

primary supply. Coincidentally, the United States is the major world consumer of the metal. While the domestic potential resource position is not large in comparison to estimated world total, some means of employing these would tend to minimize future spot supply problems. Specifically, an appraisal of domestic pyrochlore resources and the practicability of extracting columbium from such substances deserve attention.

The close natural association of columbium and tantalum continues to present technologic and economic problems. Improvement in separation techniques would tend to reduce costs.

The broad field of interchangeability is, as in the case of other alloying elements, a factor in this instance. Costs influence, for example, the relationship between ferrovanadium and ferrocolumbium and, in turn, the design of structural members that employ either. Accordingly, innovations that effect cost reduction in either the manufacture of ferrocolumbium or high purity metal would tend to extend supplies or several commodities and broaden the uses of columbium in specialized applications.

Recovery from secondary sources includes technologic problems that will become magnified as the diversified application of columbium is increased and new alloys and applications affect the character of scrap and salvaged end products.

COPPER

Installed productive capacity and the level of technologic development governs supply and, assuming the latter will be as energetically pursued and as effective as in the past, world supplies should be adequate to meet requirements projected over the next three or four decades. While the United States leads the world in both production and consumption, the extent to which it meets its future requirements from domestic sources is likely to decrease. As one of the key commodities in this industrial economy domestic copper production growth should be insured even recognizing that imports will have to supply an increased percentage of future United States demand. Cost reductions at every stage from exploration through fabrication will have to not only accommodate the continuously decreasing tenor of raw materials but permit effective competition of foreign operations. Any technologic advance that contributes to cost reduction is, in this instance, a subject for concerted attention.

The supply of a host of byproducts and coproducts depends upon the rate of copper production, processing and refining. The current annual value of these, recovered from the domestic processing of predominately copper ores, is more than \$1.3 billion. Any innovation or technologic improvement that affects the recovery or use of the coproducts improves the overall economics of copper production, coincidental to the direct benefits to the coproduct, and thus merits attention.

Major opportunities for cost reduction are present in the initial extraction (mining) process. Attention to improvements in conventional systems as well as new approaches (in-situ-nuclear-leaching) is demanded. Large quantities of low-grade copper-containing waste are bypassed or moved in the mining operations. Further, large quantities of low tenor copper-containing waste are discharged from the concentrator. Such material represents a large copper loss which should be recovered, possibly by leaching.

Improved recovery of copper from the waste products of milling and refining would effect important additions to the domestic copper supply. By the same token, the ultimate disposal of the waste products from these operations is, as in the case of mining, a growing problem that promises increased processing costs if new concepts or practices are not developed.

Except for few dissipative uses much of the copper used adds to a "reserve" that is ultimately recoverable. At present this reserve supplies about a fifth of the domestic demand. From any standpoint—conservation, supply, economics, or other—improvements in the salvaging and processing systems for recovering and recycling the secondary metal (and its coproducts) merits immediate and intensive investigation.

The domestic extraction industry faces potentially critical land-use conflicts. Unless opposing views on surface restoration standards, waste disposal, and pollution issues are reconciled without excessive increases in operating costs the competitive position of United States supplies will deteriorate sharply. Current smelting practices generate sulfur-containing fumes, some of which exhaust into the atmosphere through high stacks. Such discharges represent both a serious air pollution problem and a loss of a valuable potential product—sulfur. This is