

DEPARTMENT OF
MINES AND TECHNICAL SURVEYS

MINES BRANCH

SCIENTIFIC AND TECHNICAL PAPERS
PUBLISHED BY THE STAFF IN 1965

OTTAWA

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1966

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 is the third supplement to IC 151 and is divided into three sections.

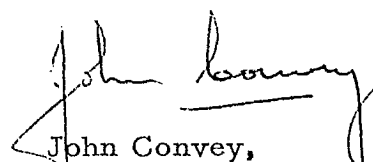
Section 1 consists of the titles of papers published during 1965 in the Mines Branch Series (Monographs, Research Reports, Technical Bulletins, and Information Circulars) together with an abstract or summary of each paper. These reports are available from the Queen's Printer, Ottawa, at the prices indicated 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 1965 by the Mines Branch staff. An abstract or summary again accompanies each title in order to inform the reader of the main content of the paper. The periodicals containing these papers are available in many technical libraries.

Section 3 contains a list of the 1965 titles available in the Investigation Report Series and also of the titles from previous years that have now been released for general distribution. This series includes the results of investigations carried out by the Mines Branch at the request of industry and of 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 this 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.

June, 1966


John Convey,
Director.

AVANT-PROPOS

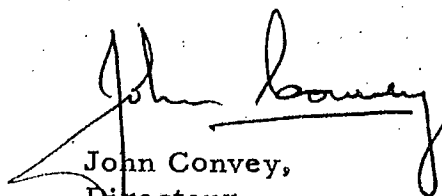
La circulaire d'information IC 151 (juin 1963) a été la première d'une série de rapports annuels scientifiques et techniques publiés par la Direction des mines. La présente circulaire d'information constitue le troisième supplément à IC 151 et elle est divisée en trois sections.

La première section embrasse les titres des études publiées en 1965 dans la série de la Direction des mines (monographies, rapports de recherche, bulletins techniques et circulaires d'information) de même qu'un résumé de chaque étude. On peut se procurer ces rapports chez l'Imprimeur de la reine à Ottawa, au prix indiqué, ou les commander selon le numéro de catalogue assigné à chaque rapport. (Les rapports antérieurs à 1962 sont énumérés au Catalogue sectionnel de gouvernement canadien n° 12, juillet 1962).

La section n° 2 comprend tous les titres des études publiées en 1965 dans les journaux scientifiques et techniques par le personnel de la Direction des mines et un résumé accompagne chaque titre pour renseigner le lecteur sur le sujet traité. Les périodiques dans lesquels les études ont été publiées se trouvent dans plusieurs bibliothèques techniques.

La section n° 3 comprend une liste des titres de 1965 disponibles dans la série des rapports de recherche de même que les titres des années précédentes qui sont maintenant offerts au public. Cette série comprend les résultats de recherches effectuées par la Direction des mines à la demande de l'industrie ou d'autres organismes du gouvernement, de même que de recherches entreprises par la Direction des mines sur des matériaux ou des procédés particuliers. Plusieurs rapports de recherche ne sont pas disponibles parce qu'ils sont confidentiels ou d'un intérêt très limité. Ceux qui sont énumérés dans la présente circulaire d'information sont disponibles pour consultation dans les dossiers de division mais, dans la majorité des cas, il n'existe pas d'exemplaires supplémentaires pour la distribution. Cependant nous croyons que même cette disponibilité restreinte pourra être utile à nombre de personnes ou sociétés qui ont des problèmes particuliers et pourra prévenir la duplication inutile de recherches déjà faites par la Direction.

Nous espérons que cet index supplémentaire sera aussi bien accueilli complète des travaux de la Direction des mines qui est au service de l'industrie minéralogique et métallurgique au Canada.


John Convey,
Directeur.

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Previous Reports in This Series

Information Circular 151 (1962)

Information Circular 162 (1963)

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SECTION 1 - MINES BRANCH SERIES

MONOGRAPHS

Mines Branch Monograph No. 870.

Water Survey Report No. 14

*The Upper Great Lakes Drainage
Basin in Canada, 1957-63*

Surface waters of the Upper Great Lakes basin, a part of the Great Lakes-St. Lawrence River system, are for the most part very soft, to soft (below 60 ppm as CaCO₃ hardness); surface waters in a few areas are in the medium-hard to hard range.

Waters of the main St. Lawrence River system in this portion of the basin are quite constant in chemical quality, even softer than many tributary streams, but there is a definite increase in mineralization in parts of the Georgian Bay region of Lake Huron.

Most tributary rivers show little significant change in chemical quality, including turbidity, with season or river discharge. Many rivers are, however, highly coloured. Tributary rivers generally show decreased mineral content with increased discharge, except for some rivers whose discharge is controlled by dams, power development, etc. when the opposite relationship has been noted.

The good quality of these surface waters is evident from the large proportion used in organized systems without any treatment other than chlorination. Additional treatment is usually for colour removal.

Price: \$2.50

Catalogue No. M32-870

Mines Branch Monograph No. 871.

In preparation.

Water Survey Report No. 15



RESEARCH REPORTS

**R 9. Properties of Sand-Cast
Magnesium Alloys - Part I:
Binary Magnesium-Zinc Alloys**

B. Lagowski* and J.W. Meier**, June 1958. 29p. Illus.

The magnesium-zinc alloy system is today the most important base for high-strength magnesium alloys. Unfortunately, published data on properties of binary Mg-Zn casting alloys are both limited and controversial. It was, therefore, necessary to undertake a systematic study of the effect of composition and various melt treatments on the foundry characteristics, amenability to heat treatment, mechanical properties, and metallographic structure of this alloy series. Work on grain refinement of magnesium-zinc alloys included superheating, carbon inoculation, and additions of small amounts of aluminum, iron, manganese, titanium and zirconium. Results of the investigation show the necessity for considerable revision of long accepted data.

*Senior Scientific Officer, **Principal Metallurgist, Non-Ferrous Metals Section, Physical Metallurgy Division, Mines Branch.

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Cat. No. M38 -1/9

**R 22. Properties of Sand-Cast
Magnesium Alloys - Part II:
Metallography of Magnesium-
Zinc Alloys**

B. Lagowski*. August 1958. 17p. Illus.

As an extension of Part I, Binary Magnesium-Zinc Alloys, issued as Research Report R 9 dated June 1958, the present report describes in more detail the latest developments in studies of the Mg-Zn phase diagram and reviews typical microstructures of cast alloys containing up to 30% Zn. A discussion of the effect of various heat treatments and the resulting microstructures at various stages of phase changes is presented.

*Senior Scientific Officer, Non-Ferrous Metals Section, Physical Metallurgy Division, Mines Branch.

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Cat. No. M38 -1/22

**R 56. Properties of Sand-Cast
Magnesium Alloys - Part III:
Effect of Titanium Additions to
Magnesium-Zinc Alloys**

B. Lagowski* and J.W. Meier**, Jan. 1960. 32p. Illus., tables.

A study was undertaken to determine the effect of titanium additions on the properties of sand-cast magnesium-zinc alloys. Results indicate that some grain refinement was obtained for alloys containing 1-8% Zn which resulted in improved mechanical properties.

The most effective grain refinement was obtained in the range of 6-7% Zn, with properties in the fully heat treated (T6) condition of UTS-39 kpsi, 0.2% YS - 24 kpsi and 8% elongation. Although these values are higher than those obtained on the binary Mg-Zn alloys, they are still not comparable with those obtainable from zirconium-containing alloys (ZK61-T6).

*Senior Scientific Officer, **Principal Metallurgist, Non-Ferrous Metals Section, Physical Metallurgy Division, Mines Branch.

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Cat. No. M38 -1/56

**R 63. Properties of Sand-Cast
Magnesium Alloys - Part IV:
Mg-Ag, Mg-Ag-Zr and
Mg-Ag-Zn-Zr Alloys**

B. Lagowski* and J.W. Meier**, May 1960. 30p. Illus., tables.

The long-term research program on high-strength magnesium alloys, being conducted since 1945 at the laboratories of the Physical Metallurgy Division, Mines Branch, Department of Mines and Technical Surveys, Ottawa, has included a study of binary and more complex alloys based on the magnesium-silver system.

The results of the investigation related to sand-cast Mg-Ag, Mg-Ag-Zr and Mg-Ag-Zn-Zr alloys are presented and show that all three of these alloy groups have good ductility and are amenable to solution strengthening.

Precipitation-hardening, to any appreciable extent, was found only in certain alloys of the Mg-Ag-Zn-Zr system. Some of these alloys show exceptionally high yield strength.

*Senior Scientific Officer, **Principal Metallurgist, Non-Ferrous Metals Section, Physical Metallurgy Division, Mines Branch.

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Cat. No. M38 -1/63

R 102. *The Effect of Some Test Bar Variables on the Mechanical Properties of Aluminum Alloys*
A. Couture* and J. W. Meier**. 40p. Illus., tables.

The effect of machining on the tensile properties of aluminum alloy test bars was investigated. Although certain of the differences in ultimate strength and elongation were found to be statistically significant in some cases, they were of the same order as differences that are observed between melts of the same composition.

A comparison of 0.1% and 0.2% yield strength values, obtained on test bars of various aluminum alloys, showed that the linear relationship between these two values is different for most of the alloys investigated.

Similarly, linear relationships between the elongation values used in North America (4D) and in Great Britain (3, 5D) were found for the alloys investigated. *Senior Scientific Officer, **Principal Metallurgist, Non-Ferrous Metals Section, Physical Metallurgy Division, Mines Branch.

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Cat. No. M38 -1/102

R 110. *A Spectrometric Study of the Attenuation in Air of Gamma Rays from Mineral Sources*
A. F. Gregory* and J. L. Horwood**. 121p. Illus., tables.

The distributions of intensity and energy of the gamma-ray flux about selected sources were measured with a scaler and a 100-channel gamma-ray spectrometer. The sources investigated were: separate mineral concentrates of uranium, thorium and potassium, and pellets of cobalt-60. The observations are compared with established theory.

The observed spectrograms showed the following quasi-exponential variations with increasing air distance between source and detector:

- (1) a decrease in integral count-rate
- (2) a decrease in photopeak heights;
- (3) an increase in the Compton continuum, especially at low energies.

While these changes lead to a gradual loss of photopeak resolution with increasing distance, the major photopeaks are well resolved at distances of at least 700 feet when suitable counting times are chosen.

*Geologist, Geophysics Division, Geological Survey of Canada Branch.
**Senior Scientific Officer, Mineral Sciences Division, Mines Branch.

\$1.25

Cat. No. M38 -1/110

R 128. *The Determination of Lead by a Solvent Extraction-EDTA Titration Procedure*
A. Hitchen*. 28p. tables.

A rapid, simple and precise method has been developed for the determination of 0.05 to 500 milligrams of lead, in mixtures of lead, titanium and zirconium precipitates used for the manufacture of ceramic transducers, and also in lead ores, concentrates and minerals. Lead is determined by titration with disodium ethylenediaminetetraacetate using Xylenol Orange as indicator, after separation from interfering elements by chloroform extraction of lead diethyldithiocarbamate. Complexation with cyanide and tartarate eliminates the interfering effect of most elements except bismuth, antimony, tin, manganese, and phosphate. The interference of all these except bismuth can be prevented by special procedures, which are described. In the case of bismuth, the method permits it to be determined along with the lead by a successive titration, and a procedure for accomplishing this is also given.

*Senior Scientific Officer, Extraction Metallurgy Division, Mines Branch.

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Cat. No. M38 -1/120

R 135. *Experimental Flotation Cell*
L. L. Sirois* and T. Takamori**. 9p. Illus., tables.

A pneumatic experimental flotation cell was built to provide a well regulated apparatus to help in the study of the function of carbohydrate derivatives in oxide flotation. It was designed to permit direct control over all the variables which are encountered in flota-

such as fluctuation in the level of the pulp, temperature, and variations in aeration, impeller speed and rate of removal of froth. Many tests done with this cell showed that it could give reproducible results.

*Scientific Officer, Metallic Minerals Research Laboratory, Mineral Processing Division, Mines Branch.

**National Research Council Postdoctorate Fellow, Hokkaido University, Japan.

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Cat. No. M38 -1/135

R 142. A Brief Study of Nickel-Rich Alloys of the Ni-Hf-C and Ni-Zr-C Systems

D. C. Briggs*. 16p. Illus., tables.

A brief study has been made of the incidence, form and stability of carbides of hafnium and zirconium in a nickel-base system. Alloys were studied in the Ni-Hf-C system up to 1 at. % C and 1 at. % Zr. In each system a second phase was found that was extracted electrolytically and identified by X-ray diffraction techniques as a monocarbide of the reactive metal. Both HfC and ZrC were found to lack stability with changes in temperature; both ternary systems exhibited mild ageing response.

*Scientific Officer, Physical Metallurgy Division, Mines Branch.

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Cat. No. M38 -1/142

R 143. Kinetics of the Carbon Catalyzed Air Oxidation of Ferrous Ion in Sulphuric Acid Solutions

G. Thomas* and T. R. Ingraham**. 13p. Illus., tables.

Air oxidation of acidic ferrous sulphate solutions is catalyzed by activated carbon. The oxidation rate during most of the reaction can be expressed by:

$$-d[Fe^{++}]/dt = k [O_2] [C] f [H_2SO_4] [Fe^{++}] / [Fe^{++} + Fe^{+++}]$$

For molar concentrations of each of the variables, the rate of oxidation ranges from 0.07 to 1.3 moles of ferrous ion oxidized per litre of solution per minute, for various types of 100-by-150-mesh activated carbon. The rate increases with increasing fineness of the carbon; it also increases almost linearly with increasing sulphuric acid concentration up to 2M, but thereafter decreases almost

linearly to 10M H₂SO₄. The results are consistent with the hypothesis that the carbon surface is sparsely covered with adsorbed oxygen, ferrous ions, and ferric ions. The activation energy estimated for the process is 6 kilocalories per mole in the temperatures the activation energy is negligibly small. The activated carbon can be used repeatedly, with little loss in efficiency. Two types of apparatus were tested and found suitable for the continuous oxidation of flowing solutions.

