Protection of the Working Environment

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THE WORKING ENVIRONMENT is the resultant of a complex combination of factors such as technological progress, industrial equipment and processes, the organisation of work, and the design and layout of industrial premises. It is part of the total human environment and the influence it exercises on health and efficiency should be considered in close relation to those factors in the total environment which affect man outside working hours.

Formerly, the conditions of both these environments did not differ from those to which man had adapted himself throughout the course of evolution; they changed so insignificantly and so slowly that they did not cause widespread damage to health.

In more recent times, however, the scientific and technological revolution, and the application of scientific and technical advances to industry, have brought about radical changes in the environment which can directly or indirectly influence the health of present as well as future generations. There are now in our environment many substances that are alien to it, both chemical pollutants and physical agents.

In large cities a number of sources of pollution are common to both the general environment (air, water, food) and the working environment. In assessing the degree of danger to health from the working environment it is very important to remember that a worker may be exposed to the effect of various aerosols, sulphur dioxide, carbon monoxide and other chemical substances, as well as ionising radiation, noise and microwaves, not just at work but also in his private life.

The extremely rapid changes taking place and the continuous appearance of new pollutants make it necessary to assess environmental changes in a scientific and objective manner so as to find ways and means of keeping them under control, and of foreseeing the dangers and preventing them in good time.

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The present article will deal only with chemical pollution of the environment and will not refer to other environmental factors affecting health, except in isolated instances.

Pollution of the general environment

A few words must first be said about pollution of the general environment as it affects the health of the workers, and first and foremost about atmospheric pollution through combustion. Over 2,000 million tons of oil are burned every year throughout the world and the quantities of solid and gas fuels are even greater. The main substance resulting from combustion is carbon dioxide, which has no direct effect on human health. But other combustion products—aerosols, sulphur dioxide—pollute the air in industrial areas to such an extent that they have certainly contributed to an increase in diseases of the respiratory system. It is also believed that the increased incidence of lung cancer is partly due to the presence of 3,4-benzpyrene in the atmosphere. Such pollution naturally represents a considerable addition to the pollution to which workers are already exposed at work.

Large towns are faced with a severe problem as a result of vehicle exhaust emissions which, together with all the above-named combustion products, are an important source of pollution.

The effect of these pollutants on the health of the population is fairly well known. But very little is known of the losses they cause to humanity in the form of stunted plant growth, late ripening of fruit and smaller crop yields. A fuller picture of the harmful consequences of increased air pollution would encourage a search for efficient ways to combat it, a problem which contemporary technology would be quite capable of solving.

A serious source of environmental pollution affecting water, soil and food is the use of pesticides, world production of which doubles every five years and is now nearing 10 million tons annually. In contrast to the forms of pollution already mentioned, which result from the unintentional escape of harmful substances into the general environment, pollution from pesticides is harder to combat. Once pesticides have been released into the environment where they are intended to do their useful work, their subsequent dispersal by wind and water is largely uncontrollable and unpredictable. That is why the only way to prevent this type of pollution is to impose stricter limitations on the use of pesticides harmful to man or to prohibit them entirely.

In many industrial areas fresh water supplies are seriously polluted by industrial chemical effluents. This is another source of possible exposure of workers to harmful chemical substances whose effects are combined with those of chemical pollution of the atmosphere at the workplace.

Unfortunately, medical science has as yet found only limited scientific criteria to assess the combined effects of the pollution of the general and the working environment taking into account the total pollution dose absorbed by the body. This should be one of the first tasks of modern hygiene and industrial toxicology.

Main features and causes of pollution of the working environment

The most serious changes occurring in the working environment are the result of the rapid development of chemistry and chemical technology and the increasing use in production processes of new physical methods. That is why the predominant feature of workplace pollution is the combination of chemical substances with one another and the combined effects of chemical substances and physical factors. For instance the increasing use of lasers in various fields of science, technology and production entails not only the danger of harmful radiation but also that of the chemical substances arising out of the use of laser installations (benzene and its derivatives, carbon disulphide, ozone and others).

