on methods of manufacture so that the newest developments will be available for the program.

A further example of the cooperation between the Division of Medical Sciences and the American Red Cross is seen in the recent arrangements regarding requests from England. The British Ministry of Health has decided that all requests for medical and nursing personnel, hospitals and hospital equipment, medical and surgical equipment and supplies must come through the British Red Cross to the American Red Cross. Similarly, all American offers must be so routed. The Red Cross has asked the Division of Medical Sciences to assist in passing on personnel. Henceforth all requests from physicians, nurses and related personnel will be cleared and approved jointly by the two bodies.

Many of the questions brought before the committees demand immediate research before an answer can be given. Many important projects have been submitted or formulated, and on a few, active investigation has commenced under private auspices. Fortunately a few more can begin now owing to the allocation of a small appropriation of Federal funds. These include basic studies on the cause and treatment of shock, on the preparation and evaluation of blood substitutes for transfusion, on the chemotherapy of infections, on the cause and relief of fatigue, on the determination of night blindness and dark adaptation and on certain aspects of aviation physiology. Some of these last projects are being carried on in cooperation with the National Defense Research Committee.

However, there is a crying need for extension of all the above projects and for the immediate prosecution of a great many more investigations already approved. These include an extensive study of the chemotherapy of wounds and burns, a search for new drugs for the treatment of malaria and other tropical diseases, studies on wound healing, on the medical aspects of chemical warfare and additional research into the physiology of high altitude flying, leading to the greater effectiveness and well-being of our aviators. As time goes on and new questions arise, new projects will be initiated.

At the present time, some of the committees have completed the tasks set before them, while other committees have not yet been called on to any extent. But all are prepared for future demands and can be called whenever necessary. The structure as given here is not final and other committees will be organized when the need or request comes.

STRATEGIC MINERALS IN WAR AND PEACE[1]

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IT has become the custom to speak of minerals as strategic when they are necessary for war and when they must be secured in whole or in part from abroad. Despite the general abundance of mineral supplies in the United States, it is necessary to import substantial quantities of manganese, chromium, tungsten, tin, mica, nickel, antimony, quartz crystals, industrial diamonds and some varieties of graphite and asbestos. Some of my listeners may wonder why such things are essential to war effort.

The answer is, in brief, that modern war is a mechanized war, and all these materials are needed in the process of mechanization, and on a larger scale than ever before. Raw materials are required in intricate combinations. Alloys are playing an ever larger role. The absence of a single constituent, even though used in small quantity, may have far-reaching and disastrous effects on industrial operation. While only a few pounds of manganese go into a ton of steel, there are no satisfactory substitutes, and it is impossible to make this ton of steel by established metallurgical practice without the manganese. Every one knows that the machinery of modern war requires steel in huge quantities.

The list of strategic minerals is not a fixed one because, as the scale of preparation for war expands, shortages appear in other minerals. Already shortages are beginning to appear in certain minerals not on our strategic list, and, judging by the experience of the last war, still others will come.

The strategic mineral problem now occupying so much of the attention of the government agencies engaged in preparing our national defense is that of acquiring necessary reserves to carry the country through an emergency in case supplies are cut off from outside sources, while at the same time keeping industry supplied for its current needs.

First, it is necessary to estimate the amounts needed. This is a difficult problem because of the continuous expansion and shifting of war plans. Allowance must be made for increased amounts of these minerals which

[1] Radio address from Station WMAL, Washington. The address was brought to the fifty-third annual meeting of the Geological Society of America meeting in Austin, Texas, December 27, 1940.

may be available in an emergency from domestic sources. There are many domestic deposits of low-grade ores not usable in ordinary times. A survey must be made of all such deposits and of the many new technologic processes of treatment of low-grade ores that are now coming forward. There also are new technologic processes of consumption and substitutions which tend to reduce the amounts of high-grade supplies required. Estimates must be made of how much may be saved by restricting civilian uses. Allowances must be made for savings due to restriction of exports, as well as possible additional needs of those nations fighting against aggression—needs which must be supplied.

Finally, a figure is arrived at which represents the irreducible minimum of raw materials which must be stocked up for emergency after giving full weight to all domestic supplies and possible savings.

The size of the necessary stockpile having been estimated, the actual purchase may be started. This, also, is by no means a simple process. At the present time trade routes are so restricted and shipping is so scarce that it is difficult to keep up necessary supplies for industry, for current consumption, to say nothing of securing additional quantities for stockpile reserve. Almost every foreign purchase involves negotiations with governments, with private owners, with shipping companies and with the Maritime Commission, and includes consideration of exchange questions and many other factors. An important element is time. Rates of production and shipping capacity are such that deliveries of some minerals must be spread over several years.

I wish there were time to tell you some of the many interesting stories about particular cargoes of graphite from Madagascar, chromite from Turkey, tungsten and antimony from China by way of Indo-China and the Burma Road, or about the purchase of low-grade tin concentrates in Bolivia to be treated in a new smelter to be built in the United States. Scarcely a day passes without a stirring episode of mineral procurement in some part of the world in the race with the closing of trade routes.

While foreign buying necessarily is in the limelight because of rapid closing of commercial channels, domestic sources are not being overlooked. Much attention is being given to the development of low-grade supplies at home. Purchases are being made under contracts which will permit the installation of new plants and processes. Under special appropriations, the Bureau of Mines is conducting experiments in recovery of low-grade strategic ores, in accordance with a program outlined by a technological committee of the National Academy of Sciences appointed by the Defense Commission. The Geological Survey and the Bureau of Mines are making extensive field examinations to find the more promising sources. Specifications for qualities of product have in some cases been lowered to make certain supplies available.

