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DEPARTMENT OF COMMERCE
BUREAU OF STANDARDS
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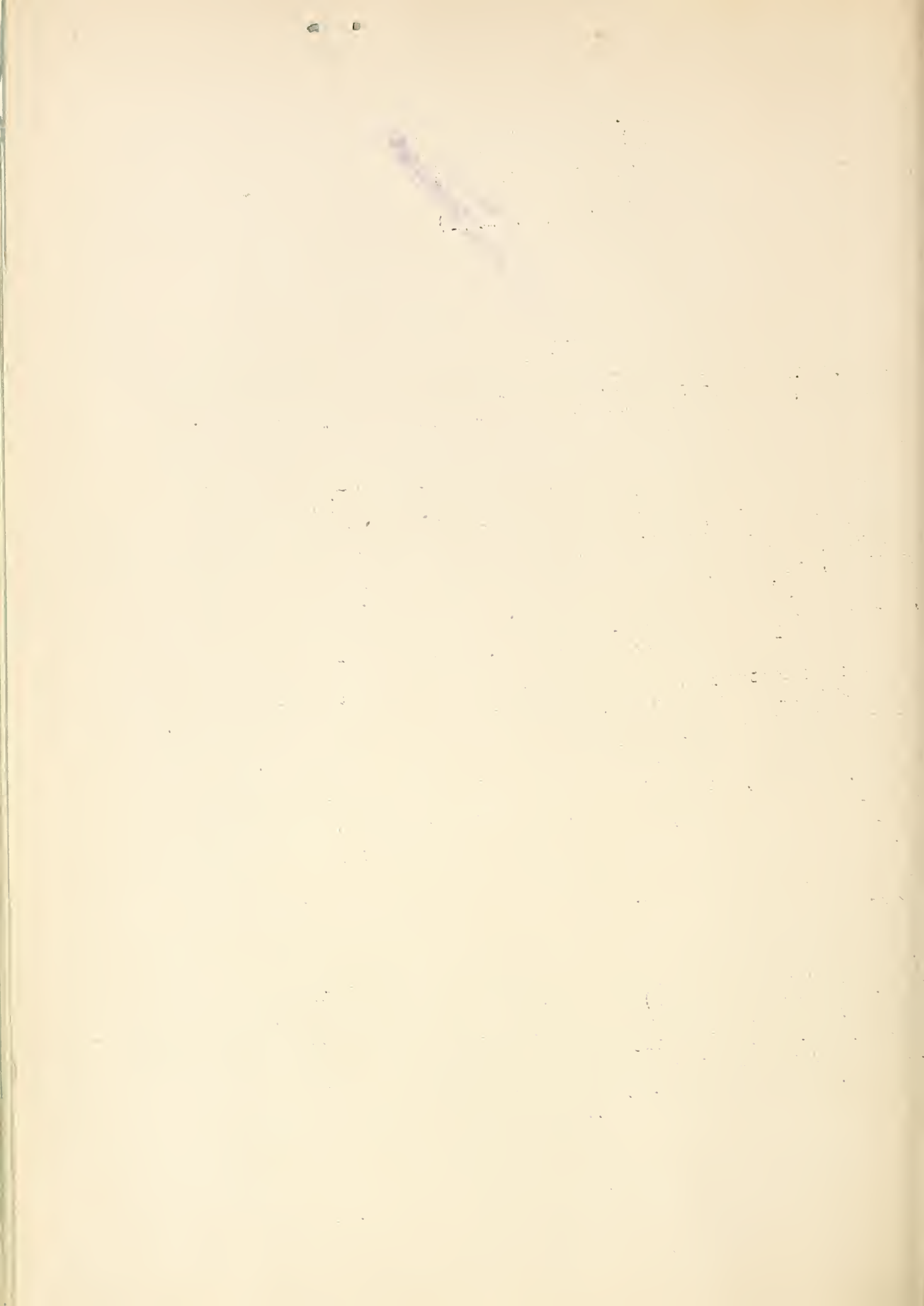
HARDENED COPPER

To meet the frequent demands made upon this Bureau for information on the subject of "Hardened Copper" this circular letter has been prepared.

