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DEPARTMENT OF
ENERGY, MINES AND RESOURCES

MINES BRANCH

SCIENTIFIC AND TECHNICAL PAPERS

PUBLISHED BY THE STAFF IN 1969

OTTAWA

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FOREWORD

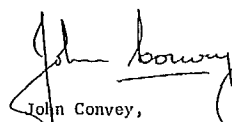
Information Circular IC 151 (June, 1963) was the first in a series of annual reviews of the scientific and technical papers published by the staff of the Mines Branch. This Information Circular IC 247 is the seventh supplement to IC 151 and is divided into three sections.

Section 1 consists of the titles of papers published during 1969 in the Mines Branch Series (Monographs, Research Reports, Technical Bulletins, Information Circulars and Reprint Series) together with an abstract or summary of each paper. These reports are available from the Queen's Printer, Ottawa, at the prices indicated and may be ordered by the catalogue number given for each report. (Pre-1962 reports are listed in Canadian Government Sectional Catalogue No. 12, July 1962).

Section 2 lists the titles of all papers published in scientific and technical journals during 1969 by the Mines Branch staff. The periodicals containing these papers are available in many technical libraries.

Section 3 contains a list of the 1969 titles available in the Investigation Report Series and also of the titles from previous years that now have been released for general distribution. This series includes the results of investigations carried out by the Mines Branch at the request of industry and other government agencies and also of investigations initiated by the Mines Branch of specific materials and processes. Many Investigation Reports are not available because they are either confidential or of very limited interest. Those that are listed in the Information Circular are available for reference in the divisional files, but in most cases there are no additional copies for distribution. However, it is felt that even this limited availability will be of value to many individuals or companies with specific interests and will help prevent unnecessary duplication of investigations already made by the Branch.

I hope that this supplementary index will be as well received as the first in this series and that it will provide the reader with a more complete view of the work of the Mines Branch in aiding Canada's mineral and metallurgical industries.


John Convey,
Director

AVANT-PROPOS

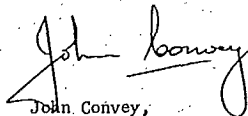
La Circulaire d'information IC 151 (juin 1963) était la première d'une série de revues annuelles des travaux scientifiques et techniques publiés par le personnel de la Direction des mines. La présente circulaire IC 247, qui comprend trois sections, est le septième supplément à IC 151.

La première section comprend les titres des travaux publiés en 1969 dans les séries de la Direction des mines (monographies, rapports de recherches, bulletins techniques, et circulaires d'information), ainsi qu'un résumé ou un sommaire de chaque étude. On peut obtenir ces différents rapports chez l'Imprimeur de la Reine, à Ottawa, aux prix indiqués, en les commandant d'après leur numéro au catalogue. (La liste des rapports publiés avant 1962 figure dans le Catalogue partitif n^o 12 du gouvernement canadien).

La section 2 comprend les titres de tous les travaux publiés par la Direction des mines en 1969 dans les revues scientifiques et techniques. Encore ici, un résumé de l'étude accompagne chaque titre, afin de donner au lecteur un aperçu de la teneur. Les périodiques où paraissent ces travaux sont à la disposition du public dans plusieurs bibliothèques techniques.

La section 3 énumère les titres des travaux qui ont paru dans la série des Rapports d'Investigations en 1969 et auparavant qui ont été rendus publics. Cette série comprend les résultats des recherches effectuées par la Direction des mines à la demande de l'industrie et d'autres services officiels, ainsi que les résultats des recherches entreprises par la Direction des mines sur des matériaux et procédés déterminés. Plusieurs de ces Rapports d'Investigations ne peuvent être consultés à cause de leur nature confidentielle ou du peu d'intérêt qu'ils présentent. Ceux qui sont énumérés dans la présente circulaire d'information peuvent être consultés dans les archives des diverses divisions, mais, dans la plupart des cas, il n'existe pas d'exemplaires pour la distribution au public. Cependant, on estime que même cette disponibilité limitée est de nature à favoriser de nombreux particuliers ou des sociétés qui s'intéressent à des domaines très précis et contribuera à éliminer le double emploi inutile en ce qui concerne les recherches déjà effectuées par la Direction.

J'espère que cet index supplémentaire sera aussi bien accueilli que les précédents dans cette série et qu'il présentera au lecteur un inventaire plus complet des travaux effectués par la Direction des mines au service des industries minières et métallurgiques canadiennes.


John Convey,
Directeur.

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Information Circular 205 (1967)

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Section 1 - Mines Branch Series

RESEARCH REPORTS

R 195 Control of Pollutant Emission and Sulphuric Acid Corrosion from Combustion of Residual Fuel Oil Part I: Low-Pressure Heating Boilers with Mechanical Atomizing Burners

G.K. Lee*, F.D. Friedrich** and E.R. Mitchell***

The paper, first of a series, deals with the burning of residual fuel oil containing 2.5 per cent sulphur under conditions prevalent in heating boilers, to assess the effects of (a) boiler load, (b) excess combustion air, (c) mean residence time, and (d) a magnesia-alumina fuel oil additive, on the formation of noxious and corrosive products of combustion. Results show that the additive can be used as an effective substitute for low excess combustion air in reducing the emission of NO_x and SO_3 . Furthermore, the additive neutralizes condensed H_2SO_4 and improves the electrical resistivity of soot particles to the point where electrostatic precipitation of soot is technically feasible. Detailed analyses of particulate matter samples taken from flames with untreated oil and oil treated with three different amounts of additive are described to elucidate the mechanism of acid soot neutralization and to obtain data on soot constituents that may contribute to atmospheric pollution. It is shown that the standard methods for measuring SO_3 concentrations in flue gas can give misleading results when soot or particulate matter is present.

Subsequent papers of the series will describe experiments of a broad research programme carried out in the same pilot-scale research boiler that provides control of boiler metal temperature (operating steam pressure) both below and above sulphuric acid dewpoint and provides flexibility in the selection of burner systems.

Ce mémoire, le premier d'une série, traite de la combustion de mazout résiduel, contenant 2.5 pour cent de soufre, dans les conditions habituelles des chaudières de chauffage, afin d'évaluer les effets de (a) la charge de la chaudière, (b) l'excès d'air de combustion, (c) la durée moyenne de résidence, et (d) un additif pour le mazout constitué de magnésie-alumine.

Les résultats obtenus montrent que l'additif peut être utilisé comme substitut efficace pour un faible excès d'air de combustion dans la réduction d'émission de NO_x et SO_3 . De plus, l'additif neutralise le H_2SO_4 condensé et améliore la résistivité électrique des particules de suie au point que la précipitation électrostatique de la suie est techniquement possible. Des analyses détaillées d'échantillons de particules pris dans les flammes d'huile non traitée et d'huile traitée avec trois quantités différentes d'additif sont décrites pour élucider le mécanisme de neutralisation des suies acides et obtenir des renseignements sur les constituants de la suie pouvant contribuer à la pollution atmosphérique. On montre que les méthodes classiques de mesure des concentrations en SO_3 dans les gaz de carneau peuvent induire en erreur lorsqu'il y a de la suie ou des particules.

Les rapports suivants de cette série décriront les expériences d'un large programme de recherche effectué avec la même chaudière de recherche à l'échelle pilote, fournissant le contrôle de la température du métal de la chaudière (à la pression de vapeur de fonctionnement) au dessous et au dessus du point de rosée de l'acide sulfurique, avec quelque flexibilité dans le choix des systèmes de brûleur.

*Research Scientist, **Senior Scientific Officer, and ***Head, Canadian Combustion Research Laboratory, Fuels Research Centre.

Price \$1.00

Cat. No. N38-1/195

R 197 Temper-Embrittlement Studies

R.F. Knight*

The extensive literature relating to temper-embrittlement phenomena is reviewed critically, and various aspects are examined, particularly as related to the effects of progressive increments of molybdenum in a series of low-alloy steels.

The experimental results show over-all agreement with the trends reported in general terms in the literature. Attempts are made to define effects quantitatively for the particular experimental conditions involved, particularly concerning the quantity of molybdenum required to achieve the optimum improvements in impact transition temperature and in the degree of susceptibility to temper embrittlement.

The distinctive grain-boundary etching effect is shown to be related to the condition of heat treatment, and not to the degree of susceptibility to temper embrittlement of the sample being examined.

Various effects of molybdenum on the room-temperature and reduced-temperature tensile behaviour of the experimental steels are presented.

Difficulties relating to the selection of criteria to define the susceptibility to temper embrittlement are discussed, and a new approach is suggested.

L'auteur fait l'étude critique des nombreux ouvrages traitant des phénomènes de fragilisation au revenu et en examine divers aspects, en particulier l'effet produit par l'addition progressive de molybdène à des aciers faiblement alliés.

Les résultats des expériences s'accordent dans l'ensemble avec les conclusions énoncées en termes généraux dans les ouvrages consultés. L'auteur s'est efforcé de traduire quantitativement ces résultats, dans les conditions expérimentales qui prévalaient au cours des essais, surtout en ce qui a trait à la quantité de molybdène nécessaire pour améliorer les caractéristiques de la température de transition (dans l'essai de résilience) et du degré de susceptibilité à la fragilisation au revenu.

Les essais permettent de conclure que l'effet d'attaque aux joints des grains est dû au mode de traitement thermique et non pas au degré de susceptibilité de l'échantillon étudié à la fragilisation au revenu.

L'auteur décrit certains effets de l'addition de molybdène aux aciers étudiés sur les caractéristiques mécaniques, à la température ambiante et à des températures plus basses.

Il relate également les difficultés éprouvées dans la sélection de critères pour définir la susceptibilité à la fragilisation au revenu et il suggère une nouvelle méthode d'aborder le problème.

*Research Scientist, Ferrous Metals Section, Physical Metallurgy Division,

Price \$1.00

Cat. No. M38-1/197

R 198 Development and Use of Computer Programs for Finite Element Analysis

Y.S. Yu* and D.F. Coates**

A computer program has been developed to simulate the stress distributions around typical, irregularly shaped mining openings. The actual, non-homogeneous mechanical properties of the rock can be taken into account in the program. The simulation also takes into account the possibility that the stresses are produced by either or both gravity and tectonic forces. In addition, supplementary computer programs to check the input data and to interpret the massive output of the finite element analysis have also been produced.

This report describes the development of these computer programs and provides detailed information and instructions on their use.

Un programme sur calculateur électronique a été mis au point pour simuler la répartition de contraintes autour d'excavations minières; typiques, aux formes irrégulières. L'on peut tenir compte au programme des propriétés mécaniques non-homogènes de la roche. La simulation tient aussi compte du fait de la possibilité que les contraintes sont produites, soit par la gravité ou les forces tectoniques, soit par les deux. En plus, des programmes supplémentaires automatiques ont été élaborés en vue de la vérification des données d'entrée et de l'interprétation de l'énorme débit de renseignements obtenu relativement à l'analyse des éléments finis.

