DEVICES FOR THE PROTECTION OF THE WORKER AGAINST INJURY AND DISEASE*

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PART II

In this second part of the lecture I shall endeavour to outline something of the part played by research in the protection of the worker against injury and disease. The work of physicists, engineers, agriculturalists, chemists, and toxicologists will be discussed. It is to be noted that such research is still necessary: it has never been pursued with greater devotion than at the present time.

7. Protection Against X Rays and Radioactive Substances

In protecting the worker against the effects of x rays and radioactive substances, including the effects of nuclear fission, the industrial doctor must collaborate closely with the physicist. In 1896, within the first few months of their discovery, it was found that x rays were stopped more effectively by lead than by any other common metal. Hence lead for protection came into early use. About 1903 there appeared a multitude of protective devices to be worn by the radiologist, including apron, jacket, gloves, and goggles. This type of protection gradually reached its peak about 1914, when the more elaborate devices gave place to means of protection which were built into the apparatus. The protective materials used include lead, lead glass, lead rubber, and lead plastics.

When installing an industrial x-ray set advice must be taken on the thicknesses of lead, barium concrete, or brick necessary to protect the worker. Where, for example, a one-million-volt set is used to detect flaws in the welds of boilers, several inches of lead may be used to secure adequate protection. When such x-ray work is done it is important that no person should remain in an area which has not been declared safe by an expert physicist. The radiation received by a worker can be assessed by means of the blackening of a small wrapped photographic film worn on the coat lapel during working hours for a week. The maximum permissible dose of x rays in any one working week is of the order of 0.5 r. From 1943 to 1948 the National Physical Laboratory carried out film tests on several thousand radiological workers, and the results indicate that about 80% receive less than 0.1 r per week from external sources of radiation (Binks, 1949). Repeated periodical blood counts must be carried out on all doctors, nurses, research workers, students, technicians, and workshop employees exposed to x rays.

Though medical practice is now almost safe so far as x-irradiation is concerned, matters are very different in the case of radium. The penetrating power of the gamma rays is so great that surgeons who handle radium closely in their work can be but ill protected. In the case of people who carry radium about, the weight of lead they can carry only partly protects them. In the luminizing industry luminous paint containing 70 μ g. of radium salts per gramme is applied to aeroplane or watch dials, compasses, gun-sights, and electrical instruments.

The potential hazards in this occupation are irradiation by alpha particles and beta and gamma rays, inhalation of emanations of radon from the luminous compound, and inhalation or ingestion of radioactive dust. A glass screen placed between the luminizer and the work protects the operative from external irradiation and the risk of inhalation is reduced to a minimum by adequate exhaust ventilation. The worker wears a rubber apron and a protective gown. The use of brushes to apply the luminous paint is prohibited and pens or solid applicators are employed. Frequent washing of the hands is necessary to remove contaminating powder. Inhalation of radioactive dust is controlled so far as is possible by daily washing of walls and benches, but ultra-violet illumination often reveals fine particles of luminous dust which come from small splashes of paint on the benches. Workers must wear beta- and gamma-ray sensitive photographic films, and tests of the expired air for radon must be repeatedly made. Routine clinical examination of luminizers is made especially to look for dermatitis, and repeated periodical blood counts are carried out.

The use of chain-reacting piles has produced risks of injury infinitely greater than those already experienced in minor degree in the radium industry, in x-ray work, and in research laboratories working with equipment such as cyclotrons and betatrons. The energy released from nuclear fission may irradiate the body with beta rays, gamma rays, or neutrons. There is also the risk of inhalation or ingestion of radioactive dusts and fission products.

Protection must be provided for the workers in factories and laboratories, and for the community near by. Dry waste is usually disposed of by deep burial underground. Liquid waste in small quantities may be disposed of by burial also, but larger quantities must be diluted or decontaminated enough to allow discharge into near-by streams in a concentration which will not be harmful. The inspection and supervision of workers is best accomplished by a special health-physics team, which might employ 70 inspectors to deal with 1,500 workers.

To detect the amount of radiation received workers must wear, either in the pocket or on the clothing, beta- and gamma-ray sensitive photographic films, the so-called personnel-monitoring meters. Mobile instruments are used to test radiation from sources or contamination of various sites and objects such as floors, walls, and desks (Fig. 7). Stationary instruments such as integrons and monitrons are used to measure and record general background radiation levels. They may be connected to an alarm system to sound a warning when a given radia-

Fig. 7.—Technician wearing protective clothing and using a portable Geiger counter. (By kind permission of Monsanto Chemical Co.)

