

OCCUPATIONAL DISEASES*

BY

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LECTURE I, Lead. Tetra-ethyl lead. Arsenic. Arseniuretted hydrogen. Phosphoretted hydrogen.

In these four lectures it has been my purpose to review from the point of view of the clinician the broad problem of disease in relation to occupation. I have given special emphasis to the mechanism by which poisoning occurs and the means of prevention used. It has been necessary often to approach the subject historically in order to show what has been achieved or what yet requires to be done. I wish it to be clear that I am not concerned solely with what happens in this country: my review takes into account occupational disease in any part of the world. It follows that I have recorded certain descriptions of working conditions and diseases which I have not had the opportunity to study personally.

INDUSTRIAL LEAD POISONING.

HISTORY.

White lead and red lead are amongst the oldest pigments known, and it is possible to trace their history with some accuracy over a period of at least two thousand years. (Klein, 1913). The earliest prototype of white lead was the native carbonate of lead known as cerussite. Xenophon (400 B.C.) makes what is probably the earliest reference to this material which he describes as cerussa and records that it was used as a cosmetic. Vitruvius (15 B.C.) referring to red lead as sandaraca states that it was discovered by accident in a cosmetic jar of white lead which had been exposed to heat in the burning of a house at Piræus. Early in the Christian era it was made by roasting ceruse. It was not until much later that the method of manufacture from lead or litharge was discovered.

The many symptoms of plumbism were noted long before they were ascribed to the action of lead. Gradually, however, physicians

came to appreciate the cause of these disturbances and the syndrome was designated saturnism, for lead, was called Saturn by the alchemists because it absorbs and devours, so to speak, all other imperfect metals. Hippocrates (370 B.C.) was probably the first of the ancients to recognise lead as the cause of the symptoms, at least he describes a severe attack of colic in a man who extracted metals. The relationship of constipation, colic, pallor, paralysis, and ocular disturbances to the action of lead on the body was observed by Nemesius in the second century B.C. Pliny (23-79 A.D.) states that the ancients painted their ships with native ceruse, that lead poisoning was known in his day, and that the workers in lead products tied up their faces in loose bags lest they should inhale the pernicious dust. Dioscorides (100 A.D.) knew that ingestion of lead compounds caused colic, paralysis, and delirium. He states that in his time white lead was made artificially from lead and vinegar. This is probably the earliest record of the artificial manufacture of white lead. One of the earliest references to its use in England is found in the Close Rolls (Edward I. 1274), where an account is rendered for painting materials supplied for the decoration of the Painted Chamber. Until the 17th century the Venetians appear to have been the principal manufacturers of white lead, and after that date the process was largely developed in Holland. Probably the earliest record of lead poisoning amongst white lead workers in England is that of Vernani (1675) — "The Accidents to the workmen are, immediate pain in the Stomach, with exceeding contortions in the Guts, and Costiveness that yields not to Catharticks, hardly to often repeated Clysters And these we find effected principally by the mineral steams in the casting of the plates of lead, and by the dust of the flakes Next, a vertigo, or dizziness in the head, with continual great pain in the loins.

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insusceptible animals as mice. He was able to show that the active growth of the bacilli did not depend merely on the necrosis of the tissue, but was due to the actual presence of silica.

ASBESTOSIS.

The asbestos industry is 2,000 years old. Herodotus (450 B.C.) relates how the Romans mined it in the Italian Alps and Ural Mountains, using it for enshrouding their corpses before cremation to permit of easy collection of the ashes for burial. They named it "amianthus," meaning undefiled, pure, incorruptible. Pliny (A.D. 50) refers not only to difficulties in the weaving of asbestos, but also to the use of respirators to avoid the inhalation of dust. Strabo (30 B.C.) and Plutarch (A.D. 70) refer to the wicks of the lamps of the vestal virgins as "asbesta,"—the unquenchable, inextinguishable, or inconsumable. It is stated that Charlemagne possessed a tablecloth made of it, which was cleansed by passage through fire.

