Colloquium and General Meeting

A Colloquium and General Meeting was held jointly with the Mine Ventilation Society of S.A. in Kelvin House, Johannesburg, on 17th November, 1971, the theme being "The Economics of Mine Ventilation".

Professor D. Howat (President) was in the chair.

The Colloquium was attended by 150 delegates and was opened by the President at 9.00 a.m.

MEMBERSHIP

The President: "I have much pleasure in announcing that the names of the candidates, having been published in accordance with By-Law 5.2.2, Council has elected them to membership of the Institute in the following Grades:

Fellows: Frederich-Wilhelm Volk, Peter Bennet Columbine.

Members: Allan Colin Lawrence, Karel Anton van Gessel, Christopher Robert Harrison, Christopher Michael George Wartley, Frank Heinrich Deist, Ralph Morris, Benjamin Johannes Nolte.

Associates: Wolfgang Freidrich Gottsman.

TRANSFERS

From Member to Fellow: Hugh Edward Keith Allen.

From Graduate to Member: Errol Vincent Bosman, Christopher Roderick Stewart Needes, Bernard Wessels Holthousen.

From Student to Graduate: David Robert Fleming.

I welcome the new members to the Institute and congratulate them on their election.

CO-OPTION TO COUNCIL

The President announced that at the Council meeting held on 5th October, 1971, it was agreed, in terms of Rule 3.9 to co-opt Dr T. B. Beeton to Council.

COLLOQUIUM

The President welcomed visitors and members. He stressed that the discussion would be informal and that any contributor requiring publication should submit his contribution in writing. He then thanked the authors for providing pre-prints of the papers.

After the President had concluded his opening remarks, he asked Professor J. de V. Lambrechts to act as Colloquium Chairman for the day and he, in turn, introduced the three Session Chairmen namely, Dr A. Whillier (Chamber of Mines and President of the Mine Ventilation Society); Mr M. Barcza (Managing Director, Corner House Laboratories); and Mr L. W. P. v.d. Bosch (Chief Consulting Engineer, Union Corporation).

The following papers were presented:

"*Fan efficiency investigation on mines of the Union Corporation, Ltd.*" by J. A. Drummond. Published in the *Journal* Feb. 1972.

"*The design of underground cooling towers*" by A. Whillier. Published in the *Journal*, Oct. 1971.

"*Some aspects of the design of cooling plant installations*" by R. Hemp. Published in the *Journal*, Nov. 1971.

"*The planning of ventilation and refrigeration requirements in deep mines*" by D. F. H. Grave and R. M. Stroh. Published in the *Journal*, Dec. 1971.

"*Cooling power of underground environments*" by D. Mitchell and A. Whillier. Published in the *Journal*, Oct. 1971.

At the conclusion of the three technical sessions the Symposium Chairman commented as follows, indicating that he would prepare a written summing up at a later stage:

"The tone of the colloquium has had a sincerely practical note about it. It would have been a pity if the ventilation experts talked only theory and little practice. This practical theme has, I am sure, made the colloquium interesting to both ventilation men and others whose daily tasks do not touch so closely on this fascinating subject. This practical theme was in evidence through all the papers and contributions.

Some of you may have felt that there was not enough emphasis on the word 'economics' as advertised in the broad title of the colloquium. I do not think this was really a valid criticism because as someone said 'it all boils down to Rands in the end!' So whether it was a case of low fan efficiency, poor design of cooling towers, wrong planning or low human efficiency due to high heat stress . . . it all boils down to money saving and therefore economics, whenever improvements are forthcoming. The title of the colloquium was thus not misplaced.

The views of senior mining men on the production side are appreciated. Let us say that this exchange of views between ventilation engineers and those who have to take the final decisions and spend the money, should prove to be most rewarding."

Professor Lambrechts finally thanked the Session Chairmen and everybody who had helped to make the colloquium a success and the meeting closed at 4.0 p.m.

