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**THIRD PROGRESS REPORT**

From the

**CHAIRMAN, METALLURGICAL ADVISORY BOARD** (3rd)

December 1, 1951

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This Report Prepared and Submitted to the  
Chairman of the Research and Development  
Board, under Contract DA-49-025-sc-83,  
Between the Department of Defense and the  
National Academy of Sciences.

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Division of Engineering and Industrial Research  
National Academy of Sciences  
National Research Council  
Washington, D. C.  
December 1, 1951

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NATIONAL ACADEMY OF SCIENCES

NATIONAL RESEARCH COUNCIL

METALLURGICAL ADVISORY BOARD

OF THE  
DIVISION OF ENGINEERING AND INDUSTRIAL RESEARCH  
2101 CONSTITUTION AVENUE, WASHINGTON 25, D. C.

December 1, 1951

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Professor C. R. Soderberg, Chairman  
Division of Engineering and Industrial Research  
National Research Council  
2101 Constitution Avenue  
Washington 25, D. C.

Dear Professor Soderberg:

I am submitting herewith the Third Progress Report of the Metallurgical Advisory Board. This report summarizes all information to date on activities of the Metallurgical Advisory Board, including those of the last three months. Therefore, it supersedes the previous progress report.

It is recommended, on behalf of the Metallurgical Advisory Board, that this report be submitted through the National Academy of Sciences - National Research Council to the Chairman of the Research and Development Board.

Very truly yours,

*Robert F. Mehl*

Robert F. Mehl, Chairman  
Metallurgical Advisory Board

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Preface

The Metallurgical Advisory Board, through the National Research Council, is distributing this Progress Report to those agencies and individuals who have contributed to, or who will be concerned with the subject matter. This report is a report under Contract DA-49-025-sc-83 between the Department of Defense and the National Research Council, which was negotiated at the request of the Research and Development Board.

The distribution of this report is as follows:

- Copies 1 and 2 - Mr. Walter G. Whitman, Research and Development Board, Chairman
- Copy No. 3 - Dr. D. W. Bronk, President, National Academy of Sciences
- Copy No. 4 - Professor C. R. Soderberg, Chairman, Division of Eng. and Industrial Research
- Copies 5 through 44 - Research and Development Board

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- Copy No. 76 - Mr. M. C. Fick, Research and Development Board
- Copy No. 77 - Mr. Earnshaw Cook, Research and Development Board

Consultants and Panel Chairmen (not listed elsewhere)

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- Copy No. 79 - Dr. C. K. Leith, Consultant, MAB
- Copy No. 80 - Mr. W. E. Mahin, Consultant, MAB
- Copy No. 81 - Mr. W. H. Meikeljohn, Consultant, MAB
- Copy No. 82 - Mr. W. Stuart Lyman, Consultant, MAB
- Copy No. 83 - Mr. W. E. Ruder, Consultant, MAB
- Copy No. 84 - Mr. H. J. French, Chairman, Panel on Nickel Conservation
- Copy No. 85 - Dr. R. M. Bozorth, Chairman, Permanent Magnet Materials Panel
- Copy No. 86 - Mr. G. C. Riegel, Chairman, Advisory Committee on Naval Gun Mounts
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The Metallurgical Advisory Board, operating under a contract between the Department of Defense and the National Academy of Sciences, has received formal assignments from the Chairman, Research and Development Board, to conduct studies and to prepare technical reports on the following subjects:

Cobalt,	High Temperature Materials;
Columbium,	Naval Armor,
Manganese;	Naval Guns;
Molybdenum;	Naval Vehicles;
Nickel,	Electro-Processes for Machining
Tantalum,	and Grinding,
Titanium-Zirconium;	Permanent Magnet Materials;
Tungsten,	Germanium,
Substitution of Alloying	Beryllium; and
Elements in Engineering Steels,	Powder Metallurgy.
Free Machining Steels,	

The purpose of these reports is to advise the Research and Development Board with respect to the technical problems involved in the production, use and conservation of metals and alloys and when desirable, to suggest the type of research programs and projects which appear necessary to the defense effort.

Formal interim reports dealing with columbium, tungsten, titanium, boron steels, availability of boron additives, (substitution of alloying elements in engineering steels) and high temperature materials have been distributed. Additional reports on cobalt, tantalum, nickel supplies, manganese supplies, free machining steels, and naval components will be ready for distribution before the end of the year.

Excellent working arrangements have been developed with the many civilian and military agencies concerned with metals. With the cooperation of these agencies, studies have been made to determine realistic balances between supplies and requirements for metals not only under current conditions but also under full mobilization. These base line estimates are essential to sound recommendations for future research and development programs.

SUMMARY (Continued)

Early in its program, the Metallurgical Advisory Board recognized the necessity for including consideration of non-metallic minerals and marginal ores in its studies. After much discussion with the several agencies immediately concerned, a contract between the Bureau of Mines and the National Academy of Sciences has been executed which will make it possible for the Metallurgical Advisory Board to extend its work into the broad field of minerals as well as metals. An expansion of the Board and of the technical staff will be required for this. It is anticipated that the reorganization of the Metallurgical Advisory Board will be completed during the fourth quarter of this year.

Section I

1.1 The Metallurgical Advisory Board, which was formally organized on February 7, 1951, is providing advisory services on twenty-one service projects. The general scope of the field of activity is indicated in the following statement in the contract between the Department of Defense and the National Academy of Sciences.

"The Contractor shall, at the written request of the Chairman of the Research and Development Board, Department of Defense, conduct studies, surveys, make critical analyses, and prepare and furnish to the Chairman advisory and technical reports, with respect to the entire field of metallurgical research, including the planning phases thereof; and shall, in addition, perform such other services as may be agreed upon in writing, from time to time, by the Chairman of the Research and Development Board and the President of the Contractor."

1.2 This progress report summarizes the status of each existing project and the personnel associated with the Metallurgical Advisory Board, staff, panels and committees. A list of the members of the Metallurgical Advisory Board and personnel of the technical staff is attached herewith. Personnel associated with panels and committees are shown in Appendix I.