Published as a paper in Unit Proc. in Hydromet., Vol. 1, Met. Soc. of AIME, 1965.

*Senior Scientific Officer, **Head, Research Section, Extraction Metallurgy Division, Mines Branch.

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Cat. No. M38 -1/143

R 144. Orientation Determinations of Crystals Using Ejection Patterns Resulting from Ion Bombardment

R. L. Cunningham* and J. Ng-Yelim**. 4p. Illus., table.

Data on six common metals are presented to indicate the general usefulness of ion bombardment for orientation determinations of fcc and bcc crystals. The accuracy is 3° or better and is attained by the use of hemispherical collectors and a simple optical projection device. No film processing is involved and a complete determination, including all operations, usually takes less than 20 min.

Published as a paper in J. of Appl. Phys., Vol. 35, No. 7, pp. 2185-2188, July 1964.

*Principal Scientist, **Technical Officer, Physical Metallurgy Division, Mines Branch.

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Cat. No. M38 -1/144

R 145. Experiments in the Au-Bi-Te System

E. W. Winkler* and N. F. H. Bright**. 3p. Illus.

The system Au-Bi-Te has been studied by thermal analysis, X-ray diffraction, DTA and metallographic polished section techniques. The join Au-

Bi_2Te_3 has a eutectic point at 67.7 mol. per cent Au: 32.3 mol. per cent Bi_2Te_3 and 472°C . The join AuTe_2 - Bi_2Te_3 has a eutectic point at 78.1 mol. per cent AuTe_2 : 21.9 mol. per cent Bi_2Te_3 and 408°C . A ternary eutectic occurs at 12 per cent Au, 86 per cent Bi, 2 per cent Te and 210°C . The system contains no ternary compound. Seebeck coefficient, electrical conductivity, hardness and Hall coefficient measurements are being made.

Published as a paper in Solid State Communications, Vol. 2, pp. 293-295, 1964.

*National Research Council of Canada Postdoctorate Fellow assigned to Mines Branch.

**Head, Physical Chemistry Section, Mineral Sciences Division, Mines Branch.

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Cat. No. M38-1/145

R 146. *Simplified Apparatus and Technique for the Determination of Crystal Orientation by Ion Bombardment*

R. L. Cunningham* and J. Ng-Yelim**. Feb. 1965. 9p. Illus.

The ion bombardment camera, designed specifically for orientation determinations, is machined from clear acrylic plastic and incorporates an ion source of the glow discharge type. A plastic orienting sphere, illuminated from within, has engraved on it the low index directions of cubic crystals. Hemispherical collectors, bearing ejection patterns, are positioned on the sphere and the orientation of the crystals may then be immediately observed.

*Principal Scientist, **Technical Officer, Physical Metallurgy Division, Mines Branch.

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Cat. No. M38-1/146

R 147. *Thermodynamics of the Thermal Decomposition of Cupric Sulfate and Cupric Oxysulfate*

T. R. Ingraham*. March 1965. 5p. Illus., tables.

The thermal decomposition of cupric sulfate and of cupric oxysulfate has been examined by determining the equilibrium gas pressure generated over each pure compound. The equilibrium data have

been used to calculate the thermodynamic properties of both compounds, and the results have been combined with previously published data to establish a predominance-volume diagram for the Cu-S-O system over the normal range of roasting temperature and gas composition used in the treatment of copper minerals. Copper oxysulfate recrystallizes at 1100°K with an apparently irreversible endothermic heat requirement of 2.9 ± 0.3 kcal per mole.

Published as a paper in Trans. of the Met. Soc. of AIME, Vol. 233, pp. 359-363, Feb. 1965.

*Head, Research Section, Extraction Metallurgy Division, Mines Branch.

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Cat. No. M38-1/147

R 148. *Kinetics of the Thermal Decomposition of Cupric Sulfate and Cupric Oxysulfate*

T. R. Ingraham* and P. Marier**. March 1965. 5p. Illus., tables.

When anhydrous cupric sulfate is heated in a stream of nonreactive gas, cupric oxysulfate is formed. When this reaction is complete, the cupric oxysulfate then decomposes to cupric oxide, which is the normal end product of reaction. The kinetics of each of these reactions has been studied using pellets prepared from finely divided cupric sulfate and from finely divided cupric oxysulfate. In each case, the pellet is well-defined, and by normalizing the decrease in interfacial area with the weight fraction of the pellet decomposed it has been shown that the interface migrates into the pellet at a uniform rate of constant temperature. The activation energy estimated for the decomposition of cupric sulfate is 57 ± 7 kcal per mole and that for cupric oxysulfate is 67 ± 8 kcal per mole. The rate of interfacial with increasing flow of a sweep gas in the range from 50 to 2000 cu cm per min. The rate of decomposition is retarded by sulphur trioxide in the sweep gas. The relationship between sulfur trioxide partial pressure and rate is consistent with the Langmuir Adsorption Isotherm governing the retention of sulfur trioxide in the interfacial layer.

Published as a paper in Trans. of the Met. Soc. of AIME, Vol. 233, pp. 363-367, Feb. 1965.

*Head, **Scientific Officer, Research Section, Extraction Metallurgy Division, Mines Branch.

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Cat. No. M38 -1/148

R 149. Research on Premium-Quality Castings in Light-Alloys

J.W. Meier*. Jan. 1965. 60p. Illus., tables.

Extensive research on the structure and properties of cast aluminum and magnesium alloys has been applied to foundry practice. The term "premium quality" is used to describe castings with reliably high mechanical properties and high integrity of the product, guaranteed by the foundry. In production, conventional equipment and manufacturing techniques may be used, but rigid control of metal purity, alloy composition, melt quality, solidification conditions and heat treatment is essential to achieve and maintain high reliability of properties in designated areas of the casting, which are graded according to design and service considerations. Examples of the excellent properties that have been obtained in aluminum and magnesium alloy castings are listed.

Considering currently achieved properties, it is believed that in the near future aluminum alloy castings with 70 kpsi (50 kg/mm²) UTS, 60 kpsi (42 kg/mm²) 0.2% YS and 10% El., and magnesium alloy castings with 60 kpsi (42 kg/mm²) UTS, 50 kpsi (35 kg/mm²) 0.2% YS and 10% El., will be developed.

*Principal Metallurgist, Non-Ferrous Metals Section, Physical Metallurgy Division, Mines Branch.

\$1.00

Cat. No. M38 -1/149

R 150. Investigations on Sand-Cast Aluminum Alloy Test Bars

W.A. Pollard* and J.W. Meier**. Jan. 1965. 96p. Illus., tables.

To aid the standardization work of ISO/TC79 on Light Metals and Alloys, a Symposium on Sand-Cast Aluminum Alloy Test Bars was held at the International Foundry Congress in Detroit in 1962.

The Canadian contribution to this symposium was a comparison of the characteristics of six test bar pattern designs, used in various countries. This report presents the results of this study, along with the discussions held at the Symposium.

The last two parts of the report deal with a novel method of studying and flow of molten metal in test bar sand moulds by means of fluorescent screen radiography.

*Senior Scientific Officer, **Principal Metallurgist, Non-Ferrous Metals Section, Physical Metallurgy Division, Mines Branch.

\$1.25

Cat. No. M38 -1/150

R 151. The Effect of Test Bar Variables on the Mechanical Properties of Magnesium Casting Alloys

A. Couture* and J.W. Meier**. Feb. 1965. 45p. Illus., tables.

The effect of machining on the tensile properties of magnesium alloy test bars was investigated. Although some of the differences in property values were found to be statistically significant, they were of the same order as differences that are observed between melts of the same composition. The results showed that the mechanical properties obtained from substandard test bars may be significantly different from those obtained on standard test bars.

The study showed that results obtained on round test bars were significantly higher than those obtained on flat test bars cut from the same parts of the castings.

A comparison of 0.1% and 0.2% yield strength values, obtained on test bars of various magnesium alloys, showed that the linear relationship between these two values is different for most of the alloys and tempers investigated.

Similarly, linear relationships between the elongation values used in North America (4D), in Great Britain (3.5D) and in Continental Europe (5D) were found for the alloys investigated.

*Senior Scientific Officer, **Principal Metallurgist, Non-Ferrous Metals Section, Physical Metallurgy Division, Mines Branch.

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Cat. No. M38 -1/151

- R 152. *Properties of Sand-Cast Magnesium Alloys-Part VI: Effect of Pouring Temperature and Holding Time*
A. Couture* and J.W. Meier**. Feb. 1965. 33p. Illus., tables.

The influence of pouring temperature and holding time before pouring on the mechanical properties and chemical composition of several magnesium casting alloys has been investigated and the results, obtained on sand-cast four-bar moulds, are reported in the present report. The pouring temperature was varied from 700°C (1290°F) to 850°C (1560°F) and the holding time from 10 min to 2 hr at normal pouring temperature. Other melts were held at 700°C or 850°C for 30 min before pouring.

In general these various treatments did not adversely affect the chemical composition and mechanical properties to a pronounced extent. However, because alloy ZH62 tends to form dross when heated to 850°C, such a high temperature should be avoided if possible. The "insoluble" zirconium content of zirconium-containing alloys may be appreciably decreased by lowering the melt temperature to 700°C. The "soluble" zirconium and rare earth contents of alloy QE22, the rare earth content of alloy EZ33 and the thorium content of alloy ZH62 may be decreased by holding the melt at normal pouring temperature for an appreciable length of time.

*Senior Scientific Officer, **Principal Metallurgist, Non-Ferrous Metals Section, Physical Metallurgy Division, Mines Branch.

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Cat. No. M38 -1/152

- R 153. *In preparation.*

- R 154. *Tin-Collection Scheme for the Determination of the Platinum-Group Metals and Gold*
G.H. Faye*. April 1965. 31p. Illus.

A program conducted in the Mines Branch laboratories on the analytical chemistry of the precious metals has led to the development of a comprehensive scheme for the accurate determination of the individual platinum-group metals and of gold in ores, rocks, and mineralogical

cal and metallurgical concentrates.

In the proposed scheme, the precious metals are collected in molten tin when the sample is fused at 1200-1250°C with a flux containing stannic oxide, sodium carbonate, silica, borax, and powdered coke. The resultant tin alloy is dissolved and the individual precious metals are isolated by ion exchange, distillation and solvent extraction processes.

This report presents the procedural details of the new scheme so that they may be applied readily to materials of a diverse nature in the smaller laboratory which lacks sophisticated and costly equipment such as a spectrograph. With the exception of the usual facilities required in the fusion step of fire assaying, standard equipment can be used in the wet chemical operations for the isolation and determination of the individual precious metals. *Senior Scientific Officer, Analytical Chemistry Subdivision, Mineral Sciences Division, Mines Branch.

75 cents

Cat. No. M38 -1/154

- R 155. *Activation Analysis With a Neutron Generator*
H.P. Dibbs*. Feb. 1965. 91p. Illus., tables.

An account is given of an activation analysis system using a neutron generator as a neutron source. The shielding requirements for high-energy neutrons and the experimental irradiation facilities are described. Activation yields have been calculated, under defined conditions, for all stable nuclides that on irradiation with 14 MeV neutrons or with thermal neutrons produce gamma-emitting isotopes. Experimental measurements have also been made to determine the sensitivity of detection of sixty-six elements. The gamma-ray spectra resulting from a number of these empirical determinations are presented.

*Senior Scientific Officer, Mineral Physics, Mineral Sciences Division, Mines Branch.

\$1.25

Cat. No. M38 -1/155

- R 156. *A Comparative Method: Apparatus and Standards for Measurement of Thermal Conductivity*
V. V. Mirkovich*. April 1965. 28p. Illus., tables.

A comparative method thermal conductivity apparatus was designed. The precision of measurements was determined by measuring the conductivity of alumina with standards made of the same alumina. The accuracy of measurements was determined by cross-checking the conductivities of alumina, forsterite, Pyroceram Code 9606 and titanium carbide. The thermal stabilities of Pyroceram Code 9606 and zirconia were examined in order to establish their values as thermal conductivity reference materials. It was concluded that: 1) with this apparatus, accurate thermal conductivity data can be obtained; and 2) Pyroceram Code 9606 can be recommended for use as a primary standard for the low thermal conductivity range.

*Senior Scientific Officer, Mineral Processing Division, Mines Branch.

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Cat. No. M38 -1/158

R 157 *Theory and Experiment in Methods for the Precision Measurement of Surface Tension*
D. W. G. White*. April 1965. 58p. Illus., tables.

Methods of measuring surface tension are appraised for their suitability to liquid metals at elevated temperatures. Selected methods are examined for their potential sources of error and the means are discussed for eliminating, minimizing, or correcting for error.

*Senior Scientific Officer, Physical Metallurgy Division, Mines Branch.

\$1.00

Cat. No. M38 -1/157

R 158. *In preparation.*

R 159. *In preparation.*

R 160. *Surface Tension of Molten Zinc and Some Zinc Alloys*
D. W. G. White*. April 1965. 66p. Illus., tables.

The surface tension of zinc and of some zinc alloys has been determined by the sessile drop method in a program of work emphasizing detailed experimental care.

From experiments carried out in a closed, isothermal cell, the temperature

coefficient of the surface tension of pure zinc over a range of temperature from the melting point (419.6°C) to 540°C was found not to be negative but to be positive. However, it was shown that by deliberately inducing continuous vapourization, a temperature coefficient of surface tension with a negative slope can be produced.