In a subsequent written summing up, the Colloquium Chairman gave the following as his impressions of some of the highlights which emerged from the papers and discussion thereof: (The names indicate the authors only).

Drummond: It was hinted that the time had arrived to consider the introduction of a South African fan test code which would be better suited to local conditions than the currently acknowledged B.S.S. code which, however, is seldom enforceable in practice. In this connection also, there was prominent reference to the thermodynamic approach of McPherson. Wide variations in the quality of maintenance of, and repair work on, fans were stressed. It was mooted that ventilation engineers responsible for estimating the basic duty specifications for large fans, frequently played safe by overestimating the pressure required, thus ensuring that there would not be a shortfall in air volume delivered. This usually meant reduced fan efficiency and it was suggested that decision makers seemed to lay more emphasis on volume of air delivered than on real eco-

nomics.

Whillier: With the large-scale adoption of underground refrigeration, the importance of efficiency of underground cooling towers was assuming significant proportions in overall plant economics. The author's paper outlined a practical design code although there was some criticism of the design criteria used. It was agreed that much remained to be done.

Hemp: With numerous variables invloved in underground refrigeration problems, the modern computer is an important tool in optimization procedures and very interesting results have emerged. Some of the points raised in discussion were:

(a) the attitude of designers of condensing equipment towards water flow rates *vis-a-vis* cleaning of tubes;
(b) the interposition of H.P./L.P. heat exchangers for reducing hydrostatic heads in working areas;
(c) the possibility of providing special airways used only for refrigerated air and not for travelling or other purposes.

Grave and Stroh: This was a very good review paper on the planning of ventilation and refrigeration requirements in deep mines with interesting comparisons between predicted and observed values of temperature increases in airways and stopes. Long-term forecasts of refrigeration requirements will be watched with interest although primarily these forecasts are needed for budget purposes and are reviewed periodocally. Changes in mining and ventilation techniques may considerably change the overall picture in the future.

Mitchell and Whillier: The new concept of specific cooling power as an index of heat stress, if generally accepted in South African gold mines is likely to oust the wet kata thermometer which has been in use for almost half a century.

CONTRIBUTION by A J Dickson*

The authors have presented a most interesting paper discussing various aspects of what may be termed the empirical and theoretical approaches to ventilation planning and describing their application of available computer programs to the planning of refrigeration requirements.

With reference to Fig. 3 of the paper, illustrating a comparison between measured and computed temperatures in a footwall haulage, it is seen that the correlation is not very good. This is possibly due to the fact that the volume flow rate of the air is below the minimum value for which Starfield's airway programme is valid. The flow rate is given as 5 m^3/s whereas the programme is not valid for flow rates below 9.4 m^3/s. To obviate this type of error the Mining Research Laboratory of the Chamber of Mines of South Africa have produced a modified version of the programme in which the programme limits are brought to the attention of the user. In addition the user is notified of any data falling outside the permissible ranges. This programme is stored in the Witwatersrand University computer under the file name MRL26.

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*Mechanical Engineering Department, University of the Witwatersrand, Johannesburg

The planning of ventilation and refrigeration requirement

by Dr F. H. Grove and R. M. Stroh

National Institute of Metallurgy

Members may be aware that the National Institute of Metallurgy publishes reports on many of its research projects. As the circulation is limited, the Director has kindly agreed to the publication in the Journal of excerpts from reports which may be of interest to members. These will be published from time to time with full details of titles etc., so that members may apply to N.I.M. for copies of the original reports if they so wish.

N.I.M. REPORT
No. 1209

THE ECONOMICS OF INSTRUMENTATION FOR THE CYANIDATION OF GOLD

5th February, 1971
Investigator: G. W. Fletcher

INTRODUCTION

In February 1970, the National Institute for Metallurgy initiated a project, code-named INVAL (Instrument Evaluation), to survey the extent to which instrumentation and automation are being used in the metallurgical industries in South Africa. A start was made with gold-reduction and uranium-reduction plants, where it is known that the different mining groups have very different attitudes towards the use of instrumentation.