NATIONAL ACADEMY OF SCIENCES  
NATIONAL RESEARCH COUNCIL

Metallurgical Advisory Board  
of the  
Division of Engineering and Industrial Research

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Director, Metals Research Laboratory  
Carnegie Institute of Technology

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Assistant Vice President and Manager  
Armco Steel Corporation

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Institute for Study of Metals  
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Assistant Vice President  
United States Steel Corporation

Earl C. Smith  
Chief Metallurgist  
Republic Steel Corporation

A. L. Boegehold  
Head, Metallurgy Section  
General Motors Research Laboratories

Kent R. VanHorn  
Associate Director of Research  
Aluminum Company of America

John Chipman, Head  
Department of Metallurgy  
Massachusetts Institute of Technology

Clyde Williams, Director  
Battelle Memorial Institute

Charles H. Herty, Jr.  
Assistant to Vice President  
Bethlehem Steel Company

Ex Officio Members

C. Richard Soderberg, Chairman  
Division of Engineering and Industrial  
Research, National Research Council

Alvin J. Herzig, President  
Climax Molybdenum Research  
Laboratories

Oliver C. Ralston, Chief Metallurgist  
U. S. Bureau of Mines

M. A. Hunter  
Dean of Faculty Emeritus  
Rensselaer Polytechnic Institute

John G. Thompson  
Chief, Metallurgy Division  
National Bureau of Standards

W. E. Jominy  
Supervisor, Metallurgical Research  
Chrysler Corporation

Liaison Representatives from the  
Research and Development Board

Earnshaw Cook  
N. C. Fick

A. B. Kinzel, President  
Union Carbide and Carbon Research  
Laboratories, Inc.

Liaison Representatives from the  
Military Services

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Watertown Arsenal

Paul D. Merica  
Executive Vice President  
International Nickel Company  
of Canada

J. B. Johnson  
Flight Research Laboratory  
Wright Field

Albert J. Phillips  
Director of Research  
American Smelting and Refining Company

N. E. Promisel  
Bureau of Aeronautics

METALLURGICAL ADVISORY BOARD

- STAFF -

Chairman: Dr. Robert F. Mehl  
Vice Chairman: Dr. Zay Jeffries  
Executive Director: Mr. Verne H. Schnee  
Executive Secretary: Dr. W. J. Harris, Jr.

- Staff Metallurgists -

Dr. Julian Glasser  
Mr. James R. Long  
Dr. David L. McBride  
Mr. Richard Doughton, Jr.

- Consultants -

Mr. C. K. Leith  
Mr. W. E. Mahin  
Mr. W. H. Meikeljohn  
Mr. W. Stuart Lyman  
Mr. W. E. Ruder  
Mr. Ford C. Ritner  
Dr. R. Winchester  
Mr. E. M. Wise  
Mr. P. M. Tyler  
Mr. George Witteman

Section 2

In this section, all authorized projects are tabulated and their status summarized.

2.1 Titanium-Zirconium

2.1.1 Authorization

Letter from Chairman of the Research and Development Board to the National Academy of Sciences, Serial No. R.D.B. 245/16, dated January 12, 1951.

This letter states in part:

"Until preliminary investigations and recommendations have been submitted by the Metallurgical Advisory Committee, it will be assumed the most important items of attack presently concern heat resistant materials for temperature service and relief for critical materials in short supply such as --

"Columbium	Molybdenum
Tantalum	Tungsten
Cobalt	Beryllium
Titanium	Cadmium"

In the field of zirconium the project was authorized as follows.

Letter from the Chairman of the Research and Development Board to the National Academy of Sciences, Serial No. R.D.B. 201/1, dated March 14, 1951. This letter states as follows:

"At the suggestion of Dr. L. R. Hafstad, Chief Reactor Division, Atomic Energy Commission, and with the concurrence of Captain Rickover, Navy Bureau of Ships, it is requested that the Metallurgical Advisory Board undertake a study of the research and development problems involved in the production and use of metallic zirconium.

"There is an urgent interest in this metal in the Armed Services and the Atomic Energy Commission."

Titanium and zirconium involve many similar problems and, therefore, require in part identical membership on the panel. For convenience, this panel while listed as a single unit, operates through titanium and zirconium sections, which have meetings at different times.

### 2.1.2 Personnel

The two sections of the panel were named and approved by the National Academy of Sciences, with membership and liaison representatives listed in Appendix I. In addition, staff members from the Metallurgical Advisory Board in this field include Mr. W. E. Mahin, Project Director and Consultant, and Mr. J. R. Long and Dr. Julian Glasser, Staff Metallurgists. A special sub-panel on Basic Research in the Field of Extractive Metallurgy in Titanium was selected, and a list of the members is included in Appendix I.

### 2.1.3 Meetings

Meetings of the titanium section of the Titanium-Zirconium Panel have been held May 18, June 22 and November 30. Meetings of the Sub-panel on Basic Research in the Field of Extractive Metallurgy were held on September 4, September 20 and October 24, 1951. Minutes of these meetings are available. No meetings have been held to date of the zirconium section of the Titanium-Zirconium Panel.

### 2.1.4 Progress

The first report of the panel, MAB-2-M, dated July 13, 1951, and the first summary report of the panel, MAB-3-M, dated July 13, 1951, both prepared by the titanium section, have been forwarded to the Research and Development Board and distributed. These reports deal with estimates of the total requirements for titanium made by the armed services and contain a series of recommendations relating to basic research on extractive metallurgy, an estimated target goal for production, and a proposed program for extensive pilot plant development. These recommendations have been considered by the Research and Development Board. Action is being taken to implement all of the recommendations through the appropriate agencies.

The Sub-Panel on Basic Research has prepared a special report listing possible research projects and laboratories which will be furnished to the Research and Development Board as a supplement to the original recommendation of the panel for a basic research program.

## 2.2 Substitution of Alloying Elements in Engineering Steels

### 2.2.1 Authorization

Letter from Chairman of the Research and Development Board to the National Academy of Sciences dated April 24, 1951. This letter states:

"As I understand it, the proposed survey of critical alloy substitutions in heat treated steels has been suggested by Mr. J. B. Johnson of the Air Force, and it has been endorsed by the Navy, as well as the steelmaking and the steel consuming industries. The boron treated steels appear to show real promise for the conservation of the critical alloy elements such as chromium, molybdenum and nickel which are used extensively in the manufacture of such end items as military vehicles, guns, tanks, ship armor, and engine parts. Conservation of these critical elements is of very real importance to our over-all defense program. While the use of boron treated steels as substitutes for certain of the engineering alloy steels has been demonstrated, their use should be extended as rapidly as possible and at the same time other means for accomplishing the same result should be investigated.