Ce rapport décrit la mise au point de ces programmes sur calculateur électronique et fournit des informations détaillées et des directives au sujet de leur utilisation.

*Scientific Officer and **Head, Mining Research Centre.

Price \$1.25

Cat. No. M38-1/198

R 199 Low-Density Catalysts and Catalyst Supports Part I: The Preparation of Highly Porous Alumina

G.T. Shaw* and B.I. Parsons*

A technique is described whereby highly porous, low-density alumina can be prepared by dehydrating hydrous aluminum hydroxide gel in thin layers or small-diameter extrusions at low temperatures until at least 25-30% of the water present has been removed, followed by conventional high-temperature drying and calcination. The procedure works well with any aluminum hydroxide gel which has been precipitated with a carbonate. The maximum allowable bulk gel temperature in the low-temperature drying step is 100°C. The preferred temperature is 75°C or less. Limited control of the pore size and pore volume (in the range 1000-20 Å radius and 0.5 to 2.2 ml/g) can be achieved by regulating the conditions affecting the bulk gel temperature in the low-temperature drying step, e.g., oven temperature, circulation of the air, thickness of gel layer, etc. The type of drying atmosphere and the age of the hydrous gel are not critical factors. The results of both laboratory-scale and pilot-plant-scale experiments are described.

Les auteurs décrivent une technique de préparation d'alumine à forte porosité et à faible densité par la déshydratation à basse température d'un gel d'hydroxyde d'aluminium hydraté en couches minces ou en profilés de petit diamètre, jusqu'à ce qu'au moins 25 à 30 p. 100 de l'eau présente ait été enlevée; cette déshydratation est suivie du séchage et de la calcination classiques à haute température. Cette technique donne d'excellents résultats avec n'importe quel gel d'hydroxyde d'aluminium qui a été précipité à l'aide d'un carbonate. La température maximale permise pour l'ensemble du gel au cours de l'étape du séchage à basse température est de 100°C. La température préférée est de 75°C ou moins. Il est possible de régulariser dans une certaine mesure les dimensions et le volume des pores (dans la gamme de 1000 à 20 Å de rayon et de 0.5 à 2.2 ml/g) en contrôlant les conditions qui affectent la température de l'ensemble du gel pendant l'étape du séchage à basse température, par exemple, la température du four, la circulation de l'air, l'épaisseur de la couche de gel, etc. Le type d'atmosphère de séchage et l'âge du gel hydraté ne sont pas des facteurs critiques. Les auteurs décrivent les résultats des expériences effectuées en laboratoire et en usine pilote.

*Research Scientists, Fuels Research Centre.

Price 75 cents

Cat. No. M38-1/199

R 200 Behaviour of Thick-Wall Galvanized Products at Elevated Temperatures

J.J. Sebisty* and R.H. Palmer*

In this investigation, the elevated-temperature behaviour of hot-dip galvanized tubing, angle and bar products of Canadian and European origin was examined. Air-atmosphere heating tests were made in the temperature range of 200-400°C (390-750°F) for periods up to one year.

Galvanized coating deterioration was found to involve separation and gradual dissolution of the outer zinc layer, in combination with transformation changes in the underlying iron-zinc alloy layers. The deterioration process was mainly dependent on the time-temperature conditions of heating, but also was significantly influenced by the microstructural characteristics of the

as-galvanized coating and the inherent chemical reactivity of the steel base. By virtue of a more favourable combination of these last two factors, one of the tubing products and one of the angle products were found to be somewhat superior at the industry-recommended limiting service temperature of 200°C (390°F).

Dans cette étude, les auteurs ont examiné le comportement à température élevée de tubages, cornières et barres d'origine canadienne et européenne galvanisés par immersion à chaud. Des essais de chauffage (air-atmosphère) ont été faits à des températures variant entre 200° et 400°C (390° à 750°F) pendant des périodes allant jusqu'à un an.

Les auteurs ont trouvé que la détérioration du revêtement galvanisé s'accomplissait par la séparation et la dissolution progressive de la couche extérieure de zinc, accompagnées de transformations des couches sous-jacentes de l'alliage fer-zinc. Le processus de détérioration dépend principalement des conditions de chauffage durée-température mais les caractéristiques microstructurales du revêtement galvanisé et la réactivité chimique inhérente de la base d'acier y jouent également un rôle important. Grâce à une combinaison plus favorable de ces deux derniers facteurs, ils ont trouvé qu'un des tubages et une des cornières faisaient preuve de qualité quelque peu supérieure à la température d'usage maximale de 200°C (390°F) recommandée par le manufacturier.

*Research Scientists, Non-Ferrous Metals Section, Physical Metallurgy Division.

Price \$1.00

Cat. No. M38-1/200

R 201 Shear Lips, Zero Isoclinics, and Fracture

L.P. Trudeau*

Examination of "shear lip" contours formed in the process of fracture under tensile stress shows that they regularly start at 60 degrees to the flat part of the fracture. These well-defined contours might be expected to have a mechanical cause that predicts their form more closely than the common assertion that they are 45-degree shear fractures. It is suggested that the "shear lips" are actually zero isoclinic contours characterized by zero shear. This hypothesis is physically plausible because the oblique part of the fracture could occur with purely normal displacements in the same way as the flat part of the fracture is formed. An equation for the elastic zero-isoclinic contour is presented and also experimental evidence, in support of the proposal, obtained from tensile tests and tests with birefringent plastic on steel crack-notch toughness specimens.

L'étude des isoclines des "lèvres de cisaillement" formées par la cassure sous contrainte par traction indiquent qu'elles commencent d'ordinaire à un angle de 60° par rapport à la partie plate de la cassure. On pourrait penser que ces lignes bien définies sont le résultat d'une cause mécanique permettant de prévoir plus exactement leur forme que l'affirmation bien connue, à savoir, qu'il s'agit de cassures de cisaillement à 45°. L'auteur pense que les "lèvres de cisaillement" sont en fait des isoclines zéro caractérisés par un cisaillement nul. Cette hypothèse est physiquement plausible parce que la partie oblique de la cassure pourrait se présenter avec des déplacements absolument normaux, de la même façon que la partie plate de la cassure est formée. Il présente une équation de l'isocline zéro élastique, ainsi que des preuves obtenues par expérience à l'aide d'essais de traction et d'essais faits avec du plastique biréfringent afin de déterminer la résistance au criquage des échantillons d'acier.

*Research Scientist, Engineering Physics Section, Physical Metallurgy Division.

Price 50 cents

Cat. No. M38-1/201

R 202 Functional Graphs of Interconnected Systems

R. Jakubowski* and M. Krieger**

This research report presents the functional graph representation of a complex system whose elements are dynamic systems. The properties of these complex systems are discussed in detail. Finally, a method for obtaining a supervisory program based on the interconnections of the dynamic systems is developed.

Cette étude donne une représentation de graphes fonctionnels d'un système complexe dont les éléments constitutifs sont des systèmes dynamiques. Les auteurs traitent de façon détaillée des particularités de ces systèmes complexes. Finalement, ils proposent une méthode d'élaboration d'un programme de surveillance fondé sur les interconnexions des systèmes dynamiques.

*National Research Council of Canada Postdoctorate Fellowship (Academy of Mining and Metallurgy, Krakow, Poland), seconded 1968-69 to Mineral Sciences Division.

**Associate Professor, Department of Electrical Engineering, University of Ottawa, Ottawa, Canada.

R 203 Theoretical Calculation of the Dendrite Non-Homogeneity in Magnesium-Zinc Alloys

R. Ciach*

The distribution of zinc in magnesium-zinc solid solution, and the maximum amount of Mg₇Zn₃ compound due to the non-equilibrium freezing of the Mg-6 wt% Zn, were calculated.

The calculation was carried out according to Krupkowski's equations which assume complete diffusion in the liquid state and no diffusion in the solid state and take into account the changes of the distribution coefficient during the solidification.

The results of calculation indicate that:

- there is a large region inside the grains containing approximately 0.74 wt% Zn, which increases significantly only near the Mg-Mg₇Zn₃ eutectic.

- out of the original 6 wt% Zn in the alloy, 4.077 wt% Zn may form Mg_7Zn_3 compound and only 1.923 wt% Zn will be in solid solution.

L'auteur a calculé la répartition du zinc dans une solution solide de magnésium ainsi que la quantité maximale de Mg_7Zn_3 causée par le déséquilibre qui se produit au cours du refroidissement du mélange Mg-6%Zn (poids).

Le calcul a été effectué selon les équations de Krupkowski qui supposent la diffusion complète à l'état liquide et l'absence de diffusion à l'état solide et tiennent compte des changements du coefficient de répartition au cours de la solidification.

Les résultats du calcul indiquent:

- qu'une zone importante à l'intérieur des grains contient environ 0.74% de Zn (en poids), pourcentage qui ne s'accroît de façon significative que près de l'eutectique Mg- Mg_7Zn_3 ;
- que du pourcentage original de 6% de Zn (en poids) de l'alliage, 4.077% (en poids) de Zn peut contribuer à former le composé Mg_7Zn_3 et seulement 1.923% (en poids) de Zn sera en solution solide.

*National Research Council of Canada Postdoctorate Fellow (from the Institute of Metals, Polish Academy of Sciences, Cracow, Poland), seconded (1967-69) to the Physical Metallurgy Division.

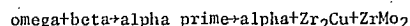
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Cat. No. M38-1/203

R 204 Transformation Reaction and Corrosion Behaviour of Two Zirconium-Copper-Molybdenum Alloys

H.M. Skelly* and C.F. Dixon**

The transformation reaction for a Zr-1.0%Cu-1.5%Mo alloy quenched from the beta phase (1000°C, 1830°F) and aged at 500°C (930°F) was shown to be:

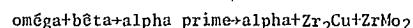


The corrosion resistance of this alloy and of a Zr-0.5%Cu-0.5%Mo alloy was found to be related to the structures produced by the transformation reaction - optimum corrosion resistance was obtained after aging for 32 and 24 hr, respectively.

Aging of specimens resulted in an increase in the size of the intermetallic particles; and larger $ZrMo_2$ particles in overaged specimens appeared to corrode at a rate greater than the matrix, causing cracking of the corrosion film and resulting in an accelerated corrosion rate for the specimens.

The type of corrosion film, like the corrosion rate, was affected by structural changes produced by the transformation reaction.