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tion level has been reached. Barriers are always necessary, and in large installations like piles they may be massive concrete walls three to eight feet (0.9–2.5 m.) thick. Distance is the best barrier, but it is often necessary to use concrete and lead for walls and doors, movable blocks and bricks to protect against beta and gamma rays, and water or paraffin to stop neutrons. Rope barriers and warning notices may be used in danger areas. Ventilation is important to prevent air-borne contamination becoming lethal. Protective clothing is valuable, and facilities for laundering must be provided. Special soaps and chemical substances are required to remove plutonium.

Despite all these safeguards some persons will be exposed to dangerous amounts of radiation. It must be remembered that the highly trained scientist is likely to take the most foolish chances and may be the hardest person to control. Routine tests of the worker's blood, sputum, expired air, urine, and stools for alpha, beta, and gamma emitters should be carried out. If these are found the worker should be removed from the risk of further absorption. A person exposed to neutrons may have induced radioactive elements in his body, when active sodium and potassium are readily detectable in the urine (Morgan, 1948).

8. Researches by Chemists

In all history there is to be found no finer contribution to industrial welfare than the invention of the miner's safety-lamp by Sir Humphry Davy. This was based upon scientific researches described by him to the Royal Society between 1815 and 1817. The investigations were undertaken at the request of a Society for Preventing Accidents in Mines formed in 1813 in consequence of the increase of colliery explosions as pits of greater depth were worked. As the result of experiments Davy found that if a piece of metal gauze is interposed between a flame and an explosive gaseous mixture the heat of the flame is absorbed and conducted away by the metal gauze so that the gaseous mixture does not explode. His lamps were brought into use in the mines in 1816. For this signal service to industry Davy received a baronetcy in 1818. Not only was he the greatest chemist of many generations but he was also the finest of men, for he declined the fortune he could have made by taking out a patent on his invention. A modification of the Davy lamp called the flame safety-lamp is in daily use in coal-mines where there is the hazard of fire-damp or black-damp.

In testing for the presence of inflammable gas the miner on duty as safety man holds the lamp as near as possible to the roof of the mine working, because methane is lighter than air. He lowers the flame of the lamp until the yellow part hardly shows. The presence of methane will be discernible as a blue cap to the flame. Since the size of the cap and the amount of methane present in the air have been correlated, it is possible to estimate the percentage of fire-damp in the air current of the mine. Should it reach the explosive level the safety man sounds the alarm.

In 1899 John Haldane investigated the black-damp in various coal-mines, metalliferous mines, and wells, and found it to consist of nitrogen mixed with small amounts of carbon dioxide varying from 5 to 15%. Black-damp causes death from simple asphyxia through deprivation of oxygen. It is exceedingly dangerous, because the victim suffers hardly any warning symptoms before life is imperilled. Were it not that the safety-lamp is usually carried in such air, and that the extinction of its flame gives ample warning, since it occurs at about 17% of oxygen, accidents would be much more frequent.

One hundred and thirty years have passed since Humphry Davy worked on the safety-lamp, and we find chemists busier than ever. The present rate of industrial development has intensified the search for new materials. The substances produced rapidly become indispensable, but their properties may remain for a long time insufficiently understood. Many of them are harmless, but others are so deadly that their use might with advantage be forbidden. The success of such prohibition depends on the discovery of innocuous substitutes. In Great Britain the use as a rubber solvent of benzene, which evaporates slowly into the general atmosphere of a workshop, has been given up for nearly 40 years. In spite of the many safe and efficient substitutes for benzene this deadly hazard is still widespread in some countries—for example, Czechoslovakia (Rejsková, 1948). In 1940 English doctors advocated the prohibition of the manufacture and use of methyl mercury compounds as seed fungicides, yet further unnecessary deaths from this hazard have since occurred in Sweden (Ahlmarm, 1948). Phenyl and tolyl mercury compounds are efficient substitutes and are harmless when handled with reasonable precautions. Experience in California has shown that organic phosphorus compounds for use as insecticides are too deadly for safe handling in factory, greenhouse, orchard, and market garden. Would it not be wiser to go on using nicotine?