The use of new technological processes such as plasma metal-cutting gives rise to still more complex combinations of physical and chemical factors. When this process is used, the ambient atmosphere may contain aerosols of metals, ozone and oxides of nitrogen; in addition, the process produces high levels of noise, ultrasonic vibrations, and electromagnetic radiation in the ultra-violet and soft X-ray bands and other ionising radiation. Never before has technology produced such a complex combination of chemical and physical hazards. New combinations of chemical and physical factors also arise from the fact that industry tends to make use of ever more powerful equipment. Instead of 5-ton to 10-ton electric furnaces, the tendency now is to use 100-ton to 200-ton furnaces for steel smelting; in addition to aerosols, gases and heat, such furnaces also produce extremely high noise levels and strong electromagnetic fields.

Another important cause of the increasing combination of various types of pollution of the working environment is the introduction of chemical processes into non-chemical branches of industry. The use of plastics of extremely varied composition, of large quantities of cooling oils and of corrosion inhibitors in mechanical engineering has added considerably to the types of air pollution in industrial premises by introducing not only a large number of chemical substances but also their highly complex combinations. For instance, modern vulcanisation of rubber produces a gas containing 40 to 50 different chemical substances; the thermal processing and moulding of plastics for manufacturing machine parts produces a complex mixture of aerosols and gases containing toxic substances and polymer particulates mixed with steam. As in the case of vulcanisation, such mixtures may be present in the air in

concentrations which are harmful to health. The use of cooling lubricants for high-speed metal-cutting produces not only aerosols of the cooling mixture itself but also thermal break-down products, including carcinogenic hydrocarbons.

Modern methods of organising work are also a cause of the increasingly complex composition of air pollution in industrial premises. The use of transfer mechanisms and production lines (for instance in mechanical engineering) requires the installation in the same plant of work operations involving different kinds of harmful substances: dust or fumes as a result of mechanical processing of machine parts and electric welding, toxic substances as a result of painting and electroplating processes, and oil aerosols as a result of metal machining. The effect of all these types of pollutants on the workers is combined with that of noise and vibration. Before the advent of automation such work was carried out in separate workshops and those engaged on it were exposed to the effects of mainly one or another of these hazards, or to a relatively simple combination of them.

Modern times have witnessed an extraordinarily rapid and widespread development of organic chemistry, petrochemistry, metallurgical chemistry, and the chemistry of elementary organic and organo-metallic compounds. Every year several hundred new chemical substances come into use in industry and agriculture, although in many cases their toxicity and danger have not been established in advance.

Among the rapidly developing branches of inorganic chemistry the production of pure and highly purified metals deserves particular attention. These metals are obtained through the various intermediate stages of halogenated, hydrated or carbonyl metal compounds, which are much more toxic than the oxides or other salts of the same metals. Moreover the production of many organo-metallic compounds (of copper, phosphorus, lead, zinc) for use as pesticides has greatly increased the number of highly toxic substances liable to penetrate the air of a working area. Many of these compounds are capable of producing toxic effects through skin absorption also.

Every day organic chemistry introduces into the production process new chemical substances, many of which are highly toxic. Moreover there is a tendency in pyrolysis to make increasing use of extremely high temperatures (600°C and higher) at which carcinogenic by-products of hydrocarbons, such as 3,4-benzpyrene, are formed. This indicates a definite increase of carcinogenic danger in a number of branches of synthetic chemistry.

It should be borne in mind that as the number of chemical substances used in industrial processes increases, there is also an increase not only of their toxic combinations but also of those which, apart from their immediate toxicity, are liable to have delayed harmful effects; such effects may be mutagenic, resulting in the destruction of cells or possibly in the

development of cancer in the person exposed or, if the gonadal cells are exposed, in mutational effects in subsequent generations; or they may be teratogenic, affecting the development of the foetus if the person exposed is a pregnant woman.