The gold-extraction and uranium-extraction processes were studied to find the economic justification for the controls used at present, and to investigate the possibility of controls that are not practised at present because of lack of the necessary instrumentation and that have economic significance sufficient to justify research expenditure on their development.

This report covers the aspects of this work that relate to gold cyanidation and precipitation.

CYANIDE CONSUMPTION AND COSTS

The following statistics are quoted from a publication[1] by the Chamber of Mines of South Africa:

Gold ore milled (members of Chamber) —
80 615 700 short tons

The value of cyanide consumed:

	R
Solid (as 100% NaCN)	1 901 832
Solution (as 100% NaCN)	2 001 233
	3 903 065

If the following prices (as 100% NaCN) are assumed:

Solid	12.08 c/lb
Solution	11.00 c/lb,

it is calculated that in 1969 the industry consumed 33 940 000 lb of NaCN equivalent to an average of 0.42 lb per short ton milled. The cost of reagent cyanide at an assumed average price of 11,5 cents per lb was 4.83 cents per short ton milled.

By comparison, if gold losses as undissolved gold are assumed to be 0,25 dwt/ton, their value was 31,25 cents per ton milled.

INSTRUMENTATION USED IN THE CYANIDATION PROCESS

The concentration of cyanide in the recovery process is traditionally controlled by an operator on the basis of the results of titration tests with $AgNO_3$ solution. King[2] states that the usual practice is to keep the free cyanide strength above 0,020 per cent KCN during dissolution, but he notes that the concentration of cyanide in solution appears to have little, if any, bearing on the time of gold dissolution, provided a minimum of 0,010 per cent KCN is maintained.

If the traditional concentrations expressed as KCN are converted to NaCN (factor NaCN/KCN=49/65=0,75) and a liquid-to-solid ratio of 1 to 1 is assumed, the NaCN consumption would be 0,30 lb per short ton milled (any cyanide recycled in the barren solutions is not included).

King[3] notes that the presence of the free cyanide is essential to the precipitation of gold and silver by zinc, and quotes 0,009 per cent to 0,017 per cent KCN as the lower units. At Randfontein the target was 0,010 per cent KCN. He notes that the common immediate remedy for poor precipitation is the addition of more cyanide to the circuit.

A literature search was undertaken to see what proposals had been made about the introduction of instrumentation into the cyanidation process, particularly to save cyanide. The findings are presented as an appendix to this report.

The following conclusions were drawn from a study of the relevant literature:

(1) The lack of primary measurement device for the on-stream analysis of the free cyanide has been the main obstacle to the use of instrumentation in the cyanidation process.

(2) The Canadian Department of Mines and Technical Surveys and the Corner House Laboratories have produced commercial titration instruments for use in the fixed-titration technique. Gold Fields Laboratories have done considerable work along similar lines but have not developed a commercial instrument.

(3) These titration instruments are probably not robust enough to be accepted enthusiastically by the mines. The necessity for the filtering of the solids from the slimes sample and the fouling of the electrodes by $CaSO_4$ and $CaCO_3$ deposits are troublesome features.

(4) Although control of the precipitation stage seems to be, at the least, equally important, emphasis seems mainly to have been placed on control of the leaching stage.

(5) Gold Fields Laboratories Reports I.D.23 and I.D.25 have established[4] that, provided the ore is leached with cyanide solution for the full leaching period, the ultimate gold dissolution when 0,005 to 0,01 per cent free NaCN is used is the same as that achieved with 0,02 per cent free NaCN resi-

dual. This statement confirms King's findings, except that it gives the NaCN concentration in terms of NaCN and not the traditional KCN.

(6) The practice of the industry to express cyanide sometimes in terms of KCN and sometimes in terms of NaCN is confusing and contributes not a little to uncertain control. Another uncertainty is the extent to which complex cyanides are included in the analysis for free cyanide by any of the analytical methods used.