L'alliage Zr-1.0%Cu-1.5%Mo trempé à partir de la phase bêta (1000°C, 1830°F) et vieilli à 500°C (930°F) a manifesté les réactions de transformation suivantes:



La résistance à la corrosion de cet alliage et de lui de formule Zr-0.5%Cu-0.5%Mo est en rapport avec les structures produites par les réactions de transformation. La résistance maximale s'est manifestée après vieillissement de 32 et 24 heures respectivement.

Le vieillissement des échantillons a entraîné un accroissement de la taille des particules intermétalliques, tandis que les plus grosses particules de $ZrMo_2$ des échantillons survieillis se sont corrodées d'une manière plus importante que la matrice, provoquant la fissuration du film de corrosion et accélérant la vitesse de corrosion des échantillons.

Le type de film de corrosion et la vitesse de corrosion ont subi des variations dues aux changements structuraux provoqués par les réactions de transformation.

*Research Scientist and **Engineer, Nuclear and Powder Metallurgy Section, Physical Metallurgy Division.

Price 75 cents

Cat. No. M38-1/204

R 205 The Application of Neutron Activation Analysis to the Determination of Copper in Minerals

H.P. Dibbs*

An account is given of the application of neutron activation analysis to the rapid, non-destructive determination of copper in minerals, using a 14-MeV neutron source. Elements that interfere in the determination of copper by this method are given, together with the errors in the estimation of copper that result from the presence of varying amounts of these elements. The possible use of a compact "sealed-tube" 14-MeV neutron generator for the field assay of copper in minerals is discussed.

On décrit l'application de la méthode d'analyse par activation aux neutrons d'une énergie de 14 MeV à la détermination rapide et non-destructive du cuivre dans les minéraux. On mentionne les éléments interférents, ainsi que les erreurs introduites par la présence de quantités variables de ces éléments. On discute aussi la possibilité d'utiliser sur le terrain une "source scellée" produisant des neutrons de 14 MeV pour la détermination en place du cuivre dans les minéraux.

*Head, Surface Science Group, Mineral Sciences Division

Price 75 cents

Cat. No. M38-1/205

R 206 Non-Metallic Thermal Storage Media For Block-Type Electric Space Heaters

V.D. Svikis*

A series of low-cost non-metallics was submitted to determinations of thermal properties, such as mean specific heat and heat capacity per unit volume, to evaluate their suitability as thermal-storage media for block-type electric space heaters. For this work a special electric furnace and a large calorimeter using water were designed and constructed.

The mean specific-heat determinations were made by the method of mixtures. The heat capacities per unit volume were calculated from the densities and mean specific heats of the materials examined.

The results indicate that of the ceramic products, rocks and mineral concentrates examined, dead-burned magnesia (over 95% MgO), 'highly calcined' alumina (over 99% Al₂O₃), hematite concentrate, and rocks rich in hematite, magnetite and/or magnesian compounds have high heat capacities. Two- and three-component bodies from ceramic products or ceramic products and rocks, bonded with aluminous cement, are economically more attractive but their heat capacities are lower than those of their single components without the cement bond. In certain cases, the dead-burned magnesia and the calcined alumina -- relatively expensive materials -- can be successfully replaced in these body compositions by mineral concentrates and rocks, such as hematite concentrate, magnetite ore, olivine, and talc. The fireclay brick and the building brick can be successfully substituted by common rocks, such as sandstone, quartzite and granite.

It is concluded that materials and material compositions rich in hematite, magnetite, and magnesian compounds are excellent low-cost thermal-storage media for block-type electric space heaters.

Divers matériaux non métalliques peu dispendieux ont été soumis à des essais de détermination de leurs propriétés thermiques telles que la chaleur spécifique moyenne et la capacité thermique par unité de volume, afin d'estimer la possibilité de leur usage comme accumulateurs de chaleur dans les radiateurs électriques du type "bloc". À cette fin un four électrique spécial et un grand calorimètre ont été conçus et construits.

Les mesures de la chaleur spécifique moyenne ont été effectuées par la méthode des mélanges. Les capacités thermiques des matériaux examinés ont été déterminées à partir des densités et des chaleurs spécifiques moyennes.

Les résultats montrent que parmi les produits céramiques, les roches et les concentrés des minéraux examinés, la magnésie grillée à mort (plus de 95% de MgO), l'alumine calcinée à fond (plus de 99% de Al₂O₃), les concentrés d'hématite et les roches à forte teneur en hématite, en magnétite ou en composés magnésiens, présentent les meilleures capacités thermiques. Les composés à deux ou trois éléments des produits céramiques ou des mélanges de produits céramiques et de roches, liés par un ciment alumineux, sont plus attrayants économiquement, mais leurs capacités thermiques sont inférieures à ceux de leurs éléments constitutifs sans liant. En certains cas la magnésie grillée à mort et l'alumine calcinée, des matériaux assez coûteux, peuvent être remplacés avec succès dans ces mélanges par des concentrés de minéraux et des roches, comme par exemple par un concentré d'hématite, de magnétite, d'olivine ou de talc. Il est possible de remplacer avec succès la brique réfractaire et la brique de construction par des roches ordinaires comme le grès, le quartzite ou le granit.

En conclusion, les matériaux ou les composés riches en hématite ou en magnétite, ainsi que les composés magnésiens, sont d'excellentes substances à bon marché pour l'accumulation de chaleur, pouvant être utilisés dans les radiateurs électriques à accumulation.

*Research Scientist, Ceramic Section, Mineral Processing Division.

Price \$1.00

Cat. No. M38-1/206

R 207 A Re-Examination of Calcium Di-Ferric Aluminate in the System CaO-Iron Oxide-Al₂O₃

A. Jongejan*

A calcium di-ferric aluminate type of compound has been prepared by several different methods. Its crystal structure appears to be very sensitive to the presence of small quantities of FeO. Since the FeO content varies during the heating and cooling of samples, it was difficult to rely on the customary quench technique to study the phase relationships in the high-iron part of the system CaO-iron oxide-Al₂O₃. An attempt has been made to determine the locations of phase-field boundaries by the use of the "cone-softening" method.

L'auteur a préparé à l'aide de diverses méthodes un composé du type aluminate diferrique de calcium. Sa structure cristalline semble très sensible à la présence de petites quantités de FeO. Étant donné que la teneur en FeO varie au cours du chauffage et du refroidissement des échantillons, il était difficile de se fier à la technique habituelle de trempe pour étudier les relations de phase dans la zone à haute teneur en fer du système CaO-Oxyde de fer-Al₂O₃. L'auteur a tenté de déterminer l'emplacement des frontières des espaces des phases en utilisant une méthode basée sur l'observation des premiers symptômes de fusion d'une éprouvette.

*Research Scientist, Physical Chemistry Section, Mineral Sciences Division.

Price 75 cents

Cat. No. M38-1/207

R 208 Combustion and Fouling Characteristics of Two Canadian Lignites

F.D. Friedrich*, G.K. Lee** and E.R. Mitchell***

The report describes combustion tests with Bienfait lignite from Saskatchewan and Onakawana lignite from James Bay. These were burned in a pilot-scale pulverized-fired boiler primarily to study combustion performance and fireside fouling tendencies under slag-tap conditions. Flame stability and complete combustion were readily obtained, although satisfactory slag tapping was not achieved with either fuel.

Exhaustive analytical work was carried out on deposit samples representing each fuel, collected from various parts of the boiler. The results indicate that, in the combustion of Bienfait lignite, selective deposition of ash constituents takes place, resulting in an eutectic composition downstream of the furnace exit. Deposit analyses, fusion temperatures and enrichment ratios are given for both fuels.

Le présent rapport décrit des essais de combustion pratiqués sur du lignite de Bienfait (Saskatchewan) et d'Onakawana (près de la baie James). Les échantillons ont été brûlés dans une chaudière d'essai à l'état pulvérisé en vue surtout de déterminer l'efficacité de combustion et les tendances à l'encrassement aux environs du foyer sous des conditions propres au décrassage. Les deux types de combustible ont donné une flamme stable et se sont consumés entièrement, bien que ni l'un ni l'autre n'ait permis un décrassage satisfaisant.

Des analyses détaillées ont été pratiquées sur des échantillons de dépôts de chaque combustible, recueillis en divers endroits de la chaudière. Les résultats ont révélé que les constituants de la cendre du lignite de Bienfait se déposent sélectivement et présentent une composition eutectique après la sortie du four. L'analyse des dépôts, les températures de fusion et les taux d'enrichissement sont fournis pour chacun des combustibles.

*Senior Scientific Officer, **Research Scientist, and ***Head, Canadian Combustion Research Laboratory, Fuels Research Centre.

Price 75 cents

Cat. No. M38-1/208

TECHNICAL BULLETINS

TB 102 The Effect of Single Element Additions to Aisi Type 430 Stainless Steel in Dip-and-Dry Corrosion Tests

H.M. Weld*

The corrosion properties of a series of eight stainless steel alloys were determined in a "Dip-and-Dry Corrosion Test". This cyclic type of test has been frequently used to test stainless steel alloys for automobile trim and it has shown some correlation with actual field test results.

Each alloy series tested was made from a basic AISI Type 430 ferritic stainless steel but modified by a number of small additions of one of the following elements: Mo, V, W, Ta, Si, Re, Pd, or Ge. The final composition never exceeded 3.11% of addition element.

The corrosion resistance of AISI Type 430 stainless steel containing 1.5% and 3.1% Mo showed a marked superiority, both in appearance and in weight loss, compared to the base alloy. An alloy containing 1.8% Re also has superior corrosion resistance in this test.

Small additions of tantalum, silicon or germanium, to AISI Type 430, all improved corrosion resistance with increased alloy content. Tungsten produced a slight improvement in corrosion resistance and appearance. Vanadium or palladium additions did not improve these corrosion properties of their alloys, and showed no consistent trend with increasing alloy addition.

La résistance à la corrosion d'une série de huit alliages d'acier inoxydable a été déterminée au moyen d'un "essai de corrosion par immersion-séchage". Ce type d'essai cyclique a été utilisé fréquemment pour l'étude des alliages d'acier inoxydable servant à la fabrication de garnitures d'automobile et il a montré une certaine corrélation avec les résultats des essais en service.

Chaque série d'alliages étudiée était constituée d'acier inoxydable ferritique de type AISI 430 auquel on avait ajouté de petites quantités d'un des éléments suivants: Mo, V, W, Ta, Si, Re, Pd, ou Ge. L'élément d'apport n'a jamais dépassé 3.11 p. 100 dans la composition finale.

La résistance à la corrosion de l'acier inoxydable de type AISI 430 contenant 1.5 et 3.1 p. 100 de molybdène a montré une nette supériorité, tant pour l'apparence que pour la perte de poids, sur l'alliage de base. Un alliage contenant 1.8 p. 100 de rhénium a aussi montré une résistance à la corrosion supérieure au cours de cet essai.

