6

DISEASES OF OCCUPATION

AND

VOCATIONAL HYGIENE

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WITH ILLUSTRATIONS AND REFERENCE TABLES

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exposure to paint for lead to be their cause. The symptoms must therefore be due to the inhalation either of the vapor of turpentine alone or combined with emanations from the linseed-oil. Baly of Liverpool attributes the malaise to the inhalation of certain aldehydes given off by lead paints. He found that lead oxide gave off more "unsaturated aldehyde" than lead carbonate. Henry A. Gardner[3] did not find any metal present in the vapors given off by lead-painted surfaces. These vapors contain varying percentages of carbon monoxide and carbon dioxide, to the former of which he thinks the headache, vertigo and retching may be ascribed. Under certain conditions, where traces of sulphuric acid are present, carbon monoxide is given off. In the blood taken from the heart of a guinea-pig, which I had exposed to vapors from a freshly painted surface, the spectroscope showed the presence of carbon monoxide.

The driers which are added to paints are to some extent, therefore] responsible for the symptoms complained of by people who have been living in newly painted houses. Turpentine is a drier, lead is another, so too are benzol, benzine and petroleum spirit. Benzol and benzine vapor causes disintegration of red blood corpuscles, also hemorrhages on mucous membranes, and tender inflamed gums, conditions which recall those observed in scurvy.

The outcry against the use of lead has, particularly in house and ship painting, been followed by the introduction of various substitutes. For leadless paints the demand has increased during recent years. Zinc white is being more widely used and for internal decorative purposes it answers quite as well as white lead, but for external purposes the majority of master painters prefer lead carbonate. They regard its covering properties and enduring powers as superior to those of zinc. Lithopone, which is a mixture of zinc sulphide and barium sulphate, is also coming into repute in house painting. Space will not permit of a comparison being drawn between the various forms of paints. For internal decoration it may be said that zinc paints give all the covering power required and are freer from danger than lead paints, although in one well-known occasion several persons became ill where zinc paint had been used owing to the presence of arsenic, which is frequently present in zinc and which in this particular instance had not been removed after smelting of the ore. The ordinary paints in use have distinctly bactericidal properties. Newly painted rooms are therefore more or less aseptic.

Between 1900 and 1909 there were reported to the Home Office 1973 cases of lead poisoning with 380 deaths of house painters. Paralysis of the hands and fingers is extremely common in house painters. Tancquerel des Planches found paralysis present in 8 per cent. of lead-poisoned French house painters, Teleky in 14.5 per cent. of Austrian painters, and Legge in 22.7 per cent. of British house painters. In the United States it was found that one in every six painters gave a history of having had plumbism in one form or another, in other words 16.6 per cent.

SECTION VIII

NAPHTHA AND BENZOL POISONING

BY ALICE HAMILTON. M. D., Chicago, Ill.

A study of the literature of poisoning from the products of petroleum such as naphtha, benzine, gasoline, and from the products of coal-tar distillation, such as benzol, reveals a great deal of confusion and the student will often be left with a question in his mind as to just which one of the many complex bodies belonging to these two groups was involved in any specific instance of poisoning. This is partly because in the majority of cases a mixture was used, not a chemically pure substance, but it is also true that to distinguish between the physiological effects of poisoning by benzine and by benzol is difficult if not impossible. The similarity of names adds to the confusion. Benzene is a synonym for benzol, not for benzine, but it is not always possible to be sure, especially in French and Italian reports, exactly what body is meant when one of these words is used. Another confusing factor is the similarity of uses of the two groups of chemicals. Though it is clear that the fumes in a benzol still or in a petroleum refinery are of fairly well-known nature, it is not possible to say which will be present in a rubber factory, a dry-cleaning establishment, a varnish factory, or a room in which motor cars are tested, for both benzine and benzol are used for all these purposes. Therefore it is easy to see why some observers have not attempted to decide the real nature of the poison which was present, while others have reported their cases in such a way as to arouse doubts in the minds of critics.

V. Jaksch,[1] Roth,[2] Lewin,[3] Rambousek,[4] emphasize the differences between the petroleum distillates and the coal-tar, holding that the latter have a special toxic action on the central nervous system. Lehmann,[5] whose exhaustive article is the most authoritative pronouncement we have on the question, finds a difference in degree between the toxicity of benzol and benzine, but not a difference in kind. It seems, however, best to treat the two classes of substances separately, at the same time realizing that in some instances it is not possible to discover just what compound was involved.