However, though asbestos occurs in every country, it is only within the last 50 years that it has been used for industrial purposes. In 1860 the annual world production totalled only 500 tons, a figure which had risen to 434,938 tons in 1929. The term asbestos is a collective name applied in commerce to a variety of silicate minerals which differ from each other in chemical composition and physical properties, but resemble one another in their finely fibrous nature and flexibility. Their value depends on the facility with which they can be split into long and short flexible fibres, their resistance to acids, and their insulating properties with respect to heat and electricity. Most of the asbestos in commerce is either fibrous serpentine such as chrysotile, or a fibrous mineral of the hornblende group, of which the most important are crocidolite and amosite. Chrysotile is essentially a hydrated silicate of magnesium, containing little iron and practically no calcium. The hornblende varieties contain less magnesium and usually more aluminium, and iron, crocidolite and amosite being mainly silicates of iron.

Capable of being spun into yarn and woven into cloth, or of mixing with cement, rubber, resin, bakelite, or graphite, to form a variety of useful products, it provides the engineering,

electrical, building, chemical and other trades with materials of very great utility. These include a wide range of insulation products, as well as cement sheets for building work, brake and clutch linings, electrodes for welding, acid resisting filtering cloth, packings, jointings, and wrappings for steam pipes.

Raw asbestos in crude and fibre form is imported chiefly from South Africa, Canada and Russia, and stored in sacks in open sheds. The crude asbestos, as required, is carried to a rotary mill and opened, two or three sacks at a time by hand. This process is dusty. The operation which follows is that of crushing, to separate the rock from the fibre, which then passes by vacuum suction into a closed-in machine for fiberising. This machine delivers flocculent, soft, fibrous material, free from grit. It is the custom in the trade to blend the material and this involves emptying out a number of sacks upon the floor and raking the material over to mix it thoroughly (fig. 42).



Fig. 42.—Method used to apply exhaust ventilation for blending of crushed asbestos. The draught acts directly above the middle of the heap. Such a method is hopelessly inadequate.

(Report on Conference concerning Methods for Suppressing Dust in Asbestos Textile Factories, 1931).

For the manufacture of yarn and cloth cotton is often incorporated with the fibre before carding. The carding machine consists of large fast-running cylinders, covered with innumerable minute wire hooks to ensure that the fibres are laid parallel (fig. 43). From the end of this machine the material is received as a sliver or rope. Stripping the carding machines (fig. 44) and cleaning the cylinders with a wire brush is a very dusty occupation.



Portable vacuum plant for cleaning asbestos carding machine. Note the revolving brush fitted with a cover and connected to a vacuum cleaner.

See Conference concerning Methods for Suppressing dust in Asbestos Textile Factories, 1932.

doubling, and weaving follow the carding. Dry weaving is usually for wet weaving has the disadvantage certain fittings on the machinery-textiles, such as millboards, are employed. Filtered asbestos is mixed with clay, cement, and water and run through a series of sedimentation tanks to produce a fine pulp. This passes along as an emulsion, becoming drier and doughy on its way, until it is eventually spun on a cylinder. From this it is saved and dried in the drying room. Operations, such as sawing, grinding, and polishing, give rise to much dust. Slabbing machines are made almost entirely of hand-loom lengths of asbestos and are filled with filtered asbestos by hand or shovel, levelled by beating and sewing.

Workers of asbestos remained for long years. They have come to light with a disconcerting suddenness. The first case of asbestosis known in this country was in 1900 and the second in 1924.

chronic pulmonary asbestosis as a definite clinical entity (Merewether and Price, 1930). From that time the view that dust from silicates is comparatively innocuous was no longer tenable. It is now suggested that when the silicates of asbestos are dissolved in the lung tissue silicic acid is liberated and acts as a chemical irritant to which connective tissue is particularly sensitive.

Regulations have now been applied to the industry by the Home Office. The principle of locally applied exhaust ventilation is enforced to prevent the escape of asbestos dust into the air of any room in which persons work. Hand cleaning of the cylinders of carding machines is prohibited while any other person is present, nor may it be done by hand strickles or other hand tools. Those cleaning cylinders, filling insulating mattresses, and entering chambers containing loose asbestos should be provided with an efficient apparatus by means of which they can breathe air free from dust. These regulations have stirred up other countries so that interest in the matter is now world-wide. Reports of a heavy incidence of asbestosis have been made recently in some German factories, especially in Dresden (Krüger, 1931) and Berlin (Gierbis and Ucko, 1932).

