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METALS IN NATIONAL DEFENSE[1]

By Dr. ZAY JEFFRIES
GENERAL ELECTRIC COMPANY

When near the middle of 1940, the Advisory Commission to the Council of National Defense was established, it was only natural that great stress was put on the importance of metals and minerals and equally natural that Dr. C. K. Leith should find himself in the center of this activity. Dr. Leith has made a profound study of the relationships between minerals and war. He has served the government, directly and indirectly, for more than a quarter of a century and, for the past twenty years, he has advocated the stock-piling of such minerals as are not obtainable or of which there is a deficiency in the Western Hemisphere. He has eloquently pointed out that the nations controlling the great mineral deposits of the world should lead in both industrial and war strength; that no continent is self-sufficient in all the minerals necessary for either a complete industrial development or the most efficient prosecution of war; that the mineral distribution is such that no continent can obtain all the necessary minerals without sea transportation, and hence that the value of sea control can hardly be overestimated.

Dr. Leith early called on the National Academy of Sciences for technologic help on manganese and tin. By February, 1941, the problems were multiplying to such an extent that he asked the academy to arrange for a comprehensive organization to provide the Office of Production Management, successor to the Advisory Commission, with advice on metals and minerals.

Dr. Frank B. Jewett, the president of the academy,

[1] Read at the meeting of the National Academy of Sciences, Madison, Wisconsin, October 14, 1941.

created such an organization known as the Advisory Committee on Metals and Minerals of the National Academy of Sciences and the National Research Council. Mr. Clyde Williams, head of Battelle Memorial Institute, Columbus, Ohio, is chairman—and a most able one. The committee has been subdivided into four main groups, as follows:

Ferrous Minerals and Ferro-Alloys Group
Chairman, Gilbert E. Seil, 11 members
Non-Metallic Minerals Group
Chairman, R. P. Heuer, 12 members
Tin Smelting and Reclamation Group
Chairman, F. W. Willard, 6 members
Metals Conservation and Substitution Group
Chairman, Zay Jeffries, 27 members

Problems on which advice is sought originate in OPM and clear through Dr. Leith to Mr. Williams, who makes the specific assignments to the proper group. Studies are made and reports are prepared which are submitted to OPM through Dr. Jewett. In the preparation of reports, help is sought from the most authoritative sources, including individuals, universities, companies, government agencies and bureaus and independent laboratories. It is a pleasure to report that all these groups have cooperated splendidly. They not only have given of their time and energy but have literally opened the archives of their confidential information. I hope that after this terrible international storm has passed there will be given adequate recognition of such service.

Even in a brief statement of this work it should be pointed out how effective is the administration of the committee work by Dr. Jewett. His broad experience in administering technical matters, together with his jealous guardianship of the prerogatives, functions and reputation of the academy, combine to make him the ideal leader of this undertaking.

Some of the committee reports are confidential, some are confidential in part, and others are available for release to interested parties. In the short time allowed for this presentation, only a few high spots can be covered. Being more familiar with the group of which I am chairman, I shall confine my remaining remarks to the work of the Metals Group. Any opinions offered are personal.

Before the complete organization of the Metals Group on March 15, 1941, we had responded to an urgent request from Dr. Leith for a report on the nickel situation. A shortage was not only impending, it was at hand. To date, twenty-three other formal reports have been submitted. Still other reports are being prepared, and no end of problems seems in sight while the emergency lasts.

To gain some idea of the scope of the studies, it may suffice to name the metals on which formal reports have been or are being made. These include nickel, aluminum, magnesium, zinc, chromium, manganese, vanadium, tungsten, molybdenum, copper, tin, antimony, cadmium, lead, cobalt, mercury, iridium, ruthenium, low-alloy structural steels, die castings and steel and cast-iron rolls. Other reports cover specific processes relating to one or more of these metals.

The OPM has specialists on each of the major metals, and our committee cooperates closely with them. The metal pictures change so rapidly that it is necessary to contact these specialists at intervals to avoid working on obsolete phases of the metal problems. By working on the right problems our group helps OPM to a better understanding of the metal requirements for both defense and non-defense and, it is hoped, toward a wiser administration of the metal allocations.

The steps taken last March to ease the nickel shortage, by substitutions, put an added burden on other metals such as chromium, copper, vanadium, etc. A threatened aluminum shortage put a heavier load on copper and zinc, among other metals, and a zinc shortage still further strained the copper supply. A shortage in one metal tends to eat into the stocks of other metals.