"As requested by the terms of the Contract No. DA-49-025-sc-83 between the National Academy of Sciences and the Signal Corps, I am pleased to request formally that the National Academy of Sciences, through the Metallurgical Advisory Board, undertake a survey of critical alloy substitutions in heat treating steels as a special assignment. I understand that you anticipate completing the survey prior to June 15, 1951. I hope it is possible."

Note: Additional M.A.B. efforts relating to substitutions of alloying elements are covered under Item 2.13 of this report entitled "Naval Components".

### 2.2.2 Personnel

A special subcommittee was formed to consider the availability of boron additives. A list of the members of this subcommittee is attached in Appendix I.

### 2.2.3 Meetings

Meetings of the Panel have been held June 4 and October 26, 1951 and a meeting of a special Subcommittee on Boron Availability was held July 9, 1951. Minutes of these meetings are available.

2.2.4     Progress

A report, MAB-4-M, dated July 16, 1951, covering the use of boron steels was submitted to the National Academy of Sciences and was released for publication by the Research and Development Board as an insert in the August issue of "Metals Progress", Journal of the American Society for Metals. Copies of the report have been distributed.

The report of the Subcommittee on Availability of Boron Additives, MAB-6-M, dated September 1, 1951, has been distributed to members of the Subcommittee and of the Boron Panel for comment. The Panel has called attention to the shortages of alloying elements to a number of associations including the steel founders, the producers of large forgings the railroad industry and related groups.

A draft of a report recommending a series of research projects has been reviewed by the Panel and will be distributed in the near future.

The Panel has agreed to undertake a study of rare earth additions to steel, and to act as the reviewing panel for reports prepared on Naval guns, Naval armor and Naval components.

## 2.3 Manganese

### 2.3.1 Authorization

Letter from the Chairman of the Research and Development Board to the National Academy of Sciences dated June 5, 1951. This letter states the problem as follows:

"In accordance with Contract No. DA 49-025-sc-83 between the National Academy of Sciences and the Department of the Army, it is formally requested that the Metallurgical Advisory Board initiate studies of:

\*\*\*\*\*

"2. the general problem of the conservation of manganese,

\*\*\*\*\*

"The use of manganese \* \* \* as (an) alloying element (s) is an important part of the general study of this element but this use cannot be separated from the broad problem of conservation and substitution."

### 2.3.2 Personnel

A panel was named and approved by the National Academy of Sciences with membership as attached in Appendix I. Dr. C. H. Herty, Jr. is Chairman of the panel and Dr. D. L. McBride, Staff Metallurgist, has been named to assist in coordinating this activity.

### 2.3.3 Meetings

The first meeting of the Manganese Panel was held on July 13, at which time it was decided that a task force of the qualified personnel in the field would be hired for a period of a few weeks to review problems connected with ore beneficiation of the largest and most available ore deposits and the problems connected with the production of useful manganese alloys, either ferro-manganese or silico-manganese, from these ore bodies and from open hearth slags. Meetings were held September 10 and on Oct. 1 to review reports prepared by the

task forces and to outline in detail the report of the panel. Minutes of these meetings are available

2.3.4 Progress

A task force was selected as follows: for problems concerned with beneficiation, the Galigher Company; for problems concerned with hydrometallurgy, Mr. Sullivan of Battelle Memorial Institute; and for problems concerned with pyrometallurgy, Dr. D. L. McBride of the Metallurgical Advisory Board. The reports of task forces were reviewed. It is anticipated that a summary report will be distributed in the near future. The preliminary draft of this report has been reviewed and discussed by representatives of the Defense Minerals Production Agency and the Metallurgical Advisory Board. It is understood that this report will be utilized in the consideration of new projects dealing with manganese by the Defense Minerals Production Agency.

## 2.4 Nickel Conservation

### 2.4.1 Authorization

Letter from Chairman of the Research and Development Board to the National Academy of Sciences, Serial No. RDB 201/7, dated July 3, 1951. This letter reads in part as follows:

"In my letter to you of January 12, 1951, it was requested that the Metallurgical Advisory Board undertake preliminary investigations and make recommendations on critical materials in short supply. While nickel was not specifically enumerated, it was then, and is now, our intention that it should fall within the purview of the above quoted letter to you.

"Accordingly, I request that the Metallurgical Advisory Board undertake a study of the conservation of nickel.

\* \* \* \* \*

"I note that such a study will be of interest to the Defense Minerals Administration and to the National Production Authority, both of whom have substantial problems in supplying Defense requirements."

### 2.4.2 Personnel

Personnel of the panel on Nickel Conservation is listed in Appendix I.

### 2.4.3 Meetings

Meetings of the Panel on Nickel Conservation were held October 2 and November 5. Minutes of these meetings are available.

### 2.4.4 Progress

The Panel on Nickel Conservation is attempting to identify the end uses of nickel requiring the largest amounts of nickel, and most likely to offer fruitful fields for conservation efforts. The panel is arranging with appropriate agencies to obtain accurate statements of military and essential supporting civilian requirements for the full mobilization program. Various members of the panel have been assigned the supervision of studies to determine the specific end use items in the fields of aircraft, ordnance equipment, ships, high alloy castings,

electronic equipment, and chemical industry equipment. These reports were reviewed at the meeting of the Nickel Conservation Panel on November 5. Additional reports are being prepared to outline the progress made in conservation of nickel in cast alloy steels, in heat treatable steels, and in the electrical equipment industry.

2.5 Nickel Supplies

2.5.1 Authorization

Letter from Chairman of the Research and Development Board to the National Academy of Sciences, Serial No. RDB 201/7, dated July 3, 1951. This letter reads in part as follows:

"In my letter to you of January 12, 1951, it was requested that the Metallurgical Advisory Board undertake preliminary investigations and make recommendations on critical materials in short supply. While nickel was not specifically enumerated, it was then and is now, our intention that it should fall within the purview of the above quoted letter to you.

"Accordingly, I request that the Metallurgical Advisory Board undertake a study of the conservation of nickel.

\* \* \* \* \*

"I note that such a study will be of interest to the Defense Minerals Administration and to the National Production Authority, both of whom have substantial problems in supplying Defense requirements."

