AGARD

ADVISORY GROUP FOR AEROSPACE RESEARCH & DEVELOPMENT

7 RUE ANCELLE 92 NEUILLY SUR SEINE FRANCE

AGARD REPORT No. 585

on

Directory of Organizations, Investigators, and Programs in High Temperature Corrosion Research

NORTH ATLANTIC TREATY ORGANIZATION

DISTRIBUTION AND AVAILABILITY
ON BACK COVER

AND PROGRAMS IN HIGH TEMPERATURE CORROSION RESEARCH

AGARD Report No.585

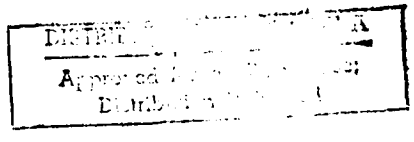
NORTH ATLANTIC TREATY ORGANIZATION

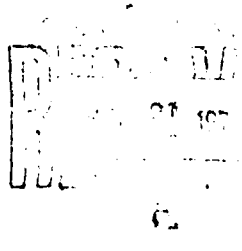
ADVISORY GROUP FOR AEROSPACE RESEARCH AND DEVELOPMENT

(ORGANISATION DU TRAITE DE L'ATLANTIQUE NORD)

DIRECTORY OF ORGANIZATIONS, INVESTIGATORS, AND PROGRAMS IN HIGH TEMPERATURE CORROSION RESEARCH

Prepared for
The NATO/AGARD Working Group on Basic and Applied
Research and High-Temperature Corrosion





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Recommending effective ways for the member nations to use their research and development capabilities for the common benefit of the NATO community;

Providing scientific and technical advice and assistance to the North Atlantic Military Committee in the field of aerospace research and development;

Continuously stimulating advances in the aerospace sciences relevant to strengthening the common defence posture;

Improving the co-operation among member nations in aerospace research and development;

Exchanging of scientific and technical information;

Providing assistance to member nations for the purpose of increasing their scientific and technical potential;

Rendering scientific and technical assistance, as requested, to other NATO bodies and to member nations in connection with research and development problems in the aerospace field.

The highest authority within AGARD is the National Delegates Board consisting of officially appointed senior representatives from each Member Nation. The mission of AGARD is carried out through the Panels which are composed of experts appointed by the National Delegates, the Consultant and Exchange Program and the Aerospace Applications Studies Program. The results of AGARD work are reported to the Member Nations and the NATO Authorities through the AGARD series of publications of which this is one.

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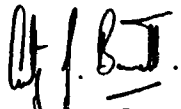
SUMMARY

This directory of research organizations, investigators, and research programs or areas of research was prepared from information gathered by the NATO/AGARD Working Group on Basic and Applied Research on High-Temperature Corrosion, and the European Federation of Corrosion's Working Group on Corrosion by Hot Gases and Products of Combustion.

The directory lists the organizations, together with the investigators and the research areas (or specific programs) in which they are working, alphabetically by countries. There are 178 organizations from eleven NATO countries included. A category index indicates the high-temperature corrosion research areas in which the various organizations are conducting research. The two research areas currently receiving the most attention are (1) material behavior under corrosion and (2) reaction kinetics and diffusion processes, in which 119 and 97 organizations, respectively, are working. An alphabetical index of investigators includes approximately 240 names.

The AGARD Structures and Materials Panel has an ongoing program of work in this field, organized and coordinated by the Working Group listed on page "v" under the Chairmanship of Mr. T. F. Kearns.



Anthony J. Barrett
Chairman,
Structures and Materials Panel
AGARD

DIRECTORY OF HIGH TEMPERATURE CORROSION RESEARCH

Organizations, Investigations, and Programs

In recent years increased attention has been devoted to the topic of high temperature oxidation and corrosion of structural alloys as a result of increasing operating temperatures being used in the design of aerospace propulsion systems and airframes. The Advisory Group for Aeronautical Research and Development (AGARD) organized under the North Atlantic Treaty (NATO) set up a Working Group on Basic and Applied Research on High Temperature Corrosion Organization of Aerospace Alloys to Study this important topic. At the request of this Working Group, DMIC prepared this directory of the research organizations and principal investigators active in high temperature corrosion and the topics on which they are working. We believe that the directory affords an overview of work in progress and will aid in the assessment of the distribution of the effort and recognition of gaps and objectives not being effectively pursued.

Information on U. S. and Canadian programs in the directory was obtained by DMIC through a direct mail questionnaire sent in 1970 to researchers who were believed to be active in high-temperature corrosion research. Information on European programs was taken from a 1967 survey of European high-temperature corrosion research conducted by the Working Group on "Corrosion by Hot Gases and Products of Combustion" of the European Federation of Corrosion (EFC). The information selected from the EFC survey was limited to NATO countries * and to high-temperature corrosion in the categories listed below.

	Category Index
1.1	Thermodynamics, phase diagrams, reaction equilibria
1.2	Electrochemical problems
1.3	Reaction kinetics and diffusion processes
1.4	Aerodynamic factors (mechanism of deposition)
1.5	Rheological investigations (viscosity of the melts)
2.1	Development of corrosion-resistant materials
2.2	Surface protection of materials
2.3	Material behavior under corrosion
3.1	Additives
3.4	Surface treatment of pipes, supports, and other parts of furnaces, boilers, turbines, etc., exposed to high temperature

In the interest of uniformity, these category codes were used in Table 2 of this directory. In addition, when more complete information was not available, these categories were used to indicate the areas, in Table 1, in which research was being conducted by the European laboratories.

(*) Spain is not within NATO but some laboratories in this Country known to have interests in High Temperature Corrosion work have been included in this directory by courtesy of the Spanish laboratories concerned.

Members of the NATO/AGARD Working Group on Basic and Applied Research on High-Temperature Corrosion

T. F. Kearns	United States, Chairman
A. Deruyttere	Belgium
H. V. Kinsey	Canada
J. P. Poulignier	France
F. Bollenrath	Germany
A. Griselli	Italy
P. Kofstad	Norway
A. d'Oliveira Sampaio	Portugal
H. P. van Leeuwen	Netherlands
K. A. Rowland	United Kingdom
N. Tallan	United States
R. I. Jaffee	U. S., Specialist
J. Dunham	U. K., Liaison, Propulsion and Energetics Panel, AGARD

Members of the European Federation of Corrosion Working Group on Corrosion by Hot Gases and Combustion Products

H. Souresny	Austria
H. Zitter	"
M. Caubo	Belgium
Prof. Leclerc	"
Prof. Pourbaix	"
E. Aggernaes	Denmark
Z. Bret	Czechoslavakia
Prof. Tikkanen	Finland
Prof. Bardolle	France
Dr. Manenc	"
K. Lorenz	Germany
W. Möller	"
A. Rahmel	"
W. Schlüter	"
Dr. Tuillo	Italy
D. Borgese	"
J. M. N. Jelgersma	Netherlands
Dr. de Jonge	"
P. Kofstad	Norway
S. Feliu	Spain
J. H. González	"
L. O. Härdelius	Sweden
O. Stelling	"
A. Bukowiecki	Switzerland
Th. Geiger	"
M. Heise	"
A. B. Hart	United Kingdom
G. Wood	"

TABLE 1. DIRECTORY OF ORGANIZATIONS, INVESTIGATORS, AND PROGRAMS

BELGIUM

1. Belgian Center for Corrosion Study, CEBELCOR
Avenue Paul Héger, Grille 2
B-1050 Bruxelles
M. Fourbaix (02)49.63.96
A. Pourbaix
G. vanMuyldaer
Programs:
1. Preparation of an atlas of chemical and electrochemical equilibria for oxides, hydrides, sulfides, chlorides, hydrates, and other compounds, with special reference to the conditions of stability of protective films
2. Preparation of diagrams of electrochemical equilibria of materials in the presence of molten salts (carbonates, chlorides, fluorides, sulfates) and in the presence of semiconductive oxides

2. Centre de Recherches Metallurgiques (C.R.M)
rue du Val Benoit, 69
B-4000, Liege (04) 52.70.50
A. Davin
D. Coutsouradis
L. Habraken
Programs:
1. Dry corrosion of superalloys in sulphidizing and carburizing atmospheres
2. Development of hot corrosion resistant cobalt base alloys
3. Evaluation of coating stability under hot corrosion conditions

3. Faculté Polytechnique
Département de Chimie
Laboratoire d'Electrochimie
Rue de l'Epargne
Mons
Prof. H. Van der Poorten
Programs:
1. Corrosion of refractory metals by molten silicates
2. Reaction kinetics and diffusion processes
3. Material behavior under corrosion

4. Institut Belge des Hautes Pressions
Sterrebeek
L. Deffet
P. Hestermans
Research Areas:
2.3

5. Institut de Metallurgie de la Faculte des Sciences Appliquees
de l'Universite Catholique de Louvain
de Croylaan, 2
3030 Heverlee
Leuven
Claude Vanleugenhaghe 016/327.47
Program:
1. Corrosion of inconel 600 alloy in water vapor at high temperature
2. Reactions in the system Ac_2O_3-ThO_2-W and La_2O_3-ThO_2-W including daughter products Re, Pb, and O. Study of phase diagrams, volatilization, permeability
3. Reactions in the system ThO_2-W-O-Re-Pb
4. Reactions in the system LaN-AlN-N-W-Pb
5. Steam oxidation of chromium coatings on steel
6. Hot salt cracking of titanium alloys

