

PNEUMOCONIOSIS

ABSTRACTS

VOLUME III—1951-1955

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Published for the
BUREAU OF HYGIENE AND TROPICAL DISEASES
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PNEUMOCONIOSIS
ABSTRACTS

VOLUME III

FOREWORD

THIS volume is a sequel to the two preceding volumes of *Pneumoconiosis Abstracts* which were published in 1953 and 1954. These volumes contain abstracts reprinted from the *Bulletin of Hygiene*; the first volume covered the years 1926 to 1938, the second 1939 to 1950, and the present volume covers the years 1951 to 1955 inclusive. The set of three volumes, therefore, contains a comprehensive collection of abstracts of the important papers published in this field during a period of 30 years.

In each volume, the abstracts are arranged in logical order, but readers will note that papers by the same authors are sometimes published together in series and some may accordingly appear to be in inappropriate sections. This has been done deliberately to show the trend of research.

The first two volumes were published by Sir Isaac Pitman and Sons, Ltd. and the text was re-set in type. In the present volume the abstracts have been reproduced by Messrs. Butler and Tanner by a photographic process and the volume has been published by the Pitman Medical Publishing Company for the Bureau. For various reasons, changes were made in the type face used for printing the *Bulletin of Hygiene* during the period and the type reproduced in the present volume is therefore not uniform.

In many of the abstracts, references are made to "this *Bulletin*"; these relate to the *Bulletin of Hygiene*. Page numbers quoted in these references therefore are not necessarily those of the present volume, but to assist the reader, the relevant page numbers in this or the earlier volumes have been printed as footnotes. A few references concern papers not included in *Pneumoconiosis Abstracts* and these have been left without annotation.

Acknowledgment is made to the many abstracters who gave their time and thought and knowledge to the compilation of these abstracts. Acknowledgment is also made to Mr. J. Rathborn, formerly Secretary of the Bureau, who carried out the preliminary selection and sorting of the abstracts and who constructed the index.

Bureau of Hygiene and Tropical Diseases
London, W.C.1
January, 1959

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SECTION I

GENERAL

General—History—Epidemiology—Aetiology—Pathology—Respiratory Functions—Radiology—Clinical Findings—Treatment—Prevention—Legal Subjects

INTERNATIONAL LABOUR ORGANISATION. **Third International Conference of Experts on Pneumoconiosis, Sydney, February–March 1950. Record of Proceedings.** Vol. I. pp. xi + 323 mimeographed. Vol. II. pp. iv + 337 mimeographed. 1953. Geneva: International Labour Office.

This Conference was attended by delegates from Australia, Canada, Denmark, France, New Zealand, Norway, Sweden, Switzerland, Union of South Africa, United Kingdom and United States, together with I.L.O. experts, representatives of managements, trade unions, and other interested bodies and observers. It is noteworthy, as indicating its wider scope, that the subject of this Conference was Pneumoconiosis, not Silicosis, as formerly. The record of the Proceedings is not published in full; the papers have been retained unabridged, but the verbatim record of the discussions has been reduced to half of its length. It does not seem to have lost by this; in fact, by giving only the essential remarks in concentrated form, its value and interest may be enhanced. As it is, there is ample evidence of the thoroughness and care given to the various items under discussion, and the wealth of experience available.

The verbatim record is followed by the Report of the Conference which includes an appendix dealing with a suggested International Scheme for the Classification of Radiographs in some of the Pneumoconioses. This is based on, and differs only in minor details from, the classification first proposed by Dr. FLETCHER and his colleagues of the Pneumoconiosis Research Unit in Cardiff [this *Bulletin*, 1950, v. 25, 475]. In recommending the adoption of this classification the Conference emphasize that it should be used for radiographic purposes only, and not for any other purpose such as the assessment of clinical conditions or disability. There follow the papers presented to the Conference, which occupy about the remaining half of volume 1 and the whole of volume 2. Some of these papers include illustrations, and many contain useful references.

The Conference first considered the definition of pneumoconiosis, and Dr. MIDDLETON contributed an excellent comprehensive paper describing the reactions produced by different kinds of dust in the lungs. [Incidentally, he has some serious words to say about the practice of returning to grain the dust which has separated from it in various stages of handling, so as to maintain the weight.] The subject obviously

bristles with difficulties and the Conference eventually accepted the following definition, which does not appear to the reviewer to have entirely solved the problem.

"Pneumoconiosis is a diagnosable disease of the lungs produced by the inhalation of dust, the term 'dust' being understood to refer to particulate matter in the solid phase, but excluding living organisms."

One of the most interesting discussions was that on Recent Advances in the Pathogenesis and Pathology of the Pneumoconioses. The numerous subjects, to which reference was made from various aspects, included acute silicosis, Shaver's disease, coal miners' pneumoconiosis, the effects of various abrasives, diatomaceous earth, beryllium, aluminium, some vegetable dusts, and the part played by ultra-small particles. Dr. MEREWETHER commented on the relationship between pneumoconiosis and lung-cancer, quoting British figures showing a ten-fold greater incidence of lung cancer in asbestosis than in silicosis. Dr. VORWALD delivered an interesting paper in which he dealt with the importance of very small particles, objections to the complete acceptance of the solubility theory as the only aetiological factor in silicosis, and the influence of industrial processes in changing the chemical composition of the dust produced. He and several other speakers referred to the inhibitory effects of aluminium and other dusts, and also to problems in the interpretation of the results of animal experiments. The relative advantages of the inhalation and injection techniques with experimental animals were discussed. With reference to his paper on The Classification of Dusts which cause Pulmonary Disability, Dr. GREENBURG stated that the problem had become over-simplified in the United States, where there was a tendency to regard dusts as essentially of two kinds; the one, harmful, including crystalline free silica, asbestos and some others which produced serious effects, was constantly in mind; the other, including dusts which did not produce serious effects, was frequently neglected. He drew attention to the potentially harmful effects of breathing sufficient quantities of any dust. X-ray appearances, he said, meant practically nothing in interpreting the amount of abnormality present. He emphasized the importance of not overlooking the vast amount of information which came to the attention of physicians engaged in general and private practice.

