The author traces briefly the emergence of industrial research in extractive metallurgy in North America and compares the relative effectiveness of this function in the mining industry with industrial research in the chemical process industry. Industrial research is defined as research structured to produce a profit. Profits are produced by people. Organizational structures and management practices which get in the way of people committed to producing profits not only decrease productivity, but tend to lose the services of the more capable profit producers. Research management should manage the function rather than the people therein. A productive future for industrial research in extractive metallurgy is assured provided
1) we make appropriate adjustments in management structure and practice, 
2) management really involves its professional people in the solution of business problems, 
3) there are challenging, clearly defined profit goals, and 
4) it is recognized that the one essential resource required is suitably motivated capable human beings.

Dr. CARLETON C. LONG was born in Boulder, Col. He received the degree of B.S. in chemical engineering at the University of Colorado in 1931. Stanford University conferred the degree of M.A. in 1932. Dr. Long received his Ph.D. at the University of Colorado in 1935. He has been with the St. Joseph Lead Co. since 1935, first as research engineer, Zinc Smelting Division. He became director of the plant research department in 1937, and in 1955 became director of research. He has made distinguished contributions to the art of electrothermic winning of zinc from sulfide ores and from lead blast furnace slag.

A member of AIME since 1937, Dr. Long has been head of the Lead-Zinc Committee of the Extractive Metallurgy Division. He was a founder of that division and was its chairman in 1950. In 1951, he was chairman of the Metals Branch, now The Metallurgical Society. He served as director of AIME in 1950, 1954-57, 1959-63, and as vice president in 1961-63. He is former director, vice president, and president (1960) of The Metallurgical Society. He has served as chairman of the AIME Charles F. Rand Award Committee and twice as chairman of the AIME James Douglas Gold Medal Award Committee. Currently, he is a member of the Advisory Committee of the Pittsburgh section of the AIME.

Dr. Long is former chairman of the Pittsburgh section, American Institute of Chemical Engineers, and is a member of the American Chemical Society; the Electrochemical Society; American Association for the Advancement of Science; the American Society for Metals; Pennsylvania Society of Professional Engineers; the National Society of Professional Engineers, and several other technical organizations, including the American Society for Engineering Education. He is or has been active in Engineers' Joint Council and Engineers' Council for Professional Development.

Active in the affairs of the Industrial Research Institute, Dr. Long is chairman for the Seminar Committee, which annually provides a seminar on Industrial Research Management at Harvard Business School.

Dr. Long's technical writings have largely concerned the extractive metallurgy of electrothermic zinc. He also has written extensively on the development of young engineers.

Dr. Long is a Fellow of The Metallurgical Society.
I am honored by this privilege to give the 12th Extractive Metallurgy Division lecture. I am honored both by the invitation to share my experience with my colleagues in the profession and by joining the eleven preceding Extractive Metallurgy Division lecturers. In reviewing their themes, I find that, with but one exception, the lectures have all concerned the technical or material aspects of extractive metallurgy.

These erudite reviews encompass the extractive metallurgy of titanium, copper, lead, zinc, reactive metals, carbothermic aluminum, separation engineering on the moon, nonequilibrium unit processes, vaporization of metallic oxides and sulfides, and the reduction of metals in solids.

Each of these ten lectures concerned either a commodity or a process. In 1967, Professor Schlechten broke this pattern by provocative discussion of education for extractive metallurgists. So also shall I depart from the historical pattern. My remarks will be controversial. I do this intentionally. I seek not to say words you may find agreeable. My mission is to induce you to make your own analysis of the thesis I present. I shall examine that aspect of research which determines success or failure of technical achievement and engineering innovation—the human side of research.

I became a director of research in 1937, just two years out of graduate school, and have been a director for 33 years. This tenure has given me much more opportunity than that of the average research director to make mistakes. It has also given me opportunity to observe mistakes of other research organizations. I think I have learned something from the errors of my own and those of others. With this background, I am happy to pass on some of the philosophy I have developed over the years.

Here in Denver, it is appropriate to discuss industrial research in extractive metallurgy. Just one hundred years ago, at a location 20 miles from this spot, there occurred the first major triumph of extractive metallurgical research on western ores. Nathaniel Peter Hill, a young instructor in chemistry at Brown University in Providence, R.I., undertook a research project to extract values from ores of the Central City region. Combining his knowledge of chemistry with a study of smelting in Wales, he developed a new process. He then built a smelter—today we would call it a pilot plant—at Blackhawk and operated it with commercial success. This was the beginning of industrial research in extractive metallurgy in Colorado.

Why did Nathaniel Hill succeed where others failed? Of the several reasons I shall name three. He understood industrial research—not just the research method, but how to bring the research results down to commercial utility. He became involved in the romance of his research. This led to an advocacy so strong that failures and disappointments were as naught. Most important, he was not enmeshed in the smothering bonds of a managerially inept organization.

The metamorphosis of Nathaniel Hill from an academic instructor to a successful manager of industrial research furnishes an example with which it is convenient to define a few terms. Briefly, industrial research is the conversion of knowledge—such as the findings of academic research—to products useful to mankind. Industrial research is applied research structured to produce a profit. Harvey Brooks has pointed out that, as definite categories, the terms “basic” and “applied” research tend to be meaningless—that whether research is basic or applied depends on one’s point of view. As a classic example, he notes that almost all of Pasteur’s work is properly termed applied research, yet it revolutionized the conceptual structure of biology and, in that sense, was basic.

In his perceptive analysis, “The Technical Spectrum”, Darken neatly debunks “... ... the attitude that fundamental research should be sharply distinguished from applied research and the rest of the spectrum.”

John R. Pierce adds that it is even more meaningful to distinguish between “good” and “bad” research than to attempt to categorize as applied or basic. “Good research substantially or usefully increases our understanding of important things or our ability to do important things.” From this viewpoint, I suppose it’s reasonable to say that all successful industrial research is, by definition, good research—but not all industrial research is successful.

Industrial research does not stand by itself. It is part of a business strategy involving
1) a plan of action to achieve certain corporate objectives,
2) creation of the required technology, and
3) means for using these results in the corporation’s manufacturing operations.

Since I shall repeatedly tie my argument into the term “profits”, I must define this key word. I use the term “profits” to designate the gain that accrues from the constructive application of human effort.

What’s left over after comparing the end point situation with the beginning is the amount of profit created. In most civilizations, it is customary to measure profits in terms of the current medium of exchange—such as dollars—but this is not basic, it’s merely a convenience. In animal husbandry, the profits created by research on disease control might well be expressed as cattle or swine. Similarly, the increase in human energy and other qualities of life created through efforts of health services research is a profit. Profit is the means that enables an organization to serve society. Let’s keep the real meaning of profits firmly in mind as we explore industrial research in extractive metallurgy.

At the 1967 Operating Metallurgy Conference, the 1962 EMD Lecturer, Albert J. Phillips, presented an excellent and highly human summary of the present state of the art of industrial research in extractive metallurgy in his down-to-earth paper, “The Design of Metal Producing Processes”. He emphasizes, as I have, the business consequences which hinge on the unfolding of a properly founded research project. More importantly, he brings out clearly the key roles played by interpersonal relationships and human judgment.

Let’s now trace briefly the development of industrial research in extractive metallurgy and compare it with the much better known chemical process industry. Even after excising personal biases, it is evident that research in the chemical process industry is far ahead of that in the mining industry. Not only has the CPI outshone us in the level of sophistication of research skills and the resulting technology, but they have demonstrated a superior ability to cope when the competi-