

more productively—space that already is hard to find in many heavily populated communities. Waste storage often creates hazardous conditions and contributes to water and air pollution. Moreover, many solid wastes contain potentially valuable mineral and metal constituents which should be recovered and recycled to the production stream.

The importance to the overall economy of recycling materials is evident. Of the total copper consumed in the United States each year, 42% is reclaimed or "secondary" copper. Recycling accounts for 58% of our lead, 45% of our iron, 26% of our zinc, and 19% of our aluminum. These returns are derived only from materials that are easily treated, however. Millions of dollars worth of metals are discarded each year, because they are locked chemically and mechanically into materials from which they cannot be separated by standard smelting technology.

Here, in the United States, we now enjoy a high standard of living far beyond precedent for any country in the world. But, in attaining that standard, we have consumed in the past three decades alone more minerals and fuels than previously were used by all the people of the earth throughout its history. As a result, much of the copper now produced on the North American continent comes from ores containing less than 1% copper, as compared to grades of 5 to 20% copper used 60 years ago. An increasing percentage of domestic iron ore is taconite, a rock considered unusable only a few years ago when direct-shipping hematite was available. This trend toward the use of leaner ores is evident for many other metals.

The lesson is clear: The United States has exhausted or nearly exhausted its rich deposits which were easily discovered and easily mined, and is being forced to import rich ores or use domestic ores of lower quality. Clearly, the natural resources of the entire world will not be adequate to supply increasing demand indefinitely unless far more efficient systems for recycling used materials can be devised.

The Department of the Interior, charged with conservation and wise use of the Nation's resources, has consistently sought ways to reuse the waste products and scrap generated by the minerals industries and the consuming public. Through the Bureau of Mines, the Department has been actively seeking solutions to solid waste problems for more than two decades. In general, the objective has been to develop new and improved methods for recovering metal values from wastes and for refining substandard primary metals. The approach has been that of applying scientific knowledge and expanding the technology of extractive metallurgy to solve difficult secondary metals problems. The value of this approach and the innovative capability it requires, are demonstrated by the following accomplishments:

Cadmium-magnesium alloy bomb casings, left from World War II, remained in stockpiles for years and were assumed to be worthless because the alloy defied separation by known metallurgical practice. The Bureau developed a process for recovering both metals, at significant savings to the Government, through vacuum distillation.

Drawing on technology from the heavy chemicals industry, the Bureau has successfully used amalgam electrolysis to recover tin, cadmium, and zinc from process residues.

Processes have been developed in which two waste materials effectively refine each other. Galvanizers' dross containing iron is mixed with zinc die-cast scrap containing aluminum, and the mixture is melted. The iron from the dross combines with aluminum from the die castings to form solid crystals of iron-aluminum compounds. These are easily separated by filtering or centrifuging, and the zinc from both scrap materials can be refined.

Another process developed by the Bureau uses a different type of waste material for removing aluminum from die-cast scrap. Spent galvanizers' sal skimmings, containing too much chlorine for treatment at smelters, is added to the molten scrap to cause volatilization of aluminum chloride. The zinc is refined, and the skimmings become marketable when the chlorine content is reduced below 2%.

A process recently patented by the Bureau removes alumina from zinc with the aid of ferric chloride. Unique features of the method are that both iron and chlorine in the ferric chloride are effective refining agents; and ferric chloride, which normally boils below the temperature of the operation, is prevented from escaping by using a carrier flux of other salts.