Substantial production from domestic sources can hardly be expected for another year. Many of the domestic operations will be so high in cost that they will not outlast emergency conditions. However, there is good reason to hope that the correlated effort now being made to establish new processes may result in some operations of a permanent nature, which will lessen our future dependence on foreign sources.

Progress in acquiring stockpiles both from foreign and domestic sources is necessarily slow. Funds were made available too late. Trade channels were restricted before we started. But steady progress is being made. Fortunately, industrial inventories of several of the needed minerals are now large enough to tide us over present delays, and there is good reason to hope that, if the emergency eventually cuts this country off from outside supplies, enough reserve will have been accumulated from domestic and foreign sources to enable us to carry on. In the meantime, special and local shortages will be met by the application of priorities.

So much for the problem of acquiring strategic minerals for our own emergency use. The strategic mineral problem, however, is much broader than this. Every other nation needs strategic minerals, although not the same list as ours. Certain nations have waged the unspectacular war of trade—the war of minerals—just as intensively as they have waged the war of bullets and tanks and planes. They have paid the closest attention to the other fellow's channels of supply. They have denied to their potential enemies certain minerals and mineral products they produce in excess. They have purchased large supplies of materials they do not need, to keep them from their enemies. They have bought to help friends. These are the tactics which must be studied closely in preparing for military conflict or in building up defenses to ward it off.

When military warfare begins, economic warfare of the type I have just described gives way to total embargo and blockade, and this also must be planned for, if a nation is to be completely prepared.

What is done about strategic minerals, both in defense and offense, will be a considerable factor in determining the outcome of a war so largely mechanized as this one. It is a question of how much metal can be brought to bear at the earliest date. Wars can not be won by *potential* resources; resources must be used and used to the hilt. Germany has brought into action every ounce of available raw material, while its opponents, with overwhelmingly greater potential supplies, have yet to reach the peak of their use. Ger-

many has also greatly improved her raw material position by occupation of Western Europe, but still lacks important minerals. Potentially the balance of raw material power is still with the English and even more so with the English-speaking people, including ourselves.

The key to the problem in its larger aspects is control of the sea. No nation, not even our own, richly supplied as we are, could long fight a mechanized war without access to foreign sources of mineral supplies. Whoever holds control of the sea dominates the strategic mineral situation. The huge scale of the movement of strategic minerals required by modern industry gives an unprecedented significance to the part played by control of the sea in waging modern war.

Even yet I have not mentioned all the problems of strategic minerals. Minerals are strategic not only for waging war, but for preventing war. In peace there is the problem of equality of access to raw materials necessary for modern industry and industrial prosperity.

The industrial machine in our country calls for the same kind of raw materials as that of any other country. Every single commercial mineral is strategic from the standpoint of some of the nations. If we accept the principle that industrial welfare and peace of the world require the welfare of each of its parts, it seems clear that the time is fast approaching when laissez-faire in the distribution of the necessary raw materials must give way to more orderly administration of the world's resources in the interest of world needs as well as national needs alone. The trend in this direction has already gone further than most people realize. An increasingly large part of the movement of minerals between nations is by some form of international agreement. This does not mean the sacrifice of national interest for an international ideal, but rather a recognition of the fact that resources must be administered as a trust in the interest of world peace, which, after all, means only enlightened self-interest.

The English-speaking peoples have long had commercial control of nearly three fourths of the world's minerals and, through their domination of sea-lanes, have exercised an even wider control. The United States, already the largest single owner and user of world minerals, is now expanding its mineral realm by extensive foreign loans secured by minerals. Germany, Italy and Japan have stated specifically that redistribution of raw materials is one of their major objectives. If the English-speaking peoples retain their control of the sea, they will retain control of the raw materials necessary to win the war. But after the war, what then? The whole problem of inequality of distribution of raw materials among the nations will remain. Certain adjustments and concessions can and should be made, but it can scarcely be hoped that these steps will go as far as really to equalize access to raw materials among the nations as long as the suspicion remains that dominance and not equality is really what is wanted by the "have not" nations. In fact, nothing short of dominance of most of the world's minerals will insure any nation of needed supplies.

There remains, then, the great opportunity for the "have" nations to organize control of the world's raw materials more efficiently and to use this power affirmatively to keep the peace. The power inherent in the possession of minerals coupled with control of the sea is the power necessary to control and limit armaments. Like the policeman's stick, it need not be used often, but the mere fact of its existence and the knowledge that it will be used, if necessary, may serve as a deterrent to recalcitrant nations. A firm control of raw materials, which are the ultimate source of the power to wage modern war, may not stop war—any one can start a war—but it seems to be the only power in sight really capable of limiting the incidence and spread of war.

I have reviewed strategic minerals from the standpoint, first, of our national supplies; second, of the supplies of potential enemies; and third, of the prevention of war. These are not separate problems. The more we study them, the more it dawns on us that they are merely phases of one great problem, and that is the intelligent adjustment of human activity to a newly emerging element of our physical environment. It is new in the sense of scale. As populations outstrip national agricultural resources, industrialization furnishes the only means of maintaining or improving standards of living. Industrialization requires minerals in ever greater volume. In no country are all the necessary minerals indigenous. As world industry grows, as grow it will, the problem of raw material supply, already serious, will become ever more acute, and success in securing supplies will determine the future ranking of nations in industrial and military power.

Whether we purchase a stockpile or develop new supplies at home or exploit new supplies abroad or make loans to China or Brazil based on mineral supplies, we are changing the future world pattern of control and distribution of raw materials in a way which may have profound effects on international relations. Until we have evolved a clearer concept of the role of strategic minerals in relation to both war and peace, we can not be sure of the effects of our present steps from the long-range point of view. The immediate problem of securing emergency supplies is pretty well in hand, but the strategic mineral problem in its larger aspects is far from solved.