Because the steel production is ten times that of all other metals combined, it has taken much of the substitution load and, in the end, it must provide the lion's share of any substantial increase in metal consumption. Now, steel is scarce. A few months ago it seemed as if lead would be plentiful. Unavailability of such metals as copper, zinc and aluminum in sufficient quantities to meet the large non-defense demands has finally resulted in an acute lead shortage.

Thus the story of the past six months has been one of a succession of metal shortages encompassing all the major metals. Of the important defense metals, the supply of molybdenum alone seems to be ample. If the emergency lasts a year or two longer we may look for a shortage of molybdenum.

To make the situation worse, there is the criticism that our stock-piles of essential metals are too low This is true, but the critics are displaying hindsight wisdom and not foresight wisdom such as is found in Dr. Leith's recommendations over the past twenty years. Large stock-piles of strategic metals can not be built up during a world war. The substantial accumulations must be made in peace-time, and authorizations were not adequate until it was too late.

Are things actually as bad as this recitation sounds? Are the shortages real? Is there a ray of light ahead? Surely we do not want to be complacent in the midst of a program calling for every constructive effort; but neither should we become hysterical and lose our sense of proportion. In pointing out some of the brighter facets I shall try to steer the middle course between complacency and hysteria.

First, the shortages are not caused by a lower supply, but by a greatly increased demand. The supplies of the various metals are the greatest in history. Some of the minor metals are available in amounts exceeding twice the normal consumption. Even the steel production is 25 per cent. above that for a reasonably good peace-time year. For the past twelve months the people of the United States have been on a buying spree. Fear of shortage and fear of higher prices both induce buying for future use. The extent of purchases beyond immediate needs is unknown, but, judging from spot checks, this must have been an important factor in the large demand.

When it is realized, however, that this tremendous non-defense use of metals has been concurrent with a major program of building and equipping defense plants, the wonder is not that shortages appeared but that it was possible to provide metals for both activities. As the defense plants are brought into production they will naturally require a larger percentage of the metals, but they will also need a larger percentage of the labor, transportation, electrical energy and many services, thus tending to lessen dislocation resulting from the curtailment of the use of metals in non-defense industries.

Another favorable factor is the quality of the available alloys. The supply of steel-alloying elements, such as nickel, chromium, molybdenum, vanadium and even manganese, is so much greater than normal that a larger percentage of alloy steel is being made than ever before. The enhanced quality of the alloy steels not only makes possible more war material from a given tonnage, but it will make our munitions, all along the line, superior to those of the Axis Powers. So, to the greatest metal quantity of all time we can add the highest average quality of all time.

Now, a few words about the stock-piles. Notwithstanding the late start and the war conditions, stocks of some of the most strategic metals have been accumulated. While these stocks are not nearly as large as desired, they are large enough to cushion any sudden blow, and they have been built under most trying circumstances. Then there is additional comfort on the stock-pile matter. Because we have been for years the greatest industrial nation and have consumed more metal than any other country, we have the greatest of all stores—the metals in use. Except for normal scrap recovery, we have never really drawn from this vast store of metal because we have never had the need to do so. This reservoir can be tapped to almost any extent required by the emergency. For example, if aluminum is desperately needed, 100,000,000 pounds can be drawn off in a few weeks.

Again, we have watched the succession of shortages, but have we learned anything from the experience? Yes, we have learned much. We have found that in many places non-metals, such as plastics, glass, fabric, wood, etc., can be substituted, at least temporarily, for metals. We have seen that, although there are places in which the use of a particular metal is well-nigh indispensable, there are sufficient uses of nearly all the metals in which a wide variety of substitutions of other metals can be made so that all the available metal can be consumed. It is concluded from this that increases in the supply of any metal help the whole situation. The increases can be made where expansion is easiest, cheapest or soonest. This gives assurance that steel expansion will solve many of the shortages in non-ferrous metals, at least during the emergency. This is, indeed, an important conclusion.

Another important factor is over-expectation on the part of the inexperienced. The American people are in the habit of expecting miracles in production. Vast numbers of automobiles, electrical appliances and the like come streaming from the factories without seeming effort or delay. Who thinks about the long periods of research, of trial-and-error, of machine development, of process perfection, of training skilled workers and the many other steps which necessarily preceded the production flow? In the transformation from a peace-time to a defense economy, time-consuming groundwork must also be laid. Part of it has been done, but there is still much of it left to do. Progress eventually must be rated on what comes off the production line, but at the moment it must be judged by the soundness of the preparations. They are sounder than many people think.