6. Katholieke Universiteit Leuven
Department Metaalkunde
3030 Heverlee
Leuven
Dr. M. J. Brabers
Research Areas:
1.1, 1.3, 2.2, 2.3
1. Reactions in the system Ac_2O_3-ThO_2-W and La_2O_3-ThO_2-W including daughter products He, Pb and O. Study of phase diagrams, volatilization, permeability.
2. Reactions in the system ThO_2-W-O-He-Pb
3. Reactions in the system LaN-AlN-N-W-Pb
4. Steam oxidation of chromium coatings on steel
5. Hot salt cracking of titanium alloys

7. Laboratoire Belge de l'Industrie Electrique, LABORELEC
Rhode-Saint-Genese
G. Taelemens
Research Areas:
2.2, 3.4

8. Laboratoire Central
Rue de la Discipline
6060 Gilly
S. A. Glaverbel (07)31.01.65
Programs:
1. Reaction of alloys with molten salts (silicates)
2. High temperature coatings development (plasma-spraying and diffusion coatings)
3. Temperature effects on coatings and intermediate layers

9. SCK/CEN (Centre D'Etude de L'energie Nucléaire)
Metallurgy Department
2400 Mol
F. Casteels
Programs:
1. Compatibility of W(W-Re) with oxides (PbO, WO_3, Bi_2O_3, ThO_2, La_2O_3, Ac_2O_3, BaO, Ba, Pb, Bi) in the temperature range 1500 - 2200 C

CANADA

10. Atomic Energy of Canada Limited
Chalk River Nuclear Laboratories
Materials Science Branch
Chalk River, Ontario
B. Cox (613) 687-5581 Ext. 563
Programs:
1. Oxidation of zirconium

11. Ecole Polytechnique
Département de Génie Métallurgique Chimique
Division de Métallurgie
2500 Avenue Marie Guyard
Montreal, 250, Quebec
M. Rigaud (514) 739-2451 Ext. 282 or 241
Programs:
1. Oxidation of nickel, cobalt, niobium, nickel-cobalt, nickel-niobium alloys
2. Initial stages of film formation
3. Spectrophotometric study of products formed during the oxidation of nickel binary alloys Ni-Nb, Ni-Ti, Ni-Al

12. Falconbridge Nickel Mines, Ltd.
Metallurgical Laboratories
Process and Products Development Group
5810 Yonge Street
P.O. Box 900
Thornhill, Ontario
Dr. L. A. Morris
Programs:
1. Oxidation of austenite stainless steels
2. Oxidation and hot corrosion of high chromium, nickel-chromium alloys
3. Sulfidation of high chromium, nickel chromium, alloys

13. McMaster University
Department of Metallurgy and Materials Science
Hamilton, Ontario
Prof. W. W. Smeltzer (416) 522-4971
Programs:
1. Oxidation properties of zirconium and a zirconium-2.5 w/o niobium alloy
2. Oxidation-decarburization properties of steels
3. Thermodynamics of binary alloys and oxygen
4. Oxidation properties of iron-silicon and nickel-iron alloys
5. Oxidation properties of nickel
6. Reactant transport properties in oxide films and scales
7. Sulfidation properties of nickel-chromium alloys

14. National Research Council of Canada
Metallic Corrosion and Oxidation Section
Chemistry Division
Ottawa 7, Ontario
Donald Caplan (613) 993-2518
Programs:
1. Oxidation of Fe, Ni, Cr: kinetics, effect of pressure, purity, surface preparation, cold work, surface contamination with Si, C, S
2. Electron-optical characterization of metal surfaces: high energy electron diffraction and X-ray emission analysis of surfaces and their reaction products: Fe, Ni, W, Ta, Si
3. Initial stages of film formation on Fe, Ni, Si, and W single crystals: nucleation, epitaxy, kinetics, ultrahigh vacuum techniques
4. Grain structure and cavities in oxide layers
5. Oxidation of Fe-C alloys
6. Anodically formed oxides on Fe: kinetics, electrochemistry, electron-optical examination, and autoradiography
7. Contamination of metal surfaces from hot ceramics; gas phase transport mechanism

15. National Research Council of Canada
National Aeronautical Establishment
Structures and Materials Laboratory
Ottawa, Ontario
J. M. Trenouth (613) 993-2812
Dr. W. Wallace (613) 993-9280
Dr. E. P. Whelan (613) 993-2812
Programs:
1. Preparation and evaluation of vacuum pack Cr-Ti-Si coatings on B66 alloy (nearing completion)
2. Oxidation of silicide compounds, diffusion coatings, and binary Nb alloys (being initiated)
3. Corrosion of silicide coatings by Na_2SO_4 and NaCl
4. Oxidation kinetics and breakdown mechanisms in diffusion coated niobium and niobium-base alloys
5. Oxidation kinetics and structural stability of intermetallic compounds
6. Impurity diffusion of Cr, Ti, Si in niobium
7. Oxidation resistance of commercial aluminide coatings on superalloys 713C and IN-100 (recently completed)

16. Orenda Limited
Box 6001
Toronto International Airport
Toronto, Ontario
W. Paul (416) 677-3250
Programs:
1. Evaluation of high-temperature corrosion properties of nickel- and cobalt-base superalloys after long term exposure to straight oxidizing atmospheres
2. Evaluation of turbine components after long periods of service in Orenda's industrial base turbine engines
3. Study of the effects of various surface treatments such as shot peening and aluminide coatings

17. Queen's University
Centre for Metal and Mineral Technology
Chemical Metallurgy Research Group
Kingston, Ontario
John R. Wilson (613) 547-2816
Programs:
1. High-temperature corrosion of metallic and refractory materials in oil combustion products (including sulfidation and vanadate corrosion)
2. High-temperature corrosion of molybdenum in aggressive gaseous environments (mainly halogen gases and hydrogen sulfide)
3. Corrosion of metallic and refractory materials by molten salts and slags (predominantly the refractory metals by molten fluorides, and commercial refractories by molten oxides)

18. Sherritt Gordon Mines, Ltd.
Research and Development Division
Fort Saskatchewan, Alberta
L. F. Norris (403) 543-2211
Programs:
1. Improvement of the oxidation resistance of dispersion strengthened nickel-chromium alloys (includes static and dynamic oxidation testing, hot corrosion testing from 1800 - 2200 F)

19. University of Western Ontario
Faculty of Engineering Science
Materials Science Group
London, Ontario
C. Roy
J. S. Sheasby (519) 679-3302
Programs:
1. Stress generation during oxidation of zirconium alloys
2. Effects of growth stresses on oxide morphology for zirconium alloys
3. High-temperature corrosion resistant coatings for zirconium alloys
4. Effect of surface orientation of the metal substrate on the oxide film growth
5. High-temperature oxidation behavior of niobium
6. Lower oxide formation during oxidation reactions
7. Electrical properties of oxides during formation on a metal

DENMARK

20. Universität von Kopenhagen, Kemisk Lab. IV
Copenhagen
N. F. Grönlund
Research Areas:
1.1, 1.2

FRANCE

21. Centre d'Etudes Nucléaires de Saclay
Service de Chimie des Solides
Boîte Postale N° 6
92 Fontenay-aux-Roses
R. Darras
J. Paidassi
Research Areas:
1.3

22. Centre National de la Recherche Scientifique
15 Rue Georges Urbain
94 Vitry-sur-Seine
P. Lehr
Research Areas:
1.1, 2.1, 2.2, 2.3

23. Centre de Recherches Métallurgiques de l'Ecole des Mines
60, Boulevard Saint-Michel
75 Paris V°
P. Lacombe
G. Beranger
Research Areas:
1.2

24. Centre de Recherches de la Société Métallurgique d'Imphy
Imphy-58
P. Legendre
Research Areas:
2.1, 2.2, 2.3

25. Ecole Centrale des Arts et Manufactures
Centre Recherche Physique
1 Rue Mongolfier
Paris 3e
Gregoire
Research Areas:
2.3

26. Ecole des Mines
Laboratoire de Chimie-Metallurgie
Parc de Saurupt
54 Nancy
Roux
Slama
Research Areas:
1.1, 1.3

27. Ecole Nationale Supérieure de Chimie de Paris
47 Rue des Ecoles
75 Paris 5°
J. Benard (See also #42)
J. Oudar
Research Areas.
1.2, 2.2

28. Ecole Nationale Superieure Electrochimie et Electrometallurgie
39-41 Boulevard Gambetta et Rue Hoche
38 Grenoble
Besson
Research Areas:
1.2, 1.3

29. Forges et Aciéries du Saut du Tarn
6 avenue de Messine
75-Paris 8eme
M. Mailhos
Research Areas:
2.2

30. Institut de Recherches de la Siderurgie
185 Rue du Président-Roosevelt
78 St.-Germain-en-Laye
J. Manenc
Research Areas:
1.3, 2.2

31. Laboratoire de Recherche sur la Réactivite des Solides associés au CNRS
21 Rue Monge
21 Dijon
P. Barret
Research Areas:
1.1, 1.3

32. Office National d'Etudes et de Recherches Aérospatiales-ONERA
29, Avenue de la Division Leclerc
92 Chatillon-sous-Bagneux
P. Galmiche
A. Hivert
R. Pichoir
G. Slodzian
H. Bückle
Research Areas:
1.1, 1.3, 2.1, 2.2

33. Société Nationale d'Etudes et de Construction de Moteurs Aéronautiques-SNECMA, Laboratoire Central-Usine d'Evry-Corbeil
Boite Postale N° 56
91 Corbeil
Brunetaud
Ferre
Research Areas:
2.2, 2.3

34. Société Nationale Industrielle Aérospatiale-SNIAS
Laboratoire Central
Rue de l'Industrie
92 Courbevoie
Sertour
Research Areas:
2.2