Two papers, submitted by Drs. FROST and GEORG of Denmark, and by Professor ROSSIER of Switzerland, dealt with the value of functional and laboratory tests for disability. In a lively discussion on the subject, Dr. FLETCHER enumerated the desiderata of a practical test; it should be objective (*i.e.*, independent of the subjective judgment of the observer and the desires of the subject), valid, specific, simple, sensitive, and related to normal controls. It seemed to be generally agreed that though reasonably accurate information could be obtained on pulmonary function, there are at present no physiological or laboratory tests which can be adapted in the field for routine examination of large numbers of workmen. The maximum breathing capacity was probably the only simple and reasonably sensitive test for respiratory function available at present.

The discussion on early diagnosis, differential diagnosis and clinical aspects did not bring to light any new methods. It was emphasized that diagnosis must depend not on X-ray appearances alone but on the 3 elements: an occupational history of adequate exposure to the dust; a physical examination showing signs and symptoms compatible with the disease; and a chest radiograph showing the characteristic pattern. Professor GERNEZ-RIEUX believed that methods of diagnosis generally employed were inadequate. In his unit a systematic tomographic examination was first performed. Bronchoscopy and histological examination of biopsy specimens were also carried out, and thorough bacteriological examinations and agglutination tests where tuberculosis was suspected, a therapeutic test with streptomycin being sometimes added.

The sessions on dust investigation included consideration of the rates of settlement of dust of different sizes, various problems of drilling, the importance of very small particles, dust sampling methods, and the value of electrostatic precipitators in removal of dust from the working atmosphere. In addition to Dr. Greenburg's paper already mentioned, papers were contributed on Research on Industrial Dust in the Netherlands (Drs. GROENEVELD and HARTOGSENSIS), and Analytical Requirements for the Appraisal of Dust Exposures (Professor T. F. HATCH). This last is a particularly important and interesting paper, in which are discussed the complex interrelations between several factors that characterize dust exposures and the resulting hazard. The inadequacy of present methods of analysis is pointed out.

In regard to preventive measures, the Conference emphasized the importance of pre-employment and periodical medical examinations, drawing attention to the need for technical competence in the examiners. The examinations should include a satisfactory chest radiograph, and information such as the period of exposure to dust and its type and concentration should be available. The main efforts of prevention should, however, be directed towards dust suppression and control, and the Conference agreed that methods now known could protect the worker against hazardous exposure. Several references were made to the danger of sandblasting. Though this was generally accepted as high, there was some difference of opinion as to the

statement the Conference should make on the subject. Dr. MEREWETHER very strongly advocated a recommendation that blasting with siliceous materials should be abolished, while Professor HATCH and Dr. GREENBURG considered that, with the development of protective measures, the flat statement that such blasting was highly dangerous was not true in all cases. In the end these differing views were incorporated in the Report of the Conference. Recommendations were made that the I.L.O. should enquire into the possibility of controlling grain dust associated with the handling of cereal cargoes, that Governments, local authorities, contractors and others should have their attention drawn to the occurrence of cases of silicosis after relatively short exposure to dust in civil engineering undertakings such as tunnelling and excavations, and that there should be greater co-operation between pneumoconiosis-producing industries and health authorities in the campaign against tuberculosis. Many interesting papers were presented on aspects of prevention, including two from the I.L.O. reviewing legislation and giving extracts from Laws and Regulations in different countries. Professor E. J. KING and his colleagues submitted an account of experiments on the inhibitory action of alumina, confirming that the silicotic process was markedly retarded, but stating that if it were to be prevented altogether, a sufficient concentration of alumina must be maintained in the lungs during the entire life of the animal. Dr. G. HILDICK SMITH showed that a high degree of efficiency could be achieved in mining conditions by the use of electrostatic precipitation.

The last subjects considered were compensation and treatment, including rehabilitation. As it seemed impossible to lay down generally acceptable standards for assessment of disability the Conference agreed that this must be left to the judgment of the examiner. Every effort should be made to place a worker in alternative employment if he had to leave his usual job, but the provision of alternative employment should not prejudice the amount of his compensation.

A proposal by United Kingdom members for a subsequent conference at an early date, to consider preventive methods from the point of view of the engineer, physicist and chemist, was unanimously adopted, as was a proposal by a United States member that the Office should prepare a directory of workers in the field of pneumoconiosis.

The closing speeches included a review of the Conference's work by Dr. GRUT (I.L.O.). Outstanding in the results, he said, were a clear and simple definition of pneumoconiosis, a review of disability and compensation problems, the important conclusion that methods were now known which allowed adequate protection against dust, and the adoption of a trial radiological classification. To the reviewer these volumes appeal as being a comprehensive source of up-to-date information on most of the important practical, and many of the theoretical, problems connected with pneumoconiosis. There is a useful index. The report is not on sale and copies are not now procurable.

A. T. Doig

BRITISH MEDICAL BULLETIN. 1950, v. 7, Nos. 1/2, pp. iii+144, numerous illustrations. **Part I: Industrial Hazards. Part II: Commentary. History. Documentation.**

* * *

The papers on the pneumoconioses include one on coal miners' pneumoconiosis by Dr. C. M. FLETCHER and Professor J. GOUGH, on silicosis and other pneumoconioses by Dr. E. L. MIDDLETON, and on byssinosis in the British cotton textile industry by Dr. R. S. F. SCHILLING. In the first of these the well-known work of the Medical Research Unit at Cardiff is described, and the pneumoconiosis of coal workers is shown to be conditioned by the amount and kind of dust up to a certain limit of progression, and the occurrence of an infective element if further development takes place; the factors which determine the mode of action of the dust and the reasons for the geographical incidence of the disease are still obscure and research is continuing. In the second article the extending scope of the work on the pulmonary dust diseases is shown to go far beyond the minerals containing silica and to include metals and metallic compounds and vegetable dusts. In the third article the history of cotton workers' "asthma" is traced, and the results of research and investigation are recorded; the conclusion reached, however, is that more work is needed to clarify the aetiology of the disease and to ensure its prevention.