The mystery of the toxic effects of beryllium compounds is only partly solved. Berylliosis is a delayed granulomatous lung disease arising from the inhalation of beryllium compounds. It may be caused by handling zinc manganese beryllium silicate used as a phosphor in the manufacture of fluorescent strip lamps. Owing to its deadly effects its use for this purpose has been abandoned and other materials substituted. Simpler beryllium compounds have produced berylliosis in unusual circumstances.

The United States Atomic Energy Commission has investigated the contamination of the atmosphere in the neighbourhood of a plant producing beryllium oxide, beryllium copper, and beryllium metal. During the previous ten years 1,600 workers had been employed. Compared with five known cases of the chronic disease within the factory, ten cases with at least one death occurred in persons living within three-quarters of a mile of the plant, though they had never worked there. The atmospheric concentration of beryllium three-quarters of a mile away from the factory ranged from 0.01 to 0.1 μg . per cubic metre (Eisenbud *et al.*, 1949). The challenge of a poison deadly in such minute amounts is therefore made not only to the guardians of health within the factory but also to public health authorities in industrial communities in general. Indirectly, therefore, the splitting of the atom has given us new and grave responsibilities besides those connected with radioactive substances.

The work of chemists leading up to the discovery of safe substitutes for harmful materials used in industrial occupations dates back more than a hundred years. Mercury poisoning was common in the mirror-making industry until silvering was introduced. In 1835, working on the oxidation of alcohols, Justus von Liebig isolated acetaldehyde. Seeking a test for aldehydes, he observed that a test-tube becomes coated with silver if an ammoniacal solution of silver nitrate is warmed with an aldehyde. The mirror so formed provided a more perfect reflecting surface than an ordinary mercury mirror, and mercury poisoning disappeared in the trade. The invention of gold electroplating by Wright and Elkington in 1840 also led to a great reduction of mercury poisoning, because this process replaced that of fire-gilding, in which mercury was

volatilized from an amalgam by heat over a fire. In 1898 Sévène and Cahen substituted the harmless phosphorus sesquisulphide for yellow phosphorus in the manufacture of matches. This abolished phosphorus poisoning in the match industry and made possible the international prohibition of the manufacture and import of yellow phosphorus matches effected by the Berne Convention of 1906.

An outstanding contribution to the reduction of the risk of lead poisoning was the invention of the wet-pulping method in the manufacture of white lead. The house painter is protected against the dust of lead paint, at one time raised by the dry rubbing-down of lead-painted surfaces, because he now uses waterproofed sandpaper which enables him to keep the job wet. Chemists have produced a low-solubility glaze which protects the potter from the dust of white lead; similarly, paint technologists have protected the painter of metals by the invention of non-setting red lead. The use of litharge rubber—that is, rubber in which litharge has been incorporated in a mother batch to the extent of 90%—has abolished the production of lead dust in certain processes in the rubber industry. Substitutes must be found for toxic solvents. Work on refrigerants has produced the harmless dichlorofluoromethane in place of methyl chloride.

Prevention of silicosis in the potteries and the grinding trades has been greatly assisted by two discoveries. The first is the successful adoption of alumina in place of powdered flint for firing chinaware in the potteries. The second is the discovery by Edward G. Acheson, of Monongahela, Pennsylvania, in 1891, of the first synthetic abrasive, silicon carbide. Seeking to synthesize diamond, he was heating clay and coke in an electric arc. He obtained a product as hard as the natural abrasive corundum, and wrongly thought that what he had produced was a compound of carbon with corundum, hence "carborundum," a misnomer adopted as a trade name for silicon carbide. It has a hardness of 13, compared with 15 for diamond and 10.5 for sandstone. It has therefore largely replaced sandstone and other natural silica rocks in the grinding trades. Neither clinically nor experimentally has it been shown to cause lung disease. Where sandstone wheels are still used the operations of rodding and hacking as well as the actual grinding of metals must be carried out under a continuous stream of water which is drawn away from a trough at the base of the rotating grindstone.