35. Société Ugine-Kuhlmann
Laboratoire de Venthon
73 Albertville
J. P. Givord
Research Areas:
2.2

36. Trefimetaux G. P.
Département de Recherches Avancées
141 Rue Michel Carré
95 Argenteuil
Syre
Molinier
Research Areas:
2.1

37. Université d'Amiens
College Scientifique
18 Place St. Michel
80 Amiens
F. Marion
Programs:
1.1, 1.3

38. Université de Lyon
69 Lyon
Uzan
Research Areas:
1.3

39. Université de Marseille
Laboratoire de Chimie Generale
Lab. de Cristallographie
13 Marseille
M. Lafitte
Dreschler
Research Areas:
1.1, 1.3, 2.3

40. Université de Nancy
Laboratoire de Chimie Minérale
13 Place Carnot
54 Nancy
Vigne
Research Areas:
1.3, 2.2, 2.3

41. Université d'Orleans
Labor de Chimie des Solides
21 Rue Saint-Etienne
45 Orleans-la-Source
J. Bardolle
Research Areas:
1.1, 1.3

42. Université de Paris
Lab. de Chimie
47 Rue des Ecoles
Paris 5e
J. Benard
J. Oudar (See also #27)
Research Areas:
1.1, 1.3

43. Université de Poitiers
Laboratoire de Chimie
5 Cité de la Traverse
Poitiers
G. Valensi
Research Areas:
1.1, 1.2, 1.3

44. Université de Tours
Laboratoire Chimie Generale et Minerale
1 bis Boulevard Tonnellé
37 Tours
P. Belin
Research Areas:
1.1, 1.3

GERMANY

45. August Thyssen-Hütte AG
41 Duisburg-Hamborn
Kaiser-Wilhelm-Str. 100
Ch. Strassburger
Research Areas:
2.3

46. Babcock-Werke
Forschung und Entwicklung
42 Oberhausen
Postf. 34/35
H. Jahn
H. Büskens
Research Areas:
2.3

47. Battelle-Institut e.V.
6000 Frankfurt/Main 90
Postschliessfach 900/60
H. Ahlborn
Programs:
1. Oxidation resistance of high-temperature alloys containing special additions

48. Berliner Kraft- und Licht-AG, BEWAG
1 Berlin 30
Stauffenbergstr. 26
K. Wickert
Research Areas:
1.3, 1.5, 3.1

49. Brown, Boveri & Cie
Zentralstelle für Werkstofftechnik
68 Mannheim 1
Postfach 351
H. Möller
Research Areas:
1.1, 1.3, 2.2, 2.3, 3.1, 3.4

50. Dechema-Institut
6 Frankfurt
Rheingau-Allee 25
Dr. A. Rahmel
Programs:
1. High-temperature oxidation of iron and steels
2. Electrochemical studies of corrosion in alkali-sulfate and V_2O_5 melts.

51. Deutsche Edelstahlwerke AG
415 Krefeld
Oberschlesienstr. 16
Dr. K. Bungardt
Dr. G. Lennartz
Research Areas:
1.3, 2.2, 2.3

52. Edelstahlwerk Witten AG
581 Witten
Postfach 1369
J. Bruch
Research Areas:
2.1, 2.3

53. Forschungsvereinigung Verbrennungskraftmaschinen
6 Frankfurt-Niederrad 1
Lyoner Strasse
F. Umland
W. Möller
Research Areas:
1.1, 1.3, 2.1, 2.3, 3.1, 3.4

54. Hamburgische Elektrizitätswerke
2 Hamburg 1
Gerhart-Hauptmann-Platz 48
Pfeiffer
Research Areas:
1.1, 1.2, 1.3, 2.3

55. International Nickel Deutschland GmbH
4 Düsseldorf
Kreuzstr. 34
R. Ergang
W. Herder
Research Areas:
2.3

56. Kraftwerk Union AG
433 Mülheim (Ruhr)
Postfach 1420
H. Schieferstein
Research Areas:
2.2, 2.3, 3.4

57. L. u. C. Steinmüller GmbH
Mat.-Prüfanstalt
527 Gummersbach
S. Pollmann
Research Areas:
1.3, 1.5, 2.2, 2.3

58. Mannesmann-Forchungsinstitut GmbH
41 Duisburg-Wanheim
Schwenk
Research Areas:
1.2, 1.3, 2.3

59. Max-Planck-Institut für Eisenforschung
4 Düsseldorf
Max-Planck-Str. 1
Bohnenkamp
Research Areas:
1.2, 1.3, 2.3

60. Max-Planck-Institut für Physikalische Chemie
34 Göttingen
Bunsenstr. 10
Prof. Carl Wagner
Research Areas:
1.1, 1.2, 1.3

61. Max-Planck-Institut für Metallforschung
7 Stuttgart 1
Seestr. 75
Dr. H. J. Engell
H. J. Grabke
Research Areas:
1.1, 1.2, 1.3, 2.1, 2.2, 2.3

62. Stahlwerke Südwestfalen AG
Hüttental
5903 Geisweid/Kr. Siegen
W. Wesseling
F. W. Frantes
Research Areas:
2.1, 2.3

63. Technischer Überwachungsverein Bayern e.V.
8 München 23
Kaiserstr. 14
K. Köhler
Baumann
Research Areas:
2.2, 2.3

64. Technischer Überwachungsverein Essen e.V.
43 Essen
Steubenstr. 53
Baatz
Hermann
Research Areas:
2.2, 2.3, 3.1

65. Thyssen Röhrenwerke AG
Metallurg. Abteilung
4 Düsseldorf
Höherweg 271 a
E. Kranz
Research Areas:
1.1, 2.1, 2.3

66. Universität Bonn
Mineralogisch-Petrologisches Institut
53 Bonn 1
Liebfrauenweg 3
A. Neuhaus
N. Gebhardt
Research Areas:
1.1, 1.3, 2.2, 2.3

67. Universität Dortmund
Institut für Physikalische Chemie
46 Dortmund
August-Schmidt-Strasse
H. Rickert
Research Areas:
1.1, 1.2, 1.3

68. Universität Karlsruhe
Institut für Chemische Technik
75 Karlsruhe
Kaiserstrasse 12
Dr. E. Fitzer
Programs:
1. Formation of SiO_2 glass layers by oxidation of WSi_2, $MoSi_2$, SiC and Si_3N_4; kinetics of the oxidation and the oxygen diffusion through the glass as the controlling step
2. Kinetics of the reactions of the silicon-donors with base alloys; diffusion of silicon in Me_5Si_3-phases; diffusion of basic alloy components to the oxide-forming layers. The following diffusion couples are studied: $MoSi_2$/Mo, $MoSi_2$Nb, $MoSi_2$/Ta, $NbSi_2$Mo, $NbSi_2$Nb, WSi_2/Mo, WSi_2/Nb, WSi_2/W, Mo_5Si_3/Ta_5Si_3, Mo_5Si_3/Nb_5Si_3, W_5Si_3/Nb_5Si_3, Ta/Cr, Nb/Cr, Ta/NiCr, Nb/NiCr
3. Applied research on the formation of Si-donors on high temperature alloys (for example hot pressing, vapor plating)
4. Basic research on reactions of refractory silicides with nitrogen; exploration of such compounds as diffusion barriers on Cr-alloys against nitrogen absorption
5. Mechanical properties and recrystallizatior behavior of SiO_2-forming compounds at high temperatures
6. Compatibility of SiO_2 and Si-donors with oxides of the basic alloys; modifications of SiO_2-forming compounds by borides and germanides; oxidation kinetics and sintering mechanisms; transport mechanisms in such complex oxides

69. Universtät Münster
Institut für Metallforschung
Lehrstuhl für Anorganische Analytische Chemie
44 Münster
Schlossplatz 2
F. Umland
Th. Heumann
Research Areas:
1.1, 1.2, 1.3, 2.3, 3.1

70. Verein Deutscher Eisenhüttenleute e.V.
4 Düsseldorf
Breite Str. 27
W. Schlüter
Research Areas:
1.1, 1.2, 2.1, 2.2, 2.3

71. Vereinigung der Grosskesselbetreiber
43 Essen
Kurfürstenstr. 27
H. Kirsch
Research Areas:
2.3, 3.1

72. Vereinigte Kesselwerke AG
4 Düsseldorf
Werdener Str. 3
Steller
Research Areas:
2.3, 3.4

ITALY

74. Arsenale Meccanico Nucleare
Piazza Carignano 2
Genoa
L. Boselli
Research Areas:
1.2, 1.3

74. Centro Sperimentale Metallurgico S.p.A. sede legale
Via di Castel Romano
Roma
G. Bando
Research Areas:
1.1, 1.2, 2.1, 2.2, 2.3

75. ENTE Nazionale Per l'Energia Elettrica
Via Giovan Battista Martini
Roma
P. Sturla
Research Areas:
2.2, 2.3, 3.1, 3.4

76. Istituto Metalli Leggeri-Comitatuto Corrosioni
Via S. Giovanni sul Muro n. 9
Milano
Rossi
Research Areas:
2.3

77. Laboratorio FIAT
Stabilemento Grandi Motori
Corso G. Agnelli 200
Torino
C. Simonetti
Research Areas:
2.3

78. SNAM Progetti
Laboratorio Rinuti Studi e Ricerche
S. Donato Milanese
Milano
C. Verga
Research Areas:
2.3

79. Università di Bologna
Istituto di Metallurgia
Viale Risorgimento, 4
Prof. Paolo Spinedi
Programs:
1. Oxidation of metals in dry oxygen by means of spectrometric and thermogravimetric methods