* * *

E. L. Middleton

JÖTTEN, K. W., KLOSTERKÖTTER, W. & PFEFFERKORN, G. [Edited by.] *Die Staublungenerkrankungen*. Vol. 2. Bericht über die 2. Internationale Staublungen-Tagung des Staatsinstitutes für Staublungenerforschung und Gewerbehygiene beim Hygiene-Institut der Westfälischen Wilhelms-Universität Münster/Westf. vom 2. bis 4. Nov. 1953. [**Dust Diseases of the Lungs. Report of the 2nd International Congress on Dust Diseases of Lungs, Institute for Investigation of Dust Diseases of Lungs and Industrial Hygiene, Institute of Hygiene of Westphalia—Wilhelms University, Munster, 2-4 November, 1953**] pp. xxxv-424, 273 figs. 1954. Darmstadt: Dr. Dietrich Steinkopff. [DM 40.]

This Report of the Second International Conference on Pneumoconiosis, under the auspices of the State Institute for Pneumoconiosis Research, was held at the Hygiene Institute of the Westphalian Wilhelms-Universität at Munster, Westphalia, in November 1953. The first Conference in the series was held in November 1949.

The 46 papers submitted to the Conference cover the whole field of research on pneumoconiosis in a most thorough and up-to-date manner. They are grouped under 4 heads: pathology; the action of different dusts in animal experiment; fundamental research in the chemical, physical and mineralogical fields and in investigations by electron-microscopy;

and clinical aspects of research including radiology, prevention by mechanical, physical and medical measures and the treatment of pneumoconiosis.

Professor H. GÄRTNER (Homburg/Saar) in an opening address (pp. 3-16) reviewed the progress of pneumoconiosis since the previous German conference 4 years before. He gave some figures of the incidence in Germany. The number of persons receiving compensation for industrial diseases for the first time, in 1951, was 9,306, over double the number for 1938, and of these 6,090 had pneumoconiosis; almost 5,200 were miners. Of the 9,306 cases, 457 were fatal, 385 from pneumoconiosis and over half from tuberculosis. In the Saar the number of notified cases of pneumoconiosis rose from 146 in 1946 to 1,274 in 1952; 88 per cent. of the patients were miners. Tuberculosis was present in 40 per cent. of those notified during the 5 years 1946-50. In 1952 the percentage of tuberculous cases was diminished in the Saar as in the Republic. He referred to the discussions at the Sydney Conference on the solubility theory and to the results of researches on crystal structure comparing the effects of crystal lattice, fibrous and platy forms of silicates, and of the combinations of the contained atoms and their positions, on the activity of the minerals and of particle size. Many other scientific questions arising from experimental work on the action of silica on the tissues included variations in pH, the presence of inflammation, and fresh fracture of minerals. The mode of action of silica on the tissues was discussed and the work of many observers was quoted; he thought that it could now be said that true, fully developed silicotic nodules had not been produced with certainty by experiment without the crystalline structure of quartz; all other minerals and the amorphous form of silica in diatomaceous earth induced growth of diffuse connective tissue. He emphasized that animal experimentation must occupy the central place in aetiological research. Referring to research in Germany and England on the influence of hormones on silicotic fibrosis he considered that this line should be followed up, less in connexion with therapy or prophylaxis than in regard to the problem of the influence of constitution; work in this direction was being done by BECKMANN at Bochum on coal miners. He referred to the use of aerosols on dust clouds and by inhalation for causing aggregation and precipitation. The practical possibility of ending the production of pneumoconiosis lay in the prevention of dust by the technician, who holds the solution of the problem.

The Pathology of Pneumoconiosis. W. DI BIASI (Bochum) submitted *Remarks on a Few Points on the Pathological Anatomy of Silicosis* (pp. 16-26). In opening the section on pathology he discussed 2 questions: how dust reached the alveoli where alone it could cause silicotic changes; and where these changes first originated in the lung tissue. He agreed with MORTURA that the changes developed in tissue spaces around the lymph vessels. The lymphatic vessels were not generally destroyed although they might be compressed and perhaps obstructed by dust



cells or free dust, and at the roots of the lungs silicotic glands might distort the lymph channels, but not in the lung itself where new lymph vessels might be formed. The nodules caused by quartz differed from those due to mixed dust in that their borders were sharply defined from the surrounding lung tissue; small quantities of quartz could lead to silicotic changes when exposure had been prolonged. The "focal emphysema" of South Wales coal miners' pneumoconiosis was also known in the Ruhr, as circumnodular emphysema, and was considered to be an important factor in explaining the impairment of function. The work of GOUGH was referred to, as was also his method of using mounted unstained sections. The importance of gross changes at the roots of the lungs in causing functional damage was emphasized as a result of study in recent years. Evidence had been found at autopsy of severe silicotic changes in the glands at the hilum without change anywhere in the lung; such changes had been found in old men who had not been engaged in dusty occupations and these could not fail to be important to the respiration and pulmonary circulation, and they could lead to distortion of bronchi, bronchiectasis, chronic emphysema and strain on the right heart. To what extent and in what direction the observed involvement of nerves in the fibrotic masses was important was not estimated.