In the alloy program, the effects of aluminum, copper, lead and tin on the surface tension of 99.999+% Zn have been determined.

*Senior Scientific Officer, Non-Ferrous Metals Section, Physical Metallurgy Division, Mines Branch.

\$1.00

Cat. No. M38 -1/160

R 161. *Properties of Sand-Cast Magnesium Alloys - Part VIII: Foundry Characteristics of Magnesium-Zinc-Silver-Zirconium Casting Alloys*
B. Lagowski* and J. W. Meier**. May 1965. 32p. Illus., tables.

In continuation of earlier work, additional casting alloys were developed in the magnesium-zinc-silver-zirconium system to achieve the optimum combination of mechanical properties and foundry characteristics. In particular, some work was directed to the production of thin-walled premium-quality castings.

The effects of section thickness, heavy chilling, and hot water quenching after solution treatment on the mechanical properties of high-strength magnesium casting alloys were investigated. Results of a study of foundry characteristics, including hot tearing, fluidity (castability), susceptibility to microshrinkage, linear shrinkage and density, are reported.

It was found that alloy ZQ91-T6 shows great promise for applications in more complex, and especially in thin-walled castings.

*Senior Scientific Officer, **Principal Metallurgist, Non-Ferrous Metals Section, Physical Metallurgy Division, Mines Branch.

75 cents

Cat. No. M38 -1/161

R 162. *Fe-Ta Oxides: Phase Relations at 1200°C*
A. C. Turnock*. June 1965. 8p. Illus., tables.

Subsolidus phase relations of the oxides in the system Fe-Ta-O were experimentally determined at 1200°C, 1 atm total pressure, and variable partial pressures of oxygen. Tantalum pentoxide reacts readily with either ferrous or ferric oxide at subsolidus temperatures and the following ternary compounds have been synthesized: $Fe_4Ta_2O_9$, $Fe_3Ta_2O_8$, $FeTaO_4$, $FeTa_2O_6$, solid solutions between the latter two compounds, and tantalum magnetites. The compositions of solid solutions between $FeTaO_4$ and $FeTa_2O_6$ were very sensitive to variation of oxygen pressure. This sensitivity explains the oxidation behavior of tapiolite. The incorporation into magnetite of up to 7 at. % Ta was demonstrated, with a resulting increase in the size of the unit cell and decrease in magnetic permeability.

Published as a paper in J. of the Amer. Ceram. Soc., Vol. 48, No. 5, 1965.

*Senior Scientific Officer, Physical Chemistry Section, Mineral Sciences Division, Mines Branch.

25 cents

Cat. No. M38 -1/162

R 163. *Production of High-Purity Magnesia*

G. A. Kent*. June 1965. 15p. tables.

This investigation was carried out to produce magnesite, or magnesia, with low iron content. Flotation and magnetic separation of uncalcined magnesite ore yielded concentrates in the order of 2% Fe (as Fe_2O_3) and 0.5% SiO_2 . Calcination of the concentrates, followed by flotation and magnetic separation, further reduced the iron to about 1% Fe_2O_3 and the silica to about 0.4%. Leaching calcined ore or concentrate with dilute acetic acid produced magnesia containing less than 0.01% Fe_2O_3 and low silica. A procedure for producing high-grade magnesia is suggested.

*Senior Scientific Officer, Industrial Minerals Milling Section, Mineral Processing Division, Mines Branch.

50 cents

Cat. No. M38 -1/163

R 164. *The Hot-Tearing of Copper Alloys*

A. Couture* and J. O. Edwards**. June 1965. 59p. Illus., tables.

A test and a rating method have been developed to assess the hot-tearing susceptibility of cast copper alloys. Thirteen alloys were rated, and, while the limitations of individual hot-tear tests are well known, it is considered that such a rating should serve as a general guide to enable foundrymen to select alloys with the best hot-tear resistance where this may be important in a particular casting design.

The probable process by which these alloys - particularly tin bronzes - solidify is tentatively related to the hot-tearing mechanism, which is discussed in general terms.

From this type of study, it may be possible to design alloys of improved hot-tear resistance, or to anticipate hot-tearing difficulties in new alloys designed from other considerations.

*Senior Scientific Officer, **Head, Non-Ferrous Metals Section, Physical Metallurgy Division, Mines Branch.

\$1.00

Cat. No. M38 -1/164

R 165. *Design and Construction of a Facility for Research on the Inelastic Behavior of Geologic Materials*

H. R. Hardy, Jr. *. Sept. 1965. 148p. Illus., tables.

This report describes the design and construction of a facility for research on the inelastic behavior of geologic materials. It includes the development of the following: a room-sized constant temperature enclosure capable of maintaining temperatures constant to $\pm 1/5^\circ C$; a programmable pneumatic-hydraulic axial loading system, which makes it possible to carry out creep, stress relation, constant rate of straining, constant rate of loading and cyclic loading experiments; and a system for accurate measurement and recording of strain, stress, confining pressure and temperature. Also included are details on the preparation and strain gaging of test specimens.

*Scientific Officer, Physics Section, Fuels and Mining Practice Division, Mines Branch.

\$1.50

Cat. No. M38 -1/165

R 166. *Corrosion Behaviour of
Uranium-Bearing Resulphurized
Chromium Stainless Steels*

G. J. Biefer* and W. M. Crawford**. July 1965. 41p. Illus., tables.

Uranium alloying additions to the resulphurized steels conferred markedly improved corrosion resistance in nitric acid solutions at room temperature when U/S ratios were 3.5/1 or more, the performance of such steels approaching or equalling that of AISI Type 430 stainless steel.

*Head, Corrosion Section, **Scientific Officer, Ferrous Metals Section, Physical Metallurgy Division, Mines Branch.

75 cents

Cat. No. M38 -1/166

R 167. *Corrosion Fatigue of
Structural Metals in Mine
Shaft Waters*

G. J. Biefer*. July 1965. 29p. Illus., tables.

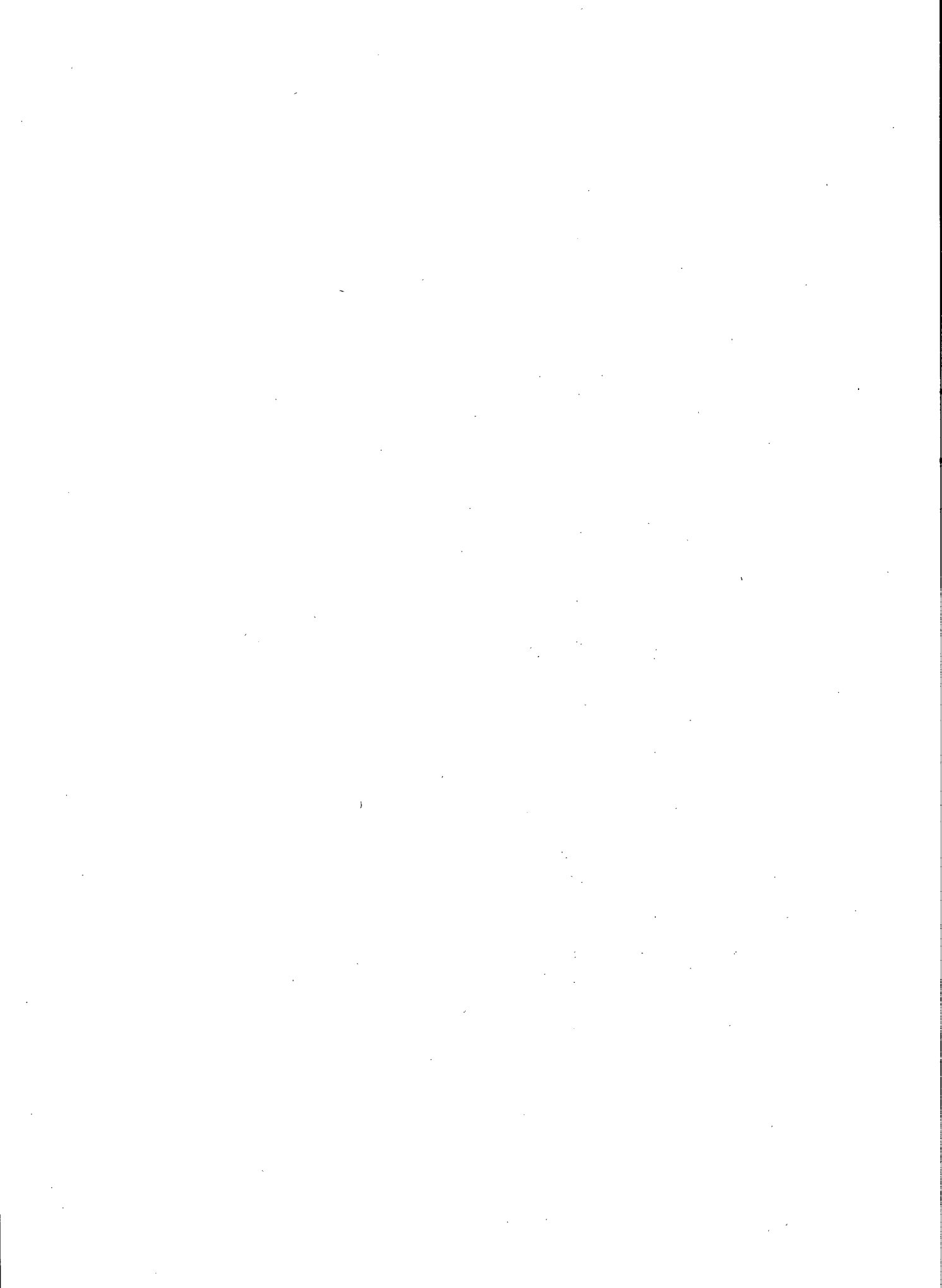
In the corrosion fatigue measurements, drainwaters collected in the shafts of three different Canadian mines were used as corrodents. The mine waters had been selected on the basis of their relatively large differences in acidity and/or composition.

It was found that the corrosion fatigue strengths of the four steels were similar despite their differences in tensile properties.

The corrosion fatigue behaviour of the aluminum alloy (ASTM Type 6061-T6) was found to differ markedly in the three mine waters. A high damage ratio was shown in a mine water in which the corrosion rate was low and the attack uniform. Much lower damage ratios were shown in mine waters which produced localized corrosion attack.

*Head, Corrosion Section, Physical Metallurgy Division, Mines Branch.

Cat. No. M38 -1/167



TECHNICAL BULLETINS

TB 57. *A Slime Level Indicator*

R. H. Goodman*, Oct. 1964. 11p. Illus.

A simple method of detecting the slime level in a thickening tank is described. The detector uses optical transmission techniques and simple associated electronic circuitry. The unit has been tested and found to perform satisfactorily. *Scientific Officer, Physics and Radio-tracer Subdivision, Mineral Sciences Division, Mines Branch.

56 cents

Cat. No. M34 -20/57

TB 58. *The Effect of Uranium Additions on the Corrosion Behaviour of AISI Type 430 Stainless Steel*

G. J. Biefer*. Nov. 1964. 22p. Illus., tables.

AISI Type 430 stainless steels, and similar steels with 0.017-3.11% uranium, were subjected to laboratory corrosion tests in several aqueous solutions. The results indicated that uranium additions in the range 0.1-0.5% brought about improvements in corrosion resistance. To determine whether the laboratory results are correlated with improved corrosion resistance under service conditions, AISI Type 430 steels with 0%, 0.25% and 0.5% uranium are undergoing long-term field tests.

*Head, Corrosion Section, Physical Metallurgy Division, Mines Branch.

50 cents

Cat. No. M34 -20/58

TB 59. *Humidity and Static Electricity in Pneumatic Loading of Blasting Explosives*

J. A. Darling* and D. A. B. Stevenson**. Nov. 1964. 32p. Illus., tables.

The occasional generation of static electricity in ammonium nitrate jet loaders is a serious matter because of the potential hazard presented to the operating personnel through the premature ignition of the blasting caps and initiating devices resulting from the development and discharge of static electrical charges.

Previous methods of control of these hazards have included the introduction of conductive hoses and the grounding of the

metal injector of loaders. Electric blasting caps have been forbidden in bottom primed drill holes. In addition static proof safety fuses and detonating fuses have been developed.

This work explores the possibility of controlling the generation of static electricity by additions of water or of water vapour to jet loaders. It has been discovered that this water vapour may be automatically provided by exposures of ammonium nitrate or ammonium nitrate-oil mixtures to an air stream of high relative humidity immediately prior to loading. This exposure limits, to safe values, the voltages produced in the ammonium nitrate-hose wall static electricity generating system that may be operating in a pneumatic loader.

*Senior Scientific Officer, **Head, Explosives Research Laboratory, Fuels and Mining Practice Division, Mines Branch.

75 cents

Cat. No. M34 -20/59

TB 62. *Addendum to Bureau of Mines Report No. 826 (Volumes 1-3, 1949), 'Drilling and Sampling of Bituminous Sands of Northern Alberta*

K. W. Bowles* and R. G. Draper**. Dec. 1964. 13p. Illus.

The report on the drilling and sampling of the bituminous sands of Northern Alberta was published in three volumes in 1949 and presents an appraisal of the bituminous sands from the results of drilling, sampling and analysis.

This addendum gives a brief description of the method of analysis and shows how these data were used to evaluate the average bitumen and clay contents of the drill-hole cores. An explanation of other relevant items is also included. This information was not covered by the 1949 report, but is considered necessary for the proper understanding of the procedures that were employed in carrying out the investigation. *Senior Scientific Officers, Fuels and Mining Practice Division, Mines Branch.

50 cents

Cat. No. M34 -20/62

TB 63. The Preparation of Commercial-Grade Vanadium Pentoxide from Boiler Ash Fly
J. A. Vezina* and W. A. Gow**. Jan. 1965. 16p. Illus., tables.