Petroleum *and* Its Distillates.—Petroleum is a dark brown, oily liquid derived from the subterranean distillation of vegetable matter. It has a structure of enormous complexity, differing in different regions. Pennsylvania petroleum contains a complete series of hydrocarbons from CH_4 to $C_{16}H_{34}$, also the solid hydrocarbons $C_{35}H_{52}$, $C_{27}H_{56}$ and $C_{30}H_{62}$. When distilled, the lighter compounds pass over at 30°C. to 170°C. These are the

on leaving work, the dizziness and staggering coming on in the open air. Loss of appetite and a feeling in the morning of having been drunk the night before were usual features of this mild benzine poisoning.

More serious symptoms follow exposure to heavier fumes. Lewin[8] says that in the oil regions of Pennsylvania and in the refineries at Point Breeze he was told of men who when they went down into the tanks became so excited and irrational that they could with difficulty be persuaded to come out. In still more serious cases, which are rare in proportion to the numbers employed, there is a rapidly increasing weakness, quick and weak pulse, labored respiration, delirium and coma. A physician in a town where there is a large rubber factory told me of such a case in his practice. The patient, a strong man, had been dipping wooden forms in a tank filled with a solution of rubber in benzine, to make seamless surgeons' gloves. He felt dizzy and ill and left work, but on his way home he staggered and would have fallen, had not two men helped him. Later, when in bed, he lapsed into unconsciousness and when the physician saw him he was comatose, very pale and almost pulseless. He recovered completely.

Wichern[11] describes an accident in a benzine tank where some remnants of benzine were floating on the surface of the water poured in to clean it. A man who climbed in was overcome by fumes and fell with his face in the benzine. He was quickly rescued but was unconscious, his muscles strongly contracted. He had severe chills and vomiting and though he recovered he had some irritation of the throat for 2 weeks.

Cleaning out vats and tank cars is one of the most common causes of acute benzine poisoning.[4] The latest report of the German Factory Inspectors[12] tells of a workman who entered the benzine cylinder of a washing machine in a dry-cleaning establishment while there was still some benzine left in it, and was found lying unconscious overcome by the fumes, although the machine stood by an open door. Fumes from the benzine used in quick drying paints were responsible for two cases of poisoning noted in the last report of the British Factory Insepctors.[13]

Another industry which is an increasingly important source of benzine poisoning is the automobile. Gowers[14] has reported a very interesting case of pseudomyasthenia, involving chiefly the muscles of the throat and tongue, in a tester of motor cars who was continually exposed to fumes of gasoline in a state of incomplete combustion. In our own country Potts[15] has described a case of "encephalitis" due to gasoline poisoning in a man who worked for 4 months filling automobile tanks. After about 2 months of headache, nausea, and visual disturbances, he fell unconscious while at work and when aroused complained of intense headache. There was weakness of the right third nerve and of the left side with partial incoordination of the left arm and the gait was cerebellar in type. The weakness of eye and arm were permanent.

A very extensive instance of gasoline poisoning occurred in the digging of

a tunnel in Montreal and involved no less than **42** cases. Fumes from the gasoline engine were responsible.

Fatal cases are rare. Lehmann[5] has collected several from the literature and added one, a man who spilled **40** liters of benzine in a low cellar, tried to sc[illegible] it up, came out complaining of feeling faint and tired and a half hour la[illegible] found lying dead outside the door. Zimmermann's[15] fatal case di[illegible] trying to remove with benzine the crusts which had formed on the inside of a tank. Lewin[8] heard of fatal cases of poisoning in the American oil fields and refineries among the workmen who have to enter the tanks. One of the English cases of poisoning from the use of benzine in paint ended fatally. These paints are especially dangerous when the surface to be painted is warm.

A striking case of fatal poisoning by petroleum products is given by Korschenewski,[17] who has had long experience in the Russian oil regions. A healthy young man had worked all day at the pumps which control the flow of naphtha from a well. At evening he felt weak and ill. The next morning he expectorated quantities of tarry blood which did not redden on exposure to the air. By noon he was jaundiced, there were purpuric spots in the skin, vomiting of blood, delirium, convulsions, and death on the following day. As we shall see later this resembles closely some of the cases of fatal poisoning from benzol.