Silico-Tuberculosis (pp. 27-50). G. GERSTEL (Gelsenkirchen) considered the general pathology of tuberculosis in so far as it was important for explaining silico-tuberculosis, and special attention was given to the reaction of the body to infection. In regard to management the slow cicatrizing processes were not favourably influenced by sanatorium treatment and rest but antibacillary treatment was highly valued. In tuberculosis the personal factor was the important one; age reacted differently from youth; the susceptibility of young girls to tuberculosis after exposure to quartz dust was well known from the experience with the packing of scouring powders containing silica and alkali, and cases were reported from many countries. It had been shown that the danger of silicosis was greater in families with a tuberculous history. The influence of physical build on the higher incidence of silico-tuberculosis was proved in several dusty industries when compared with that of simple silicosis; in the asthenic types the ratio of silicosis to silico-tuberculosis was 13:4, in the pyknic and athletic types it was 5:12. Professor Gerstel quoted statistics to show the increasing danger with prolonged exposure to dust in mines of the Ruhr and Rhenish Prussia, in various industries in Saxony, in porcelain workers or in metal grinders in Solingen where the incidence of tuberculosis was more than twice that of the general population; in the mining towns of the Ruhr silico-tuberculosis was an important source of infection. The presence of tuberculosis was not necessary for the development of severe silicosis or for a fatal termination. The pseudotumoral form was found in 73 per cent. of simple silicosis and in only 60 per cent. of silico-tuberculosis. A fundamental fact was established

that the susceptibility to tuberculosis increased from the commencement of dust inhalation. The danger from any dust was increased with its free silica content. New questions had been raised through the modern therapy of tuberculosis and through the introduction of organic silica compounds. In conclusion the German Law relating to compensation for industrial diseases as applied to silicosis and tuberculosis was discussed.

Pneumoconiosis in a Feldspar Worker (pp. 51-8). W. ROTTER and H. GÄRTNER (Homburg/Saar). The case described was that of a man, aged 53, who had been employed digging quartzose feldspar in the open for 9 years with no dust risk; afterwards he was employed for 11 years at a machine grinding the rock, and, although exhaust draught was provided, there was a definite risk of dust inhalation. He developed pulmonary tuberculosis and died. Examination of the lungs showed, besides the tuberculous lesions, scattered milary or sub-milary nodules of a large-cell granulomatous type which contained many amorphous grey or black particles 1-2 μ in diameter, and colourless double-refracting particles 1-4 μ in diameter. The reticulin and collagen fibres were not, or only slightly, increased and there was no concentric arrangement in the nodules. Similar particles were seen in large cells in the lymph glands in which the double-refracting particles were more sparse. Rational analysis of the material showed quartz 45.4 and 38.3 per cent.; particle sizes were 40-45 per cent. from 2 μ downwards. Lung tissue extracted by the hydrogen peroxide method showed the residual dust to be of similar composition to the raw material but the kaolin lines were stronger in the lung material, by X-ray diffraction, probably owing to a higher concentration in the air-borne dust cloud. Electron-microscopic examination of the lung dust showed mineral particles from 3 μ downwards; many were under 1 μ and some were in aggregates. Whether the changes found here should be called modified silicosis or silicatosis was open to question, but the silicate feldspar certainly had played a part in the histogenesis of the lung changes, the quartz being restrained in its action; the sharp distinction between this and true silicosis due to quartz seemed artificial.

Morphology of Pneumoconiosis in Pottery Workers in Upper Franconia (pp. 58-64). E. KIRCH (Würzburg). The author described the results of 136 autopsies on porcelain workers. In three-fourths of the severe cases of simple pneumoconiosis tumour-shaped masses were found about the size of a fist; in the remainder the masses were smaller. They were almost always multiple and in several lobes, the upper lobes being chiefly affected. In typical cases the lungs were pigmented with a greenish or bluish colour and a metallic sheen; the lymph glands were similarly affected, and enlarged. Cavities were frequently present in the fibrotic masses even in the absence of tuberculosis. By histological examination the structure of the masses showed an irregular arrangement of fibres, and deposits of dust. Besides the larger masses there were numerous smaller

nodules surrounded by a thick layer of macrophages. Numerous nodules composed of aggregations of dust cells were found throughout the lungs, especially in air-containing parts; the appearances suggested actively progressive changes long after exposure had ceased. Chronic bronchitis and bronchiectasis were frequently found; emphysema was present in almost all cases, sometimes of bullous type; thickened pleura was more frequent than in other forms of silicosis. Tuberculosis was present in 91 of the 136 cases and 62 of these also had severe silicosis; in most cases the tuberculosis was of an active caseating type. Later investigations seemed to indicate that the proportion of cases of pneumoconiosis and of combined tuberculosis had improved in the period after the war. The pneumoconiosis of porcelain workers appeared to be of a special form.

Functional Anatomy in Pneumoconiosis (pp. 64-70). H. v. HAYEK (Vienna). Professor von Hayek described the minute anatomy of the lungs in relation to the reaction to the presence of dust. He found at 3 sites morphological changes of the epithelium which were important: 1, in the narrowest part of the air passages where the bronchioles played an important part in dust retention; 2, at the apertures in the alveolar walls where the alveoli open into the interstitial spaces; 3, in the alveoli which are situated at the margins of the lobes and where deposited dust often affected the epithelium. In the bronchioles where there are no mucus-secreting cells he succeeded, by experiment, in changing the character of the epithelial cell by means of adrenaline and aleudrin, increase of ciliated epithelium hastening removal of mucus whereas increase of secreting cells retarded it. In the walls of the alveoli 2 kinds of cells were seen: one which might under certain conditions assume a spherical form and thus, retracting the tissue process of which it formed a part, open the passage between the alveolar and interstitial spaces, and, by a reverse extending process, close the gap. This is illustrated in a diagram. This effect was studied experimentally on 3 guineapigs by enclosing them in separate boxes and dusting with coal dust; one was treated with increased oxygen, another with CO_2 and reduced oxygen, the third was used as control. After half-hour treatments on 14 days the lungs of the animal receiving increased oxygen appeared clear and those of the animal receiving CO_2 and reduced oxygen were deeply blackened compared with the control. It could not yet be said how these findings could be applied to the action of epithelium in the air spaces.

