Edited by H. A. Shapiro

PNEUMOCONIOSIS

Proceedings of the
International Conference
Johannesburg 1969

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EDITED BY

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Preface

This Conference (convened in Johannesburg from 24 April to 2 May 1969) was the third International Conference on Pneumoconiosis to be held in South Africa. The first one took place in Johannesburg in 1930 and the second (also in Johannesburg) in 1959.

The Third Conference was attended by over 250 participants, including some 60 overseas participants among whom were included well-known scientists in industrial medicine from the United Kingdom, the United States of America, Canada, France, Italy, Belgium, Switzerland, Finland, West Germany, Australia, Japan, Rhodesia, etc. The South African participants included scientists, engineers and administrative officials actively engaged in research and the administration of compensation legislation, etc.

Pneumoconiosis is an important industrial problem which requires the application of control and preventive measures, intensive research in the medical and engineering fields and a constant review and reassessment of legislative measures. The purpose of the present Conference was, therefore, to bring together recognised experts in the various disciplines in order to pool, on an international basis, knowledge, experience and ideas; to review the present state of research and preventive and control measures; and to determine the further research necessary to deal with the problem effectively.

Publication of the *Proceedings* of this important international survey has been made possible by the Department of Mines.

We are indebted to the participants for their co-operation in approving their contributions for publication. The excellent summaries of the various discussions have been included as a result of the work of the very efficient band of rapporteurs. We also wish to thank Mrs. E. C. Shute for the preparation of the Subject and the Author Index.

To allow the *Proceedings* to reflect the international character of the authors, a rigid conformity of presentation has not been imposed on their contributions. The lists of References at the ends of articles should often be regarded as bibliographies as well as footnotes applicable to the text.

H. A. Shapiro,
PH.D., M.B., CH.B., F.R.S.S.Af.,
Editor.

Johannesburg, 1970.

International Conference on Pneumoconiosis, Johannesburg 1969

Message from the Minister of Mines of the Republic of South Africa

It is a great pleasure for me to introduce to you this book, The Proceedings of the International Pneumoconiosis Conference held in Johannesburg from 23 April to May 2, 1969, under the aegis of my Department.

As is well known, the mining industry of this country is large and consists of both mining and processing of a great variety of minerals. Although each of these is associated with specific health hazards, such hazards may vary because of the circumstances in which the mining takes place.

The last Pneumoconiosis Conference held in Johannesburg, was in 1959 and it was considered opportune that, after a decade, this subject (so important to my country) should be reviewed by experts from the Western world in conclave with our own South African scientists.

Approximately 70 overseas scientists were present at the discussions which covered a wide field including both the medical and the engineering aspects. Lines of research were suggested which could be carried out in our country and which could benefit those who work in dusty occupations in many different countries throughout the world.

I am confident that this book, which records the papers and the discussions, will be of interest to a wide field of readers whose work brings them into contact with the problem of pneumoconiosis.

Minister of Mines, of Planning and of Health.

Pretoria,
September 1969.

Message from the President of the 1969 International Conference on Pneumoconiosis

When I was asked by the Minister of Mines, Dr. the Honourable Carel de Wet, M.P., to lead the Organizing Committee and to act as President of another international conference on pneumoconiosis, my thoughts turned to the last conference which was held in Johannesburg in 1959.

At that time the Pneumoconiosis Research Unit had been in existence for only 3 years and scientists from various countries were invited mainly to advise our young but enthusiastic research team on the best evolution of their research projects.

Based on the recommendations of the 1959 Conference, the foundation laid by scientists of previous generations such as Pitchford, Irving, Mavrogordato, Simson and Strachan and the activities of the present scientists, the 1969 Conference has paved the way for continued progress and for continued intellectual curiosity.

With my colleagues of the Organizing Committee I considered that every effort should be made to tackle many of the still unresolved problems inherent in exposure to dust.

As will be appreciated, we have at our disposal unique facilities and material for purposes of research and we are anxious to repay, through close collaboration, some of the scientific debts we owe to other countries.

At the conclusion of the Conference our Organizing Committee and the Vice-Presidents agreed on the best methods by which we in this country can continue to play an active part in assisting to solve problems of universal importance. It is sincerely hoped that the final decisions, which include recommendations about the extension of the terms of reference of the Pneumoconiosis Research Unit and the provision of adequate funds for such purposes, will be speedily put into effect in the interests of all concerned.

I regard intellectual contact at the international level as an enriching experience, both to the giver and the receiver; the deliberations of the present conference are ample justification of this philosophy.

Grateful thanks are extended by myself and the Organizing Committee to all who have made contributions to the success of the Conference.

Professor S. F. Oosthuizen,
President.