2.5.2 Personnel

Personnel of the Panel on Nickel Supplies is listed in Appendix I.

2.5.3 Meetings

To date it has not been necessary for the Panel on Nickel Supplies to hold a formal meeting. The activities of this panel consisted of a review of the report, and comments have been handled to date by correspondence between members of the panel.

2.5.4 Progress

Mr. John Sullivan of Battelle Memorial Institute has been retained as a consultant to the Panel on Nickel Supplies and has prepared a report dealing with the possibility of increasing the supply of nickel by the use of lean ores. This report is currently being reviewed by the panel members. It is anticipated that the panel report will be completed in the near future for distribution.

2.6 High Temperature Materials

2.6.1 Authorization

Letter from Chairman of the Research and Development Board to the National Academy of Sciences, Serial R.D.B. 245/16, dated January 12, 1951.

Paragraph 2 of this letter states:

"Until preliminary investigations and recommendations have been submitted by the Metallurgical Advisory Committee, it will be assumed the most important items of attack presently concern heat resistant materials for temperature service and relief for critical materials in short supply such as -

"Columbium	Molybdenum
Tantalum	Tungsten
Cobalt	Beryllium
Titanium	Cadmium"

2.6.2 Personnel

Mr. J. B. Meierdirks, Jr., Technical Aide, of the Metallurgical Advisory Board has conducted extensive field work, and Mr. A. J. Herzig of M.A.B. is acting as Technical Director of this project. Mr. Herzig is also a member of the N.A.C.A. Subcommittee on Heat Resisting Materials. In view of the existence of two exceedingly competent committees which cut across Service lines, one established by the National Advisory Committee for Aeronautics and one a joint committee of the American Society for Testing Materials and the American Society of Mechanical Engineers, no technical advisory panel was formed by the Metallurgical Advisory Board. In accordance with an informal agreement between Dr. Dryden, N.A.C.A. and Dr. R. F. Mehl, M.A.B., the Subcommittee on Heat Resisting Materials of the N.A.C.A. is acting as a panel to review and comment on the report.

2.6.3 Meetings

There have been no formal meetings and it appears that none is needed.

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2.6.4 Progress

A report on high temperatures, MAB-5-M, dated September 15, 1951, has been distributed. This report deals with the broad problems of the conservation of strategic alloys required for the aircraft gas turbine program. As a metallurgical report it emphasizes possible approaches to the substitution of materials with low alloy content and the conservation of materials in the production of gas turbines. It recommends that additional emphasis be placed on the research and development of materials which will meet the needs of a program for conservation. The report encourages the early test and evaluation of newly developed low alloy, heat resisting materials and calls attention to measures which may insure maximum conservation by reducing the proportion of fabrication scrap and by arranging for adequate salvage of scrap.

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## 2.7 Permanent Magnet Materials

### 2.7.1 Authorization

Letter from the Chairman of the Research and Development Board to the National Academy of Sciences, dated September 14, 1951. This letter states in part:

"At the request of the Research and Development Board, Dr. Mehl, Chairman of the Metallurgical Advisory Board, has investigated the desirability of organizing a formal study of permanent magnet materials.

"At a meeting here attended by representatives of the Signal Corps and the Research and Development Board, it was agreed that none of our existing committees were in the position to undertake this study. It was further agreed that the proposed work could fit in with the present program of the Metallurgical Advisory Board particularly as it would supplement work now in progress on cobalt.

"...it is formally requested that the Metallurgical Advisory Board undertake a study and prepare a technical report for the Research and Development Board on permanent magnet materials."

### 2.7.2 Personnel

The panel has been selected and approved by the National Academy of Sciences with membership and liaison representatives as given in Appendix I.

### 2.7.3 Meetings

A meeting of the panel was held October 30, 1951. Minutes of this meeting will be available in the near future.

### 2.7.4 Progress

The objectives of the panel are being defined at the present time because the work of the panel is strongly influenced by the availability of Alnico 5 magnets and, therefore, by requirements of cobalt. The first objective of the panel is to obtain a definitive statement on cobalt supplies and requirements. After that, an appraisal will be made of substitute materials. The status of research and development in this field will be studied and such recommendations as are pertinent will be made.

2.8 Tungsten2.8.1 Authorization

Letter from Chairman of the Research and Development Board to the National Academy of Sciences, Serial No. R.D.B. 245/16, dated January 12, 1951. This letter states in part:

"Until preliminary investigations and recommendations have been submitted by the Metallurgical Advisory Committee, it will be assumed the most important items of attack presently concern heat resistant materials for temperature service and relief for critical materials in short supply such as --

"Columbium	Molybdenum
Tantalum	Tungsten
Cobalt	Beryllium
Titanium	Cadmium"

2.8.2 Personnel

Dr. Zay Jeffries, Vice Chairman, Metallurgical Advisory Board, and Mr. Ford Ritner, M.A.B. Consultant.

2.8.3 Meetings

It has not been considered necessary to hold a formal meeting to consider the problems in the field of tungsten.

2.8.4 Progress

A summary report on tungsten, MAB-8-M, issued as of August 15, 1951, has been distributed. This report reviews supplies and requirements for tungsten and includes recommendations for action. The report has been distributed to the general staff of the Army for their use in determining policy in the field of projectile development. A copy of the report was also forwarded to Senator Lyndon B. Johnson, Chairman of the Preparedness Subcommittee for his information. A series of proposals for tungsten conservation were forwarded by Senator Johnson to Mr. Whitman, Chairman of the Research and Development Board, and in turn, forwarded to the Metallurgical Advisory Board for evaluation. Dr. Jeffries evaluated these suggestions, which included the use of tools tipped with high speed steel and the adoption of higher speed machining methods. His conclusions were forwarded to Mr. Whitman and in turn to Senator Johnson.

2.9 Columbium

2.9.1 Authorization

Letter from Chairman of the Research and Development Board to the National Academy of Sciences, Serial R.D.B. 245/16, dated January 12, 1951.

Paragraph 2 of this letter states:

"Until preliminary investigations and recommendations have been submitted by the Metallurgical Advisory Committee, it will be assumed the most important items of attack presently concern heat resistant materials for temperature service and relief for critical materials in short supply such as --

"Columbium	Molybdenum
Tantalum	Tungsten
Cobalt	Beryllium
Titanium	Cadmium"

2.9.2 Personnel

Dr. Zay Jeffries, Vice Chairman, Metallurgical Advisory Board, and Mr. E. M. Wise, M.A.B. Consultant.