At present seven groups of carcinogens (substances producing cancers) may be identified:

(i) polycyclic aromatic hydrocarbons and industrial products containing them (soot, pitch, products of combustion and pyrolysis of organic raw materials, coal and shale tars, some oil products, synthetic polycyclic aromatic hydrocarbons and others);

(ii) aromatic amines, which are synthetic compounds mainly used in the synthesis of other chemicals, e.g. dyes and pigments (2-naphthylamine, benzidine, amino-diphenyl and others);

(iii) azo compounds, also widely used for the industrial dyeing of textile fibres (whose structure is close to that of methylaminoazobenzene and its derivatives);

(iv) peroxy compounds, widely used in the production of plastics (peroxide, hydroperoxide and others);

(v) alkylating agents, used as chemical intermediates and, experimentally, in human medicine (derivatives of mustard gas, ethyleneimines and others);

(vi) metals and metalloids (beryllium, chrome, nickel, arsenic, selenium);

(vii) other carcinogenic agents (asbestos, certain polymers, pesticides and others).

This list of carcinogens is far from complete; by no means all the substances of every group have been mentioned. It does indicate, however, the widespread use of carcinogenic substances and processes, which makes the problem of occupational cancer a much more urgent one, requiring the adoption of a whole set of special measures.

Among the large number of substances discovered for industrial and domestic use there are several hundred mutagenically active chemicals, some of which have turned out to be more active than ionising radiation. Very frequently these are the same substances as those which have a carcinogenic effect.

The widespread presence of very different dust pollutants in the air of working premises is borne out by the fact that at present no fewer than 60 types of pneumoconioses (dust diseases of the lung) have been identified. A tremendous number of workers in a large number of occupations in various branches of industry come into contact with some sort of industrial dust. This is due to the greatly increased use made in the

last 30 years of various minerals, organic and mixed raw materials and waste in pulverised form for the extraction of chemical elements needed for technical processes, powder metallurgy and the manufacture of various building materials, etc.

It should be stressed that in most cases when production is organised in accordance with the requirements of occupational health, air pollution in the working environment is either entirely eliminated or else the concentration of pollutants in the air is reduced to a minimum, thereby minimising the risk of occupational disease. The same applies to particularly dangerous substances with carcinogenic or mutagenic properties.

The specific technical causes of air pollution in the working environment by chemical substances and dust are many and vary with the branch of industry, but they can be grouped in the following categories:

(1) Leakage in the equipment used. This may be due to faulty construction or to the abrasive action of certain substances. It leads to frequent dismantling of the equipment for maintenance work during which the workers are even more exposed to the effects of pollution.

(2) The intermittent and periodic nature of technical processes, making manual operations essential. In spite of widespread mechanisation, there are still a great many production processes which are not fully mechanised and require the constant presence of the worker in an area in which dust, gas or vapour is given off. This applies particularly to the manual selection of samples for analytical control which interferes with the integrity of enclosed production systems.

(3) Air pollution caused by chemical substances and smoke from untreated waste from the undertaking concerned or neighbouring undertakings. Pollutants are introduced into the work premises with the air brought in by the ventilating system. There can also be considerable pollution of the ambient atmosphere coming from nearby chemical and petrochemical undertakings, ferrous and non-ferrous metal plants, and thermal power stations.

(4) Absence of proper health control over plans for industrial buildings to ensure compliance with occupational safety and health regulations before an undertaking becomes operational.

(5) Overcrowding of machines and other equipment in industrial areas and premises, as well as poor design and siting.

(6) Absence of essential information concerning the toxicity of the chemical substances used and their maximum allowable concentrations in the atmosphere, so that necessary precautions are not taken.

An analysis of air pollution in industrial conditions, as well as of other occupational hazards, shows that not all of the above factors have

equal weight. The main safeguard of the working environment is of course compliance with physiological and health requirements in all matters relating to industrial equipment and technology. That is why it is so important in attempting to solve this problem to ensure that there is full co-operation between those concerned with occupational safety and physiology on the one hand, and equipment manufacturers and technicians on the other.

The working environment and workers' health

Pollution of the working environment together with other negative aspects of industrial work and failure to apply adequate safeguards are the direct cause of occupational diseases. The list of occupational diseases continues to grow from year to year as new chemical or other agents are introduced into production processes without the necessary preventive measures being taken.