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Officers of the Conference

Patron: The Hon. Dr. Carel de Wet, *Minister of Mines of the Republic of South Africa.*

President: Prof. S. F. Oosthuizen, *Professor of Radiology, University of Pretoria, President of the South African Medical and Dental Council and Medical Adviser to the Minister of Mines of the Republic of South Africa.*

Secretary-General: Dr. G. K. Sluis-Cremer, *Director of the Miners' Medical Bureau of the Republic of South Africa* and *Director of the Clinical Sciences Division of the Pneumoconiosis Research Unit of the C.S.I.R.*

Assistant Secretaries-General:

Dr. I. Webster, *Director of the Pathology Division of the Pneumoconiosis Research Unit of the C.S.I.R.*

Mr. J. F. Brauckmann, *Administrative Deputy Director of the Miners' Medical Bureau.*

Honorary Vice-Presidents: Mr. J. J. A. Nel, Dr. S. M. Naudé, Dr. A. J. A. Roux, Dr. T. Muller, Prof. J. H. S. Gear, Dr. A. J. Orenstein, Mr. J. G. Mackeurtan, Mr. F. G. Hill, Mr. F. Baunach.

Vice-Presidents:

Dr. Murray C. Brown: *United States of America.*

Dr. J. C. Gilson: *United Kingdom.*

Prof. P. H. Rossier: *France.*

Prof. E. C. Vigliani: *Italy*

Mr. T. L. Gibbs: *South Africa.*

Rapporteurs

Pathology: Dr. B. Goldstein, Dr. I. Prinsloo Dr. S. D. Berson.

Clinical Sciences: Dr. F. J. Wiles, Dr. H. v. Doorn.

Dust Physics: Dr. R. S. J. du Toit, Mr. L. W. Isserow, Mr. A. F. H. Lombard, Mr. P. H. Kitto.

Radiation Hazards: Dr. J. K. Basson.

Editorial Committee

Dr. G. K. Sluis-Cremer, Dr. I. Webster and Prof. H. A. Shapiro (*Editor*).

Sponsors

The Conference was held under patronage of the Ministry of Mines of the Republic of South Africa and the Hon. the Minister of Mines, Dr. Carel de Wet, the Patron of the Conference.

The Conference was sponsored financially by the Department of Mines of the Republic of South Africa, the Asbestos Mining Industry of South Africa, the Chamber of Mines of South Africa and the Mining Trade Unions. Accommodation for the Conference and other conference facilities were provided by the South African Institute for Medical Research.

Organizing Committee

Chairman: Prof. S. F. Oosthuizen.

Members: Dr. G. K. Sluis-Cremer, Dr. I. Webster, Dr. J. K. Basson, Prof. J. H. S. Gear, Mr. F. A. Snyman, Dr. R. S. J. du Toit, Mr. J. F. Brauckmann.

Ladies Committee

Convener: Mrs. J. Webster.

Members: Mrs. E. Oosthuizen, Mrs. J. E. V. Sluis-Cremer, Mrs. J. C. Snyman, Mrs. H. Basson, Mrs. J. Gear, Mrs. N. Brauckmann, Mrs. G. E. F. du Toit.

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Chairman: I. J. Selikoff, *Environmental Sciences Laboratory, Mount Sinai School of Medicine, United States of America*

Chairman: J. C. McDonald, *Department of Epidemiology and Health, McGill University, Canada*

Thursday, 24 April 1969

Symposium on Asbestosis

Chairman: S. F. Oosthuizen, *Adviser to the Minister of Mines of the Republic of South Africa*

Chairman: J. C. Gilson, *Medical Research Council, Pneumoconiosis Unit, United Kingdom*

Chairman: E. C. Vigliani, *Clinica del Lavoro, "Luigi Devoto", Italy*

Chairman: Murray C. Brown, *Public Health Service, United States of America.*

Friday, 25 April 1969

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Chairman: S. Forssman, *National Institute of Occupational Health, Sweden.*

Chairman: J. F. Murray, *South African Institute for Medical Research, Johannesburg, South Africa*

Symposium on the Radiology of Asbestosis

Chairman: E. P. Pendergrass, *Department of Radiology, University of Pennsylvania, United States of America*

Symposium on the Radiology of Pneumoconiosis

Chairman: G. Worth, *Krankenhauses Bethanien, Germany*

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Symposium on Coal Workers' Pneumoconiosis

Chairman: F. M. Engelbrecht, *Department of Physiology, University of Stellenbosch, South Africa*

Chairman: P. H. Rossier, *Medical Clinic, University of Zurich, Switzerland*

Chairman: J. H. S. Gear, *South African Institute for Medical Research, Johannesburg, South Africa*

Symposium on Chronic Bronchitis and Emphysema

Chairman: G. Wright, *Department of Medical Research, Saint Luke's Hospital, United States of America*

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Chairman: W. T. Ulmer, *Medical Division of the Silicosis Research Institute of Bergbau-Berufsgenosschenshaft, West Germany*