De faibles additions de tantale, de silice et de germanium à l'acier AISI 430 ont toutes amélioré la résistance à la corrosion en fonction de la quantité d'élément d'apport. Le tungstène a entraîné une légère amélioration de la résistance à la corrosion et de l'apparence. Les additions de vanadium et de palladium n'ont pas amélioré la résistance à la corrosion de leurs alliages et n'ont pas montré de tendance soutenue à mesure qu'on augmentait leur proportion.

*Research Scientist, Corrosion Section, Physical Metallurgy Division.

Price 75 cents

Cat. No. M34-20/102

TB 103 Improvement of a Continuous Process for the Production of High-Purity Tungstic Trioxide from Scheelite: Precipitation and Removal of Iron With Ammonium and Magnesium Chlorides

J.A. Vezina* and W.A. Gow**

Test work was carried out to remove iron and other impurities from a sodium tungstate solution. This constituted an improvement to the process previously developed at the Mines Branch for refining Canadian scheelite concentrates of grades as low as 41 per cent WO_3 . In this test work, by making the intermediate sodium tungstate solution ammoniacal and adding specific quantities of magnesium chloride and ammonium chloride, the iron concentration was decreased from 0.33 to 0.007 gram Fe per litre.

When the basic process was modified to include this iron-removal step, it was capable of producing ammonium paratungstate of a chemical purity suitable for the production of tungsten metal.

The additional cost involved in the precipitation of the iron from the process circuit was \$0.023 per pound of tungsten obtained.

Divers essais ont été effectués afin d'éliminer le fer et les autres impuretés d'une solution de tungstate de sodium. On a ainsi amélioré le procédé mis au point antérieurement à la Direction des mines pour l'affinage des concentrés de scheelite canadienne titrant aussi peu que 41 p. 100 de WO_3 . Au cours de ces essais, en rendant ammoniacale la solution intermédiaire de tungstate de sodium et en y ajoutant des quantités déterminées de chlorure de magnésium et de chlorure d'ammonium, il a été possible de réduire la concentration en fer de 0.33 à 0.007 gramme par litre.

Après que le procédé de base eut été modifié de façon à inclure cette étape de l'élimination du fer, on a été en mesure de produire du paratungstate d'ammonium d'une pureté chimique convenant à la production de tungstène métal.

Le coût additionnel que représente ce procédé de précipitation du fer est de \$0.023 par livre de tungstène produite.

*Research Scientist, and **Head, Hydrometallurgy Section, Extraction Metallurgy Division.

Price 50 cents

Cat. No. M34-20/103

TB 106 An Introduction to the Theory, Measurement and Application of Semiconductor Transport Properties of Minerals

T.M. Baleshta* and H.P. Dibbs**

An introductory account is given of some of the basic ideas of semiconductor physics and of the measurement techniques frequently used to characterize semiconductor transport behaviour. The application of some of these ideas and measurements to mineral beneficiation is discussed.

Cette étude comporte un exposé préliminaire de certains concepts de base de la physique des semiconducteurs et des méthodes de mesure généralement utilisées pour caractériser les propriétés semiconductrices de certains minéraux. Les auteurs traitent également de l'application de certains de ces concepts et méthodes de mesure à l'enrichissement des minéraux.

*Research Scientist and **Head, Surface Science Group, Mineral Sciences Division.

Price \$1.00

Cat. No. M34-20/106

TB 107 Reduction of Ferric Iron by SO₂ with Heat or SO₂ with Activated Carbon

B.H. Lucas* and G.M. Ritcey**

In a liquid-liquid system for the separation and recovery of individual rare earths, co-extraction of ferric iron is a serious problem. This study was done to determine whether the problem could be solved by converting the iron to the ferrous state, as opposed to precipitating the ferric iron to remove it from solution. In the precipitation of ferric iron, some co-precipitation of rare earths occurs. A synthetic iron solution, and a uranium barren solution containing 3.17 g Fe⁺³/l and 0.34 g Fe⁺²/l, were used in the test work.

The ferric iron in the barren solution was reduced by 90% at 90°C in 31 minutes by addition of twice the stoichiometric amount of SO₂. An alternate method used 1.5 times the stoichiometric amount of SO₂ at room temperature and 15 g/l activated carbon; retention time was 15 minutes. All of the test work was carried out in an oxygen-free system. On the basis of this work the activated carbon-SO₂ method was the more economical. Measurement of the oxidation potential can be used as a method of control.

Dans un système liquide-liquide pour la séparation et la récupération individuelle des terres rares, la coextraction du fer trivalent présente de sérieuses difficultés. Cette étude a été menée en vue de déterminer s'il était possible de résoudre le problème en ramenant le fer à l'état bivalent plutôt qu'en précipitant le fer trivalent pour le retirer de la solution. Dans la précipitation du fer trivalent, une solution de fer synthétique et une solution pauvre en uranium contenant 3.17 g Fe⁺³/l et 0.34 g Fe⁺²/l ont été utilisées dans les essais.

Le fer trivalent de la solution pauvre en uranium a été réduit dans une proportion de 90 p. 100 en 31 minutes, à une température de 90°C, par l'addition du double de la quantité stoechiométrique de SO₂. Une autre méthode a consisté à utiliser 1 1/2 fois la quantité stoechiométrique de SO₂ à la température ambiante et 15 g/l de carbone activé; la période de rétention a été de 15 minutes. Tous les essais ont été effectués en l'absence d'oxygène. En se fondant sur les résultats de ces essais, les auteurs concluent que la méthode au carbone activé et au SO₂ est la plus économique. La mesure du potentiel d'oxydation peut être utilisée comme moyen de contrôle.

*Research Scientist and **Senior Scientific Officer, Hydrometallurgy Section, Extraction Metallurgy Division.

Price 50 cents

Cat. No. M34-20/107

TB 108 The Floatability of Twenty-One Non-Metallic Minerals

R.A. Wyman*

The floatabilities of twenty-one non-metallic minerals as affected by pH regulators, collectors and modifiers have been determined. Symbols have been used in presentation of results to afford ease of comparison.

The work herein reported extends that contained in Technical Bulletin TB 70, "The Floatability of Eleven Common Non-Metallic Minerals" (April 1965). Ten additional minerals are included and fourteen additional collectors.

This project is intended to assist those working on the flotation of non-metallic minerals.

La présente étude fait état de l'action des régulateurs de pH, des agents collecteurs et des agents modificateurs sur la flottabilité de vingt et un minéraux non métalliques. Afin de simplifier la comparaison, on a utilisé des symboles pour la présentation des résultats.

Ces données représentent une extension des études contenues dans le Bulletin technique TB 70, intitulé "La flottabilité de onze minéraux communs non métalliques", publié en avril 1965. Dix nouveaux minéraux ont été inclus, ainsi que quatorze agents collecteurs supplémentaires.

Ces travaux ont été entrepris en vue d'aider les chercheurs dans le domaine de la flottation des minéraux non métalliques.

*Head, Industrial Minerals Milling Section, Mineral Processing Division.

Price \$1.00

Cat. No. M34-20/108

TB 109 The Coal Mining Industry of Poland

T.W. Wlodek*

This report supplies details, judged to be of interest to the parallel Canadian industries, on the history, resources, management and administration, safety programs, labour status and other facets of the mining industry of Poland, which has been reorganized, mechanized and expanded, under government ownership, since 1945. With an estimated 16 billion tons of mineable coal available and an annual output of some 127 million tons--a fourfold increase in 20 years--in 1966 Poland ranked fourth in Europe and seventh in the world as a coal supplier.

New mining methods, new mining machinery, comparisons of production and efficiency attained underground, new trends and applications for the future, safety programs, and the special status of the Polish miner are all discussed and illustrated.

Dans le but de renseigner l'industrie minière canadienne, ce rapport renferme des détails intéressants sur l'histoire, les ressources, la gestion, l'administration, les programmes de sécurité, le statut de l'ouvrier et d'autres facettes de l'industrie houillère en Pologne, qui a été réorganisée, mécanisée et développée depuis 1945 en tant qu'entreprise nationalisée. Avec des réserves évaluées à 16 milliards de tonnes et une production annuelle de quelque 127 millions de tonnes (qui a quadruplé en 20 ans), la Pologne occupait, en 1966, le quatrième rang des fournisseurs européens et le septième rang des fournisseurs mondiaux de charbon.

Ce rapport explique et illustre les nouvelles méthodes d'extraction et le matériel nouveau; il donne les comparaisons sur l'efficacité de l'exploitation souterraine, il précise les tendances et les applications nouvelles pour l'avenir; enfin, il traite des programmes de sécurité et du statut spécial du mineur polonais.

*Senior Research Scientist, Special Projects, Mines Branch.

Price 75 cents

Cat. No. M34-20/109

TB 111 Exploratory Stress-Corrosion Cracking Tests on Some Low-Alloy High-Strength Steels

G.J. Biefer*

Using a test rig in which the test specimens are small bent strips, held in this configuration under spring loading, stress-corrosion cracking (SCC) tests were performed in several media upon four alloys resembling AISI Type 4320 but with different Si and Mn contents. One of the steels had the composition of "HY-Tuf"**, a proprietary steel said to have high resistance to hydrogen-embrittlement cracking.

A steel containing 1.48% Si and 0.68% Mn showed the best all-round resistance to SCC in tests in normal sulphuric acid (with and without a cathodic "poison"), boiling calcium-ammonium nitrate, and 3.5% NaCl solution, outperforming the steel having the "HY-Tuf" composition.

Au moyen d'un appareil d'essai utilisant des éprouvettes sous forme de petites bandes recourbées, retenues en place par un ressort, des essais de fissuration par corrosion sous tension ont été pratiqués dans diverses solutions sur quatre alliages ressemblant à l'acier AISI de type 4320 mais ayant une teneur différente en Si et en Mn. L'un des aciers avait la composition du "Hy-Tuf"***, un acier de spécialité censé posséder une haute résistance à la fissuration due à la fragilisation par l'hydrogène.

Un acier ayant une teneur de 1.48 p. 100 en Si et de 0.68 p. 100 en Mn a manifesté la meilleure résistance à la fissuration par corrosion sous tension à tous points de vue lors des essais dans l'acide sulfurique (avec et sans "empoisonnement" cathodique), dans le nitrate de calcium-ammonium en ébullition et dans une solution de NaCl à 3.5 p. 100. L'acier en question s'est avéré plus résistant que l'acier de composition "Hy-Tuf".

*Head, Corrosion Section, Physical Metallurgy Division.