A method has been developed for the preparation of commercial grade vanadium pentoxide from boiler fly ash submitted by Canadian Petrofina Limited. Laboratory tests have shown that a sulphuric acid leach, followed by the oxidation of the leach solution with sodium chlorate and the precipitation of the vanadium with ammonia, will produce commercial vanadium pentoxide of a grade suitable for the production of ferro-vanadium alloys.

The overall recovery of vanadium was about 90 per cent and the consumption of chemical reagents was about 3.5 lb H₂SO₄, 0.25 lb NaClO₃ and 1 lb NH₃ per pound of recovered V₂O₅.

*Senior Scientific Officer, **Head, Hydrometallurgy Section, Extraction Metallurgy Division, Mines Branch.

50 cents

Cat. No. M34 -20/63

TB 64. The Preparation of High-Purity Ammonium Metavanadate from Impure Vanadium Pentoxide by Precipitation with Ammonium Chloride
J. A. Vezina* and W. A. Gow**. Jan. 1965. 21p. Illus., tables.

High-purity ammonium metavanadate can be obtained as a precipitate when the filtered solutions from the leaching of crude vanadium pentoxide are treated with ammonium chloride. The effect of using an excess of sodium carbonate, as a leaching agent, on the rate of leaching of vanadium pentoxide has been qualitatively investigated, and the effects of excess sodium carbonate, and of the concentration of vanadium pentoxide in the leach liquor, on the efficiency of precipitation with ammonium chloride have been quantitatively determined. Data are given showing the results obtained when both pure and crude vanadium pentoxides are treated in this way. Conditions are specified which result in the dissolution of 97% of the vanadium from crude vanadium pentoxide, and in the precipitation of 99% of the dissolved vanadium as ammonium metavanadate of high purity.

*Senior Scientific Officer, **Head, Hydrometallurgy Section, Extraction Metallurgy Division, Mines Branch.

50 cents

Cat. No. M34 -20/64

TB 65. Evaluation of Peat Moss in Some Bogs of the Rainy River District, Ontario

R. Bruce Graham* and T. E. Tibbetts**. Feb. 1965. 95p. Illus., tables.

In this report, seventeen peat bogs in the Rainy River District of Ontario are illustrated by aerial photographs and are assessed from the viewpoints of location, access, area, depth, cover, drainage, and nature of the peat material present. The locations of several other bogs in the district are noted.

Analytical procedures and the importance of sampling are emphasized in this demonstration of the methodology of evaluating the potential of peat bogs for commercial development.

*Consulting Geologist, R. Bruce Graham and Associates Limited, Toronto, Ont. **Head, Coal and Peat Preparation and Surveys, Fuels and Mining Practice Division, Mines Branch.

\$1.25

Cat. No. M34 -20/65

TB 66. An Investigation of Fuel-Oil Additives to Prevent Superheater Slagging in Naval Boilers

G. K. Lee*, E. R. Mitchell**, R. G. Grimsey*** and Lt. Cmdr. S. E. Hopkins****. March 1965. 23p. Illus., tables.

Prior to 1958, the Royal Canadian Navy experienced a persistent slag accumulation on superheater tubes of boilers in the St. Laurent class destroyer escort vessels. This accumulation blocked combustion gas passages in a few months of operation. Conventional methods of removal were totally inadequate and it was necessary to resort to chipping, both manually and with pneumatic hammers. Even then it was not possible to clean tubes completely to bare metal, but they were cleaned sufficiently to show that corrosion was not a problem. The RCN experimented with acid soaking and water lancing but found the slag impervious to both.

As a result of this experience, the RCN, in conjunction with the Defence Research Board, instituted a project under No. A 18-47-05-01 to study the problem. The project was undertaken by the Mines Branch, Department of Mines and Technical Surveys, Ottawa, Canada, and it was at this stage that the authors were asked to develop a practical slag removal process and to discover methods to inhibit slag formation.

Published as a paper in Proc. of the Amer. Power Conf., Vol. XXVI, 1964. *Senior Scientific Officer, **Head, Combustion Engineering Section, Fuels and Mining Practice Division, Mines Branch. ***Staff Officer Fuels and Lubricants, ****Project Officer, Royal Canadian Navy, Department of National Defence.

25 cents

Cat. No. M34 -20/66

TB 67 *In preparation.*

TB 68. *A Combined Spectrophotometric-Fluorimetric Method for the Determination of Aluminum in Products from Wet-Process Phosphoric Acid Manufacture*
D.J. Barkley*. May 1965. 27p. Illus., tables.

This report describes methods for the determination of aluminum in products obtained during the manufacture of wet-process phosphoric acid from Florida land-pebble phosphate ore. The methods feature a combination of spectrophotometric and fluorimetric techniques to permit the determination of aluminum over a wide range of concentration.

*Scientific Officer, Extraction Metallurgy Division, Mines Branch.

50 cents

Cat. No. M34 -20/68

TB 69. *Silica Sand-Canadian Sources of Interest to the Domestic Glass Industry*
R.K. Collings*. April 1965. 9p. Illus.

There are few deposits of naturally occurring, high-purity, silica sand in Canada. However, natural sand and sandstone, or friable quartzite deposits, from which sand can be produced, occur at numerous locations. Investigation has

shown that material from many of these deposits can be upgraded to silica-sand quality. Glass sand, an extremely pure form of silica sand, produced from two Canadian deposits is being utilized by the Canadian glass industry; however, most of this industry's sand requirements continue to be imported from the United States.

This paper outlines the present trend in the consumption of glass sand in Canada, indicates present sources of silica sand, and describes several Canadian deposits that are of interest as potential sources of silica for the Canadian glass industry.

Published as a paper in J. of Can. Ceram. Soc., Vol. 32, 1963.

*Head, Non-Metallic Minerals Section, Mineral Processing Division, Mines Branch.

25 cents

Cat. No. M34 -20/69

TB 70. *The Floatability of Eleven Common Non-Metallic Minerals*
R.A. Wyman*. April 1965. 35p.

The aqueous systems, including pH regulators and collectors, that effect the floatability of eleven common non-metallic minerals are outlined. The effect of six common modifiers on the floatability of these minerals in the aqueous systems employed is also outlined. Results are presented graphically for ease of comparison.

As the work is extended to include other minerals, similar minerals from different sources and additional aqueous systems, further reports will be issued.

The project intended to assist workers in the solution of problems involving non-metallic mineral flotation.

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

75 cents

Cat. No. M34 -20/70.

TB 71. *Weldability of Titanium and Titanium Alloys*
K. Winterton*. April 1965. 22p.

The literature on the welding of

titanium and its alloys is reviewed.

Titanium is very reactive and is easily contaminated by carbon, hydrogen, oxygen or nitrogen. During welding, the hot metal must be protected at all times from the atmosphere, and it may be necessary to pay special attention to the purity of inert gases used for shielding.

Commercially pure titanium and the alpha alloys are the most readily weldable, and have been considered as a group. The alpha-beta and beta alloys can be joined, but the welds tend to be brittle, and vary in their response to heat-treatment. These alloys often need individual techniques and treatment to obtain optimum properties in the welded joints.

The most useful fabrication methods are tungsten inert-gas welding, metal inert-gas welding, and resistance spot and seam welding, and these have all been used extensively in aero-space applications. Good brazing methods have been developed and may be useful for "honey-comb" structures. Other specialized methods, such as electron-beam welding and explosive welding, have been tried successfully. In the U.S.S.R., submerged-arc welding and electro-slag welding are the most popular methods. *Head, Welding Section, Physical Metallurgy Division, Mines Branch.

50 cents

Cat. No. M34 -20/71

TB 72. The Status of the Hydrogen Problem in Steel.

R. D. McDonald*. July 1965. 15p. Illus.

Hydrogen problems in steel are described, with particular emphasis on the problem of embrittlement of ultra-high strength steels as manifested by delayed failure. Ways are described in which hydrogen enters steel and is recognized by tests. Theories that have been developed over the years of research are related and explained briefly in order of sequence up to the most recent proposals advanced. These theories serve to explain many of the observations concerning hydrogen, although gaps in the knowledge still exist.

Alleviation of embrittlement still depends heavily upon diffusion treatments at baking temperatures, although many ways of preventing entry of hydrogen are being tried with moderate success.

*Senior Scientific Officer, Ferrous Metals Section, Physical Metallurgy Division, Mines Branch.

50 cents

Cat. No. M34 -20/72

TB 73. Polarization Measurements on ASTM Type 6061-T6 Aluminum Alloy in Three Ontario Mine Shaft Waters

G. J. Biefer*. Aug. 1965. 22p. Illus., tables.

Cathodic polarization measurements carried out on ASTM 6061-T6 aluminum alloy in three Ontario mine waters of different acidities and compositions provided a rapid estimate of relative corrosion rates even though these rates were too low to be readily measured by conventional weight-loss methods.

The results showed that corrosion rates in water from the Helen Iron ore mine were much lower than those in waters from the two other mines. This correlated with the corrosion fatigue behaviour of ASTM 6061-T6 alloy in the same waters. *Head, Corrosion Section, Physical Metallurgy Division, Mines Branch.

50 cents

Cat. No. M34 -20/73

TB 74. A Comparison of the Effects of Uranium and Molybdenum Alloying Additions on the Corrosion Resistance of AISI Type 430 Stainless Steel

G. J. Biefer* and J. G. Garrison**. Sept. 1965. 22p Illus., tables.

To compare the effects of uranium and molybdenum alloying additions, laboratory corrosion tests were performed on AISI Type 430 stainless steels containing 0.24% and 0.55% uranium, and 1.02% and 2.03% molybdenum. In comparison with a similar unalloyed steel, both additions brought about qualitatively-similar improvements of corrosion resistance both in non-oxidizing sulphuric acid and hydrochloric acid solutions and oxidizing ferric chloride solution. In these solutions, the corrosion resistance of the molybdenum-bearing steels was definitely superior to

that of the uranium-bearing steels.

The uranium content for maximum corrosion resistance appears to lie at 0.5% or less. It is therefore clear that molybdenum is capable of imparting greater improvements in corrosion resistance to AISI Type 430 stainless steel than uranium, although higher levels of molybdenum are necessary to achieve this.

*Head, and **Technician, Corrosion Section, Physical Metallurgy Division, Mines Branch.

76 cents

Cat. No. M34-20/74

TB 75. *A Sonic System for the Determination of 'In Situ' Dynamic Properties and for the Outlining of Fracture Zones*
G. E. Larocque*. Aug. 1965. 27p. Illus.

A sonic system is described which has been developed for probing the rock around mining openings. With this system, transit time measurements of a few hundred microseconds to many milliseconds can be made with an accuracy of 5%. The sonic apparatus is relatively portable and entirely independent of external power requirements, allowing its use in remote mining locations.

*Scientific Officer, Mining Research Laboratories, Fuels and Mining Practice Division, Mines Branch.

50 cents

Cat. No. M34-20/75



INFORMATION CIRCULARS

- IC 166. *Bibliography of High Temperature Condensed States Research Published in Canada, October-December, 1964*
N. F. H. Bright*. Jan. 1965. 8p.

This report contains bibliographic information concerning research work on high-temperature condensed states published in Canadian journals from October to December, 1964, inclusive.

*Head, Physical Chemistry Section, Mineral Sciences Division, Mines Branch.

50 cents

Cat. No. M38 -3/166

- IC 168. *The Notch Toughness of Ultra-High-Strength Steels in Relation to Design Considerations*
R. C. A. Thurston*. Dec. 1964. 54p. Illus., tables.

Data for the notch toughness of ultra-high-strength steels, as found in the literature, are presented and reviewed in terms of the type of steel, the strength level, and the appropriate test parameter. Some attention is given to the effects of the more important factors involved in the processing of the steel.

Design requirements are analyzed with reference to the demands of the particular application (e. g. pressure vessel, rocket motor case, hydrofoil), the fabrication procedures involved, the environment, and the applicability of non-destructive and proof testing. A number of possible design parameters or criteria, related to the more significant laboratory toughness tests, are examined with respect to their suitability and applicability in the light of present knowledge regarding ultra-high-strength steels. Where possible, the examination is complemented by a comparison with the results of service performance and/or medium or full-scale laboratory tests under simulated service conditions.

*Head, Engineering Physics Section, Physical Metallurgy Division, Mines Branch.

75 cents

Cat. No. M38 -3/168

- IC 169. *The Athabasca Tar Sands as a Source of Crude Oil*

D. S. Montgomery*. Sept. 1964. 16p. Illus., tables.

A general review is presented of the variable nature of the Athabasca bituminous sand resource, and the chemical composition of the bitumen is given at various stages during the refining from raw material to finished products. The research conducted at the Mines Branch on vapour-phase hydrogenation of coker distillates is described, emphasizing the effect of hydrogen pressure on the rate of catalyst deactivation. In conclusion, the quality of the hydrogenated products is described in general terms, and some observations are made on the reasons why large-scale operation is essential if an economically viable process is to be achieved.

*Senior Scientist, Fuels and Mining Practice Division, Mines Branch.

50 cents

Cat. No. M38 -3/169

- IC 170. *A Review of the Properties of Zinc Sulphide*
E. H. Nickel*. April 1965. 42p. tables.

The physical and chemical properties of zinc sulphide, as reported in the literature, are reviewed and summarized. The topics covered include crystallography, structure, composition, stability relations, physical properties, optical properties, electronic and magnetic properties, thermodynamic properties, lattice dynamics, and methods of synthesis.

*Senior Scientific Officer, Mineralogy Section, Mineral Sciences Division, Mines Branch.