Chronic benzine poisoning is said by many to be rare, the workers in rubber inctories, dye-houses, etc., having no more ill health than falls to the lot of all factory people. Lehmann[5] and Goldschmidt[18] say that German benzine workers show little if any effect from the fumes and Lewin[8] found the ordinary work in American oil wells and refineries to be attended with no noticeable effect on health. On the other hand Russian writers, who have had experience in establishments where conditions are bad, find much ill health traceable to the constant inhaling of benzine fumes. Berthenson[19] reviews the literature on this subject and shows that in workers who are employed for long periods there develops bronchial catarrh, dyspepsia, malnutrition, anæmia, nervous derangements (Korschenewsky, Petkewitch). In the Baku oil region among **8465** employees there were, in **1895, 1475** cases of respiratory disease, chiefly bronchial catarrh, and **1216** cases of skin disease.

Dor[illegible]'s[20] cases are usually quoted as striking instances of chronic benzine poisoning. The men were rubber workers and the most prominent symptoms complained of were pains of a tearing character in muscles and joints, tenderness on pressure, weakness and coldness of the right hand, psychic depression, loss of memory, difficult speech. There was increased excitability of the skin to mechanical irritants and heightened tendon reflexes.

In addition to poisoning from fumes there is a toxic action exerted on the skin by the petroleum products, especially the heavier. Paraffin workers develop multiple Papillomata, or pemphigus-like or eczematous eruptions.

Benzine also causes skin lesions. Last year many cases of skin diseases were reported from the printing trades of Berlin,?' and were traced to the introduction of a new, benzine-containing fluid for cleaning ink from type. The disease was described as a localized eczema, with redness, tenseness, blisters and later scaling.

More often the lesions caused by contact of the skin with petroleum are described as typical acne lesions. Lewin[8] found this in the American oil country. The irritating effectof the oil causes inflammation of the sebaceous ducts, retention of secretion, suppuration, multiple skin abscesses, etc. In the great factories for agricultural implements in this country the men and girls employed in the preparing and spinning rooms in the twine mills often suffer from very distressing acne. This twine is treated with a mixture of fuel oil 95 per cent. and wool oil 5 per cent. to soften it and keep it from being devoured by field insects when it is in use. The workers feel the effects of this oil most in summer when they work with their sleeves rolled up because of the heat.

Benzol.—Pure benzol is C_6H_6 and boils at 80.4°C., but the commercial variety contains substitution products as well, chiefly toluol and xylol, distilling at 80° to 85°C. It is a solvent for rubber, fats, gums, celluloid, and therefore much used in industry, but not as much in this country as benzine. Commercial benzol contains also a trace of carbon bisulphide, and there is a variety used in Germany in the rubber trade and for varnish which has 16 per cent. or even 60 per cent. of this compound.

Lehmann[8] and his colleagues and Chassevent and Garnier[22] have come to the same conclusions as the result of animal experiments, namely, that the symptoms caused by crude, by commercial and by pure benzol are the same in kind but that the action of the first two is more rapid and intense because of the presence of toluol and xylol, both of which are more toxic than benzol. Rambousek,[4] however, finds pure benzol more poisonous than the two others and so do Agasse-Lafont and Heim.[23]

Symptoms.—The symptoms caused by the inhalation of these fumes point to a poison with a selective action on the central nervous system, and they are as follows in the order of their appearance: muscular tremors, salivation, violent twitchings, eshaustion, paralysis, narcosis, respirations first quick, then slow, rapid pulse, low temperature. Usually the animal recovers but can may show a striking idiosyncrasy and die after a short exposure, from respiratory failure. Lehmann[5] found no characteristic changes in organs or blood but Chassevent and Garnier[22] found congestion of the abdominal organs and peritoneum, and ecchymoses and ulcers along the upper border of the stomach in the mucous coat. Santesson,[24] experimenting with crude and with pure benzol, was able to produce hemorrhages into the mucous membrane of the stomach and the intestines and into the lungs. He concludes that benzol dissolves the body fat and that emboli of fat lodge in the smaller vessels causing first stasis and then rupture of the vessel wall. Selling[25] found blood

mononuclears forming 71 per cent. and the large, 10 per cent.* Selling calls the condition one of aplastic anæmia, for in spite of the great loss no regenerating forms of blood corpuscles were found. He found the substance to be crude benzol chiefly, and with it as also with pure benzol he was able to bring about in rabbits a marked leucopenia, reaching 20 per cu. mm. at which point death occurred.