**Crucible Steel Company of America designation.

***Marque de commerce de la Crucible Steel Company of America.

Price 50 cents

Cat. No. N34-20/111

TB 112 Further Studies of the Leaching of Uranium Ores from Elliot Lake, Ontario

H.H. McCreedy*, W.A. Gow**, F.J. Kelly*** and H.W. Smith****

The uranium mines of Elliot Lake area in Ontario, Canada, were brought into production in the mid-1950's. At that time the extraction plants were designed to utilize an acid leaching process which, although adequate in that about 95 per cent extraction of the uranium was attained, was not thoroughly understood. Because of this the plant operators found it necessary to make trial-and-error adjustments to the operating conditions, one of the more important of these being to increase the temperature of the pulp during leaching. It was found that as the leaching temperature increased the acid addition needed for acceptable extraction decreased, the combined effect being a reduction in operating costs. A recent laboratory study has served to clarify further this relationship between leaching temperature and acid requirement. At the same time the effects of other operating variables were also studied more thoroughly than had been done in the past. The results of this investigation, which are reported in this paper, not only supplied new information related to the extraction of uranium from the Elliot Lake ores, but also emphasized the fact that currently used processes may not be understood sufficiently. Consequently, it may be profitable for operators to study existing processes further before they embark on major process changes.

Les mines d'uranium de la région d'Elliot Lake, Ontario, sont en exploitation depuis le milieu des années 1950. A cette époque, les usines d'extraction étaient conçues pour utiliser un procédé de lessivage à l'acide qui, tout en permettant l'extraction de l'uranium dans une proportion de 95 p. 100, n'était pas entièrement compris. Pour cette raison, les exploitants d'usines devaient expérimenter constamment avec le procédé de traitement, notamment en haussant la température de la pâte durant le lessivage. Il fut établi que la quantité supplémentaire d'acide nécessaire à l'extraction efficace variait inversement avec

L'augmentation de la température pendant le lessivage, le résultat net étant une diminution des frais d'exploitation. Une étude récente en laboratoire a permis de préciser davantage le rapport qui existe entre la température de lessivage et la quantité d'acide requise. A la même occasion, on a étudié plus à fond les effets de certaines autres variables de fonctionnement. Les résultats de cette étude, qui font l'objet du présent rapport, ont non seulement fourni de nouveaux renseignements sur l'extraction de l'uranium des minerais d'Elliot Lake, mais ont aussi fait ressortir le fait que les procédés actuels ne sont peut-être pas assez bien compris. Par conséquent, il serait peut-être à l'avantage des exploitants d'approfondir leur connaissance des procédés existants avant d'entreprendre des modifications importantes.

*Research Scientist, **Head, Hydrometallurgy Section and ***, Senior Scientific Officers, Extraction Metallurgy Division.

Price 50 cents

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TB 113 Stagemwise Separation of Uranium, Thorium and the Rare Earths by Liquid-Liquid Extraction

G.M. Ritcey* and B.H. Lucas**

Rare earths and thorium are found associated with uranium at Elliot Lake, Ontario, one of the major uranium-producing areas of Canada. In addition to the recovery of uranium by ion exchange processing, minor quantities of thorium and rare earths are recovered as bulk concentrates. The work described shows the development of a stagewise separation of individual rare earths by liquid-liquid extraction from sulphuric acid barren liquors from the uranium recovery circuit. This is accomplished by the use of an alkylphosphoric acid dissolved in a kerosene diluent. Residual uranium and thorium are co-extracted with an amine, prior to rare-earth processing. The bench-scale results have indicated that extraction coefficients of individual rare earths, and separation factors between rare earths, are affected by the aqueous feed pH, solvent concentration, and the atomic number of the rare earth. The data presented show the possibility of selective separation of the rare earths singly or in small groups. A proposed flowsheet is given.

On retrouve des terres rares et du thorium en association avec de l'uranium à Elliot Lake (Ontario), qui est l'une des principales régions productrices d'uranium au Canada. En plus de récupérer de l'uranium par échange d'ions, on recouvre également de petites quantités de thorium et de terres rares sous forme de concentrés. La présente étude décrit la mise au point d'un procédé de séparation sélective des terres rares par extraction liquide-liquide à partir des solutions libres d'acide sulfurique provenant des circuits de récupération de l'uranium. Ceci s'accomplit par l'emploi d'acide alkylphosphorique dissous dans un diluant à base de kérosène. L'uranium résiduel et le thorium sont extraits avec une amine avant la récupération des terres rares. Les résultats des essais en laboratoire montrent que les coefficients d'extraction des diverses terres rares et les facteurs de séparation de ces dernières sont influencés par le pH de l'alimentation aqueuse, la concentration du solvant et le numéro atomique de la terre rare en question. Les résultats présentés indiquent la possibilité d'effectuer des séparations sélectives des terres rares individuellement ou par petits groupes. Un schéma de circulation est également proposé.

*Senior Scientific Officer and **Research Scientist, Hydrometallurgy Section, Extraction Metallurgy Division.

Price 75 cents

Cat. No. M34-20/113

TB 114 Stress-Corrosion Cracking Tests on Some High-Strength Steels, Using the USNRL Cantilever Method

G.J. Bieffer* and J.G. Garrison**

A stress-corrosion cracking test developed at the U.S. Naval Research Laboratory, Washington, D.C., has been used at the Physical Metallurgy Division to test the cracking susceptibility of a number of high-strength steels.

Results are reported which were obtained in stress-corrosion tests on an 18% Ni maraging steel (both parent and weld metal), an HP-9-4-25 steel, a copper-nickel low-alloy steel developed at the Physical Metallurgy Division, and a 17/4 PH stainless steel in each of the H900 and H1000 conditions. For each of these steels, the tendency to fracture under dry conditions was compared with that resulting from immersion in 3.5% NaCl solution in the unpolarized state. The effects of cathodic protection by 5083 aluminum alloy and zinc were also investigated.

Un essai de fissuration par corrosion sous tension mis au point par le U.S. Naval Research Laboratory, à Washington, D.C., a été employé par la Division de la métallurgie physique pour déterminer la susceptibilité à la fissuration d'un certain nombre d'aciers à haute résistance.

Le présent bulletin décrit les résultats d'essais de fissuration par corrosion sous tension exécutés sur un acier "maraging" à 18% de Ni (métal de base et métal de fusion), sur un acier HP-9-4-25, sur un acier faiblement allié au cuivre et au nickel mis au point par la Division de la H900 et H1000. Dans chacun de ces aciers, la tendance à la fissuration à sec a été comparée avec celle qui résulte de l'immersion du métal dans une solution de NaCl à 3.5 p. 100 à l'état non polarisé. Les auteurs ont également étudié les effets de la protection cathodique au moyen de zinc et d'un alliage d'aluminium 5083.

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Price 75 cents

Cat. No. M34-20/114

INFORMATION CIRCULARS

IC 207 Bibliography on Rock Bolting Methods in Mining Practice. Part I: Abstracts from World Literature to End of 1957

Mary Ruth Corlett Paterson*

Issued as Part I of a proposed series, the bibliography which comprises this information circular represents a serious attempt to assemble all the published information of the theory and practice of rock bolting to the end of 1957. It was completed as a two-year project in library research in London, England, in 1958. Part II, now in preparation, will cover the decade 1958-1967.

In this bibliography, some 280 references (each with a brief abstract) are grouped according to subject matter under main headings of Theory, Testing Equipment, Specifications and Standards, Drilling and Dust Control, Safety Precautions, Practice (General), and Practice (Regional--by countries). Chronology is from late to earlier.

Three appendices list Conferences, Suppliers of Equipment, and Sources of Information. Indexes are included of Authors, of Companies and Other Public Bodies, and of Subjects.

La bibliographie qui fait l'objet de la présente circulaire vise à réunir tous les ouvrages publiés jusqu'à la fin de 1957 sur la théorie et la pratique du boulonnage des roches. Cette bibliographie est le résultat de deux années de recherche en bibliothéconomie entreprise en 1958 à Londres. Une deuxième circulaire, en voie de préparation, couvrira la période de 1958 à 1967.

Dans cette bibliographie, quelque 280 ouvrages de référence (chacun accompagné d'un bref résumé) sont groupés selon leur sujet sous les titres suivants: théorie, appareils d'essai, prescriptions techniques et normes, forage et suppression de la poussière, mesures de sécurité, pratique (générale), pratique (régionale ou par pays). La chronologie va du plus récent au plus ancien.

On trouvera dans trois appendices une liste des conférences qui ont porté sur ce sujet, des fournisseurs de matériel et des sources de renseignement. On trouvera aussi les index des auteurs, des sociétés et autres corps publics et des sujets.

*In 1958, then Miss Mary Ruth Corlett of Kingston, Ontario, Mrs. Paterson compiled this bibliography at the University of London (England) as part of her requirements for a diploma in Library Science. Reassembled and co-ordinated at the Mines Branch, Ottawa, during the summer of 1968, it is being reproduced and distributed by the Mines Branch as a Canadian contribution to scientific knowledge, by permission of the author.

Price \$1.25

Cat. No. M38-3/207

IC 209 Canada's Historic First Iron Castings

Harry Miller

This publication throws new light on the remarkable quality of the iron castings made at Canada's historic first ironworks, Les Forges Saint-Maurice. A brief outline is provided of the history of that famous enterprise, located eight miles from Trois-Rivières, Province of Quebec. It was founded in the days of New France, over two hundred and thirty years ago (1738). The blast furnace was finally closed down for good in the year 1883.

This new information on early cast iron in Canada is the outcome of an investigation, by the Mines Branch, of the exact nature of the iron in the Potash Kettle shown in Figure 1. This remarkable large casting is fully authenticated as a product of Les Forges Saint-Maurice, by the cast-in foundry mark, F S^t M, clearly to be seen on the lip of the vessel. This study was undertaken as part of an investigation by the author into the use, by pioneer settlers in Canada, of large cast iron vessels in their making of potash alkali from hardwood ashes.

The iron made at Saint-Maurice was smelted with charcoal from a very pure bog-iron ore found nearby. Laboratory reports show this iron has a composition very low in harmful impurities and favourably compares with historic Swedish charcoal irons. The investigation revealed that the iron in the potash kettle has outstanding quality in its resistance to red-heat temperatures and corrosion.

La présente publication projette une nouvelle lumière sur la qualité remarquable des objets en fonte exécutés aux Forges Saint-Maurice, premières installations d'une fonderie dans l'histoire du Canada. Une brève esquisse est faite sur l'histoire de cette fameuse entreprise, située à huit miles de Trois-Rivières dans la Province de Québec. Celle-ci fut fondée du temps de la Nouvelle-France, soit plus de deux cent et trente ans (1738). Le haut-fourneau a été finalement et définitivement fermé en 1883.