(7) The following indicate that a saving in cyanide is possible:
   (a) Using their titrator during a four-month test at Bralorne mines, the team from the Canadian Department of Mines and Technical Surveys reduced NaCN consumption from 0,5623 to 0,444 lb/short ton without affecting the assay of the tailings. Further reduction to 0,3542 lb/short ton resulted in trouble in precipitation.
   (b) Confirmation[5] has been received that Carliell, working at East Geduld and Marievale, has been successful in reducing the cyanide consumption at Marievale. Expressed as NaCN, the 1962 to 1968 average was 0,460 lb/ton milled. During the period January to November, 1969, the consumption was reduced to 0,291. An increase of 0,004 dwt per ton of gold in the solution leaving the precipitation stage might have occurred.

(8) The cyanide specific-ion electrode seems to be the cheap and practical primary measurement device through which a new approach can be made to the instrumentation of the cyanidation process.

PROPOSED INSTRUMENTATION FOR THE CYANIDATION PROCESS

The following instrumentation is proposed:

(1) the measurement of the tonnage of dry solids entering cyanide leaching by the combination of mass flowmeter and gamma gauge, and the electronic computation of the dry solids flow to give a recorded flow of dry solids and an outgoing signal;

(2) the use of this signal through a manually set ratio controller to impulse the cyanide feeder (where NaCN solution is used, the feeder could be a variable-speed Clarkson feeder or a variable-stroke metering pump, and where Aero brand cyanide is employed, a variable-speed solids feeder, e.g. Patterson, would be used);

(3) the use of the same tonnage signal to impulse the feed to lime through a second ratio controller and a second variable-speed solids feeder;

(4) the feeding of both cyanide and lime reagents in feed-forward control into a measuring tank ahead of the pachucas or into the first pachuca vessel; and

(5) the use of a specific-ion cyanide electrode and a pH glass electrode located in a flow-cell installed in a sampling line that recycles a portion of the solution after the Stellar filters back to the precipitation vessel. In this location, the solution is free from solids and the troublesome filtration of slurry samples is avoided.

The cyanide concentration and the pH value would preferably be recorded (two pens on a single recorder). Optionally, an alarm could be provided to give warning of a low concentration of cyanide, and the control could be extended, if desired, to initiate automatic recycling of Stellar filtrate to precipitation under conditions of low cyanide concentration. Alternatively, the cyanide electrode could be arranged as in (2) to impulse a feed of cyanide into the precipitation vessel, where a designated cyanide concentration will be maintained.

ECONOMICS OF THE PROPOSED INSTRUMENTATION

If 20 mines together milling 40 000 000 short tons of ore per annum adopt the proposed system and the 1969 average of 0,42 lb of NaCN per short ton milled is reduced to 0,30,

Annual saving in syanide $= 4.8 \times 10^6$ lb of NaCN

Value of cyanide saved annually $= 0.115 \times 4.8 \times 10^6$ rand $=$ R552 000

Average annual saving per mine $=$ R27 600.

For a three-year payout time, this saving would justify the expenditure of about R80 000 by each mine.

The instrumentation proposed in Section 4 could certainly be installed for well under this figure, particularly since the most expensive item — the combined mass flowmeter and gamma gauge — is often already installed.

N.I.M. REPORT
No. 1203

THE CHROMITE OF THE BUSHVELD IGNEOUS COMPLEX. AN ASSESSMENT OF PUBLISHED INFORMATION

1st March, 1971
Investigator: S. A. de Waal

The chromite of the Bushveld Igneous Complex occurs mainly in the Critical Zone, i.e. immediately below the Merensky Reef, in sheetlike bodies parallel to the igneous layering. The associated minerals are pyroxene, plagioclase, magnetite, ilmenite, rutile, illite, chlorite, serpentine, talc, and saponite.