2.9.3 Meetings

A meeting was held on May 9, 1951, to bring together representatives of the high temperature engine users, producers of power plant equipment, contractors for Atomic Energy Commission projects and representatives of the National Production Authority. The minutes of this meeting are available. A list of the people who attended the meeting is attached herewith.

2.9.4 Progress

A report on columbium, MAB-9-M, dated September 28, 1951, has been forwarded to the Research and Development Board and distributed. This report includes recommendations for action. At the request of General F. H. Griswold of the Munitions Board, copies of this report were sent to the Under Secretaries of the Army, Navy and Air Forces. Other activities of the Metallurgical Advisory Board in the field of columbium have been taken up in the report on High Temperature Alloys and in studies of nickel conservation with special attention to stainless steel.

2.10 Tantalum

2.10.1 Authorization

Letter from Chairman of the Research and Development Board to the National Academy of Sciences, Serial No. R. D. B. 245/16, dated January 12, 1951. This letter states in part:

"Until preliminary investigations and recommendations have been submitted by the Metallurgical Advisory Committee, it will be assumed the most important items of attack presently concern heat resistant materials for temperature service and relief for critical materials in short supply such as --

"Columbium	Molybdenum
Tantalum	Tungsten
Cobalt	Beryllium
Titanium	Cadmium"

2.10.2 Personnel

Dr. Zay Jeffries, Vice Chairman of the Metallurgical Advisory Board, Dr. R. Winchester, M.A.B.

2.10.3 Meetings

No formal meetings have been held as yet in this field.

2.10.4 Progress

Informal meetings have been held with representatives of a number of government agencies in order to determine the present status of supply and requirements and to establish the end uses requiring tantalum. A report in progress will indicate essential end use items and will include a statement of possible substitutes where they are known.

2.11 Cobalt

2.11.1 Authorization

Letter from Chairman of the Research and Development Board to the National Academy of Sciences, Serial R.D.B. 245/16, dated January 12, 1951.

Paragraph 2 of this letter states:

"Until preliminary investigations and recommendations have been submitted by the Metallurgical Advisory Committee, it will be assumed the most important items of attack presently concern heat resistant materials for temperature service and relief for critical materials in short supply such as ---

"Columbium	Molybdenum
Tantalum	Tungsten
Cobalt	Beryllium
Titanium	Cadmium"

2.11.2 Personnel

Dr. Zay Jeffries, Vice Chairman, Metallurgical Advisory Board, and Mr. E. M. Wise, M.A.B. Consultant.

2.11.3 Meetings

One meeting was held on June 7, 1951, to bring together representatives from all industries utilizing cobalt, including the high temperature alloys producers and users, producers of electronic equipment and magnets, representatives of the chemical and ceramic industry and the producers of enameled ware. The minutes of this meeting are available. A list of those who attended the meeting is attached herewith in Appendix I.

2.11.4 Progress

It is anticipated that a report will be completed in the near future summarizing the available information on supplies and requirements, and suggesting the research and development work which may be needed to meet the critical situation anticipated when the jet program is expanded. Other Metallurgical

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Advisory Board activities bear on the cobalt situation in particular studies of high temperature alloys and a new project on permanent magnet materials because of the critical shortage of cobalt. The report being prepared on the general subject of cobalt is a base line statement of supply and requirements which are a very broad summary of the end uses of alloys and other materials containing cobalt.

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## 2.12 Molybdenum

### 2.12.1 Authorization

Letter from Chairman of the Research and Development Board to the National Academy of Sciences dated June 5, 1951. This letter includes the following paragraph:

"In accordance with Contract No. DA-49-025-sc-83 between the National Academy of Sciences and the Department of the Army, it is formally requested that the Metallurgical Advisory Board initiate studies of

\*\*\*\*\*

\*\*\*\*\*

"3. the general problem of the conservation of molybdenum

"The use of \*\*\* molybdenum as an alloying element in steel is an important part of the general study of this element but this use cannot be separated from the broad problem of conservation and substitution."

### 2.12.2 Personnel

Mr. R. S. Archer, M.A.B. Consultant, made a preliminary study of this program.

### 2.12.3 Meetings

A series of preliminary meetings were held by Mr. Archer with representatives of various agencies in Washington and with industrial personnel concerned with this problem. It was not considered necessary to hold a large formal meeting.

### 2.12.4 Progress

It is considered that the program of studies of pure molybdenum is being effectively coordinated at the present time and a review of this program does not appear to be necessary. Therefore, the entire problem is being referred to the Panel on Substitution of Alloying Elements in Engineering Steels and it is being considered as a steel alloying element conservation problem.

2.13 Naval Components

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2.13.1 Authorization

Letter from the Chairman of the Research and Development Board to the National Academy of Sciences dated June 5, 1951. This letter says in part:

"In a memorandum dated May 10, 1951, to Mr. John T. Koehler, Assistant Secretary of the Navy, has requested that the Research and Development Board make available the services of the Metallurgical Advisory Board for the investigation of the problems of conservation and substitution of the critical alloying elements used in certain basic Navy programs such as guns, armor, jet engines, combat vehicles and certain others.

"As I understand it, the Metallurgical Advisory Board, in accordance with its original directive, is currently conducting investigations of critical elements in short supply which necessarily include consideration of the jet engine program, and in addition it has initiated studies of the conservation and substitution of these elements in the heat-treating steels as an additional assignment. This request of the Navy to broaden the scope of these investigations to include special studies of the development of alternate alloys for use in the production of armor and the manufacture of guns and combat vehicles has my endorsement. Therefore, in accordance with Contract No. DA-49-025-sc-83 between the National Academy of Sciences and the Department of the Army, it is formally requested that the Metallurgical Advisory Board initiate studies of:

\* \* \* \* \*

"3. alternate metals and alloys for use in the manufacture of combat vehicles."

2.13.2 Personnel

The cooperation of the American Society for Metals has been enlisted in this project. Dr. Taylor Lyman, Editor of "Metals Handbook," selected from the membership of the American Society for Metals, five representatives to serve on a special committee on each of the projects. The report of this committee is reviewed by the Metallurgical Advisory Board Panel on Substitution of Alloying Elements in Engineering Steels prior to distribution of the report. Committee members selected are given in Appendix I.