Cette nouvelle contribution sur les débuts de l'industrie de fonte au Canada est le résultat d'une recherche faite par la Direction des Mines sur la nature exacte du fer d'un chaudron à potasse, représenté à la Figure 1. Cette coulée, remarquable par sa grandeur, est reconnue avec certitude, comme étant un produit des Forges Saint-Maurice, par une estampille de fonderie " F S^t M ", que l'on peut voir facilement sur le bord du chaudron. L'étude a été entreprise comme une partie d'une recherche faite par l'auteur pour retrouver l'usage fait par les occupants pionniers au Canada, de grands récipients en fonte pour leur production de la potasse produite des cendres de bois dur.

Le fer produit à Saint-Maurice a été fondu utilisant le charbon de bois et un minerai de marais très pur que l'on trouvait dans le voisinage. Les rapports du laboratoire montrent que ce fer avait une teneur très basse en impuretés nuisibles et qu'il se compare avantageusement avec les vieux fers au charbon de bois des Suédois. L'investigation a relevé que le fer du chaudron à potasse avait une excellente qualité de résistance à la température du rouge et aussi à la corrosion.

Price \$1.25

Cat. No. M38-3/209

IC 211 Air Pollution: Causes and Control

H. Whaley*, F.D. Friedrich**, G.K. Lee* and E.R. Mitchell***

The Mines Branch is engaged in a dual program of controlling combustion-source air pollution. The first is an extensive combustion research program in which pollutant formation in flames is minimized and followed by the chemical neutralization, so far as possible, of sulphur dioxide (SO₂), sulphur trioxide (SO₃), nitrogen oxides (NO_x), and acid soot. The effectiveness of efficient combustion and an additive for residual fuel oil are described. The second program is one of controlling ground-level concentrations of combustion gases by recommending the chimney height necessary for adequate dispersion. To do this, an empirical plume-rise equation was developed as a sound basis for the CCRL (Canadian Combustion Research Laboratory) dispersion standard which is discussed and presented in graphical form.

La Direction des mines est engagée dans un double programme de contrôle de la pollution atmosphérique provenant de la combustion. Le premier est un vaste programme de recherche sur la combustion, dans lequel la formation d'agents de pollution dans les flammes est réduite au minimum et suivie de la neutralisation chimique, aussi complète que possible, de l'anhydride sulfurique (SO₂), l'anhydride sulfurique (SO₃), les oxydes d'azote (NO_x) et la suie acide. On décrit ici l'efficacité d'une bonne combustion ainsi qu'un additif pour mazout résiduel. Le second programme en est un de contrôle des concentrations des gaz de combustion au niveau de sol en recommandant la hauteur de cheminée nécessaire pour une dispersion adéquate. Pour ce faire, on a élaboré une équation empirique d'élévation du panache comme base saine pour les normes de dispersion CCRL (Laboratoire canadien de recherche sur la combustion). Cette norme est discutée et présentée sous forme graphique.

*Research Scientists, **Senior Scientific Officer, and ***Head, Canadian Combustion Research Laboratory, Fuels Research Centre.

Price \$1.00

Cat. No. M38-3/211

IC 212 A Review of Copper Converting

D.A. Reeve*

The development of copper converting is traced from its beginnings up to the present day. Methods are reviewed for improving converter operations at various plants, both in Canada and abroad. The physical chemistry of (a) the constitution of mattes charged to converters, (b) the converting process itself and (c) converter slags is discussed, and problems caused by magnetite formation and copper losses are mentioned. Emphasis is laid on the new technological developments of air-blast enrichment with oxygen and continuous copper converting. It is concluded that insufficient data are available on the basic chemistry of the converting process.

L'auteur étudie les progrès du convertissage du cuivre depuis ses débuts jusqu'à nos jours. Il passe en revue les méthodes employées pour améliorer les procédés de convertissage dans diverses usines au Canada et à l'étranger. Il étudie la chimie physique de (a) la constitution des mattes servant de charge aux convertisseurs, (b) le procédé de convertissage proprement dit et (c) les scories des convertisseurs, faisant état des problèmes causés par la formation de magnétite et les pertes de cuivre. Il fait ressortir les progrès technologiques réalisés dans l'enrichissement à l'oxygène par courant d'air et dans le convertissage continu du cuivre. Il conclut que les renseignements sur la chimie de base du procédé de convertissage sont insuffisants.

*Research Scientist, Extraction Metallurgy Division.

Price 75 cents

Cat. No. M38-3/212

IC 213 Application of Solvent Extraction to Common Base Metals (A-Review)

G.M. Ritcey*

This review describes some of the more pertinent solvent extraction systems, as found in the literature, for the extraction and separation of the common base metals from various aqueous media. The advantages and disadvantages of certain organic reagents are indicated. The economics of solvent extraction processing are discussed briefly.

Cette étude décrit quelques-uns des systèmes d'extraction par solvant les plus pertinents, relevés dans les divers ouvrages courants de divers milieux aqueux. L'auteur indique les avantages et les désavantages de certains réactifs organiques et discute brièvement de l'économie de l'extraction par solvant.

*Senior Scientific Officer, Extraction Metallurgy Division.

Price 75 cents

Cat. No. M38-3/213

IC 214 Bibliography of High-Temperature Condensed States Research Published in Canada, October-December, 1968

N.F.H. Bright*

This report contains bibliographic information concerning research work on high-temperature condensed states published in Canadian journals from October 1 to December 31, 1968.

Le présent rapport contient des renseignements bibliographiques sur les recherches effectuées sur les états condensés aux températures élevées, publiées dans les revues scientifiques canadiennes au cours de la période d'octobre 1 à décembre 31, 1968.

*Head, Physical Chemistry Section, Mineral Sciences Division.

Price 50 cents

Cat. No. M38-3/214

IC 215 Analyses and Characteristics of Oil Samples from New Brunswick, Newfoundland and Nova Scotia

R.P. Charbonnier*, R.G. Draper*, W.H. Harper** and A. Yates*

The 22 oil analyses gathered in this publication have been performed in the Fuels Research Laboratories of the Mines Branch in Ottawa, according to the U.S.B.M. Routine Method of Distillation. Some reservoir characteristics are also included.

Les 22 analyses de pétrole rassemblées dans cette publication ont été faites aux laboratoires de recherches sur les combustibles de la Direction des mines, à Ottawa, suivant la méthode U.S.B.M. de distillation. On a aussi inclus quelques caractéristiques des gisements.

*Senior Scientific Officers, and **Technical Officer, Fuels Research Centre.

Price 75 cents

Cat. No. M38-3/215

IC 216 Analyses and Characteristics of Oil Samples from Quebec

R.P. Charbonnier*, R.G. Draper*, W.H. Harper** and A. Yates*

The 7 oil analyses gathered in this publication have been performed in the Fuels Research Laboratories of the Mines Branch in Ottawa, according to the U.S.B.M. Routine Method of Distillation. Some reservoir characteristics are also included.

Les 7 analyses de pétrole rassemblées dans cette publication ont été faites aux laboratoires de recherches sur les combustibles de la Direction des mines, à Ottawa, suivant la méthode U.S.B.M. de distillation. On a aussi inclus quelques caractéristiques des gisements.

*Senior Scientific Officers, and **Technical Officer, Fuels Research Centre.

Price 75 cents

Cat. No. M38-3/216

IC 217 An Index of the Scientific and Technical Papers Published by the Staff in 1968

Price \$1.00

Cat. No. M38-3/217

IC 218 Bibliography of High-Temperature Condensed States Research Published in Canada, January - March, 1969

N.F.H. Bright*

This report contains bibliographic information concerning research work on high-temperature condensed states published in Canadian journals from January 1 to March 31, 1969.

Le présent rapport contient des renseignements bibliographiques sur les recherches effectuées sur les états condensés aux températures élevées, publiées dans les revues scientifiques canadiennes au cours de la période de janvier 1 à mars 31, 1969.

*Head, Physical Chemistry Section, Mineral Sciences Division.

Price 50 cents

Cat. No. M38-3/218

IC 220 Analyses and Characteristics of Oil Samples from British Columbia and Northwest Territories

R.P. Charbonnier*, R.G. Draper*, W.H. Harper** and A. Yates*

The 6 oil analyses gathered in this publication have been performed in the Fuels Research Laboratories of the Mines Branch in Ottawa, according to the U.S.B.M. Routine Method of Distillation. Some reservoir characteristics are also included.

Les 6 analyses de pétrole rassemblées dans cette publication ont été faites aux laboratoires de recherches sur les combustibles de la Direction des mines, à Ottawa, suivant la méthode U.S.B.M. de distillation. On a aussi inclus quelques caractéristiques des gisements.

*Senior Scientific Officers, and **Technical Officer, Fuels Research Centre.

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Cat. No. M38-3/220

IC 221 Analyses and Characteristics of Oil Samples from Manitoba

R.P. Charbonnier*, R.G. Draper*, W.H. Harper** and A. Yates*

The 19 oil analyses gathered in this publication have been performed in the Fuels Research Laboratories of the Mines Branch in Ottawa, according to the U.S.B.M. Routine Method of Distillation. Some reservoir characteristics are also included.

Les 19 analyses de pétrole rassemblées dans cette publication ont été faites aux laboratoires de recherches sur les combustibles de la Direction des mines, à Ottawa, suivant la méthode U.S.B.M. de distillation. On a aussi inclus quelques caractéristiques des gisements.

*Senior Scientific Officer, and **Technical Officer, Fuels Research Centre.

Price 75 cents

Cat. No. M38-3/221

IC 223 Bibliography of High-Temperature Condensed States Research Published in Canada, April - June, 1969

Norman F.H. Bright*

This report contains bibliographic information concerning research work on high-temperature condensed states published in Canadian journals from April 1 to June 30, 1969.

Le présent rapport contient des renseignements bibliographiques sur les recherches effectuées sur les états condensés aux températures élevées, publiées dans les revues scientifiques canadiennes au cours de la période d'avril 1 à juin 30, 1969.

*Head, Physical Chemistry Section, Mineral Sciences Division.

Price 50 cents

Cat. No. M38-3/223

IC 224 Analyses of Coal and Coke During 1968

W.J. Montgomery* and G.C. Behnke**

The Solid Fuels Laboratory of the Fuels Research Centre is responsible for all analytical work on coal and coke encompassed by this publication. This information circular, issued as the eighth of an annual series, tabulates the analyses of coal samples analysed by the Centre during 1968.

It must be clearly understood that no responsibility is taken by the Centre for the accuracy of the sampling procedures adopted for procuring the samples for which analyses are reported in this circular, excepting those taken by Centre officers.