In five years 37 workers in asbestos have attended my out-patient department: 25 were women and 12 were men. Of these 30 were judged to be suffering from pneumoconiosis due to the inhalation of asbestos. Seven of these have since died; and in four autopsies showed that the pneumoconiosis was complicated by pulmonary tuberculosis. Many had worked in more than one department, but the principal occupations in order of frequency were as follows:—spinner, weaver, disintegrator, mixer, mattress maker, card cleaner, store-keeper, slab maker, presser, machinist. The average length of exposure before the onset of symptoms was seven years. Of the patients who died, one was a weaver who had been exposed for 18 months and another a store-keeper who had been at work for 19 years. In many cases there was a long interval between removal from exposure and the onset of symptoms: the longest such interval was eight years.

The presenting symptom was dyspnoea. This was early and progressive after commencing

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Fig. 44.—Stripping an asbestos carding machine before a modern type of exhaust ventilation was locally applied.

(By kind permission of British Belting and Asbestos, Ltd.)

was nearly always associated with non-productive cough, as many as 18 cases having little or no sputum. Hemoptysis never occurred in the absence of pulmonary tuberculosis; it was found in three cases. In 16 cases pain occurred between the shoulders, under the scapula, or behind the sternum; it was never more than slight. In two cases a diagnosis of acute pleurisy had been made during the period of employment in asbestos, but in no case had a pleural effusion occurred. A history of warts was obtained in 13 cases, of laryngitis in three, and of conjunctivitis in two.

The patients were usually well nourished. Clubbing of the fingers was present in six cases. Cyanosis was occasionally noticed but was only slight. Examination of the chest showed limitation of the respiratory excursion on both sides. The percussion note was never seriously impaired, but slight dullness was

sometimes found at the bases. The breath sounds were vesicular, and auscultation sometimes revealed scattered, medium, crepitant rales, often with a metallic tone, and situated especially at the bases. Added sounds were absent on repeated examination in ten cases. For obvious reasons the condition is not unilateral, and therefore displacement of the heart and other mediastinal structures was not found.

Thirteen cases showed asbestosis bodies in the sputum. These are golden-yellow structures of elongated head-like form, often with bulbous ends (Cooke and Hill, 1927). The appearance of fully formed bodies has been compared to beads on a necklace. The beads vary in size, and make up an irregularly segmented body. These bodies have been found to vary in length from 20 to over 200 microns. An asbestos fibre forms the central core in each body (Molyneux).

ey are best seen with an oil immer- and show up clearly without staining yellow structures (fig. 45). They can d by hematoxylin. The tubercle as found in the sputum of five of the ases, and already four of these have



asbestos bodies from the lung juice in a case of asbestosis pneumonokonioidosis (x 600). A girl (21) who had been employed in the spinning department of an asbestos factory for four years. Abnormal signs were present in both lungs, and asbestos bodies and tubercle bacilli were found in the sputum. At autopsy asbestos pneumonokonioidosis and pulmonary tuberculosis were found in both lungs.

-A.R., woman, aged 37. Worked from 1918 in the spinning department of an asbestos factory; the protection from dust was poor. 1928: 1930: shortness of breath, and occasional pain on breathing. On examination: warts on fingers, the largest 2 by 1 mm. of fingers. Dyspnea, but no cyanosis. No displaced heart sounds normal. Displacement of base of right lung, with slight diminished breath sounds, and extensive crackle sounds. A few crepitations at base of both lungs (fig. 46). 1935: Shortness of breath worse; dry cough. On examination: no warts. Physical signs in chest unchanged.

measuring the length of time which

fibrosis develops more rapidly. With continued exposure to high concentrations of dust the fibrosis may be fully developed in seven years, and may cause death after about 13 years' exposure. It must be remembered that the existence of a clinically recognisable degree of asbestosis fibrosis in any individual is an additional adverse factor in the prognosis of any acute infection of the lungs such as pneumonia or broncho-pneumonia. Precise information as to the incidence of pulmonary tuberculosis amongst asbestos workers cannot be obtained, but there is reason to believe that the outstanding susceptibility to this complication in silicosis does not apply to the same extent in asbestosis.