9. Improvements by Engineers

Engineering devices have contributed alike to the prevention of accidents and to the diminished risk of absorption of toxic substances. Whenever possible mechanical means should be substituted for hand carriage; examples

of this are seen in the use of cranes, rails, hoists, and traveling belts. In the manufacture of window-glass and plate-glass it is necessary to protect the wrists and ankles against injury. However, the wearing of canvas and leather wristlets and anklets does not entirely prevent cut tendons. Engineers have given their help by devising suction apparatus enabling a crane to pick up huge sheets of glass without manual assistance (Fig. 8). Exposure of the worker to toxic substances can be reduced by the use of covered conveyers and hoppers and automatic closed-in packing machinery. In collaboration with physiologists engineers have done extensive work on caissons, air locks, diving suits, and air chambers to prevent decompression sickness. Glass-workers' cataract has been minimized by the inven-

tion of a glass-bottle-making machine producing bottles at the rate of 40 a minute and at one-ninth the original labour cost.

In the prevention of silicosis engineers have made important contributions. The use of steel rollers for milling corn has removed the need for fashioning millstones from natural silica rock. Where castings and other metal objects are cleaned by sand-blasting the man wears special clothing so arranged that he breathes pure air from outside the sand-blasting cabinet. It is

FIG. 8.—Large sheet of plate-glass lifted by sucker crane. (By kind permission of Pilkington Bros., Ltd.)

better to use steel-shot blasting in which crushed ball-bearings replace sand. The steel powder resulting is harmless. The hydro-blast is both the most modern and the safest apparatus used to clean castings. A high-velocity jet of sand and water is projected on to the castings, thereby removing moulding material, cores, and scale. The velocity of the water as it leaves the hydro-blast gun is in excess of three miles per minute. It can be readily understood that this apparatus has greatly improved the cleaning of castings and much reduced the dust in the atmosphere of fettling shops where it has been installed.

In hard-rock mining wet drilling is now widely used. John G. Leyner, of Denver, Colorado, has been called the outstanding mechanical genius of rock drilling. In 1897 he brought to practical success the principle of the pneumatic hammer drill. A blast of air was blown through a hollow drill-steel to remove rock cuttings from the hole. This produced so much dust that the drill became known as the "widow maker" and miners refused to use it. In 1898 Leyner obtained a patent on the commingling of air and water in the drill-steel. This is the principle of the axial water feed and is the basis of all wet rock drilling to-day (Holman, 1947). Where wet drilling proves impossible or objectionable, foam-drilling equipment can be used. By means of compressed air a viscous foam is forced through the drill-steel from a closed vessel. The foam traps the dust completely and the amount of water used is only about one gallon per hour. Near the rock face after shot-firing a mist projector is used to allay dust. It is really an atomizer using compressed air and spraying a mixture

of castor oil and water in which the proportion of oil to water is about 1 in 100.

In coal-mining the methods are not the same as for hard-rock mining. Coal cutting must be done in a wet state, and this is achieved by directing two jets of water on to the saw picks of the endless chain of the coal cutter at the points where they enter and leave the coal face. The quantity of water so used varies from one to five gallons per yard of cut, the result being that little dust is raised when the coal is subsequently worked. Water infusion of the coal face is practised through bore-holes, the water being forced in under pressure so that it spreads through the cleavage planes in the coal and wets the loose dust which is always present in the joints and seams. Hand spraying by water jets is used for wetting down the face and the pile of coal both before and during work (Hay, 1949).

10. Agricultural Researches

The Hungarian red pepper industry affords an interesting and unique example of the application of research in agriculture to the protection of the worker. In the sixteenth century, Turkish invaders of Hungary introduced the paprika plant, which they grew for medicinal purposes. In modern times the species *Capsicum annum longum* has been cultivated in the region of Szeged, and this town is the centre of the Hungarian red pepper industry. The fruit of the plant when dry is deep red and is four inches (10 cm.) long, one inch (2.5 cm.) broad at the stalk, and tapers to a point. Women called splitters cut open the fruit with a knife and strip out a series of thin pale ribs which line it longitudinally. The ribs are discarded before grinding, because they contain too much of the pungent principle capsaicin. Fruits picked late in the season are often infested with the mould *Mucor stolonifer*, the colonies of which are removed along with the ribs by the women splitters (Fig. 9). The air of the workroom is then clouded by spores and mycelia, which settle everywhere as a fine dust.