Chairman: M. Gelfand, *University College of Rhodesia and the Pneumoconiosis Medical Bureau, Rhodesia*

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Chairman: J. R. Rüttner, *Histopathologischen Institut, Universitat, Zurich, Switzerland*

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Chairman: F. G. Hill, *Rand Mines Limited, South Africa*

Chairman: F. Lavenne, *Institute of Mining Hygiene, Belgium*

Chairman: L. Noro, *Institute of Occupational Health, Finland*

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Symposium on Aspects of Pneumoconiosis Compensation

Chairman: G. K. Sluis-Cremer, *Miners' Medical Bureau, South Africa*

Friday, 2 May 1969

Symposium on Radio-Activity in Mining

Chairman: A. J. A. Roux, *Atomic Energy Board, South Africa*

Chairman: S. F. Oosthuizen, *Adviser to the Minister of Mines of the Republic of South Africa*

Symposium on the Engineering Aspects of Pneumoconiosis

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Chairman: P. H. Kitto, *Chamber of Mines of South Africa*

Chairman: V. Timbrell, *Medical Research Council, Pneumoconiosis Unit, United Kingdom*

Tuesday, 29 April 1969

Chairman: W. H. Walton, *Institute of Occupational Medicine, United Kingdom*

Chairman: C. T. Hardy, *Government Mining Engineer's Division, Department of Mines, South Africa*

Symposium on Asbestos

THE INHALATION OF FIBRES

V. TIMBRELL
Pneumoconiosis Research Unit of the Medical Research Council, Penarth, Glamorgan, U.K.

A previous study (Timbrell, 1965) examined the influence of the diameter and length of fibres on the respirability of these particles. This paper extends the discussion to the influence of the fibre shape, with specific reference to the relative respirability of chrysotile and amphibole asbestos.

PARTICLE DEPOSITION MECHANISMS

The mechanisms operating to deposit particles in the lung and the relevant particle parameters are:

i. Gravitational settlement: free falling speed.
ii. Inertial impaction: proportional to free falling speed.
iii. Interception: size.
iv. Diffusion: size.

Diffusion is efficient only for particles smaller than 0.5 microns in small air spaces and is of little importance for the long fibres that can penetrate deeply into the lung.

FIBRE DIAMETER

The observation that fibres of a range of different materials recovered from lungs are very slender is explained by the fact that the free falling speed of a fibre is approximately proportional to the diameter squared and almost independent of the length. Only if a fibre is of small diameter can it avoid deposition from gravitational settlement and inertial impaction high in the respiratory tract and succeed in penetrating to the pulmonary air spaces.

Fibres of amphibole asbestos (amosite, anthophyllite and crocidolite) found in lungs are straight and have a maximum diameter of about 3 microns (Timbrell, Pooley and Wagner, this Conference, p. 120). Chrysotile fibres, on the other hand, are often partially opened bundles of very fine fibrils, whose length and diameter are difficult to define. When, however, chrysotile fibres in lung sections are tight bundles, the maximum diameter of these is approximately the same as for the amphiboles. Aerosol spectrometer examinations of partially opened bundles and aggregates of chrysotile fibres have shown that some of these can have low falling speeds for their size. This explains why 'thick' chrysotile fibres are sometimes found in lungs.

FIBRE LENGTH

For particles of compact shape, such as those of coal and silica, the important deposition mechanisms operating in the upper respiratory tract are gravitational settlement and inertial impaction. Only if these compact particles are less than about 10 microns in diameter can they penetrate deeply into the lung. Even the largest of these particles is small compared with the diameters of the narrow airways so that interception, which depends on the relative sizes of particle and airway diameter, is of little consequence.

For fibres, however, interception can be very important. A long fibre, if it is slender, may avoid deposition in the upper respiratory tract from gravitational settlement and inertial impaction and penetrate deeply to the pulmonary air spaces. In these regions the length of the fibre may be comparable to the diameters of the airways, and interception becomes a major deposition mechanism.

The previous study showed that the efficiency of deposition of fibres by interception increases with increase in fibre length and with decrease in airway diameter. Interception must be expected to concentrate long fibres in the narrow air ducts and particularly at bifurcations. Elsewhere at this Conference (Timbrell, Pooley and Wagner, p. 120) the length distributions of amosite fibres in rat lung sections are compared with the length distribution of the fibres to which the animals were exposed. These results show that fibres 50 microns and longer were present in the lungs: the fibres in the lung were on average shorter than those in the cloud and the longer fibres were mainly in the narrow air ducts, particularly at bifurcations. Although other factors were probably involved the results agree with the conclusions reached from analysis of the interception effect in the previous study.