Although several chemical analyses and partial analyses of chromite and chromitite from the Bushveld Igneous Complex have been published in the literature, only a few are sufficiently detailed for use in detailed mineralogical studies. An assessment is made of the available data, and a series of graphs was constructed. From these graphs and from a knowledge of the chromium-to-iron ratio and the location of the sample, the unit-cell formula can be closely estimated.

The physical properties of these chromites and chromitites have received considerable attention, but much remains to be learnt. One important aspect to be studied

is the reason for the friability and lumpiness of chrome ore. Another is the magnetic susceptibility of chromite, which is related to the ratio of ferric ions to ferrous ions within the mineral. This ratio, in turn, has an effect on the reduction properties of the chromite.

N.I.M. REPORT
No. 1361

AN ELECTRON-MICROPROBE ANALYSIS OF GOLD IN THE WITWATERSRAND BANKET AND IN ORES FROM THE BARBERTON MOUNTAIN LAND

29th October, 1971
Investigator: E. A. Viljoen

INTRODUCTION

The purpose of this investigation was the determination of the true composition of gold grains in ores from the Witwatersrand, and the identification of other silver-bearing minerals.

Samples representing a horizontal as well as a vertical distribution across the Witwatersrand basin were analysed, thus including samples from the Dominion Reef, the Ventersdorp Contact Reef, and the Black Reef.

These analyses were then compared with those of gold grains of hydrothermal origin from the Barberton Mountain Land.

EXPERIMENTAL METHODS

Polished sections were investigated optically, and gold grains were marked for electron-microprobe analysis.

The composition of the gold grains was determined from a comparison of the X-ray intensities for the elements present in the samples with those for pure standards, gold-silver alloys, and gold-copper alloys. The values thus obtained were corrected with the aid of a computer for the effects of absorption, fluorescence, dead time, and atomic number.

All the analyses were done in the centre of the gold grains, but additional analyses were done in areas where a difference in colour had been noticed.

DISCUSSION AND CONCLUSIONS

The results are discussed under three headings: the distribution of silver in Witwatersrand ores, the depletion and enrichment of the silver, and the distribution of silver in ores from the Barberton Mountain Land.

Distribution of silver in Witwatersrand ores

Gold is the major source of silver, but the silver content of galena in the Dominion Reef was up to 3 per cent and in the Vaal Reef up to 2 per cent. No discrete silver-bearing minerals were encountered.

The silver content of the gold varies from 0.3 to 32.1 per cent in the different reefs, and a considerable variation can be found in the same sample, e.g., 7.7 to 11.7 per cent in the Ventersdorp Contact Reef at the Western Reefs Mine. A relatively large variation is found in the Carbon Leader, the silver content of gold from the Blyvooruitzicht Mine being between 7.7 and 11.0 per cent. The gold in the Main Reef Leader (Geduld Mine) is closely associated with carbon and has a silver content of between 26.7 and 32.1 per cent.

Silver depletion and enrichment in the gold

Two gold grains had been enriched in silver.

(1) A gold grain associated with skutterudite in the Dominion Reef had a silver content of 4.3 per cent in the centre and 13.5 per cent at its edge.
(2) A gold grain associated with pyrite and gangue in the Basal Reef had a silver content of 8.3 per cent in the centre and 10.3 per cent at the edge.

The high silver content of the gold in the Carbon Leader at the Blyvooruitzicht Mine, and in the carbon-rich portion of the Main Reef Leader at the Geduld Mine, could be due to the following:

(a) gold derived from different source areas,
(b) enrichment of detrital gold by hydrothermal solutions, and
(c) enrichment during metamorphism by solid diffusion from other silver-bearing constituents.

An excellent example of the depletion of silver is found on the West Rand in the Monarch Reef. The sediments and detrital gold were transported from a source in the north towards the south, with an increase in the deposition of gold. The depletion of silver, which increases with the distance of transport, can be followed from north to south as follows: West Rand Consolidated Mines Limited, 11.6 per cent silver ——> Luipaardsvlei Mine, 7.5 per cent silver ——> Randfontein Estates Mine, 0.52 per cent silver.