2.13.3 Meetings

2.13.3.1 A meeting of the Diesel Engine Committee was held September 6 through September 7, 1951, to complete the report.

2.13.3.2 A meeting of the Naval Gun Mount Committee was held November 27, 1951.

2.13.4 Progress

2.14.4.1 The Bureau of Ordnance selected a 3" gun mount for study by the special Metallurgical Advisory Board - American Society for Metals Committee. Mr. W. Stuart Lyman, Consultant to M.A.B. is preparing background information on the present materials and the proved alternates for use by the committee. It is expected that an advisory report on acceptable substitutes will be prepared by the end of December.

2.13.4.2 The ASM-MAB Committee on the Diesel Engine has completed their study of substitute materials. A series of lower alloy alternate materials and heat treating procedures were recommended for consideration by the Navy Department. These suggestions were chosen to represent normal decrease in combat effectiveness of the equipment. They represent the leanest alloy steels to which consideration could be given at this time. Where necessary, research and development programs were suggested. A draft of the report is being circulated for comment. It is anticipated the final report will be distributed in December. A draft copy has gone to the Bureau of Ships for their information.

2.13.4.3 The Bureau of Aeronautics has asked that the Metallurgical Advisory Board review an aircraft turret in order to determine the extent to which alloy conservation can be achieved. After preliminary studies of the problem by W. Stuart Lyman, Consultant to the M.A.B., the American Society for Metals is nominating a committee to review present materials and to suggest alternates.

2.14 Naval Guns

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2.14.1 Authorization

Letter from the Chairman of the Research and Development Board to the National Academy of Sciences dated June 5, 1951. This letter says in part:

"In a memorandum dated May 10, 1951, Mr. John T. Koehler, Assistant Secretary of the Navy, has requested that the Research and Development Board make available the services of the Metallurgical Advisory Board for the investigation of the problems of conservation and substitution of the critical alloying elements used in certain basic Navy programs such as guns, armor, jet engines, combat vehicles, and certain others.

"As I understand it, the Metallurgical Advisory Board, in accordance with its original directive, is currently conducting investigations of critical elements in short supply which necessarily include consideration of the jet engine program, and in addition it has initiated studies of the conservation and substitution of these elements in the heat-treating steels as an additional assignment. This request of the Navy to broaden the scope of these investigations to include special studies of the development of alternate alloys for use in the production of armor and the manufacture of guns and combat vehicles has my endorsement. Therefore, in accordance with Contract No. DA-49-025-sc-83 between the National Academy of Sciences and the Department of the Army, it is formally requested that the Metallurgical Advisory Board initiate studies of:

\* \* \* \* \*

"2. alternate metals and alloys for use in the manufacture of guns."

2.14.2 Personnel

A small ad hoc committee is being formed to function under the Metallurgical Advisory Board Panel on Substitution of Alloying Elements in Engineering Steels. A list of the members of this committee is included in Appendix I.

2.14.3 Meetings

Informal meetings have been held with members of the Office of Naval Materiel and the Bureau of Ordnance. In the near future, a meeting will be held of a group making a preliminary study of the scope of the problem.

2.14.4 Progress

Preliminary study by the Metallurgical Advisory Board staff has resulted in a partial definition of the problem. The objectives of the ad hoc committee are under consideration and the method of approach is being formulated.

2.15 Naval Armor

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2.15.1 Authorization

Letter from the Chairman of the Research and Development Board to the National Academy of Sciences dated June 5, 1951. This letter says in part:

"In a memorandum dated May 10, 1951, to Mr. John T. Koehler, Assistant Secretary of the Navy, has requested that the Research and Development Board make available the services of the Metallurgical Advisory Board for the investigation of the problems of conservation and substitution of the critical alloying elements used in certain basic Navy programs such as guns, armor, jet engines, combat vehicles, and certain others.

"As I understand it, the Metallurgical Advisory Board, in accordance with its original directive, is currently conducting investigations of critical elements in short supply which necessarily include consideration of the jet engine program, and in addition it has initiated studies of the conservation and substitution of these elements in the heat-treating steels as an additional assignment. This request of the Navy to broaden the scope of these investigations to include special studies of the development of alternate alloys for use in the production of armor and the manufacture of guns and combat vehicles has my endorsement. Therefore, in accordance with Contract No. DA-49-025-sc-83 between the National Academy of Sciences and the Department of the Army, it is formally requested that the Metallurgical Advisory Board initiate studies of:

"1. alternate metals and alloys for use in the production of armor."

2.15.2 Personnel

Members of the Metallurgical Advisory Board have suggested personnel to serve on this project. It is anticipated that a small Ad Hoc Committee will be appointed to make a definitive study. This committee will function under the Panel on Substitution of Alloying Elements in Engineering Steels.

2.15.3 Meetings

No formal meetings have been held in this field.

2:15.4 Progress

Preliminary discussions have been held with representatives of the Office of Naval Materiel, the Bureau of Ordnance and the Bureau of Aeronautics. It has been considered necessary to approach this project carefully and to take special care in defining the problem before attempting to establish a working panel. Arrangements are now being made for a meeting between Metallurgical Advisory Board representatives, possible ad hoc committee members and representatives of the Navy Department.

## 2.16 Electro-Processes for Machining and Grinding

### 2.16.1 Authorization

Letter from the Chairman of the Research and Development Board to the National Academy of Sciences, dated August 10, 1951. This letter states in part:

"Recently it has been called to the attention of the Research and Development Board by the National Production Authority that there is a pending shortage of diamond grinding wheels to meet current civilian and defense requirements for preparation of shaped carbide tools. Industrial diamonds and bort are stock pile items. The shortage faced at the present time does not take into account the additional requirements which will arise from expanded production of tungsten carbide core materials or of jet engine components. A substitute method for grinding and drilling hard-to-machine materials is offered by electrolytic grinding and electro-sparking techniques.

"In view of the importance of machining of carbides, tool steels, high temperature alloys and similar materials to the defense effort, it is formally requested that the Metallurgical Advisory Board undertake a project concerned with developing information as to the research and development necessary to improve the new techniques of electrolytic grinding and electro-sparking to the point where they can be applied in production."