50 cents

Cat. No. M38 -3/170

- IC 171. *An Index of Scientific and Technical Papers Published by the Staff in 1964*

50 cents

Cat. No. M38 -3/171

- IC 172. *Bibliography of High Temperature Condensed States Research Published in Canada, January-March 1965*
N. F. H. Bright*. April 1965. 8p.

This report contains bibliographic information concerning research work on

high-temperature condensed states published in Canadian journals from January 1 to March 31, 1965.

*Head, Physical Chemistry Section, Mineral Sciences Division, Mines Branch.

50 cents

Cat. No. M38-3/172

**IC 173. Analyses of Coal and Coke
During 1964**

W. J. Montgomery* and G. C. Behnke**. July 1965. 22p. tables.

The Solid Fuels Laboratory of the Fuels and Mining Practice Division is responsible for all analytical work on coal and coke, including that reported in the official "Analysis Directory of Canadian Coals", which is published by the Mines Branch (but only at intervals of five or more years). This information circular, issued as the fifth of an annual series, tabulates the analyses of commercial coal and coke samples received by the Division during 1964.

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

*Head, Solid Fuels Laboratory, **Technician, Fuels and Mining Practice Division, Mines Branch.

50 cents

Cat. No. M38-3/173

**IC 174. The Occurrence of Telluride
Minerals at the Acupan Gold
Mine, Mountain Province,
Philippines**

L. J. Cabri*. Sept. 1965. 3p.

Published as a paper in Econ. Geol., Vol. 60, No. 5, pp. 1080-1082 (1965).

*Scientific Officer, Mineral Sciences Division, Mines Branch.

25 cents

Cat. No. M38-3/174

**IC 175. Bibliography of High
Temperature Condensed States
Research Published in Canada
April-September 1965**

N. F. H. Bright*. Oct. 1965. 13p.

This report contains bibliographic information concerning research work on high-temperature condensed states published in Canadian journals from April 1 to September 30, 1965.

*Head, Physical Chemistry Section, Mineral Sciences Division, Mines Branch.

50 cents

Cat. No. M38-3/175

**IC 176. The Preparation of
"As-Polished" Metallographic
Finishes in Non-Ferrous Metals**

R. I. Hamilton* and E. F. Connors**. June 1965. 30p.

Various methods that have been shown to give consistently good results in the preparation of metallographic samples are described. The selection and application of these techniques to the various alloys is discussed relative to the class of examination required. The avoidance of certain pitfalls is discussed and information is given on a number of minor points that collectively can lead to a considerable improvement in technique.

*Technical Officer, and **Technician, Non-Ferrous Metals Section, Physical Metallurgy Division, Mines Branch.

75 cents

Cat. No. M38-3/176

*SECTION 2 - PAPERS PUBLISHED IN
PERIODICALS*



MINERAL PROCESSING DIVISION

Adsorption of Dehydroabietylamine Acetate on Quartz and Hematite

by N. Nameh and T. Salman, Can. Met. Quarterly, Vol. 4, No. 1, Jan.-Mar. 1965

Specially prepared dehydroabietylamine acetate was supplied by the Hercules Powder Company for the investigation. Adsorption tests at near-neutral and slightly basic pH values indicate that in the lower concentration range the amount adsorbed varies linearly with the concentration of the solution. The reversibility of the process was tested by removing most of the monolayer from the silica in near-neutral solutions. Up to the monolayer capacity hematite and quartz behaved very similarly in near-neutral solutions, but this capacity increased appreciably in favour of silica when the pH of solution was adjusted to values above 8.

Examples of Mineral Beneficiation by Colour Sorting

by R. A. Wyman and F. H. Hartman, Can. Mining and Metallurgical Bulletin, Nov. 1965.

The Industrial Minerals Milling Section of the Mineral Processing Division has been engaged for the past three years in a study of the separation of minerals, by means of electronic sorting equipment, on the basis of their colour. Considerable knowledge of the subject has been built up. Because the object of this study is application as a means of beneficiation, a number of examples of the separations achieved are presented.

Evolution of Concrete Compression Test Results

discussion by V. M. Malhotra, ACI Jour. Proceedings V. 62, No. 4, Apr. 1965, p. 467.

Method for Early Prediction of Concrete Strength

by V. M. Malhotra and N. G. Zoldners, Jour. Eng. Instit. of Canada, April 1965.

This study looked into the development of an accelerated strength test for hardened concrete in order to be able to predict the potential 28-day compressive strength of concrete in about 24 to 28 hours. Type 1 Portland cement from three different Canadian cement plants was used. Coarse aggregates consisted of crushed limestone and gravel, and the fine aggregate used was natural sand.

Comparative Method and Choice of Standards for Thermal Conductivity Determinations

by V. V. Mirkovich, Jour. Amer. Ceramic Society, Vol. 48, No. 8, August, 1965.

An improved version of the comparative method thermal conductivity apparatus was designed. Its accuracy was determined by measuring the conductivity of alumina with standards made of the same alumina and by cross-checking the conductivities of alumina, forsterite, Pyroceram Code 9606, and zirconia. The thermal stabilities of Pyroceram Code 9606 and zirconia were examined to establish their values as thermal conductivity reference materials. It was concluded that: (1) With this apparatus accurate thermal conductivity data can be obtained and (2) Pyroceram Code 9606 can be recommended for use as a primary standard for the low thermal conductivity range.

A New Approach to the Determination of the Tensile Strength of Cement Paste by Centrifugal Force

discussion by V. M. Malhotra, Mag. of Concrete Research, Vol. 17, No. 52, September 1965.

Some Ceramic and Electrical Properties of Bodies Fabricated from Co-Precipitated Lead-Zirconium-Titanium Hydroxides

by A. H. Webster, T. B. Weston and R. R. Craig, Jour. Can. Cer. Soc., Vol. 34, 1965.

Co-precipitated lead-zirconium-titanium hydroxides, with and without the presence of carbonate, have been successfully fabricated into lead zirconate-titanate ceramic test pieces. The effects of certain processing variables during the precipitation and drying stages on the structural, chemical and electrical properties of the ceramic bodies are described.

Some Methods of Investigating Firing Problems

by J. G. Brady, K. E. Bell, and L. K. Zemgals, Jour. Can. Cer. Soc., Vol. 34, 1965.

Differential thermal analysis (DTA), X-ray diffraction analysis (XRD), dilatometry, thermogravimetry (TGA), and shrinkage and absorption curves obtained by the temperature gradient method are used to predict and point out the nature and extent of problems encountered in firing clays or clay bodies. The firing behaviour of clays occurring near Estevan, Sask.; Claybank, Sask.; Eastend, Sask.; Edmonton, Alta.; Haney, B. C.; and Sumas Mountain, B. C. illustrate numerous typical problems and how they may be defined by the above methods.

The Composition and Properties of Ceramic Clays and Shales of Ontario
by J. G. Brady and R. S. Dean, Jour. Can. Cer. Soc., Vol. 34, 1965.

Forty-nine representative samples, all from well-populated areas of Ontario, were investigated. The clay mineral fraction of the Palaeozoic shale samples of southern and eastern Ontario, with the exception of Kettle Point, consists, essentially of well crystallized illite and chlorite. Poorly crystallized expanding mixed-layer clay minerals are characteristic of clay deposits occurring within or near the Canadian Shield. The more southerly surficial clays generally contain illites, and mixed-layer systems instead of chlorite. Montmorillonoids and vermiculites are rare except in mixed-layer assemblages.

Accelerated Test for Determining the 28-Day Compressive Strength of Concrete
by V. M. Malhotra, N. G. Zoldners, R. Lapinas, Trans. Eng. Instit. of Can., Vol. 8, No. A-14, Dec. 1965.

This report presents the results of accelerated curing of concrete test cylinders using a boiling-water method. Briefly, the method consists of standard moist curing of test specimens for 24 hours, followed by boiling for 3 1/2 hours and testing for compression one hour later.

In all, some 1512 test cylinders, 6 x 12 in., were prepared from concrete samples obtained from three different ready-mix plants (situated in the Montreal-Ottawa area) and a large number of laboratory mixes. The test cylinders were tested in compression at 28 1/2 hours, 7 days, and 28 days. The results were analysed and the advantages and limitations of the method are discussed.

The analysis of test data indicates that the relationship between the accelerated- and 28-day standard-cured strengths can be represented by a hyperbolic function of the type $Y = \frac{X}{AX + B}$ with an accuracy of ± 12 per cent.

The established relationships appear to be independent of the cements, aggregates and admixtures used.

Asbestos
by H. M. Woodroffe, Ann. Rev. No. of Can. Min. Jour., Feb. 1965.

Milling and Process Metallurgy - Technical Advances in Canada During 1964
by D. E. Pickett, Ann. Rev. No. Can. Min. Jour., Feb. 1965.

History of the Industrial Minerals Division C. I. M., J. S. Ross, J. E. Reeves (assisted in compiling), Ann. Review No. Can. Min. Jour., Feb. 1965.

Industrial Minerals - 1964
by R. K. Collings, Can. Min. Jour., Feb. 1965.

Bibliography of Mineral Research Projects Relating to the Atlantic Provinces Conducted in the Industrial Minerals Sub-Division. Compiled for the Atlantic Development Board
by staff, Industrial Minerals Sub-Division.

History of Developments in Mineral Processing in Canada from 1921 to the Present Time
by John Convey and L. E. Djingheuzian
The Can. Min. and Metal Bull., Vol. 58, No. 636, April, 1965.

Potash - 1964
by C. M. Bartley, Ann. Rev. No. Can. Min. Jour., Feb. 1965.

EXTRACTION METALLURGY DIVISION

Polarographic and Amperometric Methods Applied to Metallurgical Analysis

by A. Hitchen, Can. Mining and Met. Bull., June 1965.

A general outline is given for the determination of copper, nickel, cobalt, zinc, lead, cadmium, bismuth, manganese, uranium, molybdenum, vanadium, sulphate and fluoride by polarographic or amperometric methods in a variety of ores or metallurgical products. The detection of oxygen in gas mixtures by an amperometric method used as a safety device is also discussed.

The Production of High-Purity Niobium Oxide from Pyrochlore-Perovskite Concentrate

by F. J. Kelly and W. A. Gow, Can. Mining and Met. Bull., Aug. 1965.

A chemical process, based on laboratory investigations, is proposed for the production of high-purity niobium oxide from a pyrochlore-perovskite flotation concentrate produced from ore obtained at the Oka, Quebec, property of Columbian Mining Products Limited.

The method developed included the decomposition and dissolution of the flotation concentrate with hot, concentrated sulphuric acid. The dissolved niobium was purified and concentrated by a solvent extraction step, using methyl isobutyl ketone as the extractant. The niobium was recovered from the extractant with ammonium fluoride solution from which niobium oxide was precipitated with ammonia. Finally, the filtered and washed precipitate was calcined. Ninety-six per cent of the niobium was recovered in a product analysing 99.9 per cent Nb_2O_5 . The reagent cost was in the range of \$1.00 to \$1.25 per pound of niobium recovered.

New Process Developed for Electronic Ceramics

by K. W. Downes, Chem. in Canada, Feb. 1965.

A major objective of the Mines Branch is to promote the effective utilization of Canadian mineral resources and to en-

courage efficiency in Canadian industries that are based on those resources or that have to do with metals and their use. To this end, programs of basic research and of process development are conducted in the Mines Branch laboratories, the results of which are reported either in the scientific and technical literature or in the series of Mines Branch Reports.

The part of metals technology having to do with the recovery or production of metals is known as extraction metallurgy, and this is, as its name implies, the principal concern of the Extraction Metallurgy Division.

Analyzer Controls Free Cyanide Level

by J. C. Ingles, Can. Chem. Proc., May 1965.

A new continuous analyzer has been developed to determine the concentration of free cyanide in gold recovery circuits. Currently a benchscale prototype, the analyzer is being evaluated by the Department of Mines and Technical Surveys in a commercial circuit.

Kinetics of the Carbon Catalyzed Air Oxidation of Ferrous Ion in Sulphuric Acid Solutions

by G. Thomas and T. R. Ingraham, Unit Proc. in Hydromet., Vol. 1, Met. Soc., of AIME, Jan. 1965.

For Abstract see R 143, page

Making Decomposition Rate Measurements on Simple Inorganic Chemical Powders by Thermogravimetric Analysis
by T. R. Ingraham, Proc. of the First Toronto Symposium on Thermal Analysis, Feb. 1965.

A method is proposed and discussed with examples for normalizing rate-of-decomposition measurements to permit the extraction of meaningful rate and energy parameters.

Thermodynamics of the Thermal Decomposition of Cupric Sulfate and Cupric Oxysulfate

by T. R. Ingraham, Trans. of the Met. Soc. of AIME, Vol. 233, p. 359-363, Feb. 1965.

For Abstract see R 147, page

Kinetics of the Thermal Decomposition of Cupric Sulfate and Cupric Oxysulfate by T. R. Ingraham and P. Marier, *Trans. of the Met. Soc. of AIME*, Vol. 233, p. 363-367, Feb. 1965.

For Abstract see R 148, page

Resolution of Rate Data for Some Heterogeneous Inorganic Thermal Decomposition Reactions. by T. R. Ingraham, *Proc. of the First Inter. Thermal Anal. Conf.*, p. 178, 1965.

Frequently it is not possible to obtain single particles of sufficient size for kinetic studies and it becomes necessary to consider the use of powdered materials. When a loosely packed powder is used, the method of normalizing the data often fails completely because of the interference of the gas evolved from one particle with the reaction of another. The problem can be resolved readily, however, by compressing the powder into a regular pellet and studying the rate of decomposition of the pellet in a stream of inert gas at atmospheric pressure.

Heats of Some Polymorphic Metal Sulfate Transitions Estimated by Semi-Quantitative Differential Thermal Analysis by T. R. Ingraham and P. Marier, *Can. Met. Quart.*, Vol. 4, No. 3, p. 169-176, July-Sept. 1965.