FIBRE SHAPE

The most striking physical difference between the 2 main types of asbestos fibres is their shape: the amphiboles are straight and the chrysotiles curly, roughly resembling a stretched coil. This suggests the possibility of

important differences between the magnitudes of the size-sensitive interception effects in the lung for the 2 types of fibre. Data have therefore been collected on the shape as well as the size of fibres in industrial clouds of amphiboles and chrysotile and in clouds generated under laboratory conditions.

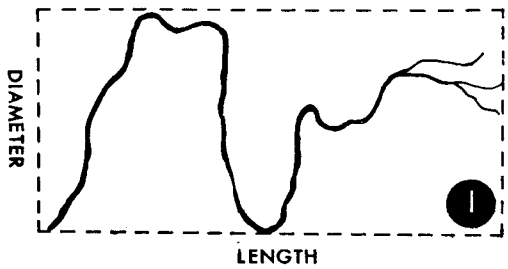

Fig. 1. Measurement of coil diameter and coil length of a curly fibre.

A complete mathematical description of the shape of a curly fibre is difficult but a simple definition is adequate for present purposes. The coil is enclosed in an imaginary cylinder. Under the microscope this cylinder normally has its axis parallel to the surface of the slide or membrane filter on which it is lying. A rectangle is visualized around the microscope image of the fibre as illustrated in Fig. 1. and the width and length are measured. These 2 dimensions represent approximately the diameter and length of the cylinder enclosing the coil. The ratio of coil diameter and coil length is referred to as the 'coil aspect ratio'. The ratio of the diameter and length of the fibre remains the 'aspect ratio'. It may be noted that if the fibre is

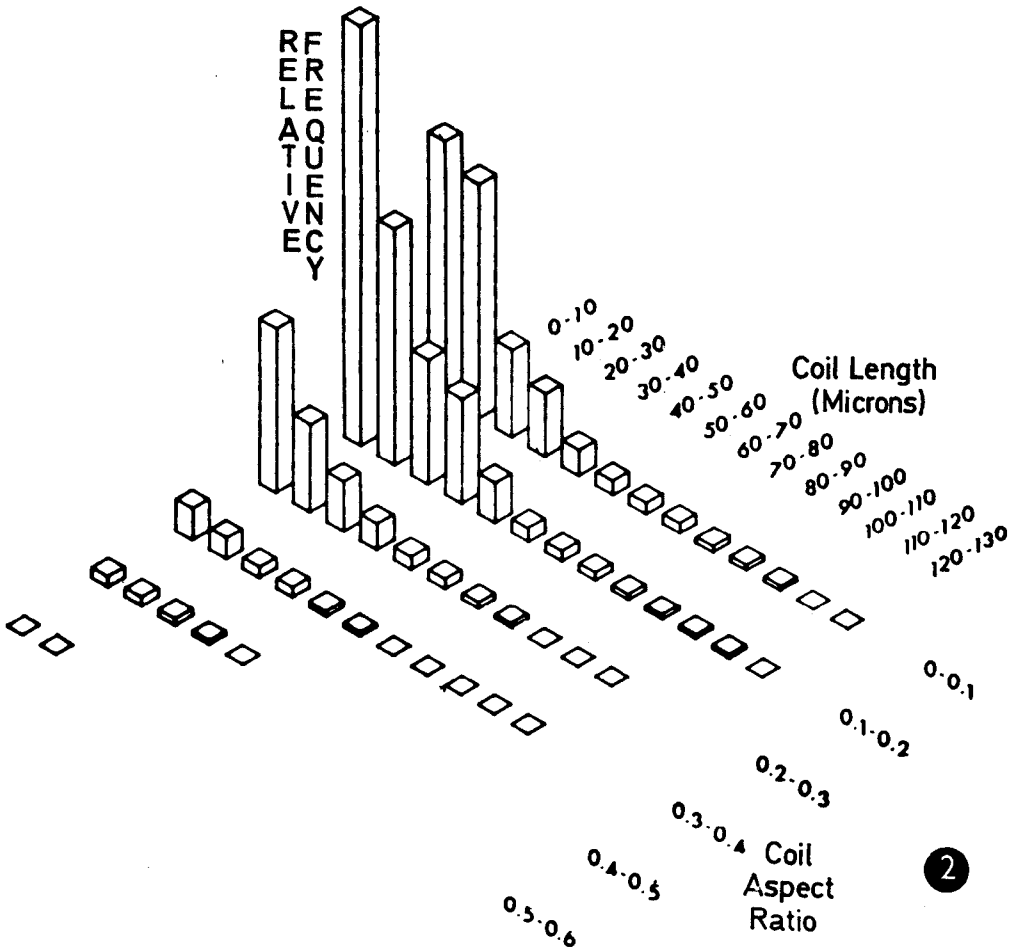

Fig. 2. Distribution of coil length and coil aspect ratio for UICC Rhodesian chrysotile.

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