### 2.16.2 Personnel

A panel has been selected and approved by the National Academy of Sciences. Membership and liaison representatives are in Appendix I.

### 2.16.3 Meetings

A meeting of this panel is scheduled for December 12 and 13, 1951.

### 2.16.4 Progress

A series of reports are being prepared by members of the panel

as follows:

The Electrolytic Process for Shaping Carbides  
Electro-sparking Process for Shaping Carbides  
Requirements of the Carbide Fabricators  
Requirements of Electro-Processes to Compete with  
Diamond Wheel Grinding  
The Diamond Bort Supply Problem  
European Developments  
Survey of Research and Development on Electro-processes for  
Machining and Grinding

These reports will be discussed at the panel meeting and will form the basis of the formal report.

## 2.17 Free Machining Steels

### 2.17.1 Authorization

Letter from the Chairman of the Research and Development Board to the National Academy of Sciences dated June 5, 1951. This letter includes the following paragraph:

"In accordance with Contract No. DA-49-025-sc-83 between the National Academy of Sciences and the Department of the Army, it is formally requested that the Metallurgical Advisory Board initiate studies of

"1. the free machining steels."

### 2.17.2 Personnel

Upon investigation and with the assistance of the A.I.S.I., it has been determined that Mr. Witteman of Bethlehem Steel Company, prepare an extensive report on free machining steels in 1948. Mr. Witteman has been asked to serve on the staff of the Metallurgical Advisory Board to prepare a new report on this subject and has been released temporarily for this service by his corporation.

### 2.17.3 Meetings

No formal meetings have been held to date.

### 2.17.4 Progress

Mr. Witteman started to work on this project on July 26, 1951. After discussion with representatives of the Ordnance Department, it is apparent that the problem to be considered under the heading of "Free Machining Steels" involves study of the machinability of ammunition components and other materials, especially the machinability of substitute alloys introduced to conserve elements in short supply. The Society of Automotive Engineers is giving consideration to the establishment of a panel on machinability to function with the military departments in this field. Arrangements are being made to have critical programs referred to this committee in order that the best experience in the automotive industry can be brought to bear on fabrication difficulties encountered in the production of military equipment.

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2.18 Selenium

2.18.1 Authorization

Letter from the Chairman of the Research and Development Board to the National Academy of Sciences dated November 23, 1951. This letter states in part:

"At the request of the Research and Development Board, the Metallurgical Advisory Board has investigated the desirability of organizing a formal study of selenium, as originally suggested by Mr. S. B. Coolidge, Jr., Deputy Assistant Administrator, Metals and Minerals, National Production Authority.

"As a result of this preliminary survey, which included discussions with representatives of the Armed Services, the producing industry, and large consuming interests, the Metallurgical Advisory Board has concluded that an extended study of the general problem of selenium is warranted.

"In accordance with the provisions of Contract No. DA-49-025-sc-83 between the National Academy of Sciences and the Department of Defense, it is formally requested that the Metallurgical Advisory Board prepare the necessary technical reports for the Research and Development Board on selenium."

2.18.2 Personnel

Mr. Paul Tyler, Consultant to the Metallurgical Advisory Board, is serving as staff representative on this problem.

2.18.3 Meetings

No formal meetings have been scheduled.

2.18.4 Progress

After a preliminary study, which has been completed by Mr. Tyler, summarizing some of the facts concerning supply and requirement and end uses of this material, a more careful investigation of means of increasing supplies is being made. Separate and special attention is being given to the possibility of substituting other materials than selenium which can also improve the machinability of stainless steels.

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2.19 Beryllium

2.19.1 Authorization

Letter from the Chairman of the Research and Development Board to the National Academy of Sciences dated November 2, 1951. This letter says in part:

"The National Production Authority reports that 94% of all available beryllium, including domestic production and imports, is currently being consumed in essential military uses or is going into the national stockpile. Accordingly, it can be foreseen that beryllium will constitute a serious production bottleneck with any further substantial increase in the level of production of military items.

"It is therefore suggested that the Metallurgical Advisory Board be asked to investigate and recommend specific measures to conserve beryllium by downgrading of alloys, eliminating non-essential uses of beryllium, and development of substitute alloys for specific purposes or components."

2.19.2 Personnel

Members of the Metallurgical Advisory Board are being consulted with respect to personnel to serve in connection with this project.

2.19.3 Meetings

No meetings have been held.

2.19.4 Progress

Members of the Metallurgical Advisory Board are being requested to suggest an approach to this problem. Personnel to serve on a panel are under consideration. A brief staff study is being prepared on the possible substitutes for beryllium copper.

2.20 Germanium

2.20.1 Authorization

Letter from Chairman of the Research and Development Board to the National Academy of Sciences, Serial No. RDB 201/15, dated October 16, 1951.

This letter states in part:

"The availability and use status of the metal germanium is questionable. Inasmuch as this situation exists and the proponents of both pro and con are so firm in their conviction, it is my desire that the Metallurgical Advisory Board make a preliminary study of germanium in order to secure enough information to decide whether a comprehensive study is warranted. . . . it is formally requested that the Metallurgical Advisory Board make this preliminary study."

2.20.2 Personnel

Personnel to study this problem will be selected during the preliminary investigation requested by the authorizing letter.

2.20.3 Meetings

During the course of the panel study, no meetings are contemplated.

2.20.4 Progress

The staff of the Metallurgical Advisory Board is preparing a preliminary report which will indicate whether or not a formal project should be undertaken by the Metallurgical Advisory Board in this field.

## 2.21 Powder Metallurgy

### 2.21.1 Authorization

Letter from Chairman of the Research and Development Board to the National Academy of Sciences, dated September 24, 1951, which states:

"In accordance with the contract between the National Academy of Sciences and the Department of the Army and with the approval of the Committee on Ordnance, it is formally requested that the Metallurgical Advisory Board broadly examine the status of the general field of powder metallurgy and advise the Research and Development Board as to whether a full-scale investigation of specific phases of this subject should be initiated."

### 2.21.2 Personnel

Mr. J. R. Long, Metallurgical Advisory Board Staff Metallurgist, is conducting a preliminary study.

### 2.21.3 Meetings

No formal meetings have been held in this field. Mr. Long, however, has met informally with a number of producers of powdered metals and end use products and has consulted with representatives of the services and other agencies.

