was possessed of an extraordinary degree of softness and tenacity. The analytical investigations made to ascertain the cause producing these properties demonstrated the presence of vanadium in the iron ore, cast iron, wrought iron, as well as in the slags obtained at the second stages of the metallurgical operation. When the important facts relating to the high physical properties imparted to all the varieties of iron by alloying them with vanadium became known, the discovery did not impress iron-makers, or induce them to utilize vanadium. It is remarkable that industrially, and in relation to its metallurgical uses, this discovery should not have been productive of immediate results. More recently it became known that vanadium, as well as titanium, were frequently found in a number of iron ores, mainly in magnetites and in bog iron. During the reduction process these two metals passed into iron products, forming multiple alloys. At first a difficulty occurred in the direct treatment of vanadiferous iron ores, owing to the peculiar properties of vanadium, the greater portion passing into the slag, forming silicated compounds, whilst another portion was separated as carbon-nitrogen compounds, which also mixed with the slags or found their way to other parts of the reduction apparatus. These difficulties have been overcome, and both cast-iron and steel alloys with vanadium are produced in a direct way from the treatment of iron ores, in which that element is present, almost the whole of the vanadium occurring in the ore being recovered. The Norwegian magnetites and iron ores with fairly high vanadium contents are almost inexhaustible.

In the preparation of vanadium steel, the addition of only ¼ per cent. of vanadium gives a high tensile strength and range of elasticity. Whereas the tensile strength of ordinary steel may be taken at 27 tons per inch, that of steel containing only 0.25 per cent. of vanadium is nearly 35 tons. The limit of elasticity is also increased by this small admixture, from 16 to 28.5 tons per sq. in. The addition of vanadium also rids the steel of traces of oxygen, and promotes a homogeneous distribution of the carbon contents. By the addition of chromium as well as vanadium, still better results are obtained. The malleability of vanadium steel can be considerably increased by annealing. A steel containing 12 per cent. of nickel and 0.5 per cent. of vanadium is stated to have a much higher breaking stress and limit of elasticity than good chromium steel. The addition of vanadium to aluminium bronze and brass also appears to promise well; other alloys have been experimented on. The main difficulties are the limited supply and high price.

In the United States, where vanadium is both produced and imported, the consumption during 1911 was about 300,000 lb. As it was then estimated that 5 lb. of metallic vanadium were required to treat a ton of steel, it followed that 60,000 tons of finished vanadium steel was the output for that year. It has been steadily increasing. The output of vanadium during 1912 in the United States was just under 300 tons. (There are no details at hand for comparison of the output of vanadium steel in Great Britain.) During that year the United States industries produced about 100,000 tons of vanadium steel, containing 7 lb. of metal vanadium per ton of steel, which is equivalent to 350 tons of metallic vanadium, obtained by treating 4,000 tons, or more, of vanadium ores, with an average of 10 per cent. of vanadium metal. The main part of these ores came from Peru, and the remainder from Colorado and Utah. If the method of extracting the oxide and preparing the alloys were less wasteful and more economical, the price of vanadium metal could be lowered and the output of vanadium steel could be increased tenfold. The actual high cost of making ferrovanadium alloys limits their employment to the manufacture of high-speed steel for many special uses. Through the employment of improved methods of dealing with low-grade ores of a better roasting, lixiviating, and precipitation of the solutions, and of careful fluxing and reducing of the mixed oxides, a high rate of extraction ought to be secured and a large portion of the loss by volatilization avoided. By an adequate adjustment of these operations vanadium products should be made at a cost approximating to that of copper, but certainly not higher than that of nickel.

Where vanadium is to be utilized in the manufacture of vanadium steel, an alloy of iron and vanadium, containing from 25 to 52 per cent. of the latter is the product which is usually placed on the market. One method of treating the vanadate ores is to fuse them with bisulphate of soda. A quantity of the latter equal to twice the weight of the ore to be treated is melted in a closed crucible, and the pulverized ore is added. The melt cools to a citron-yellow mass, which absorbs water, and becomes greenish in color. It is broken up into fragments less than an inch in diameter, and dissolved in hot water. By means of sulphuretted hydrogen and ammonia other metals are precipitated, and a red solution of sulphovanadate of sodium is obtained, which slowly precipitates sulphite of vanadium. Space will obviously not permit an exhaustive list of the uses to which vanadium can be put in connection with vanadium steel, but enough has been stated to indicate its value and importance. Some useful applications of vanadium steel may be added.

In two new types of compressors problems as to the proper valve material have recently been solved by the adoption of heat-treated vanadium steel for these parts. One of the types in question is a compressor designed for the extraction of gasoline from natural gas. Owing to the high temperatures resulting from the compression of gas, but also to the presence of gasoline in the gas entering the cylinder, the proper lubrication of the cylinders and valves of this type of compressor presented a number of difficulties. Formerly the valves were made of steel, with bronze seats and guides; but these valves soon failed, because the material was not adapted to meet the requirements. Better results have been obtained from valves with seat and guides made of heat-treated vanadium steel, cut from the solid bar. Such valves have now been in service for fifteen months in continuous operation at 200 revolutions per minute, compressing gas to 250 lb. per sq. in. As a result of endurance tests carried out in the United States on plate-valves for air-compressors, heat-treated vanadium steel has been adopted for the suction and the discharge valves of high-speed air-compressors. Such valves are of the plate-valve type cut from a steel sheet, and consist of two concentric rings with a device for centering the valves on the seats. The selection of suitable steel for such valves is considered of the greatest importance; to test the efficiency of vanadium-steel valves under the most unfavorable conditions, valves of this material have been installed in a small experimental machine running at 500 revolutions per minute. The lift to the valves was increased to ⅛ in., which is double that ordinarily used. The severe conditions under which these valves were tested are never met with in modern practice. This compressor, after registering 6,000,000 revolutions, had the valve still intact. Owing to its strength, toughness, high wearing qualities, and the fact that it withstands much