It is worth noting that in Selling's cases and in two of Santesson's there was fever, while in experimental benzol poisoning a fall of temperature seems to be invariable.

preventive Measures.—The prevention of poisoning from fumes of benzol or benzine lies in good ventilation so that the fumes may be diluted down to the point of harmlessness. Even allowing for an individual susceptibility such as we have reason to think does exist in some people, the really serious cases of poisoning have all been caused by exposure to very heavy fumes, and the reports of chronic poisoning come from those countries chiefly where industrial hygiene is comparatively neglected. High ceilings, abundant ventilation, scrupulous cleanliness are enough in cases where fumes are not heavy; artificial ventilation with air exhaust must be installed when the danger is greater, preferably, according to the British inspectors, with a down-draft as these are heavy fumes. If a vat or tank must be cleaned out, the men must be furnished with divers' helmets. For the distressing skin diseases nothing but very strict bodily cleanliness will help and in susceptible cases there is no hope of cure as long as the work is kept up.

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* The resemblance of these symptoms to those of scurvy is striking, especially as v. Jaksch found leucopenia in scurvy.

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Coal Tar.—Coal tar is obtained by dry distillation of coal and is an important by-product of illuminating gas and coke works. It is chiefly used for the production, by fractional distillation, of so-called coal-tar products, such as benzene, toluene, naphthalene, anthracene, carbolic acid, pyridine, etc., from which again are made saccharine, various drugs, dyes, perfumes, etc. About 50 per cent. of the coal tar is pitch and remains in the stills as a residue. This substance, like tar, is used in the manufacture of varnishes, metal paints, artificial fuel (briquets), etc. Crude tar is also used for preserving wood in the manufacture of roofing paper, in the construction of asphalt pavements, etc. The constitutional effects of inhalation of tar vapors are such as loss of appetite, nausea, diarrhea, headache, vertigo, catarrhal conditions of the upper air passages. In some instances, however, ischuria, strangury, albuminuria and œdema have developed, rarely of a serious nature. Affections of the skin, such as eczema, pimples and psoriasis are quite frequent among workers in tar, and may affect not only the hands and arms, but also other parts of the body. Cancroid ulcers, especially of the scrotum, are liable to develop not only among workers in the tar, lamp black and paraffine industry but also in chimney sweepers and briquet makers.

Benzol.—This important coal-tar derivative is secured by fractional distillation of tar in wrought-iron stills. Crude benzol consists chiefly of benzene and toluene. Pure benzene and pure toluene are secured by additional fractional distillation. Benzol is placed on the market as 90 per cent. and 50 per cent. benzol, and as solvent naphtha. Pure benzene vapors are very poisonous. The limit for animals is between 0.015 and 0.020 per 1000. For symptoms and branches of industry in which benzol is employed and poisoning may occur see page 724.

Dr. Rambousek[16] reports 34 cases of benzol poisoning of which 24 were acute cases and proved fatal. About one-half of the cases occurred in connection with benzene plants, either during the distillation process, or during the cleaning out of the extraction apparatus, or storage and transportation tanks. Twelve cases occurred in the rubber industry, one in the manufacture of antipyrine; one in a painter while applying a coat of asphalt paint to the interior of a large iron tank, in which benzol, instead of turpentine, was used, and three cases occurred in a color factory, from the internal use of alcohol denatured by the addition of 1 to 2 per cent, of benzol.

A case[17] of chronic industrial poisoning by *xylene,* a homologue of benzol, is referred to as having occurred in the rubber industry; also a case of carbon monoxide poisoning and several from sulphureted hydrogen gas in coal-tar distillation.

In the coal-tar distillation, at a temperature of 150–200°C., the middle oil passes over. This contains naphthalene, which upon cooling crystallizes out, and after washing with caustic soda and acid, is redistilled and hot pressed. From the remaining liquor, phenol or carbolic acid is obtained.