Silicotic Action of Dust from Furnace-Gas (pp. 70-73). F. PORTHEINE (Gelsenkirchen). Reference was made to a case of severe silicosis in a worker employed for over 30 years removing dust collected from blast-furnace gas. No further particulars are given of the case but a description of the method of cleaning the gas, and analyses, are given. The percentage of silica in 3 dust samples ranged between 10 and 16; the free silica in the fraction under 5μ was 1.8 and 2.6 per cent. in 2 samples; the percentage of iron in 3 samples of the dust ranged from about 19 to 40. In the discussion H. SYMANSKI

(Saarbrücken) referred to 150 similar workers whom he had examined radiologically and found only few, though definite, slight changes which could be called pneumoconiosis; he asked whether this was a case of siderosis or silicosis.

The Action of Different Forms of Silica in Animal Experiment (pp. 73-84). W. KLOSTERKÖTTER (Münster). In animal experiments the difference between short-lived animals and long-lived man must be taken into account; higher concentrations of dust must be used in experiments on animals to compare with the long exposure of man to dust. Experiments, carried out in association with K. W. JÖTTEN between 1951 and 1953, were made by intratracheal, and in some cases by intraperitoneal, injection or by prolonged inhalation. The experiments included injection of silica solution, silica colloid, silica gel and silicates of various constitution. Doses of 50 mgm. of dust of size $0.5-3.0 \mu$, suspended in physiological salt solution, were used by the technique of KETTLE and HILTON. Details of the experimental procedure and the results obtained were fully described and 12 photomicrographs illustrate the tissue changes. Solutions of molecular silica in low concentration showed no injurious tissue reaction. Colloidal amorphous silica was found to be a tissue poison; the fibrogenic action was not of typical nodular form. The reactions to the other forms of silica were proportional to the molecular structure; with pure silica gel the reaction was practically negative, with partly crystalline opal it was moderate, with the chiefly crystalline flint it was greater, and with pure crystalline quartz it was maximal. The differences in the solubilities of the various dusts, that is the ammonium molybdate fraction, were not so material as to explain the differences in the fibrogenic action, and it could not be said that the less soluble were dissolved out since deposits of dust were found in the nodules; the importance of the crystalline state and the crystal surface action must also be taken into account, as other observers have shown. Theories of surface action were discussed. According to the author's experimental results the fibrogenic action was not proportional to the ammonium molybdate fraction, rather was the reverse the case; the estimation of the molybdate fraction of silica, therefore, should not be the basis of a silicosis theory; the colloidal form of silica was biologically active and had a measurable effect on cell and tissue function and a fibrogenic reaction though the time factor was extended. Other aspects of the solubility theory were discussed. With regard to silicates the slight pathogenic action of potash feldspars, in spite of their lattice structure, must be linked with the presence of the Al atom. The silica tetrahedra in the mineral hornblende were in chain form; that fact and the screening effect of Al and iron should render it harmless. There was at present no theory of silicosis which was satisfactory in all details.

The Pathological Action of Different Mineral Dusts in Experimental Animals (pp. 84-95). E. J. KING (London) and G. NAGELSCHMIDT (Sheffield). Profes-

sor King reported on many experiments devised to elucidate the theory of silicosis. Most of the experiments described had been published previously, and they were collected and discussed here with special reference to the solubility theory, the influence of crystal structure, particle size and surface area, and the effect of age or weathering of minerals on their action on tissues. From experiments with amorphous silica, quartz, cristobalite and tridymite it seemed proved that crystal structure had an influence on tissue reaction. The structure alone would not explain fibrogenic action; potash feldspar, with a structure similar to that of quartz, caused very little fibrosis. Experiments made with flint dust in 5 grades of fineness (under $0.5-8 \mu$) gave a fibrogenic response inversely proportional to the particle sizes. With a constant area of the particles (700 cm^2 per rat), the optimum fibrogenic action was in the size range $1-4 \mu$, above or below this the action was less, especially with the larger particles. Experiments were made with aged or weathered dust; by removing the easily soluble surface layer by repeated extraction with Ringer's solution the solubility was reduced to $1/10$ th of the original solubility, but the fibrogenic action was the same as with the untreated dust; when treated with hydrofluoric acid this residue with low solubility showed considerably increased activity, due probably to adsorbed fluorine ions and damage to the crystal lattice structure. The ideas about silica solubility and its connexion with tissue changes must be modified because solubility is a function of specific surface area; the greater the surface area the greater is the fibrogenic action, but greater also is the solubility. A possible mechanism of the origin of silicosis was presented: dissolved silica was partly carried away and partly polymerized and held by the albumin of the cells and tissues; colloidal silica was biologically active in its newly formed state and it precipitated albumin; the silica particles must be so small as to be dissolved sufficiently, and large enough to remain for a prolonged period of time in the tissues; the prolonged irritation was responsible for the continual formation of colloidal silica for the building up of fibrotic tissue in the silicotic nodules. The tissue changes produced in the lungs of the experimental animals by the different forms of silica and periods of exposure are shown in 15 photomicrographs; the intense fibrosis produced by tridymite in 5 months is particularly striking. Commenting on the paper, LÜCHRATH (Bonn) reported on experiments which yielded similar results; he described early necrotic change in the nodules with tridymite.

The Peritoneal Test (pp. 95-105). C. VAN MARWYCK (Münster). After a short review of the literature the author described a series of experiments which he had carried out by this method on mice, using quartz, kaolin, gypsum and aluminium phosphate. He found, in agreement with RÜTTNER, that the nodules in the peritoneum showed typical concentric arrangement with a tendency to collagen formation, and that this result occurred not only with quartz dust but also with other dusts which had

hitherto not been shown to produce a fibrogenic action in the lung tissue, for example, kaolin. Various types of silicosis nodules were described of which the smallest, with a diameter of about 1 mm. , showed the typical structure; with quartz these were by far the most numerous. The time factor was important; in animals killed at the end of 5 weeks the results were most significant. The significance of the peritoneal test, relative to its practical application in determining the fibrogenic or silicosis-producing action of dust, must be regarded with a certain restraint of which the measure must be defined by further experiment. Aluminium phosphate showed a slight fibrogenic action. As a secondary finding, nodules in the liver showed the typical structure of silicotic nodules and were found only where quartz was used. Photomicrographs show tissue reactions to dust; a diagram of X-ray diffraction spectra of quartz and aluminium phosphate shows the similarity of the lines.