Proximate analysis and sulphur values are reported on the "as received" basis only, whereas calorific values are reported on the "as received" as well as the "dry" basis. As an easy reference, the analyses are arranged by province and state.

Le laboratoire des combustibles solides, au Centre de recherches des combustibles, s'occupe de tous les travaux analytiques sur le charbon et le coke mentionnés par la présente publication. Cette circulaire d'information, la huitième d'une série qui doit paraître annuellement, traite des analyses d'échantillons de charbon analysés par le Centre au cours de 1968.

Il faut bien se rappeler que, sauf pour les échantillons prélevés par ses propres fonctionnaires, le Centre n'assume aucune responsabilité en ce qui concerne l'exactitude des techniques d'échantillonnage adoptées pour obtenir les échantillons dont les analyses sont considérées dans la présente circulaire.

On indique les analyses quantitatives approximatives et les teneurs en soufre des échantillons "tels qu'ils nous sont parvenus" seulement, tandis qu'on mentionne les valeurs calorifiques des échantillons "tels qu'ils sont reçus" et aussi "à sec". Pour les fins de référence, les analyses sont classées par province et par état.

*Head, Solid Fuels Laboratory, and **Technician, Fuels Research Centre.

Price 75 cents

Cat. No. M38-3/224

IC 225 Thesaurus of Mining Terms

A.S. Romaniuk*

This thesaurus provides the language control for the technical information service being developed in the Mines Branch for mining technology, and is presented for the use of others who may be striving to systematically accumulate and rapidly retrieve mining information. It contains about 850 terms, also called keywords or descriptors, related mostly to those mining activities which occur after a mineral deposit has been located, but before metallurgical processing or marketing begins. Accordingly, the majority of terms relate to drilling, blasting, loading, hauling, crushing, rock mechanics and mining environment.

Terms were compiled according to the rules and conventions recommended by the Engineers Joint Council from the expressions used in several hundred mining reports by Canadian authors in industry, universities and government, as well as from actual requests for technical information received by the Mines Branch. Relationships between terms are shown by the following five types of cross references: USE, USED FOR, BROADER TERM, NARROWER TERM, RELATED TERM.

Le présent recueil est un guide terminologique employé par le service d'information technique que la Direction des mines est en voie d'établir pour la technologie minière; il est offert à ceux qui cherchent peut-être à compiler systématiquement et à récupérer rapidement des renseignements sur les mines. Il renferme environ 850 mots, appelés également mots clés ou descripteurs, se rapportant principalement aux activités minières survenant après la localisation d'un gisement et avant le traitement métallurgique ou la mise en marché. En conséquence, la majorité des termes concernent le forage, le dynamitage, le chargement, le transport, le broyage, la mécanique des roches, et autres sujets du milieu minier.

Les termes ont été compilés conformément aux règles et conventions recommandées par la Commission mixte des ingénieurs à partir d'expressions employées dans des centaines de rapports miniers rédigés par des auteurs canadiens dans l'industrie, les universités et les services de l'État, et à la suite de demandes de renseignements techniques parvenues à la Direction des mines. Les rapports existant entre les divers termes sont indiqués d'après les cinq genres de renvois suivants: USAGE COURANT, UTILISE POUR, TERME PLUS GENERAL, TERME PLUS RESTREINT, TERME CONNEXE.

*Head, Mining Information Centre.

Price \$1.25

Cat. No. M38-3/225

IC 228 Analyses and Characteristics of Oil Samples from Ontario

R.P. Charbonnier*, R.G. Draper*, W.H. Harper** and A. Yates*

The 54 oil analyses gathered in this publication have been performed in the Fuels Research Laboratories of the Mines Branch in Ottawa, according to the U.S.B.M. Routine Method of Distillation. Some reservoir characteristics are also included.

Les 54 analyses de pétrole rassemblées dans cette publication ont été faites aux laboratoires de recherches sur les combustibles de la Direction des mines, à Ottawa, suivant la méthode U.S.B.M. de distillation. On a aussi inclus quelques caractéristiques des gisements.

*Senior Scientific Officer, and **Technical Officer, Fuels Research Centre.

Price \$1.25

Cat. No. M38-3/228

IC 229 Oils and Basic Organic Chemicals from Coal by Hydrogenation (A Literature Review)

W.A.O. Herrmann*

The literature published since World War II on coal hydrogenation and its economics, and on the production of chemicals from coal, is critically reviewed. The advantages and disadvantages of different operating schemes are discussed from the viewpoint of the author's own experience as far back as 1936 in German coal hydrogenation plants. Some possibilities of improvement and cost savings are discussed. The feasibility of extracting basic chemicals from the products of coal hydrogenation and of converting such by-products to basic chemicals of higher value is considered, as well as the contribution of such an operation towards improving the economics of coal hydrogenation.

L'auteur passe en revue d'une manière critique les publications, parues depuis la Seconde Guerre Mondiale, sur l'hydrogénation du charbon et son aspect économique, ainsi que sur la production de produits chimiques à partir du charbon. Les avantages et désavantages de différents modes d'exploitation sont analysés du point de vue de l'expérience personnelle de l'auteur remontant à 1936, dans des usines d'hydrogénation du charbon en Allemagne. Des possibilités d'amélioration et de réduction des frais sont discutées. La possibilité d'extraire des produits chimiques fondamentaux, à partir des produits de l'hydrogénation du charbon, et aussi de convertir de tels sous-produits en des produits chimiques fondamentaux de valeur plus grande, est considérée, de même que la contribution d'une telle opération vers l'amélioration des conditions économiques de l'hydrogénation du charbon.

*Senior Scientific Officer, Fuels Research Centre.

Price \$1.00

Cat. No. M38-3/229

IC 234 Bibliography of High-Temperature Condensed States Research Published in Canada, July - September, 1969

Norman F.H. Bright*

This report contains bibliographic information concerning research work on high-temperature condensed states published in Canadian journals from July 1 to September 30, 1969.

Le présent rapport contient des renseignements bibliographiques sur les recherches effectuées sur les états condensés aux températures élevées, publiées dans les revues scientifiques canadiennes au cours de la période de juillet 1 à septembre 30, 1969.

*Head, Physical Chemistry Section, Mineral Sciences Division.

Price 50 cents

Cat. No. M38-3/234

REPRINT SERIES

RS 78 Structural Stability of Minerals with the Pyrite, Marcasite, Arsenopyrite and Lollingite Structures

Ernest H. Nickel*. Reprinted from The Canadian Mineralogist, Vol. 9, Part 3, 1968.

The structural stabilities of the disulphides, diarsenides and sulpharsenides of iron, cobalt and nickel are explained on the basis of ligand field theory. The structural stabilities can be correlated with the number of non-bonding *d* electrons of the metal atom in the structure, and can be explained by the tendency of the compounds to form structures in which maximum electron spin-pairing takes place.

The pyrite structure, which is favoured by metals with six or more non-bonding *d* electrons, and which includes pyrite, catterite, vaesite, cobaltite and gersdorffite, is characterized by metal-sulphur octahedra joined at corners, with no apparent interaction between the *d* electrons of neighbouring metal atoms. The other structures are all characterized by shared octahedral edges along one direction, so that the metal atoms are brought into relatively close proximity. In the marcasite structure, which includes marcasite and rammelsbergite, both with six non-bonding *d* electrons, the metal atoms repel each other because of completely filled t_{2g} levels. In the arsenopyrite structure, which includes arsenopyrite and safflorite, both of which have five *d* electrons that do not participate in metal-sulphur bonding, pairs of metals are drawn together to permit spin-pairing of the odd electrons. In lollingite, in which the iron atom is assumed to have four non-bonding *d* electrons, the *d* orbitals in the *c* crystallographic direction are emptied, permitting close iron-iron approaches in this direction, as well as complete spin-pairing of the electrons in the two remaining t_{2g} orbitals.

*Head, Mineralogy Section, Mineral Sciences Division.

Price 25 cents

Cat. No. M38-8/78

RS 79 Control of SO₃ in Low-Pressure Heating Boilers by an Additive

G.K. Lee*, F.D. Friedrich**, and E.R. Mitchell***. Reprinted from Journal of the Institute of Fuel, February 1969.

This paper deals with the burning of residual fuel oil containing 2.5% sulphur under conditions prevalent in heating boilers to assess the effect of boiler load, excess combustion air, mean residence time and the use of a magnesia-alumina fuel-oil additive on the formation of noxious and corrosive products of combustion. Results show that the additive can be used as an effective substitute for low excess combustion air in reducing the emission of oxides of nitrogen and SO₃. Furthermore, the additive neutralizes condensed H₂SO₄ and improves the electrical resistivity of soot particles to the point where electrostatic precipitation of soot is technically feasible. Detailed analyses of particulate matter samples taken from flames with untreated oil and oil treated with three different amounts of additive are described to elucidate the mechanism of acid soot neutralization and to obtain data on soot constituents that may contribute to atmospheric pollution. It is shown that the standard methods for measuring SO₃ concentrations in flue gas can give misleading results when soot or particulate matter is present.

*Research Scientist, **Senior Scientific Officer, and ***Head, Canadian Combustion Research Laboratory, Fuels Research Centre.

Price 25 cents

Cat. No. M38-8/79

RS 80 A Proposed Canadian Standard for Estimating Atmospheric Dispersion of Combustion Source Pollution from Chimneys

H. Whaley*. Reprinted from Atmospheric Environment Pergamon Press 1969, Vol. 3, pp. 177-195

Rising public concern over the persistent nature of air pollution may be expected to result in more stringent ambient air quality criteria. Hence, until air resource management becomes a reality, there is a requirement for a simple yet reliable method of estimating the dispersion of combustion source chimney effluents. To satisfy this need an empirical plume rise equation was developed and together with established diffusion equations, it provides the basis for the graphical stack height calculation method described in this paper. The emissions of gaseous and particulate matter are related to heat flux, stack height and maximum ground level pollution concentrations for both a severe atmospheric inversion and a neutral atmosphere. This enables the selection of a stack height to be made which should meet any stipulated ambient pollution level.

*Research Scientist, Canadian Combustion Research Laboratory, Fuels Research Centre.

Price 25 cents

Cat. No. M38-8/80

RS 81 Earth Pressure on Multiple Tunnels

D.F. Coates* and K.L. McRorie**. Reprinted from the Proceedings, Fifteenth Canadian Soil Mechanics Conference, November 1961 (NRC Technical Memorandum No. 73, June 1962)

A series of three parallel tunnels were driven some 650 ft below the ground surface. Yielding arch sets were installed in these tunnels. To determine the magnitude of the pressure acting on these sets - load cells were installed under the legs of the sets - load cells were installed in the ground adjacent to the sets - and deformation readings of the sets were observed.