Differential thermal analysis has been used to examine twenty-three metal sulphates for crystal transitions in the temperature range from room temperature to 1000°C. The heats of transition were estimated, with a probable accuracy of ± 10 per cent, for Li_2SO_4 , Na_2SO_4 , K_2SO_4 , Rb_2SO_4 , Cs_2SO_4 , Ag_2SO_4 , ZnSO_4 , CdSO_4 , PbSO_4 , MnSO_4 , and CoSO_4 .

Activation Energy Calculation from a Linearly-Increasing-Temperature Experiment. Part II by T. R. Ingraham and P. Marier, *Can. Journ. of Chem. Eng.*, p. 354, Dec. 1965.

A new method for obtaining activation energies of thermal decomposition reactions is described and illustrated by reference to CaCO_3 . Some observations are made on the mechanism of this type of heterogeneous process.

Use of Gaseous Thermal Conductivity to Determine the Thermodynamics of Barium Chloride Dehydration by M. Rigaud and T. R. Ingraham, *Can. Met. Quart.*, Vol. 4, No. 4, p. 237-246, Dec. 1965.

An apparatus was designed and used for making continuous unattended experimental measurements of the equilibrium decomposition pressures developed at various temperatures over each of the hydrates of barium chloride. The method was based on transpiration, modified to permit continuous monitoring of the gas composition by measurement of its thermal conductivity.

Use of Gaseous Thermal Conductivity to Determine the Kinetics of Barium Chloride Dehydration. by T. R. Ingraham and M. Rigaud, *Can. Met. Quart.*, Vol. 4, No. 4, p. 247-257, Dec. 1965.

The rates of dehydration of pellets of powdered di- and monohydrate of barium chloride have been studied isothermally and non-isothermally, using changes in the gaseous thermal conductivity of a carrier gas to follow the decomposition. Both decomposition reactions have a slight sensitivity to flow-rate of carrier gas, but at any selected flow rate both processes follow linear kinetics when the decomposition rate is expressed in terms of grams of weight lost per unit of interfacial area per unit time.

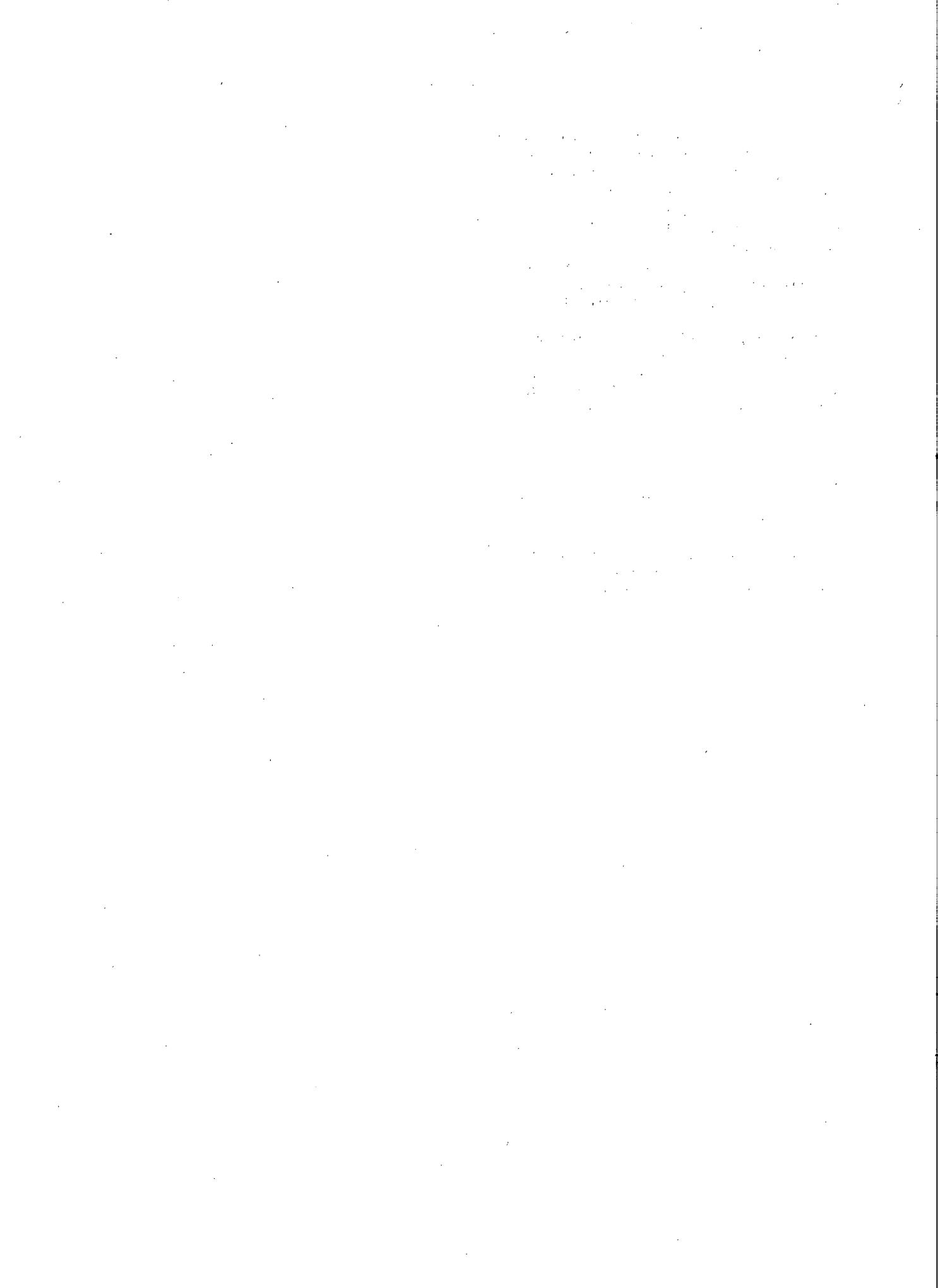
The Sulphation of Tricobalt Tetroxide and Nickel Monoxide With Fused Sodium Hydrogen Sulphate by M. C. B. Hotz and T. R. Ingraham, *Can. Met. Quart.*, Vol. 4, No. 4, p. 295-302, Dec. 1965.

The results of differential thermal, x-ray powder diffraction analyses and thermogravimetric analyses have been used to identify the reactions that occur when sodium hydrogen sulphate is heated between 150°C and 400°C with nickel monoxide and with tricobalt tetroxide. The initial reactions occur on fusion of NaHSO_4 and produce monohydrated sulphates of nickel and cobalt, Na_2SO_4 and $\text{Na}_3\text{H}(\text{SO}_4)_2$. The $\text{Na}_3\text{H}(\text{SO}_4)_2$ decomposes to Na_2SO_4 and Na_2SO_7 at higher temperatures. $\text{NiSO}_4 \cdot \text{H}_2\text{O}$ reacts with Na_2SO_4 , forming $\text{NiSO}_4 \cdot \text{Na}_2\text{SO}_4 \cdot \text{H}_2\text{O}$, which subsequently dehydrates; but $\text{CoSO}_4 \cdot \text{H}_2\text{O}$ dehydrates before reaction occurs to produce $\text{CoSO}_4 \cdot \text{Na}_2\text{SO}_4$.

Cyanide Analyzer

by J. C. Ingles, Eng. & Min. Journ., Vol. 166, No. 6, June 1965.

Instrument marries continuous titration with precision metering pumps for better control of leach solutions at gold plants.



MINERAL SCIENCES DIVISION

Relationship Between the Specific Magnetic Susceptibility and the Iron Plus Manganese Content of Chlorite
by W. Petruk, *The Canadian Mineralogist*, Vol. 8, Part 3, 1965

The specific magnetic susceptibilities of eleven chlorites were calculated from their chemical compositions and also measured by means of the Frantz isodynamic separator. The calculated values indicate a linear relationship between the specific magnetic susceptibilities and the total iron-plus-manganese content of chlorites. This relationship may be expressed by the equation $C = 0.12 + 0.559 \cdot 10^{-6} X_m$ where C is the total iron-plus-manganese expressed as FeO plus MnO, and X_m is the mean calculated specific magnetic susceptibility. The measured values for eight of the chlorites follow this relationship, but those for the remaining three chlorites deviate from it by substantial amounts.

Simultaneous Polarographic Determination of Small Amounts of Bismuth and Lead in Copper-Base Alloys
by C. H. McMaster, *Can. J. Chem.* 43, 405 (1965)

The extraction of metal diethyldithiocarbamate complexes into chloroform from an alkaline solution containing cyanide and citrate ions is a convenient means of separating small amounts of bismuth and lead from copper and uranium, and from the elements normally found in copper-base alloys. After the separation, bismuth and lead are determined polarographically using an acidic tartrate solution as the supporting electrolyte.

The Determination of Antimony in High Purity Iron by Neutron Activation Analysis
by H. P. Dibbs and C. H. McMaster, *Chem. and Ind.*, London 217 (1965)

An inherently sensitive method for antimony estimation is based upon neutron activation analysis and this method has been applied to the determination of antimony in a sample of high-purity iron.

Spectrophotometric Determination of Osmium with Pyrogallol
by G. H. Faye, *Anal. Chem.* 37, 259 (1965)

Pyrogallol has proven to be a satisfactory reagent for the spectrophotometric determination of osmium. A stable blue colour with an absorption maximum at 585 m μ is produced when chloro- or bromo-osmate (IV) at a pH of approximately 3 is heated for a short time in a boiling-water

bath with excess reagent. The useful concentration range is from 1 to 15 p. p. m. of osmium in aqueous solution and from 0.4 to 6 p. p. m. when the blue complex is concentrated by extraction into n-amyl alcohol.

Behaviour of Osmium During Evaporation of Hydrochloric Acid Solutions of Chloroosmate
by G. H. Faye, *Anal. Chem.* 37, 296 (1965)

The report shows that solutions, prepared by dissolving only chloro-osmate (ammonium) in solutions of hydrochloric acid, can be evaporated to incipient dryness, even at a vigorous boil, without losing osmium as a volatile product. Also, that in solutions having a relatively low concentration of hydrochloric acid, chloro-osmate may hydrolyze to form a difficultly soluble or unreactive species, the formation of which may lead to low results for osmium in subsequent operations.

Arfvedsonite and Aegirine - Augite from Seal Lake, Labrador
by E. H. Nickel and E. Mark, *Can. Min.* 8, 2, 185-197 (1965)

The chemical composition and optical and physical properties of co-existing arfvedsonite and aegirine-augite are described.

Fe-Ta Oxides: Relations at 1200° C
by A. C. Turnock, *J. Am. Ceram. Soc.*, 48, (5), 258-261 (1965)

This paper deals with the oxides encountered in the system Fe-Ta-O. The stability and oxidation products of FeTa₂O₆, the end-member of the tapiolite mineral series, are described.

Discussion of Empressite and Stuetzite. Redefined
by R. M. Honea and L. J. Cabri, *Am. Mineralogist*, 50, 795-801 (1965)

Phase Relations in the Au-Ag-Te System and Their Mineralogical Significance,
by L. J. Cabri, *Econ. Geol.*, 60, 8, 1569-1606 (1965)

A systematic investigation of the phase relations in the Au-Ag-Te system has provided a new basis for the interpretation of the Au-Ag-Te mineral assemblages in ores. Equilibrium phase relations in the mineralogically important area of the ternary system were determined at 290°,

335°, and 356°C, and changes in the assemblages were studied from about 50° to about 800°C. The 335°C isothermal section shows two liquid fields. A previously unreported ternary eutectic occurs at $304 \pm 10^\circ\text{C}$ with the very approximate composition of 50 Au, 15 Ag, 35 Te weight percent. Krennerite, rather than being a polymorph of AuTe_2 , is interpreted as being a single mineral entity with the approximate formula $\text{Au}_4\text{AgTe}_{10}$. It is stable up to its incongruent melting point of $382 \pm 5^\circ\text{C}$; thus, its presence in nature is not necessarily indicative of very low temperatures of formation. The incongruent melting temperature of sylvanite ($354 \pm 5^\circ\text{C}$) indicates a maximum temperature for its formation.

Hessite and petzite are each characterized by three polymorphs. Continuous solid solution exists between the highest polymorphs and extends to a composition about seven weight percent more gold-rich than stoichiometric petzite. A new phase, the "x" phase, is stable along the petzite-hessite join from about 2.5 to 14.5 weight percent gold within the approximate temperature limits 50° to 415°C .

The Occurrence of Telluride Minerals at the Acupan Gold Mines, Mountain Province, Philippines
discussion by L. J. Cabri, Econ. Geol. 60, (5), 1080-1082 (1965)

FUELS AND MINING PRACTICE DIVISION

Research and Development in Conventional Coke Making

by J. C. Botham, J. H. Walsh and M. A. Malek, 17th Dominion Provincial Conf. on Coal, Victoria, B. C., Sept. (1965)

The blast furnace operation has undergone considerable change in recent years. A number of new factors have had a marked effect in reducing the amount of coke required to produce one ton of hot metal. These factors include the use of sinter, the growing application of pellets produced from rich iron concentrates (and perhaps pre-reduced to metallic iron), higher blast temperatures up to 2000°F, higher pressure, and injection of oil, gas, and coal in the tuyeres.

New Rock Mechanics Program Underway by Canadian Government

by H. R. Hardy, Jr., Mining Engineering, Vol. 17, January 1965

The application of the mechanical model concept, along with a series of specific loading experiments, will allow the mechanical model of the particular material to be determined. Once this is accomplished and the coefficients of the model (the so-called viscoelastic coefficients) are determined, it should be possible to develop solutions for a wide range of mining engineering problems.