A proportion of the splitters, especially those who have been many years at the job, suffer from loss of weight, poor appetite, poor sleep, and even haemoptysis. There is slight fever, and signs of bronchitis develop. In its chronic form the disease presents with cough, fetid expectoration, apical dullness, and cavities, as shown in bronchograms. Necropsy shows extensive fibrosis with bronchiectasis, and right heart failure. The disease is presumed to be due to the fungus, although the presence of its spores in the sputum does not prove it is more than a saprophyte.

Although generations of women had followed this occupation, using the same method for eighty years, neither employers, workers, nor doctors became aware of its exist-

ence until 1931. Workers grinding the split fruit and those handling the finished pepper do not suffer. It was at first sought to prevent the disease by the use of cotton-wool respirators, but these had little success. Ultimately the chief botanist of the Paprika Research Institute in Szeged succeeded in cultivating a variety of the plant in which the fruit had ribs containing much less capsaicin. Since it is possible to obtain first-class red pepper by grinding this fruit whole there is now no risk to the worker of inhaling the fungus spores, for indeed the paprika splitter is no longer needed (von Kováts, 1937).

FIG. 9.—Paprika splitter in Szeged, the centre of the Hungarian red pepper industry. (By kind permission of Professor G. Gortvay, Budapest.)

11. Researches Still Necessary

It would be idle to suppose that our knowledge of occupational diseases is a finished chapter. Of the many problems awaiting detailed investigation two only will be mentioned here, both of them toxicological. Dinitro-*ortho*-cresol (DNOC) and diethyl-*para*-nitrophenylthiophosphate (parathion) are both used as sprays for crop protection. They are deadly in their effects upon man, and strict precautions are necessary to prevent harm to those who handle them in factories, greenhouses, orchards, and fields.

Dinitro-*ortho*-cresol

3 : 5-dinitro-*ortho*-cresol DNOC is a yellow crystalline solid first used as a weed killer, insecticide, ovicide, and fungicide in 1892, and is now manufactured on a large scale.

In 1933 both dinitrophenol (DNP) and DNOC were introduced into use in the treatment of obesity. Both substances act by stimulating the general metabolism, the effect being peripheral and independent of thyroxine. By 1937 many cases of poisoning and some deaths had been reported from all countries where this treatment of obesity was practised. Overdosage of DNOC caused at least three deaths in Great Britain at this time. Many people developed cataract causing total blindness in both eyes some months after completing treatment with these substances. Although less than 1% of those treated suffered from this complication it is a serious objection to the use of these compounds, since it is impossible to predict which individuals are particularly susceptible to the toxic effects. The use of both substances in the treatment of obesity consequently fell into disrepute.

Toxic symptoms and deaths occurred in persons manufacturing DNP during the first world war, and the same effects have occurred in the manufacture and use of DNOC since 1940. At least five deaths from DNOC poisoning have occurred in Great Britain alone. Four of these were in men spraying cereal crops. Deaths and cases of severe intoxication in industrial and agricultural workers have been reported from Germany, Hungary, France, the

United States of America, India, and Africa. A man aged 29 had been employed as an agricultural sprayer for one year. At the end of a day's spraying with DNOC during a hot summer he complained of feeling unwell. He went to bed and within a few hours was found to be very ill indeed. He was taken to hospital in coma and died there within half an hour. This is the typical story of the acute lethal effect of DNOC.

Early symptoms are excessive sweating, thirst, and loss of weight. Most spray operators lose weight during the DNOC spraying season though they may notice no other effects. The weight loss is more than can be explained by conditions of weather or long hours of work. There is good evidence that DNOC is a cumulative poison. After

He wore a mask, but stated that it did not fit well and he inhaled fumes which arose from the mill. In one day his hands were stained yellow and in three days his feet, ankles, and knees were yellow too. He was well until two days before admission to hospital. His first symptom was sweating at night. Next day he felt suffocated, became dyspnoeic and weak, and believed that his mouth was full of dust. The most striking feature was the profuse sweating. On examination the temperature was 100° F. (37.8° C.), the pulse rate 130, and the respiratory rate 38 a minute, but no other abnormal physical signs were discovered. There was no tremor or exophthalmos. The basal metabolic rate, determined 24 hours later, was +80%. He recovered completely within 48 hours.