The fibrosis in asbestosis is much more diffuse than that due to silica. In silicosis it occurs in the form of numerous more or less isolated foci, but in asbestosis as a fine network throughout the lungs. In radiograms it is so fine as to resemble ground glass (fig. 46). Homogeneous opacities of this nature are seen at both bases, and may later become more



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obvious as a fine punctate stippling. The interlobar pleura is usually thickened. Ultimately the fine punctate mottling can be observed to have spread beyond the limits of the lower zone to the middle and even the upper zone, but the apices usually remain free (Ellman, 1933). This fine, diffuse, punctate mottling stands out in definite contrast to the coarse nodular mottling seen in silicosis. In fact in advanced asbestosis the degree of shadowing present would have little significance if seen in silicosis (Timmermans, 1931).

FLUOROSIS.

In the middle of the nineteenth century many chemists attempted the isolation of fluorine from hydrofluoric acid, and more than one paid with his life for handling too frequently one of the most dangerous of known chemical substances. The danger arises from the volatility and extremely corrosive nature of the vapour of the anhydrous acid. Even when highly diluted with air it causes an intolerable prickling and burning sensation in the nose, mouth and eyes. If inhaled it attacks the larynx and trachea giving rise to burning pain behind the sternum, cough, expectoration, and even hæmoptysis. Unless handled with extreme care it may get under the finger nails causing great pain, and if a drop comes in contact with the skin it has a caustic effect producing prolonged and painful ulceration.

It is said that G. Knox lost his voice permanently during his early experiments on the electrolysis of the acid, and that T. Knox nearly died of its effects (Louvet, 1846). Humphrey Davy wrote that he had suffered much from the dangerous effects of hydrofluoric acid, and it is said that he abandoned his attempts to isolate fluorine because of the risk involved. P. Louvet, who continued the researches of the Knox brothers, described how his own health was profoundly altered from using the acid, and how it caused him to suffer from cough and hæmoptysis. According to Debray (1886) the death of Louvet was a result of his work but no medical details are available. In 1869 J. Nicklès died from the effects of accidentally inhaling the vapour of concentrated hydrofluoric acid (Gore, 1869).

In spite of these deaths the search for the fourth halogen went forward, until in 1886 H. Moissan isolated the element fluorine during the electrolysis of a solution of potassium fluoride in anhydrous hydrofluoric acid, in an apparatus made wholly of platinum. In this way was solved one of the most difficult problems in modern chemistry.

Compounds of fluorine have been increasing in importance in industry of late years. Hydrofluoric acid is used for etching electric light bulbs, etching glass, pickling metal and wire, and cleaning sandstone and marble. Owing to its corrosive properties it must be handled with every precaution. The fluorides enter into the composition of artificial fertilisers, and insecticides and fumigants used in agriculture. Fell (1930) has recently emphasised the danger of poisoning from hydrofluoric acid in the manufacture of aluminium by the electrolysis of cryolite.

Gudjonsson has unearthed a new hazard of modern industry, namely, fluorosis of the bones and ligaments in cryolite workers. Working with Professor P. Flemming Møller in the Occupational Hygiene Bureau of the Labour Inspectorate in Copenhagen, he was at first concerned with the incidence of pneumoconiosis among workers in dusty trades. In the vicinity of Copenhagen cryolite is crushed and refined for use in the manufacture of aluminium. Cryolite is a double fluoride of sodium and aluminium, containing as much as 54 per cent of fluorine. In the crude state it is mixed with a considerable amount of quartz, and there is thus an added risk of pneumoconiosis.

Møller and Gudjonsson (1932) examined 78 employees, all of whom had been working in a cryolite factory for more than two years. They found the following four distinct lesions.

1. *Pneumoconiosis.* This was present in various stages in half the subjects examined, the diagnosis being based on radiograms of the chest. The conclusion is unavoidable that the disease of the lungs was due to the quartz laden dust in the factory.

2. *Fluorosis of bones and ligaments.* As the radiographic investigations of the lung condition proceeded, it was found that the shadows of the ribs, clavicles, and cervical vertebrae showed unusual density and abnormalities in

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