Distribution of silver in ores of the Barberton Mountain land

Gold was the only silver-bearing mineral found in this investigation. The variation in silver content is not as large as in the Witwatersrand ores, and the values are consistent for each type of ore. Even the gold included in quartz has a composition close to that of the gold associated with the sulphides.

It is known that the composition of gold precipitated at early stages from hydrothermal solutions is silver-rich, compared with the silver-poor gold precipitated at a later stage in the paragenesis of the ore. The pink gold could therefore have been precipitated from a residual liquid low in silver content, but having a large amount of other impurities. A certain amount of nickel went into solid solution in the gold, and the remainder of the nickel and other impurities crystallized as specific minerals, their composition being governed by the relative amount of each impurity present, their affinities for each other, temperature, pressure, and other physical conditions.

Alternatively, the pink gold could have been precipitated from solutions in which other gold grains and some of their matrix material had dissolved. The gold was reprecipitated as pink gold alloyed with less silver than in the original gold, and the gold had included nickel in the alloy. The other impurities were precipitated as minute mineral inclusions in the gold.

The silver in the gold of the Witwatersrand ores is irregularly distributed, in contrast to the consistency

and regularity of silver distribution in hydrothermal deposits. This irregularity can be attributed to the mixture of sediments and detrital gold from different sources that were deposited in the Witwatersrand Basin.

It can be concluded that this variation in composition and origin could influence the leaching properties of the gold. However, more-detailed analyses of gold grains, coupled with the results of leaching experiments, are needed before the influence of composition on the leaching characteristics can be determined.

BOOK REVIEW

Metal Statistics 1960-1970. Metallgesellschaft Aktiengesellschaft. 58th Edition. Frankfurt Am Main, 1971.

The latest edition of Metal Statistics covering the period 1960-1970 contains the usual valuable collection of tabulated data on the production and consumption of the metals covered in the survey. A new feature of the present volume is an extension of the data relating to the aluminium industry giving the production of bauxite and alumina and a breakdown of metal production into production of primary metal and metal recovered from scrap.

A brief, but very valuable introduction surveys the changes in production and prices of the six major non-ferrous metals. This is particularly interesting at the present time and it is a tribute to the compilers that this section includes data up to the end of July 1971. The volume must have been produced with the utmost despatch.

D.D.H.

Solvent Extraction in Metallurgical Processes—Symposium

Antwerp, 4th & 5th May, 1972

The working group "Metallurgy" of the Technological Institute of the Koninklijke Vlaamse Ingenieursvereniging (Royal Flemish Society of Engineers) will organize on 4th and 5th May, 1972, at Antwerp, Belgium, an international Symposium on "*Solvent extraction in metallurgical processes*".

The symposium aims at bringing an extensive survey of the actual "state of the art" in technology as well as of the extraction means that are industrially applicable. The most important recent practical applications in metallurgy will be explained and discussed.

The organizing Committee announces that the following eminent experts already promised their co-operation as speakers:

Prof. Dr. HANSON (Bradford, U.K.)
Prof. Dr G. DUYCKAERTS (Liege — Belgium)
Dr FLETCHER & Dr FLETT (Warren Spring Laboratories — U.K.)
Mr WIGSTOL (Falconbridge, Norway)
Dr SPITZER (Shell — Netherlands)
Dr REINHARDT (Gothenburg, Sweden)
Drs. TEN BRINK (D.S.M. — Netherlands)
Prof. A. R. BURKIN (London, U.K.)
Mr DE TILLEUX (Eurochimic, Belgium).

For further information please address to the secretariate of the symposium:

c/o Ingenieurshuis,
Jan van Rijswijcklaan 58
B — 2000 ANTWERP