century—beginning a new epoch in warfare—added sulphur, saltpetre, and lead to the short list of essential war minerals. A couple of centuries later the newly developed charcoal-burning blast-furnace for the production of cast-iron was pressed into service to satisfy the rapidly increasing demand for larger and cheaper supplies of gun-making metals. Another two centuries were to elapse before coke was successfully substituted for charcoal in such blast-furnaces, adding coal to the muster roll of war minerals and lifting the restrictions on quantity production of cast-iron imposed by depleted forests.

The influence upon war armaments of the new industrial era that followed the invention of the steam-engine was little apparent until the middle of the nineteenth century, except in facilitating the production of the still relatively small requirements. Then, beginning with the substitution of iron for wood and of steam power for sail in warships, with the introduction of longer ranged rifled guns, and with the discovery of large-scale processes of making steel, virtually all the numerous new developments in mineral employment have been applied to military needs.

Just as transportation, communications, manufacturing, and other phases of civilian life have been completely revolutionized by these new developments and by the recent rapid progress in invention and in methods of mass production, so has the character of warfare been completely changed. As contrasted with warfare up to the beginning of the present century, modern warfare—as illustrated by the War of 1914-18 and, to a still greater degree, by the present War—demands the mobilization of the entire resources—economic (including mineral and industrial) as well as military—of the nations engaged.

A Review of Present War Minerals.—The War of 1914-18 established a record up to that time for its diversity of munitions and supplies, and for the tremendous requirements of such materials.

From the close interrelation that now exists between a nation's war operations and its industrial development, it is evident that practically all the many minerals used in the industrial arts are of war importance, directly or indirectly, and that no definite line can be drawn between minerals that are essential for war and those that are not. There are, however, several minerals, without ample supplies of which a nation, even though strong in man-power, cannot hope to defend itself successfully. These minerals are usually classed as *essential* war minerals, although they are in reality *indispensable* war minerals; they are not, however, limited to those from which armaments and munitions are actually made. Tungsten, for example, is used only in relatively small quantities, chiefly in making the high-speed tool steels necessary for high efficiency mass-production machining operations in munition factories, and is therefore listed as an essential war metal.

Iron still holds its long established position as the chief war metal, but it is no more essential than the manganese required in steel, and the nickel, chromium, cobalt, and molybdenum that, used in small proportions, give strength, toughness, hardness, resistance to shock, endurance, or other properties to the many steels used in war machines. Copper and zinc are essential for the making of brass cartridge-cases and other munitions: large quantities of zinc are used in galvanizing and in paints, and copper is widely used for electrical and communication equipment as well as for shell-bands. Lead and antimony are essential for the making of bullets for small arms and shrapnel, and lead for the storage batteries so widely used in war as in peace. Aluminium has become an essential metal, particularly for the building of aircraft, and magnesium is attaining importance for the same purpose. Platinum is valuable for electrical contact points and as a catalyser in