80. Università di Pisa
Istituto di Chimica Industriale e Applicata
Pisa
M. Baccaredda
Research Areas:
1.3

NETHERLANDS

81. Laboratory for Thermal Power Engineering
Group Combustion Technology and Steamboilers
Rotterdamseweg 139A
Delft
H. van Stia
Programs:
1. Studies of the formation and suppression of V_2O_5-corrosion in fuel-oil fired steamboilers

82. N. V. tot Keuring van Electrotechnische Materialen (N. V. KEMA)
Arnhem
J. H. N. Jelgersma
A. J. Elshout

Research Areas:
1.1, 2.3, 3.1

83. Technische Hogeschool Twente
PO Box 217
Enschede
P. J. Gellins
Research Areas:
1.1, 1.3, 2.3

NORWAY

84. Norges Tekniske Hogskole - NTH
Dep. of Metallurgy
Trondheim
A. B. Winterbottom
Research Areas:
1.1, 1.3

85. Sentralinstitutt for Industriell Forskning - SI
Blindern
Oslo 3
Forskningsveien 1
P. Kofstad
J. Kvernes
Research Areas:
1.1, 1.2, 1.3, 2.1, 2.2, 2.3

SPAIN

86. Celulosas De Huelva, S.A. Madrid
M. R. Ortega
Research Areas:
2.3, 3.1, 3.4

87. Compania Iberica Rafinadora De Petroleos, S.A.
Madrid
Research Areas:
2.1, 2.3, 3.1, 3.4

88. Esso Petroleos Espanoles, S.A.
Madrid
L. A. Lonez
M. A. Quintana
Research Areas:
2.1, 2.3, 3.1, 3.4

89. La Maquinista Terrestre y Maritima, S.A.
Barcelona
Research Areas:
2.3, 3.1, 3.4

UNITED KINGDOM

90. Admiralty Materials Laboratory
Holton Heath
Poole
Dorset
BH16 6JU
J. F. Conde Lytchett Minster 711
Programs:
1. Study of the phenomenon and mechanism of high temperature sulfidation corrosion in marine gas turbines
2. Studies of alloys and coatings using a low pressure combustion rig
3. Kinetic and other basic investigations

91. Associated Octel Co. Ltd.
Research and Engineering Dept.
P. O. Box 17
Ellesmere Port
Cheshire
W. E. Cowley
Research Areas:
2.1, 2.3

92. Atomic Energy Research Establishment
Harwell
Didcot
Berks
Dr. J. E. Antill **Abingdon 4141 Ext. 4454**
Programs:
1. Kinetics of the corrosion of metals and ceramics by gases. Particular interests include carburization phenomena and generation of stress by corrosion.
1.1, 2.1, 2.3

93. Babcock, Wilcox (Operations) Ltd.
High Street
Renfrew
Scotland
G. G. Foster
Research Areas:
2.3

94. Berkeley Nuclear Lab., C.E.G.B.
Materials Div.
Berkeley
Gloucestershire
P. P. Jennings
Research Areas:
1.1, 1.2, 1.3, 2.1, 2.2, 2.3

95. British Steel Corp.
Midland Group, Research and Development Dep.
Swinden Laboratories
Moorgate,
Rotherham
A. Nicholson
A. M. Edwards
Research Areas:
1.1, 2.3

96. Brown-Firth, Research Lab.
Attercliffe Road
Sheffield S 4 7VY
J. E. Truman
Research Areas:
2.3

97. Central Electricity Research Lab., C.E.G.B.
Kelvin Avenue
Leatherhead
Surrey
A. B. Hart
D. de G. Jones
D. R. Holmes
W. D. Halstead Leatherhead 4488
Programs:
1. Thermodynamic studies of high temperature corrosion processes
2. Vapor and decomposition pressures of alkali metal sulfates; their vapor and condensed phase reactions. Also those of Fe, Cr, and Ni sulfates, sulfides, V oxides, and mixed sulfates of the type $Na_3Fe(SO_4)_3$.
Research Areas:
1.2, 1.4, 1.5, 2.1, 2.2, 2.3, 3.4

98. The City University
St. John Street
London EC 1
A. C. C. Tseung
Research Areas:
1.3, 2.3

99. Cranfield Institute of Technology (Ex. Glasgow University)
Department of Materials
Cranfield
Bedfordshire
Dr. P. Hancock 0234 51551
Programs:
1. Mechanical properties of surface oxides
2. Influence of surface scales on mechanical properties of underlying metals
3. Effect of gaseous contamination on scaling

100. Fulmer Research Institute Ltd.
Stoke Poges
Buckinghamshire
M. A. P. Dewey Fulmer 2181
Programs:
1. Development of oxidation and sulfidation resistant cobalt and nickel alloys
2. Mechanism of sulfidation attack
3. Physical chemistry of sulfidation

101. Henry Wiggin & Co. Ltd.
Hereford
Dr. J. Heslop Hereford 6461
Programs:
1. High-temperature alloy development
2. Gaseous corrosion

102. Hirst Research Centre, G.E.C. Ltd.
East Lane
North Wembley
Middlesex
D. S. Evans
Research Areas:
1.1, 1.2, 1.3, 2.1, 2.3

103. International Combustion Ltd.
Derby, DE 2, 9 GT
Ashley
Research Areas:
2.1, 2.3

104. International Nickel Ltd.
Research and Development Lab.
Wiggin Street
Birmingham 16
E. G. Richards
Henry Lewis
R. A. Smith 021-454-4871
Programs:
1. Development of new alloys resistant to high-temperature corrosion
2.3

105. University of Leeds
Dep. Metallurgy
The Houldsworth School of Applied Science
Leeds 2
J. C. Scully
Research Areas:
1.3

106. University of Liverpool
Dep. Metallurgy and Materials Science
P. O. Box 147
Liverpool L693BX

Prof. John Stringer 051-709-6022
Programs:
1. Oxidation of tantalum, niobium, and dilute alloys based on these metals
2. Oxidation and sulfidation of cobalt-base superalloys
3. Scale fracture mechanisms
4. Morphologies of oxide scales
5. Stress generation and relief in growing oxide scales

107. University of Manchester
Institute of Science and Technology
Chem. Eng.
P. O. Box No. 88, Sackville St.
Manchester M60 1QD
J. K. Ross
G. C. Wood 061-236 3311
I. A. Menzies 061-236 3311
Programs:
1. Kinetics, nucleation and growth; structure of oxide scales
2. Oxidation under wear conditions
3. Stress and hardness measurements
4. Cyclic oxidation
5. Cr and Al diffusion coatings
6. Mechanical properties of oxides
7. Sulfidation of Ni-based alloys

108. University of Manchester
Institute of Science and Technology
Metallurgy
P. O. Box No. 88, Sackville St.
Manchester M60 1QD
R. Rolls
Research Areas:
1.3, 2.2, 2.3

109. Marchwood Eng. Lab., C.E.G.B.
Marchwood
Southampton
Hants
P. J. Jackson
Research Areas:
2.3, 3.1

110. Midlands Region, C.E.G.B.
Scientific Services Department
Hams Hall
Birmingham
L. H. Toft
Research Areas:
2.3, 3.4

111. National Gas Turbine Establishment
Pyestock
Farnborough
Hants
A. Burwood-Smith
J. F. Northwood
M. J. Weaver
Programs:
1. Effect of alloy composition and microstructure on oxidation

112. National Physical Laboratory
Teddington
Middlesex
G. O. Lloyd 01-977 3222
Programs:
1. Microstructural studies of breakaway oxidation on chromium-iron alloys
2. Hot salt corrosion of nickel-based superalloys

113. University of Newcastle Upon Tyne
Dep. Metallurgy
Newcastle-upon-Tyne, 1
R. F. Tylecote
D. Maxwell
Research Areas:
1.3

114. Nuclear Design and Construction Ltd.
Cambridge Road
Whetstone
Leicester
D. Goodison
Research Areas:
1.3, 2.2, 2.3, 3.1, 3.4

115. N. W. Region, C.E.G.B.
Scientific Services Department
825 Wilmslow Road
East Didsbury
Manchester
M. Fountain
Research Areas:
1.2, 2.2, 2.3, 3.1

116. Rolls Royce Ltd.
Bristol Engine Division
P. O. Box 3
Filton
Bristol
G. Llewellyn
D. W. Hall
Research Areas:
2.2, 2.3

117. University of Sheffield
Dep. Metallurgy
St. George's Square
Sheffield S13JD
Dr. N. Birks 78555
Programs:
1. Oxidation of metals and alloys in complex alloys

118. Shell Research Ltd.
Thornton Research Centre
P. O. Box 1
Chester
R. W. Wilson
Research Areas:
1.2, 1.3, 2.2, 2.3, 3.1, 3.4

UNITED STATES

119. Aerospace Research Laboratories
Metallurgy and Ceramics Research Laboratory
Building 450 (ARZ)
Wright-Patterson Air Force Base, Ohio 45433
Dr. N. M. Tallan (513) 255-4402
Dr. H. C. Graham
Programs:
1. Oxidation of ZrB_2, ZrB_2-SiC, and ZrB_2-SiC-C compositions
2. Oxidation of dispersion-strengthened Ni-Cr alloys
3. Oxidation/vaporization of Cr_2O_3
4. Effect of rare earth additions on oxidation of Ni-Cr-Al alloys
5. Oxidation of coated columbium-based alloys
6. High temperature oxidation of alloys containing Mo and/or W
7. Sulfidation and hot corrosion
8. Diffusion in oxide scales.