The Tissue Reactions to Mineral Dusts in the Mouse Peritoneum (pp. 106-11). J. R. RÜTTNER (Zurich). The question to which answer was sought was: were there, apart from quartz and its modifications, other minerals which caused a fibrogenic action? The author discussed a few important points and summarized general results from previous experiments. (1) Fibrous nodules were produced in the peritoneum, but not only by quartz, whose action was not absolutely specific. (2) Similar tissue reactions were brought about by (a) the crystalline modifications tridymite and cristobalite; (b) certain silicates, e.g., kaolin, and partly also by feldspar; (c) silica-free minerals, e.g., beryllium oxide, and aluminium with or without stearin coating. (3) Crystalline modifications of carbon—graphite and diamond—possessed a fibrogenic action in a certain measure which was, however, considerably less than that of quartz. (4) There were minerals like corundum and hornblende asbestos which proved to be inert under the experimental conditions and produced no fibrosis. Micrographs illustrate tissue changes; one of these shows a kaolin nodule produced after 9-10 months, which could not be distinguished from nodules produced by quartz.

Conditions and Practical Value of the Peritoneal Test of the Harmfulness of Dusts (pp. 111-25). A. POLICARD and A. COLLET (Verreuil (Oise)). This article included the results of 1,200 tests made over a period of 3 years by the peritoneal method of MILLER and SAYERS, to determine the harmfulness of various mine dusts. The tests consisted in studying the peritoneal and glandular reactions of rats, 1, 2 or 3 months after injections of sterile suspensions, in physiological salt solution, of 100 mgm. of dust of $2-3 \mu$ or under. The authors maintained the value of the peritoneal test against the pulmonary route on the ground of its rapidity and simplicity; cells and tissues reacted in the same way whether pulmonary or peritoneal; intratracheal injection of dust suspensions was not comparable with inhalation of dry dusts. The results of these 1,200 tests were described: (1) large nodules, $4-10 \text{ mm.}$, few in number with a necrotic centre surrounded by concen-

tric fibrous layers, were not specific lesions; (2) small deposits, 0.5-1 mm., without cellular or fibrous reaction, indicated dust qualitatively innocuous; (3) reaction chiefly cellular with formation of a miliary granuloma, 2-3 mm., partly cellular and partly fibrous, indicated noxious dust; (4) spherical nodules, 3-4 mm., hard, homogeneous on section and predominantly fibrous, indicated noxious dust; (5) tracheo-bronchial glands unmodified, showing microscopic particles without cellular or fibrous reactions, innocuous dusts; (6) tracheo-bronchial glands hypertrophied, showing increased cellular masses more or less altered and sometimes fibrotic, noxious dusts. Photomicrographs show the effects of experimental dusts on the mediastinum. Considerable discussion followed this paper.

The Action of Silica on the Rabbit Eye (pp. 125-8). H. KRJMMEL (Münster) gave a preliminary report on the histological changes produced in the tissues of the rabbit eye after injection of various kinds of dust, after the lapse of different periods of time, from about 2 to 28 months. The dusts were pure quartz in particle sizes of 5-10 μ , and of under 5 μ , injected into the anterior chamber; Aerosil (99 per cent. amorphous silica) corundum, quartz treated with lime water and sulphated phenol, and calcium carbonate. In conjunction with quartz calcium carbonate did not check the fibrotic reaction. Photomicrographs show the tissue changes produced by silica.

Phagocytosis of Industrial Dust in Tissue Culture (pp. 128-9). E. SCHILLER (Homburg/Niederrhein). A film was shown in which the phagocytosis of quartz, diamond and tremolite asbestos in lung cultures of mice 3 days old could be seen. As BELT, FRIEDMANN and KING had shown, asbestos dust was only slightly phagocytosed. Phagocytosis of quartz caused severe injury to the cells, as described by POLICARD, DOUBROW and BOUCHARLAT. Phagocytosis of diamond dust showed most beautifully the amoeboid activity of the cells in collecting the particles from their neighbourhood, and maintaining their activity for several days. Photomicrographs of the asbestos and diamond tests are given.

The Conditions of Chemical Reaction of Quartz Dust in the Organism in Silicosis (pp. 130-42). L. HOLTZAPFEL (Berlin). This dealt with the biochemical reactions connected with the development of silicosis, the reactions on dust in its production from the materials, and in the mouth and upper air passages; the functions of the saliva and the mucous membrane, and the dust reaction in the lungs; specific biological reactions of quartz; experiments on the growth of *Aspergillus niger* in solutions of quartz; the influence of oxygen; experiments with saliva and quartz; enzyme action and iron catalysis. In summary: the first powerful chemical reaction of dust in the organism probably took place with saliva and mucous membrane components and could lead at times to the blocking of the vascular membranes through fixation of silicic acid in organic combination. The oxygen was here of outstanding importance. The resulting reactions were probably to be seen in a dis-

turbance of the normal ferment system, and with this the silicic acid components could, through reciprocal action with oxygen, alter the normal course of reaction.

The Part played by Structure and Arrangement in the Reciprocal Action between Quartz and the Organism (pp. 142-59). R. JÄGER (Frankfurt). The author described experiments devised to elucidate the actions which took place between quartz particles and the tissue components in producing the pathological changes characteristic of silicosis. In one of the experiments on phagocytosis a protective effect was shown by vitamin B1 and a laboratory compound, a condensation product. Photomicrographs show sections of nodules from mouse mesentery, one from an unprotected animal showing fully developed fibres; the other, from an animal treated with vitamin B1 in the food, showed cellular structure with few fibres. It was not suggested that vitamin B1 or the condensation product, with the research number Jg25, were prophylactics of silicosis, but the experiments seemed to point the way to further progress.