There is nothing new or "mysterious" in "hardened copper"; immense quantities are in commercial use and more is being added daily. There are two well-known methods for hardening copper (often called "tempering"). The metal or its alloy may be hardened very considerably by mechanically working it; hammering, cold drawing, rolling, etc. Hard drawn copper wire, cold drawn tubing are examples. To supply the needs of a single industry alone, vast quantities of copper hardened by this means are used after hardening in this way, e.g., hard drawn trolley wire.

The second method of hardening copper is to alloy it with a small amount of another metal (or perhaps more than one metal). Zinc, tin, aluminum, and iron are the common additions. The alloyed metal should no longer be referred to as "copper", but should be named according to the chief alloying constituent added, i.e., brass, bronze, etc. This name may be further restricted according to other additions made, e.g. zinc-bronze, nickel-brass, etc. Vast quantities of copper hardened in this general way are in commercial use. Many of the samples of "hardened copper" submitted to this Bureau for examination have proved to be alloys of copper with small amounts of one of the elements named above.

One of the favorite methods of "hardening" copper appears to consist of manipulating the melting (perhaps unwittingly on the part of the experimenter) so that the resulting melt is impregnated with oxide. Cuprous oxide is soluble in molten copper and alloys with it in exactly the same sense that metals do. Copper hardened in this way is considerably harder and more brittle than the pure metal is, but is unsuited for most of the purposes for which copper is used.



The term "hardened copper" has been used above in its general sense to refer to copper in which the mechanical properties have been modified in the manner usually understood by the term "hardening", i.e. an increase in toughness, a decrease in ductility, etc. The popular conception of "hardened copper" is that of a metal similar to hardened steel and usually implies the "ability to carry a cutting edge".

Numerous samples of "hardened copper" have been submitted to this Bureau for examination. In many samples examined the metal was impregnated with cuprous oxide, thus indicating that an alloying with oxide had occurred during the melting as described above. The product in this case is considerably harder and more brittle than pure copper and has a peculiar red color.

The following determinations of the Brinell hardness upon different forms of copper and of a sample of so-called "hardened" copper submitted to the Bureau are of interest:

Specimen	B.H.N. (500 kg.load, 10 mm ball)
Hard drawn trolley wire (23/64" diam.)	107
Hot rolled; 1/4" sheet	68
Electrolytic (cathode) Copper as deposited	59
"Hardened" Copper, as submitted (Sample contained 5.5 % Zinc)	39

The popular interest in the so-called "lost art" of hardening or "tempering" copper is evidenced by the numerous inquiries on this subject received by this Bureau, together with samples of copper treated by some "secret" process in the endeavor to render the metal similar or equal to steel in many of its properties. The rather numerous patents covering such processes may also be cited as evidence of the interest in this field, the directions given in some of these patents for the treatment of the metal being very suggestive of the methods of working metals used in medieval times. The following may be quoted as typical:

100

100

100

100

100

100

100

100

100

100

100

100

100

100

100

100

100

100

100

100

100

"Heat the copper to 260° to 315° and subject it while hot to fumes of burnt sugar and animal fat at a temperature below that necessary to form carbon monoxide".

No industrial application appears to have been made of these patented methods for hardening copper.

Relative to the so-called "lost art of hardening and tempering copper or bronze", the following quotation from Wm. Gowland, Jour. Inst. of Metals, Vol. VII, No. 1, 1912, p. 23, is of interest and importance. Prof. Gowland, of the Royal School of Mines, is an authority upon the subject of the uses of copper in antiquity and its metallurgy:

"The castings (knives, swords, etc.) generally were hammered at their cutting edges, and it is this hammering and to it only, that the (increased) hardness of the cutting edges of both copper and bronze weapons is due, and not to any method of tempering. Much has been written about the so-called art of tempering bronze, supposed to have been practiced by the men of the Bronze Age in the manufacture of their weapons; the hardness : . . . said to be greater than can be given to bronze of the present day. I should like to correct this error, as it can only have arisen owing to its authors never having made any comparative practical tests of the hardness of bronze. Had they done so, they would have found that the ordinary bronze of to-day can be made as hard as any, in fact harder than most, of prehistoric times, by simple hammering alone".

For a more complete study of copper and its properties, Bureau Circular 73, "Copper", should be consulted.