120. AiResearch Manufacturing Company of Arizona
Division of The Garrett Corp.
402 South 36th Street
Phoenix, Arizona 85034
M. S. Roush (602) 267-2650
Programs:
1. Evaluation of seven commercial protective coatings for resistance to hot corrosion
2. Investigation of repair of diffusion coatings on turbine components
3. Investigation of the relative hot-corrosion resistance of uncoated and coated IN-738, IN-792, MAR-M 432, MAR-M 509, as compared with IN-100 and Alloy 713LC

121. Air Force Institute of Technology
Civil Engineering School
Wright-Patterson Air Force Base, Ohio 45433
Dr. James R. Myers (513) 255-3569
Programs:
1. Coatings for superalloys in gas turbine engines
2. Oxidation of ultra-pure cobalt at selected oxygen pressures over the temperature range 950 - 1250 C
3. The oxidation of René 41 and thoriated nickel filaments

122. Avco Corporation
Systems Division
Materials Sciences Dept.
Lowell Industrial Park
Lowell, Massachusetts 01851
Dr. Warren C. Steele (617) 452-8961
Programs:
1. Kinetics of gas-surface reactions (Reactions of refractory metals or coated metals with high temperature air species)
2. Graphite oxidation

123. Avco Lycoming Division
Materials Laboratories Dept.
550 So. Main Street
Stratford, Connecticut 06497
Dr. William R. Freeman, Jr. (203) 378-8211
Programs:
1. Evaluation of promising sulfidation resistant nickel-base superalloys
2. Effect of time, sulfur content, NaCl content, temperature, and alloy composition on depth of attack
3. Effect of vanadium and NaCl on corrosion rate

124. Battelle Memorial Institute
Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201
Dr. R. I. Jaffee (614) 299-3151 Ext. 1536
E. S. Bartlett (614) 299-3151 Ext. 2873
Dr. B. A. Wilcox (614) 299-3151 Ext. 2360
Programs:
1. Oxidation of superalloys, particularly cobalt-base alloys, and dispersion strengthened nickel-base alloys, such as TD NiC and TD NiCrAl
2. Studies on the effects of ThO_2 and rare earth metals and their oxides on oxidation mechanisms in nickel and cobalt alloys
3. Diffusion studies of metals in oxides and alloys. Cr^{+3} in NiO and NiCr and Al^{+3} in TD NiCrAl alloys
4. Creep in oxides
5. Plasticity in scales
6. Oxidation of tantalum, columbium, and their alloys
7. Evaluation of coated refractory materials
8. Degradation and reuse of radiative thermal protection system materials for the space shuttle (includes study of tolerance of columbium alloys for coating defects; e.g., oxygen contamination/mechanical property degradation kinetics, coating/substrate oxidation interaction, and catastrophic oxidation)

125. Bell Telephone Laboratories
Dept. of Metallurgical Engineering
Room 1A-106
Murray Hill, New Jersey 07974
Dr. J. H. Swisher (201) 582-4601
Programs:
1. Internal oxidation as a means of dispersion strengthening alloys for high-temperature cations
2. Surface oxidation of Ni-Fe alloys containing small Si and Mn additions. Controlled surface oxidation required for electrical contacts
3. Corrosion in thin film metallization

126. Bendix Research Laboratories
Materials and Processes Dept.
16-1/2 Mile Road
Southfield, Michigan 48075
S. K. Rhee (313) 352-7630
Programs:
1. Oxidation of commercial high-temperature alloys

127. Bureau of Mines
Materials Science Projects
Albany Metallurgy Research Center
P.O. Box 70
Albany, Oregon 97321
Dr. Arne Landsberg (503) 926-5811
Dr. Laurance L. Oden (503 926-5811
Programs:
1. Chlorination of gold
2. Chlorination of platinum
3. Chlorination of tungsten, molybdenum and their binary alloys
4. Materials for construction of high temperature chlorinators (under which title the corrosion of the alkaline earth fluorides in typical industrial chlorination environments was investigated)

128. Cabot Corporation
Stellite Division
Technology Dept.
1020 W. Park Avenue
Kokomo, Indiana 46901
Dr. S. T. Wlodek (317) 457-8411 Ext. 624
Programs:
1. Development of high strength Ni- and Co-base alloys with good oxidation/hot corrosion resistance
2. Evaluation of commercial Ni- and Co-base alloys in oxidation/hot corrosion
3. Development of alloys for carbonizing/oxidizing service
4. Processing techniques for highly alloyed oxidation resistant compositions

129. Clemson University
College of Engineering
Clemson, South Carolina 29631
Dr. James S. Wolf
Programs:
1. The role of self-generated scale stresses in the high-temperature oxidation of metals

130. Connecticut, University of
Department of Metallurgy
Storrs, Connecticut 06268
Dr. D. E. Devereux (203) 429-3311 Ext. 1273
Prof. N. D. Greene (203) 429-3311 Ext. 1273
Programs:
1. Effect of oxide contaminants on oxidation of silicon
2. Oxidation of lanthanide metals

131. Curtiss-Wright Corporation
Materials Engineering Dept.
One Passaic Street
Wood-Ridge, New Jersey 07075
Dr. Sam Wolsin (201) 777-2000 Ext. 2709
Programs:
1. Evaluation of diffusion coatings for Udimet 700
2. Evaluation of diffusion coatings for IN-100
3. Evaluation of the relative oxidation-hot corrosion resistance of selected nickel- and cobalt-base superalloys
4. Development of improved diffusion coatings for nickel- and cobalt-base superalloys

132. Dayton, University of
Research Institute
High Temperature Materials Engineering Group
Dayton, Ohio 45409
Dr. Dennis Gerdeman (613) 229-2517
Programs:
1. Creep of coated and uncoated Ta-222 (current)
2. Repairability of slurry silicide coatings (inactive)

133. Delaware, University of
Department of Chemical Engineering
Newark, Delaware 19711
Prof. C. E. Birchenall
Programs:
1. Diffusion of Fe^{55} in Cr_2O_3
2. Self-diffusion of iron in ferrous sulfide

134. Denver, University of
Metallurgy and Materials Science Division
Denver Research Institute
University Park
Denver, Colorado 80210
Dr. Albert S. Yamamoto (303) 753-2621
Programs:
1. Development of Ni-Cr-W alloys with emphasis on improved oxidation and sulfidation resistance (recently completed)

135. Florida, University of
Dept. of Metallurgical and Materials Engineering
Center for Applied Thermodynamics and Corrosion
Gainesville, Florida 32601
E. N. Rhines (904) 392-1451
E. D. Verink (904) 392-1451
Programs:
1. Oxidation of nickel
2. Surface films

136. Ford Motor Company
Materials Development Dept.
Turbine Operations
20000 Rotunda Drive
Dearborn, Michigan 48121
Yesh P. Telang (313) 32-31612
Warren A. Rentz (313) 33-75316
Programs:
1. Development of high-temperature nickel- and cobalt-base alloys and determination of their properties
2. Improved sulfidation resistant coatings for nickel-base alloys

137. General Electric Company
Materials and Processes Laboratory
Schenectady, New York 12305
Dr. Chester T. Sims (518) 374-2211
Ext. 5-3079, 5-9223
Gerald Wasielewski
Programs:
1. Development of nickel- and cobalt-base alloys for industrial gas turbines
2. Correlation of oxidation/corrosion test data with service life for superalloys and steels
3. Development of hot-corrosion resistant alloys for marine gas turbines (Navy/MEL)
4. Study of fuel treatments for residual fuels
5. Materials developments for hot-stage use in residual fuel marine industrial turbines

138. General Electric Company
Material and Process Technology Laboratories
Thomson Laboratory
1000 Western Ave.
Lynn, Massachusetts 01905
Dr. M. Kaufman (617) 594-5156
E. J. Beltran
Programs:
1. Hot corrosion behavior of nickel- and cobalt-base superalloys and protective coatings in simulated marine and industrial environments

139. General Electric Company
Oxidation/Corrosion Laboratory
Materials Development Engineering
Gas Turbine Department #53-337
Schenectady, New York 12305
Harvey von E. Doering (518) 374-2211
Ext. 54311
Programs:
1. Development of high temperature (1400 - 2000 oxidation data for design properties
2. Evaluation of nickel- and cobalt-base alloys and coatings in crude and residual fuels
3. Evaluation of nickel- and cobalt-base alloys and coatings in hot corrosion
4. Evaluation of corrosion inhibiting additives for vanadium bearing fuels

140. General Electric Company
Research and Development Center
Metallurgy and Ceramics Laboratory
P.O. Box 8
Schenectady, New York 12301
Dr. C. S. Tedmon Jr. (518) 346-8771
Dr. H. S. Spacil (518) 346-8711
Dr. Alan U. Seybolt (518) 346-8771
Programs:
1. Thermodynamics and kinetics of corrosion of gas turbine alloys burning impure fuel
2. Research on mechanisms of hot corrosion

141. General Electric Company
Materials and Process Technology Laboratory
Aircraft Engine Group
Building 500-M87
Cincinnati, Ohio 45215
Dr. William C. Hagel
C. S. Wukusick
Programs:
1. Hot corrosion and oxidation of superalloys

142. General Electric Company
Materials and Processes Laboratory
Aircraft Engine Group
Evendale, Ohio 45218
Dr. R. E. Allen (513) 243-6738

Programs:
1. Strengthening of FeCrAlY oxidation resistant alloys
2. The influence of high velocity (Mach 0.5-1.0) gases on surface stability in high-temperature alloys
3. Oxidation resistance and coating development for high strength Cr alloys
4. Coating development for TD NiCr
5. The influence of small quantities of rare earth elements on the oxidation resistance of Ni-base superalloys

