucible and continue until the temperature is in the vicinity of the freezing point, it necessarily follows that these fumes represent oxide previously formed, that is during the heating stage.

This loss of zinc should be allowed for in all cases, it is of special moment in certain alloys, such as manganese bronze, in which a specified content of zinc is essential in order to obtain the full range of properties from the alloy.