### 2.21.4 Progress

The preliminary study of this subject is well underway and it is anticipated that a report can be prepared in the near future to determine the extent to which additional projects in this field will be required. A portion of the work on powder metallurgy is being handled under the Metallurgical Advisory Board Panel on Permanent Magnet Materials, and in the preliminary study of problems associated with nickel-cadmium batteries.

3. Preliminary Study of Possible New Assignments for the Research and Development Board

At the request of the Signal Corps and discussions with representatives of the Research and Development Board, it has been determined that nickel-cadmium batteries may be utilized in larger quantities than present schedules indicate. A preliminary study is being made by the Metallurgical Advisory Board staff to determine the extent to which the Metallurgical Advisory Board can be helpful and suggesting alternate sources of nickel powders for this job. This preliminary study will be used to advise the Research and Development Board of the need if one exists to establish a formal Metallurgical Advisory Board project on this subject.

4. Status of the Proposed Contract Between Bureau of Mines and the National Academy of Sciences in the Field of Metals, Metallic and Non-Metallic Minerals and Fuels

4.1 Negotiation of a contract between the Bureau of Mines and the National Academy of Sciences in the field of metals, metallic and non-metallic minerals is nearing completion. A present statement of the scope of work under this contract is defined in Article I of the present draft of the contract which is quoted below.

"Article I - Scope of Work

"(a) The Academy shall, within the funds available and upon the written request of the Director, Bureau of Mines, conduct studies and surveys, make critical analyses, and prepare and furnish to the Director and to other employees designated by him, advisory and technical reports in connection with:

1. Appraisal of the technical problems involved in the production and use of metallic and non-metallic minerals, ~~substances.~~
2. Appraisal of problems involved in the treatment of low grade minerals and ores and other minerals and ores not commonly commercially processed.
3. Special problems relating to the production of raw materials, intermediates and the use of substitutes and new or different processes for production of non-metallic minerals and of metals and metal end products and the uses thereof.

"(b) The Academy shall, in addition, perform such other services involving scientific and technologic investigations concerning mining and the preparation, treatment, and utilization of mineral substances as may be agreed upon in writing from time to time by the Director of the Bureau of Mines and the President of the Academy.

"(c) The Academy shall, from time to time, report the progress of the work as required by the Director and shall, upon the completion of the work or upon cessation of performance under this contract, whichever is first, furnish to the Bureau a written report consolidating all findings, notes, data, and conclusions of the work under this contract."

4.2 A preliminary investigation of possible assignments to the Metallurgical Advisory Board under the proposed contract between the Bureau of Mines and the National Academy of Sciences is being made by the staff of the

Metallurgical Advisory Board. A draft of a report by Mr. Paul Tyler, M.A.B. Consultant, indicates that important problems exist in the following fields:

Mica	Asbestos
Marginal Ores	Beryl
Corundum	Fluorspar
Graphite	Hallornite
Iceland Spar	Industrial Diamonds
Kyanite	Magnesite
Quartz Crystal	Sulfur
Talc	

Upon completion of negotiations, arrangements will be made to advise the Bureau of Mines of this preliminary study and suggest that consideration be given to establishing formal projects.

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TITANIUM SECTION OF THE TITANIUM-ZIRCONIUM PANEL

CHAIRMAN: Dr. Bruce Gonser, Battelle Memorial Institute

M.A.B. Staff: Dr. Julian Glasser, Staff Metallurgist  
Mr. J. R. Long, Staff Metallurgist  
Mr. W. E. Mahin, Project Director and Consultant

PANEL MEMBERS:

Mr. C. I. Bradford, Director of Operations, Rem-Cru Titanium, Inc.  
Mr. E. H. Bunce, Technical Assistant to the President, The New Jersey Zinc Co.  
Dr. H. P. Croft, Research Engineer, Kennecott Copper Company  
Dr. E. A. Gee, E.I. duPont de Nemours and Company  
Dr. S. A. Herres, Metallurgist, Allegheny Ludlum Steel Company  
Dr. I. R. Kramer, Horizons Titanium Inc.  
Mr. E. I. Larsen, Executive Metallurgical Engineer, P. R. Mallory and Company, Inc.  
Mr. David Swann, Metallurgical Engineer, Union Carbide & Carbon Research Lab., Inc.  
Dr. Eugene Wainer, Horizons Inc.  
Mr. V. W. Whitmer, Metallurgist, Republic Steel Company  
Mr. N. A. Ziegler, Metallurgical Engineer, Crane Company

LIAISON REPRESENTATIVES:

Mr. F. J. Cservenyak, U. S. Bureau of Mines  
Dr. R. C. Dalzell, Atomic Energy Commission  
Mr. E. J. Dunn, Office, Chief of Ordnance  
Dr. L. D. Jaffe, Watertown Arsenal  
Mr. J. B. Johnson, Flight Research Laboratory, Wright Field  
Mr. R. R. Kennedy, Air Materiel Command  
Mr. N. E. Promisel, Bureau of Aeronautics  
Mr. O. C. Ralston, U.S. Bureau of Mines

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ZIRCONIUM SECTION OF THE TITANIUM - ZIRCONIUM PANEL

Chairman: Dr. Bruce W. Gonser, Battelle Memorial Institute

M.A.B. Staff: Dr. Julian Glasser, Staff Metallurgist  
Mr. J. R. Long, Staff Metallurgist  
Mr. W. E. Mahin, Project Director and Consultant

Panel Members:

Mr. W. S. Johnson, Atomic Power Division, Manager of Materials and Metallurgical Research, Westinghouse Electric Corporation

Dr. S. C. Ogburn, Jr., Director of Research and Development, Foote Mineral Co.

Mr. Stephen M. Shelton, Regional Director, Region 2, Bureau of Mines

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 Mr. George Beiser, Research and Development Board  
 Dr. Marshall Brown, Corrosion Engineer, E. I. DuPont de Nemours, Inc.  
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 Mr. N. C. Fick, Research and Development Board  
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June 7, 1951

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Mr. R. L. Brownlee, Carboloy Company  
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Mr. R. M. Emerson, Arnold Engineering Company  
Mr. Lorne L. Ferrall, Director of Metallurgy, Crucible Steel Company  
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