143. IIT Research Institute
Metals Division
10 West 35th Street
Chicago, Illinois 60616
Dr. V. L. Hill (312) 225-9630
Programs:
1. Development of oxidation-resistant hafnium-base alloys (current)
2. Investigation of refractory metal composites for liquid rocket engines (oxidation-corrosion in O_2, F_2, HF, BF_5 and their combinations) (current)
3. Ductile claddings for dispersion-strengthened nickel-base alloys (oxidation of Ni-Cr-Al-Y, Ni-Cr-Ta-Y, and Fe-Cr-Al-Y Alloys) (Completed)

144. The International Nickel Company, Inc.
Paul D. Merica Research Laboratory
Materials Systems Section
Sterling Forest
Suffern, New York 10901
Dr. J. W. Schultz (914) 735-2761
Programs:
1. Improved test methods for hot-corrosion and oxidation
2. Effects of alloy composition on hot corrosion and oxidation resistance of nickel-base alloys

145. Little, A. D., Inc.
R&D Division, Materials Section
Cambridge, Massachusetts 02140
Dr. Joan B. Berkowitz (617) 864-5770 Ext. 2913
Programs:
1. Effects of electric fields on hot corrosion in conducting flames

146. Lockheed Missiles & Space Company
Palo Alto Research Laboratories
Metallurgy and Composites, D/52-31, B/204
3251 Hanover Street
Palo Alto, California 94304
Dr. T. E. Tietz (415) 324-3311 Ext. 45678
R. A. Perkins (415) 324-3311 Ext. 45740
C. M. Packer (415) 324-3311 Ext. 45286
Programs:
1. Stability characterization of refractory materials under high velocity flight conditions (Air Force)
2. Nitridation resistant chromium alloys (NASA)
3. Coatings for tantalum alloys (NASA)
4. Environmental stability of high temperature alloys (IR&D)

147. Los Alamos Scientific Laboratory
Group N-1
P.O. Box 1663
Los Alamos, New Mexico 87544
Dr. R. J. Fries (505) 667-6322
Programs:
1. Chemical diffusion coefficients of carbon in the Group VI refractory metals as determined from carbide layer growth rates
2. Carbide layer growth rates of W/Mo and W/Re alloys
3. Evaporation rates of refractory metals

148. Manlabs, Inc.
21 Erie Street
Cambridge, Massachusetts 02139
Dr. L. Kaufman
Programs:
1. Stability characterization of refractory materials under high velocity atmospheric flight conditions
2. Development of boride composites for oxidation resistant components

149. Massachusetts Institute of Technology
Corrosion Laboratory
Room 8-202
Cambridge, Massachusetts 02139
Prof. Herbert H. Uhlig (617) 864-6900 Ext. 3313
Programs:
1. Initial oxidation of single crystal copper (150-250 C)

150. Michigan, University of
Department of Chemical and Metallurgical Engineering
Ann Arbor, Michigan 48104
Prof. Lawrence H. Van Vlack (313) 764-2385
Programs:
1. Oxide subscales in binary iron alloys
2. Scale and subscale formation in alloys of iron with Group VIB elements

151. NASA-Lewis Research Center
Coating Section, 49-1
21000 Brookpark Road
Cleveland, Ohio 44135
Salvatore J. Grisaffee (216) 433-4000 Ext. 393
Programs:
1. Pack and slurry coatings for superalloys and dispersion strengthened materials
2. Alloy claddings for superalloys and dispersion-strengthened metals
3. Oxidation behavior of coatings and metal claddings
4. Characterization of coatings and metal claddings
5. Development and evaluation of slurry coatings for refractory metals
6. Coatings for high performance rocket engines
7. Hot corrosion of alloys

152. NASA Lewis Research Center
Oxidation and Refractory Compounds Section, 49-1
21000 Brookpark Road
Cleveland, Ohio 44135
Dr. H. B. Probst (216) 433-4000 Ext. 267
Programs:
1. Oxidation of TD Nickel-Chromium
   Surface preparation effects
   Velocity effects
   Pressure effects
   Scale topology
   Hot corrosion
2. Oxidation mechanisms and kinetics in the Ni-Al, Ni-Al-Cr, Ni-Al-Ti, and Ni-Al-Si systems
3. Simulated turbine engine oxidation of commercial cast Ni-base superalloys
4. Vaporization of protective scales

5. Cyclic oxidation of Cr_2O_3 and Al_2O_3 forming alloys
6. Properties of spinels
7. Coating and cladding studies

154. National Bureau of Standards
Corrosion Section
Washington, D. C. 20234
Dr. J. Kruger (301) 921-2094
Programs:
1. Surface reactions and initial film formation

155. Naval Air Development Center
Mechanical Metallurgy Branch (MAMM-4)
Metallurgical Division
Aero Materials Department
Warminster, Pennsylvania 18974
Robert G. Mahorter (215) 672-9000 Ext. 2808
Programs:
1. Analyses of parts from engines subjected to naval aircraft service to determine the extent and severity of oxidation/corrosion problems
2. Studies of surface reaction kinetics with the objective of minimizing scale formation on heat resisting alloys
3. Development of NDT methods for detecting incipient hot corrosion

156. Naval Ship Research and Development Laboratory
Metals and Composites Division
Code A315
Annapolis, Maryland 21402
Walter L. Wheatfall, Sr. (301) 268-7711
Ext. 8205
Programs:
1. Hot corrosion behavior of recently developed nickel-base alloys in combustion products from diesel fuel
2. Oxidation behavior of nickel-base superalloys
3. Development of dispersion-strengthened cobalt-base alloys
4. Effect of fuel additives on hot-corrosion behavior of materials in combustion products of vanadium-bearing fuels plus ingested sea salt
5. Effect of alloying elements on hot-corrosion behavior of nickel-base alloys
6. Mechanism of hot corrosion

157. New York, State University of
Dept. of Materials Science
College of Engineering
Stony Brook L. I., New York 11790
Prof. L. Seigle
Programs:
1. Mechanism of oxidation of Ni-Al alloys

158. North American Rockwell Corp.
Science Center
Thousand Oaks, California 91360
Dr. Neil Paton (805) 498-4545
Programs:
1. Oxidation of thoria-dispersed nickel-base alloys
2. Hot salt stress corrosion of superalloys

159. Northwestern University
Department of Materials Science
The Technological Institute
Evanston, Illinois 60201
Prof J. Bruce Wagner, Jr.
Programs:
1. The diffusion of sulfur and also the diffusion of chlorine in single crystals of oxides

159. The Ohio State University
Dept. of Metallurgical Engineering
116 W. 19th Avenue
Columbus, Ohio 43210
Prof. Robert A. Rapp (614) 293-6178
Programs:
1. Oxidation of Ni-Cr-Al alloys at 1000-1200 C
2. Solubility and diffusivity of oxygen in solid nickel
3. Diffusion of chromium in nickel oxide
4. Control of oxygen activity in gaseous environments

160. Olin Corporation
Metals Research Laboratories
91 Shelton Avenue
New Haven, Connecticut 06511
Dr. M. J. Pryor
Programs:
1. High-temperature oxidation of copper-base alloys

161. Pennsylvania State University
Metallurgy Section
M. I. Building
University Park, Pennsylvania 16802
Prof. G. Simkovich (814) 865-3351
Programs:
1. Sulfidation of binary and ternary iron-base alloys
2. Oxidation of chromium-base alloys
3. Oxidation of cast irons
4. Oxidation and sulfidation of pure metals
5. Oxidation and simultaneous carburization of pure metals and alloys
6. Effect of gas solubilities in scales upon kinetics of oxidation and sulfidation

162. Pennsylvania, University of
School of Metallurgy and Materials Science
Philadelphia, Pennsylvania 19104
Prof. W. L. Worrell (215) 594-8592
Programs:
1. Kinetics of dissociation of $H_2S(g)$ on iron sulfide (FeS) at elevated temperatures
2. Nitridation of titanium at temperatures between 1200 and 1500 C
3. High-temperature corrosion of chromium and chromium-nickel alloys in SO_2/O_2 atmospheres

163 Phillips Petroleum Company
Research and Development Dept.
Phillips Research Center, Bldg. C-7
Bartlesville, Oklahoma 74003
R. M. Schirmer (918) 336-6600 Ext. 48-573
Programs:
1. Effect of sulfur in JP-5 fuel on hot corrosion of turbine blade materials in marine environment
2. Evaluation of protective coatings for resistance to hot corrosion
3. Effect of smoke-abatement additives in JP-5 fuel on hot corrosion of turbine blade materials
4. Development of turbine simulator for hot corrosion studies
5. Inhibition of hot corrosion of superalloys by fuel additives
6. Effect of pressure on hot corrosion of superalloys
7. Effect of vanadium in fuel on hot corrosion of superalloys
8. Effect of lead in fuel on hot corrosion of superalloys

164. Pratt & Whitney Aircraft
Division of United Aircraft Corp.
Advanced Materials Research and Development Laboratory
Middletown, Connecticut 06457
Dr. F. S. Pettit (302) 347-4401 Ext. 3189
Dr. G. W. Goward (302) 347-4401 Ext. 3189
Pratt & Whitney Aircraft Div.
East Hartford, Conn.
Dr. D. H. Boone
Programs:
1. Oxidation and hot corrosion (Na_2SO_4, etc.) of nickel- and cobalt-base alloys--development of more resistant alloys
2. Protective coatings for nickel- and cobalt-base alloys
3. Oxidation of uncoated and coated columbium-base alloys

