Introduction

In a normal year the U.S. iron and steel industry consumes in excess of one billion dollars' worth of ferroalloys and other additives intended to produce iron or steel of definite chemical composition.

A ferroalloy is usually defined as a metallic material containing a large proportion of a useful metal intended to be added to a melt and the balance being iron; however, the implication of iron being the other main component may or may not be true in modern practice. In a number of materials commonly regarded as ferroalloys, the proportion of iron is very low; calcium-silicon is a good example. Other additives vary from the definitely metallic pure chromium and manganese to the nonmetallic sulfur; most are obtained by a smelting process but some—titanium, for instance,—are often used as sized pieces of scrap.

Since virtually all steel and iron specifications call for manganese (contents exceeding those obtained in the molten metal and needed mainly to counteract the detrimental effects of sulfur)—manganese, usually as ferromanganese, is an additive without which the industry could not exist. The majority of steel grades call for levels of aluminum or silicon or both not obtainable from the steelmaking process; hence these two elements must be added to the liquid steel. Stainless properties can be obtained only from large chromium contents; modern high-strength low-alloy steels depend on columbium (niobium), vanadium, molybdenum, and sometimes other elements for the development of their properties. Consequently, while manganese is required in all steels and irons, the production of steel grades other than some nonalloy "plain carbon" ones is not possible without the use of other ferroalloys and additives.

It is surprising, therefore, with respect to the importance of the subject, that no comprehensive text on the use and properties of ferroalloys exists in English, while books on this subject are known in German, Russian, Polish, and reputedly Japanese. A number of papers discussing various aspects of ferroalloy use appeared in recent years in the *Journal of Metals, Iron & Steelmaking,* and *Iron and Steelmaker;* also, the subject was frequently but more or less in passing mentioned in many papers published in the *Proceed-*

ings of the National Open Hearth Conferences (later renamed Open Hearth and Basic Oxygen Steel Conferences and finally Steelmaking Conferences) and the Electric Furnace Conferences, published for many years by the American Institute of Mining and Metallurgical Engineers (AIME).

Since 1923, ASTM Committee A-9 on ferroalloys and alloying additives has been engaged in the formulation of standards for these materials. These standards are known and used throughout the world, although many national standards are now in existence. Cooperation of the committee with AIME resulted in sessions devoted exclusively to the usage of ferroalloys presented at the 1976 and 1977 Electric Furnace Conferences. It should be noted that sessions on the production (smelting) of ferroalloys were regularly included in these programs, but the use of the product was, as mentioned, covered only incidentally in some papers which discussed steel production.

The popularity of these two sessions led to a discussion within Committee A-9 regarding future work. The dependency of the United States on foreign sources of ferroalloys resulted at that time in a number of papers discussing the economics and trends of alloy usage. It was obvious to the practitioners of the art present in Committee A-9 that the conditions of use of the common alloys—manganeses, silicons, and chromiums—were well established in the industry. However, some managerial aspects of the field of ferroalloys were not well known and the technology of use of the "lesser" metals lacked any significant coverage.

With this in mind the presidium of A-9 developed plans for a symposium which would cover the less-well-known aspects of its subject.

It became obvious from the preliminary planning that discussing all alloys, even excluding the better-known ones, and all situations would not be practicable: a symposium would have to extend over an unacceptably long period and the resulting volume, unless severely abridged, would tax the resources of ASTM. Hence the program was limited to general coverage of the mentioned lesser aspects of the field and the present publication is the result of this effort.

The symposium took place 20–21 May in Denver, during an ASTM Committee Meeting week: 17 papers were presented. Since the discussions were intended to be very informal, no notes were taken and thus no discussions of the papers are included herein. By design, neither the manufacture of the materials nor the economics of supply were considered.

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