Let us elaborate somewhat on this. Special emphasis has been given in the press to the so-called aluminum shortage. During the five years ending with 1939, the average new aluminum consumption in the United States was 256,000,000 pounds annually. Current production is at an annual rate of around 700,000,000 pounds. Obviously, there is no shortage from the standpoint of normal demand. But aluminum is the key to aircraft production, and aircraft production must be still further increased. Therefore, a further expansion in aluminum output will be necessary. Now, one can make some new aluminum, by the thimbleful, in the laboratory in a day's time. But we need it in magnitudes of additional hundreds of millions of pounds. Mining operations must be expanded, new electrical machinery built, great new chemical plants must be erected and equipped, new transportation facilities must be provided, etc., all of which will require time. After all these things are done, production miracles will be performed. And so it is with much of the defense production. The public should understand these things and, understanding, they will have greater confidence in what is being done.

Certain other factors having a bearing on the metal problem should be mentioned:

1. Industry requires more metal during a period of expanding production than after the expansion is completed. The plant stocks must be increased both ahead of and in the production line. Industry has been expanding during the past year or more, and part of the apparent metal shortage has been used to fill these plant "pipe lines."
2. Plant inventories, in raw material, material in process and finished product, are not known. The fear complex should stimulate late rather large inventories, and spot checks tend to confirm this view. In general, capacities and inventories are apt to be underestimated and requirements overestimated.
3. Much equipment, labor and material, such as in the machine-tool industry, are now being extensively used to prepare defense plants for production. When the defense plants are tooled up, these facilities will be liberated, in part, for direct defense production.
4. Plans are under way all along the line to expand the production of the primary metals. The magnitudes range from millions of tons of pig iron and steel, down.

In an effort to appraise all these factors, good and bad, I venture the following opinions:

a. There will be ample metal for the greatest defense production of all time.
b. In addition, there will be ample metal to keep up all the essential services, including food, heat, light, transportation, communication, water and gas.
c. There will be a considerable amount of metal for civilian uses ordinarily regarded as non-essential for defense.
d. The kind of metal available for many civilian uses will in many cases represent impairment, but the impaired products will serve well during the emergency.
e. Many of the substitutions will probably have a long-range effect on many products and processes, and, perhaps, even on habits.

In conclusion, it may be interesting to record impressions gained from many personal contacts during the past six months and covering most phases of the metal industry. In general, the people having the least confidence in our ability to produce are those farthest from the production lines. They are the ones with little information about what is actually going on and little comprehension of what it takes to really produce. On the other hand, the men in the storm-center of production—executives, engineers, scientists, foremen and skilled workmen—have unbounded faith that our defense production will greatly surpass anything the world has ever seen. Assuming that the latter group is the better qualified to pass judgment we are, even now, in great need of unity of purpose and action lest this vast production comes too late.

THE METHOD OF CO-TWIN CONTROL

By Dr. ARNOLD GESELL

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GROWTH is an irreversible process. In investigating the growth process one might like to train a child, and then compare him with what he would have been if he had not received the training. This can not be done; there is no way to make the desired comparison. But we may study a pair of identical twins with just such comparisons in mind. We may train one twin (T) experimentally, and reserve the co-twin (C) as a control. C becomes a scientific kind of stand-in-double for T.

In 1927 the writer, in collaboration with Dr. Helen Thompson, undertook a comparative study in which two highly identical twin girls, T and C, were observed from early infancy to determine, first, their developmental correspondence and, secondly, their developmental divergence, as affected by training confined to one twin. A thoroughgoing similarity in physical and behavioral characteristics was amply established by repeated examinations and measurements.[1, 2]

The method of co-twin control had its origin in a stair-climbing and cube-behavior experiment begun when twins T and C were 46 weeks old. Twin T was trained daily in climbing a 5-tread staircase. At 52 weeks she climbed the staircase in 26 seconds. Twin C, at the age of 53 weeks, without any previous training or experience, climbed the same staircase unaided in 45 seconds. As a comparative check, Twin C was then trained for a period of 2 weeks. At the age of 55 weeks she climbed the stairs in 10 seconds. The climbing performance of Twin C at 55 weeks was far superior to that of Twin T at 52 weeks, even though Twin T had been trained 7 weeks earlier and three times longer. At 56 weeks and again at 3 years their performance on the experimental staircase was amazingly alike. These clear-cut quantitative results, sup-

[1] Arnold Gesell, "The Developmental Psychology of Twins." From A Handbook of Child Psychology. Worcester, Mass.: Clark Univ. Press, 1931. Ed. Carl Murchison, pp. 158–203.

[2] Arnold Gesell and Helen Thompson, *Genet. Psychol. Monog.*, 6: 1–124, 1929.