165. Purdue University
School of Materials Science and Metallurgical Engineering
Lafayette, Indiana 47907
Prof. Richard E. Grace (317) 749-2601
Programs:
1. Transition kinetics during linear to parabolic oxidation of chromium (recently completed) Oxidation-sulfidation kinetics of iron (current)

166. Solar Division
International Harvester Company
Process Research Dept. (Mail Zone R-1)
2200 Pacific Highway
San Diego, California 92112
A. R. Stetson
Programs:
1. Castings for dispersion strengthened alloys--NAS3-14312
2. Fused slurry silicide coatings for Ta reentry heat shields--NAS3-14515
3. Evaluation of coatings for cobalt- and nickel-base superalloys--NAS3-9401
4. Silicide coatings for tantalum and columbium alloys--NAS3-9412 and NAS3-7276 (NASA CR-72519 and NASA CR-54529)
5. Hot corrosion of coated superalloys in a gas turbine environment, Contract No. N00019-68-C 0532 (Naval Air System Command AIR 53674)

167. Stanford Research Institute
Materials Sciences Laboratory
Menlo Park, California 94025
Dr. Daniel D. Cubicciotti (415) 326-6200
Programs:
1. Volatilization of metal oxides and thermodynamics of oxides
2. Hot salt corrosion
3. Reactions with salts and oxides

168. Stanford University
Mineral Engineering Dept.
Stanford, California 94305
Prof. R. W. Bartlett (415) 321-2300 Ext. 4470
Programs:
1. Solubility and diffusion of oxygen in platinum and the effect of other metals in platinum alloys on both internal oxidation and oxygen transport. The end applications are related to high temperature coatings based on platinum group metals. (current)

169. Sylvania Electric Products, Inc.
Chemical and Metallurgical Division
High Temperature Composites Laboratory
70 Cantiague Road
Hicksville, New York 11802
Lawrence Sama (516) 931-3500
Programs:
1. Development of protective coatings for columbium alloy gas turbine blades
2. Scale-up of fused silicide coatings for columbium alloy reentry heat shields

170. Systems Research Laboratories, Inc.
Physical Sciences Division
7001 Indian Ripple Road
Dayton, Ohio 45440
Dr. W. C. Tripp (513) 426-6000
Programs:
1. Electrical behavior of ceramic materials at high temperatures (includes study of defect structure and high temperature oxidation of metals and alloys)

171. TRW, Inc.
Equipment Group
23555 Euclid Avenue
Cleveland, Ohio 44117
Dr. J. V. Peck (216) 383-2967
Dr. R. J. Quigg
Programs:
1. Aluminide coatings on superalloys
2. Non-aluminide coatings for superalloys
3. Coatings for columbium
4. Basic corrosion of superalloys
5. Development of production manufacturing techniques for coating TD Ni
6. Development of repair and reprocess coating for Ni-base alloy turbine blades
7. Development of improved coatings for Ni- and Co-base alloys
8. Manufacturing techniques for W/Si-W coated tantalum

172. United Aircraft Research Laboratories
High Temperature Materials Research
400 Main Street
East Hartford, Connecticut 06108
Dr. Michael A. DeCrescente
N. Bornstein
Programs:
1. Sulfidation mechanisms
2. Mechanism of vanadium accelerated corrosion
3. High temperature oxidation

173. United States Steel Corporation
Applied Research Laboratory MS-16
P.O. Box 38
Monroeville, Pennsylvania 15146
Dr. W. E. Boggs (412) 372-1212
Dr. E. H. Phelps
Programs:
1. Investigation of the reactions between hot sulfur-containing gases and iron base alloys (current)
2. The modification and inhibition of oxide formed on steel in slab reheat furnaces (current)
3. Effects of alloying elements on the formation of protective oxide films on heat resistant steels (terminated 1970)
4. Evaluation of high-temperature oxidation performance of ferrous alloys
5. Development of coatings for oxidation resistance

174. United States Steel Corporation
Physical Chemistry Section
Edgar C. Bain Laboratory for Fundamental Research
Research Center
Monroeville, Pennsylvania 15146

Dr. Howard W. Pickering (412) 331-3100
Programs:
1. Transition from internal to external oxidation in binary and ternary alloys
2. Preferential attack of one component of binary alloys by an aggressive gas

176. University of California at Los Angeles
Materials Department
6531 Boelter Hall
Los Angeles, California 90024
Prof. D. L. Douglass (213) 825-1622
Programs:
1. Zirconium oxidation mechanism
2. Role of oxide plasticity on oxidation
3. Influence of rare earth metals on oxidation
4. Resistance of Ni-20Cr and Ni_3Al

176. Vanderbilt University
Dept. of Materials Science and Metallurgical Eng.
Nashville, Tenn. 37203
Prof. B. D. Lichter (613) 322-2415
Programs:
1. Hot corrosion mechanisms in Ni-Cr alloys and superalloys
2. Effect of rare-earth oxide additions on hot corrosion of Ni-Cr alloys

177. Westinghouse Electric Corp.
Astronuclear Laboratory
Metals Science Section
P.O. Box 10864
Pittsburgh, Pennsylvania 15236
Dr. R. C. Svedberg (412) 892-5600
Programs:
1. Investigation of the possibility of modifving the defect structure of parent oxides to enhance oxidation protection (NASC No. N00019-70-C-0148) (current)
2. Reactivity of some vanadium alloys with the interstitials oxygen, nitrogen, and carbon at low partial pressures (AEC Contract AT(30-1)-3791 (completed)
3. Evaluation of mechanical properties, oxidation resistance and structure of slurry-silicide coated T-222 (NASA-CR-72713) Contract No. NAS3-12410 (completed)
4. Development of ductile oxidation resistant columbium alloy (AFML-TR-69-64) Contract No. AF33615-67-C-1689 (completed)

178. Westinghouse Electric Corporation
Westinghouse Research Laboratories
Churchill Borough
Pittsburgh, Pennsylvania 15235
Dr. Earl A. Gulbransen (412) 256-3475 or 3482
Programs:
1. Vaporization chemistry in the oxidation of Cr, Si, Mo and Cb
2. Thermochemistry and the high temperature oxidation of Si and SiC
3. Thermochemistry and the reaction of metals with S and O gases
4. High temperature oxidation of refractory metals
5. Thermochemistry and the combustion of aluminum and zirconium

TABLE 2. CATEGORY INDEX

Category*	Code*	Organization (Number from Table 1)	Total
Thermodynamics, phase diagrams, reaction equilibria	1.1	1,3,5,6,13,14,19,20,22,26,27,31,32,37,39,41,42,43,44,49,53, 54,60,61,65,66,67,69,70,74,82,83,84,85,92,94,95,97,99, 100,102,106,107,119,124,129,130,135,147,152,155,156,159, 167,168,171,172,173,174,175,178	61
Electrochemical problems	1.2	1,14,20,23,28,43,50,54,58,59,60,61,67,69,70,73,74,85,94,97, 102,115,118,145	24
Reaction kinetics and diffusion processes	1.3	2,3,5,6,9,10,11,13,14,15,17,19,21,26,28,30,31,32,37,38,39, 40,41,42,43,44,48,49,51,53,54,57,58,59,60,61,66,67,68,69, 73,79,80,83,84,85,90,92,94,97,98,99,100,102,105,106,107, 108,112,113,114,117,118,119,121,122,124,125,127,130,133, 135,140,141,142,144,147,149,150,152,153,154,155,156,158, 159,161,162,165,167,171,172,173,174,175,177,178	97
Aerodynamic factors (mechanism of deposition)	1.4	97,146,148,152	4
Rheological investigations (viscosity of the melts)	1.5	48,57,97	3
Development of corrosion-resistant materials	2.1	2,18,22,24,32,36,47,52,53,61,62,65,70,74,85,87,88,91,92,94, 97,100,101,102,103,104,106,107,111,119,124,128,134,136, 137,142,143,146,148,155,176,177	42
Surface protection of materials	2.2	5,6,7,8,15,16,19,22,24,27,29,30,32,33,34,35,40,49,51,56,57, 61,63,64,66,68,70,74,75,85,90,94,97,107,108,114,115,116, 118,119,120,121,124,131,132,136,138,139,142,143,146,151 152,163,164,166,168,169,171,177	60
Material Behavior under corrosion	2.3	2,3,4,5,6,8,11,12,13,14,15,16,17,19,22,24,25,33,39,40,45, 46,47,49,50,51,52,53,54,55,56,57,58,59,61,62,63,64,65,66, 69,70,71,72,74,75,76,77,78,81,82,83,85,86,87,88,89,90,91, 92,93,94,95,96,97,98,99,101,102,103,104,106,107,108,109, 110,111,112,114,115,116,117,118,119,120,121,123,124,126, 127,128,131,137,138,139,140,141,143,144,146,150,151,152, 154,155,157,159,160,161,162,163,164,166,170,171,174,175, 176,177	119
Additives	3.1	48,49,53,64,69,71,75,82,86,87,88,89,109,114,115,118,139,163	18
Surface treatment of pipes, supports, and other parts of furnaces, boilers,, turbines, etc. exposed to high temperatures	3.4	2,7,49,53,56,72,75,86,87,88,89,97,110,114,118	15

*The categories and code numbers were selected to conform to those of the European Federation of Corrosion survey.