After the introduction of locally applied exhaust ventilation and periodic medical examination of workers in the

FIG. 10.—Driver in a gas-proof air-conditioned tractor cab spraying a wheat field with DNOC. (By kind permission of Pest Control, Ltd.)

a single dose of 45 mg. by mouth, which is about half the daily dose recommended for slimming, DNOC can be readily detected in the blood four days later. Repeated doses of 75 mg. daily produce a rising blood level during dosage, and DNOC is still present in the blood in appreciable amounts two weeks after the last dose is given (Bidstrup, 1949). The relationship between toxic symptoms and concentration of DNOC in the blood is being studied. In cases of poisoning loss of weight occurs rapidly. One man who had to give up work on two occasions during the hot summer of 1947 lost 2 stone (12.7 kg.) in weight in one week. Shortness of breath, weakness, anxiety, and sleeplessness develop later. In fatal cases rapid noisy breathing, cyanosis, and a marked rise in temperature are striking features.

DNOC is absorbed through the skin by ingestion or by inhalation of dust, spray, or vapour. There is good evidence that breathing in fine dust readily produces symptoms. Nine men in a group of 21 sprayers who had used DNOC for from one to eight seasons had had symptoms of poisoning at some time. These occurred always in hot weather, when fumes from the mixing-drum and spray-tank are noticeable and the spray dries as a fine dust. Fatal cases in industry have occurred invariably during hot weather. The manufacture and use of DNOC dust appears to be particularly dangerous. Thus during the summer of 1943 fourteen cases occurred in a factory in Great Britain where a dust containing DNOC was being prepared for use against locusts.

One was that of a man aged 37 who had been employed for 17 days pouring DNOC powder from kegs into a grinding-mill.

factory concerned only one further case of mild severity was reported.

In agricultural work spray operators must be warned that they are handling a dangerous substance. Individual workers have different methods of handling DNOC both in mixing the spray and in correcting faults such as blockage of nozzles on the spray boom. Concentrations of DNOC in the blood of men doing similar jobs in identical climatic conditions vary greatly. Modifications of standard spraying equipment result in different degrees of risk. Spraying-machines working on an atomizer principle seem to be particularly dangerous, since they produce a fine spray which drifts easily and settles as a dust which flies readily. There is often no agitator in the spray tank to keep the DNOC in suspension, and the nozzles of the spray boom often become clogged.

A spray operator on such a machine was observed during most of one day to correct this fault by jumping from the moving machine, running into the spray, and hitting blocked nozzles with a spanner while the machine and spraying continued. This is specifically forbidden by his employers, but adequate supervision of individual workmen in this type of work is difficult to arrange. In one fatal case it was discovered that the man had quenched his thirst with water contaminated with DNOC.

Mixing and spraying should be done across wind so that spray and fume are carried away from the operator. Protective clothing must include gloves, rubber boots, and overalls, which should be changed frequently. It is the duty of the employer to ensure that the men make use of such protective measures. Gas-proof air-conditioned

tractor cabs for the protection of men engaged in spraying operations are in use by one firm of contract sprayers (Fig. 10). Routine medical examination of all DNOC workers should be made at weekly intervals. Men showing the early toxic symptoms—namely, excessive thirst, sweating, and loss of weight—should be suspended from work, since there is no way of telling in which individual severe intoxication and even death may result. No case of cataract in industrial or agricultural workers has yet been reported, but this potential hazard exists and must add force to the drive to find a substitute for DNOC which is not toxic to man.

Parathion

Modern methods for the control of insect pests such as aphids and red spider include the use of insecticides in which the active substances are organic compounds of phosphorus. Preparations in common use contain tetraethyl-pyrophosphate (TEPP), hexaethyltetra-phosphate (HETP) and diethyl-*para*-nitrophenylthiophosphate ("parathion," E.605.f., DPTF, or "bladan"). These compounds were first discovered in Germany in 1939. They are alkylpolyphosphates related in chemical structure and physiological action to di-*isopropyl*-fluorophosphate (DFP), which is a powerful cholinesterase inhibitor used in the treatment of myasthenia gravis, paralytic ileus, and glaucoma.

The insecticidal properties of TEPP, HETP, and parathion are similar to those of nicotine. The effects of HETP are almost certainly due to contamination by TEPP of the manufactured product. Early in 1945 a pilot plant for the production of organic phosphorus insecticides was built in Leverkusen, since nicotine had become difficult to obtain by that time. Soon after the end of the second world war the manufacture of these insecticides was started in the United States of America and in Great Britain. Preparations include liquid sprays, dusts containing 1% of parathion, and wettable powders containing up to 25% of parathion. These powders are diluted before being sprayed in greenhouses, orchards, and fields.