The paper includes the results of laboratory and field testing. Besides classification tests, the strength and modulus of deformation of the material as well as their variation with moisture content and time were determined.

The empirical data indicating the magnitude of the loads acting on the sets are presented. The results are analyzed to determine the earth pressures that were acting.

Theoretical analyses of the mechanisms that could produce these pressures have been made. The empirical results

are compared with the theoretical calculations. A discussion of the results is presented.

*Head, Mining Research Centre and **Assistant Manager, Steep Rock Iron Mines Limited.

Price 25 cents

Cat. No. M38-8/81

RS 82 The Polymorphism of the Oxide Ti_3O_5 *

H. Iwasaki**, N.F.H. Bright*** and J.F. Rowland****. Reprinted from Journal of the Less-Common Metals, Elsevier Sequoia S.A., Lausanne - Printed in The Netherlands

The oxide Ti_3O_5 has been prepared by reduction of TiO_2 (as anatase and as rutile) using Ti metal as reductant and vacuum sintering, or by using CO or H_2 as reductant. The oxides produced, and also their oxidation products at $650^\circ C$, were examined by X-ray diffraction. Three forms of Ti_3O_5 were characterized:

(a) a form designated as D-type, produced by the hydrogen reduction of anatase, which yielded rutile only on oxidation; (b) a form designated as D'-type, produced by the hydrogen reduction of rutile, which had an apparently similar X-ray diffraction pattern to that of the D-type, but which yielded a mixture of anatase and rutile on oxidation; (c) a form designated as M-type, produced by the vacuum-sintering of TiO_2 with Ti metal, which had a different X-ray diffraction pattern but which also yielded a mixture of anatase and rutile on oxidation. Forms (a) and (b) are similar to the previously-claimed high-temperature form of MAGNELI; form (c) is similar to his low-temperature form; the transition temperature is slightly in excess of $100^\circ C$.

The D'-type could be derived from the M-type. The D-type could easily be changed into the M-type by cooling from $1350^\circ C$ under vacuum. By annealing experiments, the D-type was shown to be a meta-stable form. Some crystallographic considerations concerning the oxidation behaviour of the various polymorphs of Ti_3O_5 are proposed, also a possible correlation with the various types of compounds having the pseudobrookite structure.

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**Postdoctorate Fellow, National Research Council; present address - Nippon Telegraph and Telephone Public Corporation, Tokyo, Japan.

Head, Physical Chemistry Section and *Research Scientist, Crystal Structure Group, Mineral Sciences Division.

Price 25 cents

Cat. No. M38-8/82

RS 83 1. Comparison of U and MO in Improving the Corrosion Resistance of AISI 430 Stainless Steel

G.J. Biefer* and J.G. Garrison**. Reprinted from Materials Protection 7, 39-40 and 23-26, 1968.

A comparison of molybdenum and uranium as a means of improving corrosion resistance of ferritic AISI Type 430 stainless steel is shown by laboratory tests.

*Head, and **Technical Officer, Corrosion Section, Physical Metallurgy Division.

2. Environmental Cracking Susceptibility of High Strength Steels

G.J. Biefer*

Exploratory stress corrosion cracking (SCC) and H_2 embrittlement cracking (HEC) test were carried out on high strength steels using an apparatus in which the test specimens are small bent strips held in this configuration under spring loading. Effects of alloy, electrochemical potential, test solution, pre-cracking, and coating are examined.

*Head, Corrosion Section, Physical Metallurgy Division.

Price 25 cents

Cat. No. M38-8/83

RS 84 The Surface Tension of Liquid Metals and Alloys

D.W.G. White*. Reprinted from Met. Rev. 13(124), 73-96, 1968

This paper reviews the "state of the art" of liquid metal surface tension measurement. Thus, some basic principles of thermodynamics and surface tension theory are reviewed; selected theoretical and empirical correlations with experimental data are appraised; and experimental methods and techniques are analysed for their sources of error and the means are discussed whereby such errors may be avoided, minimized or corrected.

*Research Scientist, Non-Ferrous Metals Section, Physical Metallurgy Division.

Price 25 cents

Cat. No. M38-8/84

RS 85 Lead Zirconate-Lead Titanate Piezoelectric Ceramics with Iron Oxide Additions

T.B. Weston*, A.H. Webster** and V.M. McNamara***. Reprinted from the Journal of The American Ceramic Society, Vol. 52, No. 5 May, 1969. Copyright 1969 by The American Ceramic Society

An investigation of the effects of small additions of Fe₂O₃ to lead zirconate-lead titanate ceramics with compositions between 45 and 60 mol% lead zirconate has shown that, with 2 moles of PbO to balance each mole of Fe₂O₃, the solubility of Fe₂O₃ was about 0.8 wt% in compositions near the tetragonal-rhombohedral boundary. The dielectric constant and dissipation factor for both rhombohedral and tetragonal materials were decreased by addition of iron oxide, whereas the mechanical quality factor and frequency constant were increased. The dependence of the electro-mechanical properties on grain size was qualitatively similar for both undoped and iron oxide-doped materials; the presence of iron oxide inhibited grain growth and lowered the limiting grain size below which the electromechanical properties change rapidly with grain size.

*Research Scientist, Mineral Processing Division, **Research Scientist, Mineral Sciences Division and ***Research Scientist, Extraction Metallurgy Division.

Price 25 cents

Cat. No. M38-8/85

RS 86 Applications of Digital Computers in the Quality Control of Concrete

V.M. Malhotra*. Reprinted from Publication SP-16, pp. 9-22, American Concrete Institute, Detroit, Michigan, 1967

Digital computers are used for control of concrete quality during its manufacture and for analysis and interpretation of concrete test results. Statistical parameters normally used for quality control are defined and their use is explained with the help of job control charts. The three case histories presented show: (1) the use of computers in establishing the degree of reliance of the strength of accelerated-cured test cylinders; (2) the multiple correlation analyses of 1176 compressive strength test results and several independent variables; and (3) a computer method for the trial and error fitting of a hyperbolic curve to compressive strength test results.

*Research Scientist, Mineral Processing Division

Price 25 cents

Cat. No. M38-8/86

RS 87 Improved Silver Cyanide Plating Baths: Laboratory Development

W. Dingley, J. Bednar and R.R. Rogers*. Reprinted from Publication Plating Vol. 56, No. 10, pp. 1129-1134, October 1969.

Improved silver plating results were obtained during laboratory experiments in which the bath constituents were related to one another as follows:

(1) $Y = 0.374 + 0.768X - 0.178X^2$
where Y = OH⁻ normality
and X = "free" CN⁻ normality

(2) $\frac{\text{total NaCN normality}}{\text{Ag normality}}$ is between 6.1 and 8.1

(the exact value depending on the bath composition)

The advantages of these improved silver plating baths include: low rate of cyanide consumption and carbonate formation; high current efficiency and low cell voltage when operating at comparatively high cathode current density; deposition of uniform fine-grained deposits in the absence of brighteners; insolubility of the silver anodes in the plating bath when the latter is not in use; absence of silver deposition on unconnected steel cathodes immersed in the plating bath; ability to plate satisfactory silver deposits directly on steel; ability to plate high strength steels, such as Types 1062 and 4037, directly with silver without embrittling the steels.

*Corrosion Section, Extraction Metallurgy Division.

Price 25 cents

Cat. No. M38-8/87

RS 88 Some Factors in X-Radiation Detection with the Scintillation Counter

D.J. Reed*. Reprinted from the Canadian Spectroscopy Vol. 14, Issue No. 4, September 1969.

When the scintillation counter is used to detect the K radiation of elements of atomic number 57 and greater, the escape peak may play an important role in the establishment of the parameters to be used for the measurement of X-ray intensity. Double plateaus are found and pulse amplitude curves become complex, especially for second and third order radiation. A shift in pulse amplitude with counting rate has been found for a scintillation counter using XP1010 photomultiplier tubes. This shift makes the choice of a threshold for the pulse height analyzer critical.

Lorsqu'on utilise un compteur à scintillation pour détecter les lignes K des éléments dont le numéro atomique est de 57 ou plus, le sommet peut jouer un rôle important dans le choix des paramètres à utiliser.

On obtient des plateaux doubles et les courbes d'intensité vibrationnelle deviennent complexes, spécialement pour les radiations de deuxième et troisième ordre.

On a obtenu un déplacement de l'amplitude de vibration avec le taux de mesure en se servant d'un compteur à scintillation utilisant des tubes photomultiplicateurs XP 1010. Ce déplacement rend le choix du seuil de l'analyseur très critique.

*Research Scientist, Mineral Sciences Division.

Price 25 cents

Cat. No. M38-8/88

MONOGRAPH

Monograph 877 A Combustion Handbook for Canadian Fuels 1969, Volume 1: Fuel Oil.

F.D. Friedrich*

The handbook includes most of the fuels used in commercial quantities and presents the combustion data in the form of a set of easy-to-use graphs for each fuel analysis. Specifically, the graphs show (a) per pound of fuel, the weight and volume of combustion air required and flue gas produced for a range of temperature and excess air conditions, (b) the heat losses resulting from combustion of the fuel for a range of conditions, calculated according to the ASME Power Test Code, and (c) where applicable, the theoretical concentration of SO₂ in the flue gas.

Also included is information common to all the fuel analyses, such as a psychrometric chart, a chart showing boiler radiation loss, and a brief discussion of low-temperature corrosion. Sample calculations showing the derivation of the graphs are given in Appendix A.

The method of calculating the ultimate analysis of a fuel oil is described in detail in Appendix B. In the calculations, one pound of oil is used as the basic unit of fuel. As a convenience, conversion factors dealing with each oil analysis in terms of Imperial gallons, U.S. gallons and millions of Btu (Btu x 10⁶) are given prior to each set, along with the ultimate analysis which that set represents.

*Senior Scientific Officer, Canadian Combustion Research Laboratory, Fuels Research Centre.

Price \$7.50

Cat. No. M37-139/1

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- IR 69-4 "Study of the Electrokinetic Properties and Floatability of a Sample of Natural Corundum", A.P. Page, January (1969).
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- IR 69-15 "The Effects of Some Additives on the Properties of Lead Zirconate-Titanate Ceramics", A.H. Webster and T.B. Weston, February (1969).
- IR 69-20 "Testing of Low-Strength Concrete after Standard and Accelerated Curing", V.M. Malhotra, March (1969).
- IR 69-28 "Recovery of Copper from a Sample of Ore Submitted by Alwin Mining Company Limited, Highland Valley, British Columbia", W.A. Wall, A. Stemerowicz and R.W. Bruce, April (1969).
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