TABLE 3. NAME INDEX

Devereux, Dr. O.F.
University of Connecticut (130)

Dewey, M.A.P.
Fulmer Research Institute Ltd. (100)

Doering, Harvey von E.
General Electric Co. (139)

Douglass, Prof. D.L.
University of California at Los Angeles (175)

Dreschler,
Université de Marseille (39)

Edwards, A.M.
British Steel Corp. (95)

Elshout, A.J.
N.V. tot keuring van Electrotechnische Materialien (82)

Engell, Dr. H.J.
Max-Planck-Institut für Metallforschung (61)

Ergang, R.
International Nickel Deutschland GmbH (55)

Evans, D.S.
Hirst Research Centre, G.E.C. Ltd. (102)

Ferre,
SNECMA (33)

Fitzer, Dr. E.
Universität Karlsruhe (68)

Fountain, M.
N.W. Region C.E.G.B. (115)

Foster, G.G.
Babcock, Wilcox Ltd. (93)

Frantes, F.W.
Stahlwerke Südwestfalen AG (62)

Freeman, Dr. W.R. (Jr.)
Avco Lycoming (123)

Fries, Dr. R.J.
Los Alamos Scientific Laboratory (147)

Galmiche, P.
Office National d'Etudes et de Recherches (32)

Gebhardt, N.
Universität Bonn (66)

Gellins, P.J.
Technische Hogeschool Twente (83)

Gerdeman, Dr. Dennis
University of Dayton (132)

Givord, J.P.
Société Ugine-Kuhlmann (35)

Glaverbel, S.A.
Laboratoire Central (8)

Goodison, D.
Nuclear Design and Construction Ltd (114)

Goward, Dr. G.W.
Pratt & Whitney Aircraft (164)

Grabke, H.J.
Max-Planck-Institut für Metallforschung (610)

Grace, Prof. Richard E.
Purdue University (165)

Graham, Dr. H.C.
Aerospace Research Laboratories (119)

Greene, Prof. N.D.
University of Connecticut (130)

Gregoire,
Ecole Centrale des Arts et Manufactures (25)

Grisaffee, Salvatore J.
NASA-Lewis (151)

Grönlund, N.F.
Universität von Kopenhagen (20)

Gulbransen, Dr. Earl A.
Westinghouse Electric Corp. (178)

Habraken, L.
Centre de Recherches Metallurgiques (2)

Hagel, Dr. William C.
General Electric Co. (141)

Hall, D.W.
Rolls Royce Ltd. (116)

Halstead, W.D.
Central Electricity Research Lab., C.E.G.B. (97)

Hancock, Dr. P.
Cranfield Institute of Technology (99)

Hart, A.B.
Central Electricity Research Lab., C.E.G.B. (97)

Hermann,
Technischer Überwachungsverein Essen e.V. (64)

Heslop, Dr. J.
Henry Wiggin & Co. Ltd. (101)

Hestermans, P.
Institut Belge des Hautes Pressions (4)

Heumann, Th.
Universität Münster (69)

Hill, Dr. V.L.
IIT Research Institute (143)

Oudar, J.
Ecole Nationale Supérieure de Chimie de Paris (27) (42)

Packer, C.M.
Lockheed Missiles & Space Co. (146)

Paidassi, J.
Centre d'Etudes Nucléaires de Saclay (21)

Paton, Dr. Neil
North American Rockwell Corp. (157)

Paul, W.
Orenda Limited (16)

Peck, Dr. J.V.
TRW, Inc. (171)

Perkins, R.A.
Lockheed Missiles & Space Co. (146)

Pettit, Dr. F.S.
Pratt & Whitney Aircraft (164)

Pfeiffer,
Hamburgische Elektrizitatswerke (54)

Phelps, Dr. E.H.
U.S. Steel Corp. (173)

Pichoir, R.
Office National d'Etudes et de Recherches (32)

Pickering, Dr. Howard W.
U.S. Steel Corp. (174)

Pollmann, S.
L.u.C. Steinmüller GmbH (57)

Pourbaix, A.
Belgian Center for Corrosion Study, CEBELCOR (1)

Pourbaix, M.
Belgian Center for Corrosion Study, CEBELCOR (1)
also Université Libre de Bruxelles

Probst, Dr. H.B.
NASA-Lewis (152)

Pryor, Dr. M.J.
Olin Corporation (160)

Quintana, M.A.
Esso Petroleos Espanoles (88)

Rahmel, Dr. A.
Dechema-Institut (50)

Rapp, Prof. Robert A.
Ohio State University (159)

Rentz, Warren A.
Ford Motor Company (136)

Rhee, S.K.
Bendix Research Laboratories (126)

Rhines, F.N.
University of Florida (135)

Richards, E.G.
International Nickel Ltd. (104)

Rickert, H.
Universitat Dortmund (67)

Rigaud, M.
Ecole Polytechnique (11)

Rolls, R.
University of Manchester (108)

Ross, T.K.
University of Manchester (107)

Rossi,
Istituto Metalli Leggeri-Co.-itatuto Corrosioni (76)

Roush, M.S.
AiResearch Mfg. Co. of Arizona (120)

Roux,
Ecole des Mines (26)

Roy, C.
University of Western Ontario (19)

Sama, Lawrence
Sylvania Electric Products, Inc. (169)

Schieferstein, H.
Kraftwerk Union AG (56)

Schirmer, R.M.
Phillips Petroleum Company (163)

Schluter, W.
Verein Deutscher Eisenhuttenleute e.V. (70)

Scully, J.C.
University of Leeds (105)

Schultz, Dr. J.W.
The International Nickel Co., Inc. (144)

Schwenk,
Mannesmann-Forschungsinstitut (58)

Seigle, Prof. L.
State University of New York (156)

Sertour,
Société Nationale Industrielle Aérospatiale (34)

Seybolt, Dr. Alan U.
General Electric Co. (140)

Sheasby, J.S.
University of Western Ontario (19)

Smolowitz, Prof. G.
Pennsylvania State University (164)

Simonetti, G.
Laboratorio Enel (77)

Sims, Dr. Chester T.
General Electric Co. (137)

Skarna.
Ecole des Mines (26)

Slodzian, G.
Office National d'Etudes et de Recherches (32)

Smeltzer, Prof. W.W.
McMaster University (13)

Smith, R.A.
International Nickel Ltd. (104)

Spacil, Dr. H.S.
General Electric Co. (140)

Spinedi, Prof. Paolo
Università di Bologna (79)

Steele, Dr. Warren C.
Avco Corp. (122)

Steller.
Vereinigte Kesselwerke AG (72)

Stetson, A.R.
Solar Division (166)

Strassburger, Ch.
August Thyssen-Hütte AG (45)

Stringer, Prof. John
University of Liverpool (106)

Sturla, P.
ENEL Nazionale Per l'Energia Elettrica (75)

Svedberg, Dr. R.C.
Westinghouse Electric Corp. (177)

Swisher, Dr. J.H.
Bell Telephone Laboratories (125)

Syrc.
Frehmetaux, G.P. (36)

Taelemens, G.
Laboratoire Belge de l'Industrie Electrique (7)

Tallan, Dr. N.M.
Aerospace Research Laboratories (119)

Tedmon, Dr. C.S. (Jr.)
General Electric Co. (140)

Telang, Yesh P.
Ford Motor Company (136)

Tietz, Dr. T.E.
Lockheed Missiles & Space Co. (146)

Tott, L.H.
Midlands Region, C.E.G.B. (110)

Trenouth, J.M.
National Research Council of Canada (15)

Tripp, Dr. W.C.
Systems Research Laboratories, Inc. (170)

Truman, J.E.
Brown-Firth (96)

Tseung, A.C.C.
The City University (98)

Tylecote, R.F.
University of Newcastle-Upon-Tyne (113)

Umland, F.
Forschungsvereinigung Verbrennungskraftmaschinen (53)

Umland, F.
Universität Münster (69)

Uhlig, Prof. Herbert H.
Massachusetts Institute of Technology (149)

Uzan.
Université de Lyon (38)

Valensi, G.
Université de Poitiers (43)

Van der Poorten, Prof. H.
Faculté Polytechnique (3)

Vanleugenhaghe, Claude
Université Catholique de Louvain (5)

van Muylaer, G.
Belgian Center for Corrosion Study, CEBELCOR (1)

van Staa, H.
Laboratory for Thermal Power Engineering (81)

Van Vlack, Prof. Lawrence H.
University of Michigan

Verga, C.
SNAM Progetti (78)

Verink, E.D.
University of Florida (135)

Vigne.
Universite de Nancy (40)

Wagner, Prof. Carl
Max-Planck-Institut fur Physikalische Chemie (60)

Wagner, Prof. J. Bruce (Jr.)
North Western University (158)

Wallace, Dr. W.
National Research Council of Canada (15)

Wasielewski, Gerald
General Electric Company (137)

Weaver, M.J.
National Gas Turbine Establishment (111)

Wesseling, W.
Stahlwerke Südwestfalen AG (62)

Wheatfall, Walter L. (Sr.)
Naval Ship Research and Development Laboratory (155)

Whelan, Dr. E.P.
National Research Council of Canada (15)

Wickert, K.
Berliner Kraft und Licht-AG (48)

Wilcox, Dr. B.A.
Battelle Columbus Laboratories (124)

Wilson, John R.
Queen's University (17)

Wilson, R.W.
Shell Research Ltd. (118)

Winterbottom, A.B.
Norges Tekniske Hogskole (84)

Wlodek, Dr. S.T.
Cabot Corporation (128)

Wolf, Dr. James S.
Clemson University (129)

Wolsin, Dr. Sam
Curtiss-Wright Corp. (131)

Wood, Dr. G.C.
University of Manchester (107)

Worrell, Prof. W.L.
University of Pennsylvania (162)

Wukusick, C.S.
General Electric Company (141)

Yamamoto, Dr. Albert S.
University of Denver (134)