Insecticides containing organic compounds of phosphorus are poisonous to man and animals. They are from three to five times as toxic as nicotine. All types of preparation penetrate rapidly through the skin, producing only slight irritation at the site of absorption. Exposure to as little as 0.3 g. daily has been estimated as dangerous to man. Absorption may also occur from inhalation and ingestion. The commonest early symptom of poisoning is giddiness. This may be accompanied by pin-point constriction of the pupils and by headache. The symptoms are aggravated by smoking or by taking food. From two to eight hours later nausea, abdominal cramps, vomiting, diarrhoea, muscular twitching, coma, convulsions, and signs of pulmonary oedema may develop. Incontinence of urine and faeces is common. Death may result in as short a time as one hour after the onset of symptoms. Atropine is an antidote to this form of poisoning. It should be given in doses of 1 to 2 mg. (1/60 to 1/30 gr.) at hourly intervals until the pupils are dilated. Oxygen, under slight pressure to overcome bronchial spasm, should be administered at the first sign of pulmonary oedema. The fibrillary twitching of muscles appears to affect particularly the diaphragm, and artificial respiration may be necessary. A case of poisoning with parathion is reported from Denmark (Andersen and Jersild, 1949) in which symptomatic treatment by artificial respiration saved the life of a gardener. Since the man was too ill on admission to hospital to give a complete history, the cause of his illness was not known until after he had recovered, and no atropine was given.

HETP and TEPP hydrolyse rapidly in the presence of water or alkaline solutions. Danger of poisoning from these two substances is most likely to occur when the concentrated materials are handled in manufacture or in mixing with suitable wetting agents. Parathion is more stable, and cases of poisoning have occurred recently in the United States of America. In California symptoms developed in 46 members of a group of 90 men employed picking pears from trees which had been sprayed with parathion ten days previously. All these men recovered completely, but 16 of them were seriously ill and required treatment in hospital.

A senior laboratory technician of the University of California Citrus Experimental Station died after spraying an orchard with parathion for approximately six hours. He was aware of the risks and had had considerable experience in handling both concentrated and dilute preparations of parathion. The protective clothing which he wore included overalls, cap, boots, and gloves. He had not been exposed to parathion or any similar insecticides for three days before the accident. The symptoms were headache, giddiness, nausea, and vomiting. He was given a bath and treated with oxygen, but no atropine was used. Death occurred five hours after the onset of headache. Detailed inquiry failed to show that he was careless in handling the material on this occasion, and since he had been exposed to greater concentrations of parathion for longer periods in the past it is unlikely that he was hypersensitive to organic phosphorus compounds. Three deaths have occurred in men handling concentrated parathion in manufacture and compounding. A girl repacked damaged bags of 15% wettable powder for several hours and later developed symptoms and signs of parathion poisoning from which she almost died. She wore a respirator at her work, but there was no exhaust ventilation.

Strict precautions are necessary to protect workers engaged in handling the new insecticides. These are more easily arranged and applied in factories than in field operations. In factories where parathion is made, mixed with wetting agents, or incorporated in dusts or wettable

LEARN TO USE PARATHION SAFELY

PARATHION IS A HIGHLY EFFECTIVE
INSECTICIDE, BUT IT IS ALSO HIGHLY
TOXIC TO HUMAN BEINGS

IT IS POISONOUS IF SWALLOWED, IF INHALED,
OR ABSORBED THROUGH THE SKIN

THE PRECAUTIONS PRINTED ON THE PACKAGE,
AND WHICH ARE REPEATED BELOW, ARE FOR
YOUR PROTECTION

LEARN THEM AND OBSERVE THEM!

FIG. 11.—Main headings of warning notice issued to users of parathion by Cyanamid Co., New York.

powders, exhaust ventilation should secure that this substance is absent from the atmosphere. Protective clothing must include overalls, gloves, boots, cap, and underwear, which are laundered each day and changed immediately if accidentally splashed. Ordinary clothing must be protected from possible contamination. Respirators should be available in factories for use in emergency; in field operations

they must be worn during dusting operations and the diluting of wettable powders. Thorough washing before eating or smoking is necessary, and a bath should be taken at the end of the day's work. These instructions, together with an account of the symptoms of poisoning, appear on the labels of containers as shown on the preceding page. The attention of all workers exposed to risk should be directed repeatedly to the toxic properties of these compounds and the protective measures emphasized and enforced.