The Physical Chemistry of the Quartz Surface (pp. 160-65). (The water layer on the quartz surface and its influence on adsorption.) L. MILLER and W. STÖBER (Göttingen). The authors brought forward consideration of the surface water layer as a factor in addition to those connected with the free valences in raising adsorption capacity and thereby increasing reactivity of crystal lattice structure. The water layer was held to be more firmly attached to the quartz surface than was generally supposed. Experiments on desorption were carried out to estimate quantitatively the water layer on quartz by a thermal method, by means of an apparatus which is illustrated by a diagram. The experiments were made on 3 types of quartz with different surface values. The possible value of these experiments for silicosis research was discussed.

A New Technique for Measuring Reactions at Quartz and other Surfaces (pp. 165-71). E. V. SMITH and J. A. WADDAMS (Wolverhampton). This is a description of experimental work being carried out at the Wolverhampton and Staffordshire Technical College. The study of interactions at the surface of dust particles was complicated by such factors as particle size, pretreatment, dust/reaction-fluid ratio, etc., and a programme of work was commenced at Wolverhampton on macro surfaces, aimed at discovering the nature of the basic processes which occur when these form an interface with a reacting solution. Preliminary observations were reported on the procedure for determining surface reactions. The individual techniques were described.

Isolation and Characters of Extraneous Dust from Lungs (pp. 172-82). K. THOMAS and H. STEGEMANN (Göttingen). A method is described of dissolving the whole lung, or large parts of lung, without destroying any of the contained dust, even the organic dust, with the use of a water-free formamide, which is used in industry and can be obtained easily. The process involves heating with formamide for long periods at temperatures at first not exceeding 100°.

[presumably C.], by which collagen, reticulin and elastic fibres remain behind, and later increasing the temperature to about 135°. Illustrations show the apparatus used and photomicrographs of tissue fibres being gradually reduced in the process until, after 28 hours, only the dust residues remained. Some 40 pneumoconiotic lungs had so far been reduced, and a series of results are shown giving the weight of dust, the percentage to dry weight of lung, and the proportion of silica in the dust. Chemical and physical examinations of the residues were made and animal tests were carried out by the peritoneal method and were discussed in detail.

The Reaction of Silicic Acid on the Blood Vessels and Contractile Tissue of the Lungs (pp. 182-91). H. ANTWEILER (Bochum). The author reported his experiments on the qualitative and quantitative action of silicic acid in molecular and colloidal solutions on various organs and tissues, especially on the blood vessels and respiratory passages of experimental animals. The methods and results were described in detail and illustrated. In summarizing these he said that it could be stated that molecular and colloidal dissolved silicic acid in the concentrations used could cause lasting alterations in the tissues of the lungs; the question remained whether, at the places where dust was deposited, concentrations of silicic acid could be reached similar to those which seemed to be necessary to cause tissue damage in the experiments.

Pharmacological Action of Dissolved Silicic Acid with Low and High Degrees of Polymerization (pp. 192-8). W. LÜHNING (Göttingen). The material used was Aerosil powder and solutions were made in water and in plasma. The methods and results of estimation by the ammonium molybdate reaction are described. It was found by experiment that only polysilicic acid had a biological action; that oligo- as well as polysilica went into solution in plasma as well as in water. The conditions for solution of oligosilica in plasma were even more favourable than in water; that perhaps held good for polysilica also. In the direct solution of polysilica, and in the destructive action on albumin, was seen the cause, or one of the causes, of silicosis.

A Summary Report on Fundamental Mineralogical Research connected with Pneumoconiosis (pp. 199-227). H. SEIFERT (Münster). Professor Seifert traced the connexion between the physical aspects of mineralogy where researches had been carried out by many observers in a vast field. The review included references to a very large number of published works on subjects which included electron-microscopic and polaroscopic methods of identification, quantitative estimation of free silica, particle-size determination and surface measurement, X-ray analysis of mixed dusts, and thermal effects on quartz. Turning to research on the causes of pneumoconiosis Seifert referred to the various theories: crystal structure, solubilities of quartz and silicates, weathered minerals and surface activity. Besides quartz other minerals were considered; these included talc, asbestos with reference to the origin and structure of the so-called curious bodies found

with asbestos and other minerals in the tissues; graphite, corundum, beryllium and aluminium silicate; the mixed silicosis of pottery workers, kaolin or mullite, and coal miners' pneumoconiosis. He discussed new problems raised by consideration of the lattice structure of crystals and their surface, and the interest in the principle of epitaxy. It did not appear to be necessary to place the solubility theory so sharply in opposition to the chemical theory; silicic acid as quartz or silicate was used up in course of time, and the amount of quartz remaining in silicotic lesions might determine their age. The influence of environment of crystals on their form and structure is shown by illustrations of common salt from a solution to which 25 per cent. of glycocholl had been added, and a schematic diagram of a one-dimensional, induced adsorption of glycocholl on a cubical surface of salt, as an interpretation of the influence of crystal pattern; similar models could be applied to nucleoproteins. Much more work must be carried out on an exact physico-chemical basis to provide clarity in this field.

Quantitative Animal Experiments in Silicosis Research (pp. 228-33). G. NAGELSCHMIDT and E. J. KING. Dr. Nagelschmidt referred to the experiments described by King on the effects of various factors: particle size, surface area, etc., by the intratracheal injection method. As an addition to histological examination they used radiography with a fine focus tube, but that seemed possible only for early changes. Two 3-dimensional diagrams show the degrees of fibrosis produced in rat lungs after injection (1) of equal quantities, 50 mgm., of flint of different particle sizes; (2) of equal surface areas, 700 cm²., of different particle sizes. Equal weights of different size fractions gave great differences in the degree of fibrosis; equal surface areas showed a broad maximum degree of fibrosis with the largest and finest fractions much diminished. Similar study was made of the changes in the lymph glands in the relation between particle size and time of development. The results were very regular, especially in the experiments with equal surface areas of flint; the middle sizes showed a definite maximum and the finer the particles the more rapid was the swelling of the glands. The increase in retained dust after 1 year, with constant area, was generally constant for the largest particles with about 60 per cent. of the injected dose, but the smaller the particles the more flint was found in the glands and correspondingly less in the lungs. The smallest fraction showed little gain, possibly owing to greater solubility or particles leaving the glands, or perhaps to error in analysis. Identical experiments were made with quartz and alumina, the animals being killed, first at daily and later at monthly intervals, up to 1 year. The results, which are shown in a diagram, do not present such a difference between the quartz and alumina as to indicate solubility.