Development of a Model Vibrating- grate Stoker for Strongly Caking Coals by F. D. Friedrich, Jour. of the Instit. of Fuel, March, 1965

The combination of a plate feeder with a vibrating grate appears to have considerable potential as a rugged, flexible stoker capable of burning a wide variety of coals automatically. The basic simplicity of the apparatus should permit manufacture and control costs to be competitive with those for conventional stokers.

Automatic Mechanical Coal Sampling by T. E. Tibbetts, S. F. Featherly and R. L. Miller, C. I. M., M. Bull. Vol. LXVIII, pp. 188-193 (1965)

This paper deals with coal sampling in general and with mechanical coal sampling in particular. The necessity of obtaining representative samples is emphasized. Other sections of the paper are devoted to the design and selection of automatic samplers, with a consideration of the three main types, and the testing,

operation and maintenance of these samplers. The cost of the installation of an automated sampling system must be related to the value of the material to be sampled, to the volume of coal involved, and to the savings in labour and economy which can be achieved.

Deux Innovations Canadiennes Susceptibles d'être Appliquées en France

by R. P. Charbonnier, Societe des Ingenieurs Civils De France, Paris, France, April (1965)

La mine de potasse de Kalium Chemicals Limited, dans la province canadienne de la Saskatchewan, commencera ses expéditions en octobre 1964, pour atteindre en janvier 1965 un taux de production annuelle de 600,000 tonnes de K_2O , provenant d'un gisement de 8 à 13 pieds d'épaisseur, dans sa zone la plus riche, située à 5,300 pieds de profondeur. Cette zone est donc au-delà du maximum de 3,500 pieds, généralement considérée comme la limite pratique actuelle d'exploitation économique et sûre, par les méthodes classiques du génie minier.

The Mechanics of Support and Caving in Longwall Top-Slicing

by D. F. Coates and M. Gyenge, Proc. Fourth Int. Conf. on Strata Control and Rock Mechanics, Columbia University, New York, May 1964 (1965)

As a result of this research work a better understanding of the ground mechanics associated with top-slicing was obtained. This increased understanding should make it possible, particularly on this property, to plan future operations, both in top-slicing and in other mining methods, with a better understanding of the ground reactions to be expected.

An Investigation of Gas Explosion Transmission Through Short Cylindrical Channels of Varying Length and Diameter

by E. D. Dainty and G. K. Brown, Restricted Int. Conf. on Directors of Safety in Mines Research, Sheffield, England, July (1965)

Published work on gaseous explosion transmission leads the authors to believe that there is an optimum channel length for explosion transmission through a minimum channel diameter. This paper presents experimental results and discussion confirming the existence of such an optimum length, and the length-diameter ignition transmission characteristic for a 9.5% methane-air mixture.

Glass Insert Stressmeters

by K. Barron, Soc. of Mining Engineers,
Dec. (1965)

The glass insert stressmeter, or photoelastic stressmeter, is an instrument designed to determine stress changes occurring in rocks. It has several potential advantages over other such devices in that it is a biaxial device, it is simple and it is cheap to make.

The object of this study was to assess the behaviour of the meter under biaxial loads and to examine some of the problems associated with measurement and interpretation of the fringe pattern.

The Stability of Slopes in Open Pits

by D. F. Coates, 8th Commonwealth Mining and Metallurgical Congress, Australia and New Zealand, Dec. (1965)

Many open pits in Canada are currently being planned with depths of the order of 1000 ft. The competition between safe slopes and maximum profits is thus providing greater incentives than before for improving the design of these types of mines.

Studies of Ground Behaviour in a Metal Mine

by T. S. Cochrane of Carter and K. Barron, Proc. Fourth International Conference on Strata Control and Rock Mechanics, Columbia University, New York, May 1964 (1965)

Slope Stability Studies at Knob Lake

by D. F. Coates, M. Gyenge and J. B. Stubbins, Proc. Rock Mechanics Symposium, Univ. of Toronto, Toronto, Jan. (1965)

Surface Spalling by Thermal Stresses in Rocks

by W. M. Gray, Proc. Rock Mechanics Symposium, University of Toronto, Mines Branch, Jan. (1965)

Rock Mechanics Research at Universities

Assisted by Mines Branch Grants-in-Aid by D. F. Coates, Proc. Rock Mechanics Symposium, University of Toronto, Mines Branch, Jan. (1965)

Ground Stresses in Longwall and Room-and-Pillar Mining

by H. Labasse, (Translated by Dr. H. Frisch and presented by M. A. Twidale) Proc. of the Rock Mechanics Symposium, University of Toronto, Mines Branch, Jan. (1965)

Coal

by T. E. Tibbetts, Can. Min. Jour., Vol. 86, No. 2, pp. 133-136 (1965)

PHYSICAL METALLURGY DIVISION

Simplified Apparatus and Technique for the Determination of Crystal Orientation by Ion Bombardment

by R. T. Cunningham and Joyce Ng-Yelim
Rev. Sci. Instruments **36**(1), 54-56 (Jan. 1965).

The ion bombardment camera, designed specifically for orientation determinations, is machined from clear acrylic plastic and incorporates an ion source of the glow discharge type. A plastic orienting sphere, illuminated from within, has engraved on it the low index directions of cubic crystals. Hemispherical collectors, bearing ejection patterns are positioned on the sphere and the orientation of the crystals may then be immediately observed.

Some Properties of Plain Carbon Steels Containing Uranium

by G. P. Contractor, *Iron and Steel* **38**(1), 22-29 (Jan. 1965).

Medium- and low-carbon steels, modified with uranium, were studied in order to evaluate the influence of uranium on forgeability, mechanical properties, response to heat treatment and microstructure. Uranium contents ranged up to 0.70%. The medium-carbon steels are hot short if the uranium content exceeds about 0.35%. More uranium can be tolerated in low carbon steels. The hot shortness is caused by the formation of the intergranular phase UFe_2 .

The Viscosity of Liquid Zinc by Oscillating a Cylindrical Vessel

by H. R. Thresh, *Trans. Met. Soc. AIME* **233**, 79-88 (Jan. 1965).

An oscillational viscometer has been constructed to measure the viscosity of liquid metals and alloys to 800°C. An enclosed cylindrical interface surrounds the molten sample avoiding the free surface condition found in many previous measurements.

New Materials for Welding

by K. Winterton, *Can. Welder and Fabricator* **55**(12), 12-14 (Dec. 1965); **56**(1), 12-14 (Jan. 1965)

Increasing interest is shown in quenched and tempered steels for civil construction. The tough high-strength maraging steels now have several rivals. Precipitation hardening stainless steels are being used for aerospace application, notably in the form of honeycomb panels. The use of titanium is increasing. New alloys continue to appear with titanium and the other light metals.

The Creep-Rupture Embrittlement of Copper

by H. H. Bleakney, *Can. Met. Quarterly* **4**(1), 13-29 (Jan.-Mar. 1965).

The rate of embrittlement of both high-purity and tough-pitch copper and the metallographic appearance of selected samples of the broken test bars were determined. The results indicate that the creep-rupture embrittlement of both tough-pitch and high-purity copper is influenced by oxidation through a stress-corrosion mechanism and by internal oxidation of grain boundaries.

Recent Development in Welding Processes

by W. P. Campbell, *Can. Welder and Fabricator* **56**(2), 12-16 (Feb. 1965)

Developments in welding processes have accelerated rapidly in recent years. In general, the trend has been to higher welding speeds and greater automation, or to specialized processes that make possible welding that could not have been done satisfactorily with earlier processes.

This paper describes briefly some of the newer welding processes, such as consumable-wire gas-shielded metal arc, plasma arc, electroslag and electrogas, induction, electron-beam, resistance, ultrasonic, explosive, laser, and friction.

The Fatigue of Zinc Single Crystals in Reversed Shear

by D. M. Fegredo, *J. Inst. Metals* **93**, 189-195 (Feb. 1965).

S/N curves have been obtained in reversed shear for zinc crystals, fatigued on (0001) along (1120), at 25 and -55°C. At 25°C the fatigue behaviour appears to be conventional; at -55°C the curve indicates a high stress-dependence for failure. Specimens, which were initially fatigued at -55°C, were tested in unidirectional shear at -55 and -196°C. The crystals rapidly acquired a flow stress which was approximately equal to the peak fatigue stress, and which showed a low temperature-dependence.

The Effect of Quenching on the Yield Stress of Zinc Single Crystals

by D.M. Fegredo, J. Inst. Metals 93, 268-274 (Apr. 1965)

Zinc single crystals of varying orientation were quenched from 408°C into water at 2°C and tested in tension at -196 and -55°C. Increases in yield stress of up to an order of magnitude were obtained. Annealing treatments of quenched crystals indicated that they possess greater thermal stability than crystals that are work-hardened or fatigue-hardened at -50°C. A large temperature-dependence of flow stress was obtained only for unaged, quenched crystals. The results are discussed generally in terms of the effects of quenched-in vacancies.

Fourteen new welding processes that have appeared in the last decade have been briefly reviewed. Four of these, i. e. remote control TIG welding, short-circuiting MIG welding, arc spot welding and plasma welding show a logical connection in their development. The remainder, laser welding electron-beam welding, ultrasonic welding, explosive welding, electroslag welding, electrogas welding, radio-frequency resistance welding, diffusion bonding and foil-butt seam welding tend to be individual and distinct.

Vacuum Degassing for Steel Castings
by D.E. Parsons, B. Wallace, V. Kennedy and C.W. Briggs, Tech. Research Comm. Steel Founders Soc. of Amer., Research Rep. No. 57 (May 1965)

The effect of vacuum treatment on chemical composition, mechanical properties, macrosegregation and gas content are discussed. The results of previous work on carbon steel are reviewed and new data are included pertaining to alloy steel castings of the AISI-8630, AISI-4330 grades. Vacuum deoxidation of silicon-killed and "open" steels is discussed and the application of this technique to castings production is illustrated.

Navigation Buoy Mooring Chains
by A.K. Laing, R.K. Buhr, S.L. Gertsman VIIth Int. Conf. on Lighthouses and Other Aids to Navigation, Rome (May 1965)

A wide variety of steels has been tested as potential replacements of 1 1/4 to 1 1/2 inch (0.0317 to 0.038m) diameter mild steel or wrought iron chain heretofore used to moor large navigation buoys in salt water. As a consequence of the work, it was found that the main causes of chain deterioration in this application were pitting corrosion and inter-link and barrel wear.

Magnesium Casting Out-Performs

Aluminum Forging in Mortar Base

by J. W. Meier and B. Lagowski, Modern Metals 21(5), 54-55 (June 1965)

The high-strength alloys (ZK61, QE22, and ZQ64) and the use of premium quality casting methods have made possible the development of a cast magnesium medium mortar base which is 10% lighter than the standard aluminum forging and has up to 30% higher strength with twice the rigidity.

Long-Term Ageing Behaviour of Aluminium-10% Magnesium Casting Alloys

by W. A. Pollard, J. Inst. Metals 93, 339-346 (June 1965)

The ageing and related phenomena concerning the aluminium-10% Mg casting alloy, at room temperature and up to 150°C, have been studied by tensile testing and metallographic examination over periods of up to six years. In alloys containing

10.2% magnesium, aged at room temperature, a slow but continuous increase in strength takes place, at least up to five years. However, at 50°C and above this age-hardening does not occur, but precipitation is observed, first at grain boundaries, with no change in properties, and then in Widmanstaetten form within grains, accompanied by rapid embrittlement. Reversion of the room-temperature-aged material occurs above 50°C. The results are discussed in terms of work on the aluminum-magnesium alloys and of recent theories of age-hardening.

A Study of the Constitution of the Titanium Rich Corner of the Titanium-Aluminum-Molybdenum System
by A. J. Williams, Can. Met. Quarterly 4(3), 181-203 (July-Sept. 1965)

The constitution of the titanium-rich corner of the titanium-aluminum-molybdenum system, based on a four-hour annealing time, has been investigated.

Further Development of Magnesium-zinc-Silver-Zirconium Casting Alloys
by B. Lagowski and J. W. Meier, Trans. AFS 73, 246-254 (1965); Modern Castings 48(1), 64-72 (July 1965)

In continuation of earlier work, additional casting alloys were developed in the magnesium-zinc-silver-zirconium system to achieve the optimum combination of mechanical properties and foundry characteristics. In particular, some work was directed to the production of thin-walled premium-quality castings.

A Study by Transmission Electron Microscopy of the Tensile and Fatigue Deformation of Aluminum-Magnesium Alloys
by G. W. J. Waldron, *Acta Met.* 13, 897-

The formation of a cell structure in aluminum deformed in tension was found to be inhibited by the addition of small amounts of magnesium and completely suppressed in a 7% magnesium alloy. In this material a high density of dislocations was observed to be present at failure. Suitably oriented segments of helical dislocation sources during tensile deformation.

Layer Porosity Effects in Aluminum-10% Mg Alloy Castings
by W. A. Pollard, *Modern Castings* 48, 99-107 (Sept. 1965); *Trans. AFS* 73 (1965)

The effects of layer porosity on the tensile properties of CSA test bars (similar to the "Navy" bar) and of chilled plate castings of Al-10% Mg alloys were studied for two levels of purity and over a range of magnesium contents.

As previously found for Dow-type test bars, the layer porosity occurred in the gauge lengths of CSA test bars, causing low tensile properties when the magnesium content fell below a critical value (about 10% Mg).

Research on Premium-Quality Castings in Light Alloys
by J. W. Meier, *Proc. 32nd Int. Foundry Congress, Warsaw, Poland, Paper 5*, 19 pp. (Sept. 1965); *Trans. AFS* 73, 525-540 (1965)

Extensive research on the structure and properties of cast aluminum and magnesium alloys has been applied to foundry practice. The term "premium quality" is used to describe castings with reliably high mechanical properties and high integrity of the product, guaranteed by the foundry. In production, conventional equipment and manufacturing techniques may be used, but rigid control of metal purity, alloy composition, melt quality, solidification conditions and heat treatment is essential to achieve and maintain high reliability of properties in designated areas of the casting, which are graded according to design and service considerations. Examples of the excellent properties that have been obtained in aluminum and magnesium alloy castings are listed.