No cases of poisoning from parathion or related compounds have been reported in Great Britain. Doctors should be prepared to recognize this new occupational hazard, since treatment with adequate doses of atropine is a matter of urgency if symptoms of poisoning occur.

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A recent issue of the *Statist* (February 18, p. 210) discusses the use of radioactive isotopes in industry. It is not difficult, it says, to see that the use of radioactive tracers for the location and assessment of certain elements in the body is likely to have many corresponding applications in industry. This use is already reflected in metallurgy, notably in the analysis of steel, and without doubt will be prominent among the activities of the newly opened laboratories of the British Non-Ferrous Metals Research Association. A United States patent takes radioactive tracers into the rayon industry, to determine the specific gravity of fluids used in the manufacture of viscose through the measurement of their radioactivity; and it is believed that the number of isotopes which could be of value in the radio industry is large. The uses of isotopes range from process control in general to oxidation and corrosion, and include such diverse subjects as printing ink transfer, rubber vulcanization, vapour leakage, and sedimentation. The most impressive adaptations of the technique are perhaps in studies concerned in self-diffusion in alloys and metals and segregation in ingots and castings. In the oil industry radioactive cobalt has been found of value for cleaning purposes. The article quotes a statement by Dr. Seligman, of Harwell, that for every 2,000 medical publications on the use of isotopes there are 12 concerned with their industrial application.

ORAL THYROXINE IN TREATMENT OF MYXOEDEMA

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The first report of the use of synthetic thyroxine in the treatment of myxoedema appeared as an addendum by Murray Lyon (1927) to the original paper by Harington and Barger (1927) describing the first synthesis of thyroxine. Two cases were treated, and their symptoms appeared to be satisfactorily controlled for short periods by dosages of 4 to 5 mg. of the new drug, injected intravenously. Since then a number of workers have used thyroxine to treat myxoedema (Thompson, Thompson, and Dickie, 1933; Lerman and Salter, 1934; Means, 1935). Various routes of administration were tried and dosages varied from 0.3 to 1.5 mg. a day. More recently the activities of D- and L-thyroxine on human subjects have been compared by Pitt Rivers and Lerman (1948). In this study the drugs were administered by daily intravenous injections.

Few of these workers seem to have considered the use of thyroxine as a serious alternative to thyroid extract, and the general conclusions reached, particularly in the 1933-5 period, were to the effect that thyroxine by mouth was either inferior to thyroid extract or, at all events, possessed no advantages over it. No very definite reasons were produced for these conclusions. In this work as a whole one rather gains the impression that the subject was abandoned owing to the high price of thyroxine at that time and because adequate supplies of the drug were in any case not available for general distribution. As a result we find that thyroxine has in fact been omitted from the latest edition of the *British Pharmacopoeia*.

Recent developments in the synthesis of thyroxine (Borrows, Clayton, and Hems, 1949; Chalmers, Dickson, Elks, and Hems, 1949) seem to have altered the possible future of synthetic thyroxine. Although DL-thyroxine has been on the market for some years it appears to have been little used, and a new preparation of L-thyroxine sodium has now appeared. It seems likely that in the future the price of synthetic thyroxine may well be able to compete with that of thyroid extract. In view of this and of the occasional doubts which have been expressed about the validity of the present method of standardizing thyroid extracts (Gaddum and Hetherington, 1931; Means, Lerman, and Salter, 1933; Frieden, Tuckich, and Winzler, 1949), we felt that a new approach to the question should be made, and were fortunate in obtaining samples of a number of synthetic thyroxine derivatives from Glaxo Laboratories Ltd. for clinical trial. The preparations used were L- and DL-thyroxine, L- and DL-thyroxine sodium (monosodium salts), and DL-N-formyl thyroxine. The L-thyroxine sodium contained five molecules of water of crystallization, but the doses are expressed on a dry-weight basis. Nine patients with well-marked myxoedema have been treated by mouth with one or more of these preparations over a total period of 18 months.