Electronoptical Crystal Analysis of Industrial and Lung Dusts (pp. 233-7). G. PFEFFERKORN (Münster). For analysis of the form and substance of the finest particles of dust the usual optical methods had failed and for this reason the electron microscope was used.

A diagram shows the light path in the EM8-Electron-microscope combined with electron diffraction, which enables examinations to be made by light or dark field and diffraction analyses of crystal or powder forms. This was of special value in the examination of mixed dusts. It was possible to examine particles down to 10 μ . With the technique of the dark field of defined refraction reflex there was the possibility for the first time in the electron microscope of making an unequivocal analysis of industrial and lung dusts.

Procedures in the use of the Electron Microscope for Examinations of Industrial Dusts and Their Results (pp. 238-48). W. WALKENHÖRST (Bochum). The ordinary light microscope was unsuitable for examination of air-borne dusts which were often beyond its power of resolution, and increasing use was being made of the electron microscope, with about 100 times the power of resolution. A photomicrograph $\times 1840$ shows the appearance of mineral impurities by the electron microscope which could be further distinguished by X-ray diffraction. Preparations of dust could be made by thermal or electrical precipitation, the thermal precipitator having a heated band instead of a wire, thus spreading the sample, as well as other modifications; this apparatus is shown in an illustration; it is constructed so that it can be used for light microscopy as well as electron microscopy. A kind of sedimentation cell, but with induced air current, was used for collecting mass samples for analysis by electrical precipitation. A portable form of electrostatic dust sampling apparatus is shown. Photomicrographs of dust samples and particle size curves from samples in various industrial processes are shown. The curves made from light- and electron-microscope counts show higher values for the latter, indicating that the former are misleading or false.

Investigations with the Electron Microscope and Animal Experiments on the Action of Water of Wiesbaden Hot Springs on Quartz and Silicosis (pp. 249-65). W. KIRUTH and H. W. SCHLIPKÖTER (Düsseldorf). The Wiesbaden spring water was sprayed as an aerosol, and it was shown how the droplets appeared in a room used for inhalation and in which electron-optical screens and an electrical charge and discharge were used. The appearances of droplets are shown by the electron microscope as the aerosol alone and with a suspension of quartz particles. Experiments on adsorption, with colloidal silver, showed that quartz treated with the spring water lost its power to adsorb the colloidal silver. In experiments on mice, by peritoneal injection, normal quartz gave nodule formation in 30 days; quartz treated with the spring water, as in the adsorption tests with colloidal silver, showed no, or very little, diminution in its power to produce nodules.

Clinical and Radiological Studies of Pneumoconiosis (pp. 265-83). O. ZORN (Bochum). The compensation law in Germany no longer referred to the pathological or radiographic diagnosis of the disease but to the clinical and functional state and the effect it had in lowering the earning capacity of the worker. This increased the difficulty of making an

adequate diagnosis and required tests of function. The incidence of pneumoconiosis among Ruhr miners and the complications met with, especially bronchitis, were discussed. Reference was made to the effect of stenosis of bronchi and to the types of emphysema and their causes, and methods of testing respiratory function. The reasons for failure of the usual methods of radiological diagnosis were examined and a description was given of an apparatus which incorporated an electrocardiograph in such a way as to control the moment of exposure of the photographic film; this device could be used to take the film in the phase of cardiac movement when the shadow was smallest. Two radiographs show the outline of the heart comparing the shadows in the electrocardiographic phases of the P deflection and the T wave. The phase of respiration could also be timed, and 2 radiographs compare the phases of inspiration and expiration in a case of advanced silicosis showing marked emphysema and bronchiectasis. By this method it could be seen that emphysema due to structural change showed small alterations in inspiration whereas functional emphysema showed marked changes in both inspiration and expiration.

New Results of Silicosis Research in Italy (pp. 283-93). E. C. VIGLIANI (Milan). The results of recent work done in Italy were surveyed. Reference was made to: amino-acid combinations of hyaline substance in silicosis; the cortisone effect on development in experimental silicosis; gamma-globulin estimations in silicosis; radiological studies of the mediastinum in silicosis; the incidence of silicosis among workers in pumice stone; of pneumoconiosis in bentonite workers of Ponza where the bentonite contained from 20 to 30 per cent. free silica in the form of opal; and the therapeutic use of aerosols with oxygen at varied pressures.

Amino-Acid Combinations of the Hyaline Substance in Silicotic Nodules (pp. 293-6). B. PERNIS (Milan). With PECCHIAI he isolated the hyaline substance in silicotic nodules and, after hydrolysis, examined it chromatographically; the composition found is given. They reached the conclusion that the process of hyalinization consisted in precipitation of plasma globulins, especially alpha- and beta-globulin.

Simple Tests of Cardiac and Pulmonary Function for Use by Works Doctors (pp. 295-303). R. VOLKER (Bad Oeynhausen). Clinical symptoms of early forms of cardiac and pulmonary insufficiency were difficult to distinguish in many cases from nervous or emotional disturbances, and the complicated tests involving the use of elaborate instrumental methods were not always suitable for the use of practitioners. Three examples of simple tests were given. (1) The diuresis test, based on the observation that impairment of heart function was associated with relatively increased diuresis after a period in the recumbent posture, compared with the same time spent on active work. (2) Cardiac insufficiency was detected at an early stage by the use of a mask which could be made to restrict expiration by measured amounts; this apparatus is described and graphic results are shown. (3) In the oxygen test the oxygen saturation