Solute Mixing by Thermal Convection in Horizontal Rods of Molten Alloy
by K. G. Davis and P. Fryzuk, *Trans. Met. Soc. AIME* 233, 1796-97 (Sept. 1965)

In an earlier investigation of solute distributions along unidirectionally solidified rods of dilute silver in tin alloys, it was concluded that, for rods of 2 mm diameter or larger, a very high degree of convective mixing takes place in the melt ahead of the advancing interface. Suggested causes for this mixing were (1) thermal convection, (2) convective currents set up by changes in fluid density associated with concentration gradients, and (3) currents set up by changes in volume during freezing.

Diffusion of Silver in Liquid Tin
by K. G. Davis and P. Fryzuk, *Trans. Met. Soc. AIME* 233, 1662-1664 (Sept. 1965)

The diffusivity of silver in liquid tin has been determined, using the capillary-reservoir technique, over the temperature range 250° to 500°C. The new value, $D = 2.5 \times 10^{-4} \exp(-2480/RT)$ sq cm per sec. differs from that obtained by other workers in an earlier investigation. The analysis of data from the capillary-reservoir technique is discussed.

Hypereutectic Aluminum-Silicon Alloys Produced by Powder Metallurgy Techniques
by C. F. Dixon and H. M. Skelly, *Int. J. Powder Met.* 1(4), 28-36 (Oct. 1965)

Three hypereutectic aluminum-silicon alloys containing 25%, 35% and 45% Si were prepared using powder metallurgy techniques. Pre-alloyed powders, which were fabricated by hot pressing and extruding to give material with density close to theoretical.

The main object of the investigation was to determine if atomization of the alloy would result in refinement of the primary silicon, and metallographic examination of the powders showed that this was accomplished, although additions made to the melts assisted in such refinement.

Thermodynamics of Parabolic Time Rate Law of Oxidation of Metals
by Y. L. Yao, *J. Chem. Phys.* 43(9), 3050-3051 (Nov. 1965)

The Wagner equation for the isothermal oxidation of metals is re-established. One of the assumptions used in deriving the equation is removed.

Grain Structure and Solute Segregation in Bismuth Ingots Solidified From Undercooled Melts

by K. G. Davis and P. Fryzuk, Trans. AIME 233, 1983-1986 (Nov. 1965)

A study has been made of the effect of undercooling on the grain structure and solute distribution in small ingots of pure bismuth and of a 100 ppm silver in bismuth alloy. Autoradiographic evidence shows that in undercooled melts a network of dendrites is formed throughout the melt immediately after nucleation. At large undercoolings the dendrites are very thin and closely spaced. The origin of the observed grain morphology can be explained on the basis of information about the mode of solidification revealed by the impurity substructure.

The Ejection of Atoms from Metallic Single Crystals

by R. L. Cunningham and Joyce Ng-Yelim Am. J. Phys. 33, 1064-69 (Dec. 1965)

The unique characteristics of experimental data obtained from the directional ejection of atoms from metallic single crystals subjected to ion bombardment are discussed. The advantages, for instructional purposes, are outlined.

The macrostructure, gas content (hydrogen, nitrogen and oxygen), tensile ductility, fatigue (notched and unnotched endurance limits and impact-transition temperature relation), were determined for non-degassed, vacuum stream degassed, vacuum ladle degassed and vacuum cast steel.

The steel compositions investigated were 1030 carbon steel, 18-8 austenitic stainless steel and the 8630, 4330 AISI grades.

Vacuum Degassing and Feeding of Carbon Steel Castings

by D. E. Parsons, AFS exchange paper to the Australian Assoc. of Foundry Inst., South Australian Foundrymen (Oct. 1965); (previously unreported)

This work, previously published by the American Foundrymen's Society, pertained to vacuum degassing and vacuum casting procedures for steel. The effect of vacuum treatment of liquid steel on solidification, feeding mechanical properties and composition of carbon steel in 1 in. and 4 in. sections was reported.

X-Ray Spectrochemical Analysis of High-Temperature Alloys Symposium on X-Ray and Optical Emission Analysis of High-Temperature Alloys

by A. H. Gillieson, D. J. Reed, K. S. Milliken and M. J. Young, ASTM Special Tech. Publication No. 376, pp. 3-22 (1965)

The factors involved in the correction of experimental results in the X-ray fluorescence analysis of high-temperature alloys are described and discussed. An empirical method for the mathematical correction of such results is detailed and the degree of correction assessed.

*SECTION 3 - AVAILABLE INVESTIGATION
REPORTS*

ABBREVIATIONS USED FOR ORIGINATING DIVISION (PAGES 47-52)

MPD - Mineral Processing Division

EMD - Extraction Metallurgy Division

MSD - Mineral Sciences Division

FMPD - Fuels and Mining Practice Division

PMD - Physical Metallurgy Division

PRE-1965 INVESTIGATION REPORTS RELEASED
IN 1965 FOR DISTRIBUTION

- IR 63-15
Mineralogical Investigation of Samples
from the Mount Pleasant Tin Deposit
in New Brunswick
by W. Petruk - MSD
- IR 63-18
Investigation of a Sample of Molybde-
nite Ore from Olden Township, Fron-
tenac County, Ontario, Submitted by
K. E. Variette
by T. F. Berry - MPD
- IR 63-38
Investigation of Durability of Concrete
for Manicouagan - 2 Projects
by V. M. Malhotra and N. G. Zoldners
- MPD
- IR 63-49
Investigation of a Gold Ore from Sapawe
Gold Mines Limited, Sapawe, Ontario
by T. F. Berry - MPD
- IR 63-67
Mineralogy of a Sulphide Tin-Silver Ore
from Bolivia for Prospection Limited
by W. Petruk - MSD
- IR 63-69
Physical Tests and Petrographic Study
of a Dolomite from Nogies Creek, On-
tario
by F. E. Hanes - MPD
- IR 63-72
Mineralogy of an Oxide Tin Ore from
Bolivia for Prospection Limited
by W. Petruk - MSD
- IR 63-74
Mineralogy of a Franckeite Concentra-
te of a Tin Ore from Bolivia for Pros-
pection Limited
by W. Petruk - MSD
- IR 63-103
Pilot Plant Jig Tests on Iron Ore from
the Snake River Area, Yukon Territory,
for Crest Exploration Limited
by P. D. R. Maltby - MPD
- IR 63-104
Beneficiation of Silica Land from St.
Canut, Quebec (Project MP-IM-6301)
by F. H. Hartman - MPD

- IR 64-5
Mineralogy of a Bismuth-Copper Ore from Empresa Minera De Quechula, Tasna, Bolivia for Propection Limited by W. Petruk - MSD
- IR 64-12
The Determination of Tin in Ores and Mill Products (Volumetric-Potassium Iodate Method)
by R. C. McAdam and D. J. Charette - MSD
- IR 64-14
Mineralogy of the Pollaco Tin Ore from Empresa Minera Unifroida De Potosi, Bolivia, for Propection Limited by W. Petruk - MSD
- IR 64-17
Determination of the Work Index on a Gold Ore from Norbeau Mines (Quebec) Ltd., Chibougamau, Quebec.
by T. F. Berry - MPD
- IR 64-19
The Effect of Three Types of Comminution on Gravity Concentration of Cassiterite in Samples of Tin Ore from San Jose, Bolivia
by G. O. Hayslip and R. W. Bruce - MPD
- IR 64-31
Investigation of Selected Samples of Coalings-Type Asbestos Submitted by Atlas Minerals
by A. A. Winer - MPD
- IR 64-37
Evaluation of Pozzalinic Properties of a Pumicite from Quesnel, B. C. by V. M. Malhotra and N. G. Zoldners - MPD
- IR 64-48
Surface Water Quality in the Pembina, Souris and Red River Drainage Basins in Canada - A Progress Report for the Period May 1960 to September 1963 - by J. F. J. Thomas and R. M. Gale - MPD
- IR 64-86
Removal of Zinc Oxide from Sample of Flue Dust Submitted by Dominion Foundries and Steel, Limited, Hamilton, Ontario
by G. O. Hayslip - MPD
- IR 64-95
Processing Problems at Standard Clay Products, Limited, New Glasgow, Nova Scotia
by K. E. Bell - MPD
- IR 64-100
Concentration Tests on a Copper-Nickel Ore from the Rottenstone Lake Area in Northern Saskatchewan
by G. I. Mathieu - MPD
- IR 64-102
Report on Pilot Plant Flotation of Uranium Ore from Denison Mines Limited by W. R. Honeywell and W. A. Gow - EMD

MINES BRANCH INVESTIGATION REPORTS 1965

- IR 65-11
The Determination of Hydrogen and Oxygen in Niobium by the Vacuum Fusion and Sub-Fusion Methods
by G. Smelsky and N. S. Spence - PMD
- IR 65-12
Development of Sand-Cast Magnesium Alloy Baseplate for the Medium Mortar - Summary Report
by J. W. Meier - PMD
- IR 65-13
Development of a Sand-Cast Magnesium Alloy Baseplate for the Medium Mortar. Phase I
by B. Lagowski, J. Harbec and J. W. Meier - PMD
- IR 65-14
Development of a Sand-Cast Magnesium Alloy Baseplate for the Medium Mortar. Phase II
by B. Lagowski, J. Harbec and J. W. Meier - PMD
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Development of a Sand-Cast Magnesium Alloy Baseplate for the Medium Mortar. Phase III
by B. Lagowski, J. Harbec and J. W. Meier - PMD
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Development of a Sand-Cast Magnesium Alloy Baseplate for the Medium Mortar. Phase IV
by B. Lagowski, J. Harbec and J. W. Meier - PMD
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Investigation of "Dow" Test Bar Design for Sand-Cast Magnesium Alloys
by J. W. Meier - PMD
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The Use of Scintillation and Flow Counters in X-ray Spectrography
by Dorothy J. Reed - MSD
- IR 65-22
The Use of Synthetic Standards in the Determination of Minor Constituents in Mild Steels by X-ray Spectrography
by Dorothy J. Reed - MSD
- IR 65-23
The Determination of Small Amounts of Hafnium in Mild Steels by X-ray Spectrography
by Dorothy J. Reed - MSD
- IR 65-30
Effect of High Temperatures on Concrete Made With Anorthosite Aggregate and Aluminous Cement
by N. G. Zoldners and V. M. Malhotra - MPD
- IR 65-32
Concentration of silver From a Slag from Cobalt Refinery Limited, Cobalt, Ontario
by T. F. Berry - MPD
- IR 65-36
International Standardization of Test Bars for Cast Copper Alloys
by J. O. Edwards and A. Couture - PMD
- IR 65-38
The Recovery of Copper and Magnetite from New Imperial Mines Limited, Whitehorse Area, Yukon Territory
by R. P. Bailey - MPD
- IR 65-39
Effect of Elevated Temperatures on Two Anorthositic Rocks
by F. E. Hanes and J. A. Soles - MPD
- IR 65-40
Cyanidation of a Gold Ore from Wasamac Mines Limited, Arntfield, Quebec
by T. F. Berry - MPD
- IR 65-42
Examination of Failed Exhaust Manifold from a Helicopter
by W. P. Campbell and R. D. McDonald - PMD
- IR 65-43
Determination of Zirconium in Magnesium Alloys by the Method of Document 150/TC 79/SC-1-248 and comments on the Method
A. E. Larochelle, S. R. M. Badger and W. R. Inman - MSD
- IR 65-44
Recovery of Gold and Silver for Wilmar Mines Limited, Red Lake Area, Ontario
by G. I. Mathieu - MPD
- IR 65-45
Flotation of a Copper-Zinc Ore from the Brabant Lake Area, Northern Saskatchewan
by T. F. Berry - MPD

- IR 65-49
Laboratory Evaluation of Canadian Bentonites for Use as a Binder in the Balling of an Iron Ore Concentrate
by G. N. Banks and G. T. Watts - EMD
- IR 65-50
Concentration Tests of Drill Core Samples from Merrican International Mines Ltd., Burnaby Island, B. C.
by G. W. Riley - MPD
- IR 65-54
The Determination of Sulphur in Meteoritic Materials and Basic Rocks
by D. J. Charette and J. C. Hole - MSD
- IR 65-56
The Effect of Grain Size on Diffracted Intensities of Quartz
by J. M. Stewart - MSD
- IR 65-59
Fractured Aluminum Alloy Pressure Cooker Cover
by W. A. Pollard - PMD
- IR 65-61
Analysis of Accelerated Concrete Strength Tests from Field Data Supplied by the Ottawa Pre-Mixed Concrete Limited, Ontario
by V. M. Malhotra and N. G. Zoldners - MPD
- IR 65-68
Tests on a Lithium-Drift Germanium Detector
by G. E. Alexander - MSD
- IR 65-75
Uranium Alloy Development for Non-Nuclear Application - Progress Report No. 3
by H. M. Skelly, C. F. Dixon and N. S. Spence - PMD
- IR 65-76
Dispersion-Strengthening of Zirconium Progress Report No. 1
by C. F. Dixon and H. M. Skelly - PMD
- IR 65-85
High Temperature Tensile Tests of TZM Molybdenum Alloy Sheet Material
by J. Harbec and P. J. Todkill - PMD
- IR 65-91
Polarographic Determination of Zinc in Magnesium and Magnesium Alloys (Investigation of Method ISO/IC-79/SC-1-145)
by M. Spotswood and C. H. McMaster - MSD