In the 1930s and 1940s the number of chemical substances causing recorded occupational diseases was not much more than 50. Nowadays the number of such substances runs into hundreds, while all the other new chemical substances used represent a potential danger to health.

The most widespread group of health hazards is poisoning by chemical substances and diseases of the skin (dermatitis) caused by chemical agents. Almost as numerous are diseases of the respiratory system due to dust and toxic substances: pneumoconioses such as silicosis and asbestosis, pulmonary fibrosis, bronchitis, bronchial asthma and diseases of the upper respiratory tract.

In the last two decades there has been a considerable increase in the proportion of diseases caused by physical agents in the environment, particularly noise and vibration, and in diseases connected with excessive strain on organs and systems such as the peripheral nerves and muscles, joints and ligaments. The increase in such diseases observed in many countries is the result of the inappropriate distribution of functions between man and machine in the course of mechanisation, so that man is left to perform a greater number of monotonous though not difficult movements which result in excessive strain.

There has been an increasing tendency in the past few decades to recognise as occupational diseases the psychoneuroses of persons performing work that requires a great deal of nervous and psychological concentration.

Prominent among occupational diseases are occupational cancer and other tumours affecting the skin, respiratory organs, blood, urinary tracts and the bones, as well as occupational infections and eye diseases.

There has also been a marked increase in allergic diseases resulting from the body's greater acquired sensitivity to the harmful agents en-

countered in production processes. These include in the first place allergic skin diseases, diseases of the respiratory tract (allergic bronchitis, asthma, and allergic rhinitis), and other types of allergic disorder. Certain specialists consider that the constant and excessive nervous tension so often characteristic of industrial work today is a contributory factor in the increase in allergic diseases and reactions to chemical agents.

New techniques and industrial processes face workers with many complex tasks; these frequently have to be performed at a tempo that may not correspond to their individual abilities, thus increasing nervous tension, monotony and stress, which may lead to neurosis and cardiovascular disorders. It should also be remembered that work in these modern occupations is usually performed in hypokinetic and hypodynamic conditions (i.e. it involves insufficient muscular activity), which are well-known causes of increase in cardiac ischaemia leading to myocardial infarction. As a result there is an increase in cardiovascular diseases (ischaemic diseases of the heart, hypertension, arterial sclerosis, etc.).

It will thus be seen that occupational activity has a considerable bearing on the diseases that are at present most widespread, such as cardiovascular complaints, cancer, allergy and neuro-psychological disturbances. That is why the fight against pollution of the working environment and a rational organisation of work taking full account of the human factor in the man-machine relationship are so much more important for the health of the workers than the mere prevention of occupational diseases. A co-ordinated approach to the above problems of occupational health has become vital for the health of humanity.

Main principles of action against pollution

The long history of the fight against pollution of the working environment bears witness to the fact that it is possible to solve this problem with complete success. There are many examples of radical solutions to the prevention of industrial pollution: elimination of poisoning due to many heavy metals and solvents, elimination of occupational cancer in the aniline dye industry and other branches of industry, elimination of silicosis in a number of occupations in the engineering and mining industries, prevention of the harmful effects of ionising and microwave radiations in industry, to mention only a few.

What are the general principles that should underlie action to prevent pollution of the working environment and to protect the workers' health? There are four main principles which determine the success of any action in this field:

(i) legislative, technical and medical (including health) measures should be combined and co-ordinated—a one-sided approach cannot ensure full success;

(ii) environmental protection should be based on prevention, which should permeate all measures in this field; protection can be fully effective only if all necessary steps are taken *before* a new production plant is built, a new production process is adopted, or new techniques, materials and substances are used;

(iii) all the above-mentioned measures should be made compulsory by means of legislation;

(iv) state inspection and control of the implementation of these measures and of the condition of the industrial environment should be instituted.

The more important aspects of the protection of the working environment are considered below.

Legislative measures

Human health should be considered our main wealth, taking precedence over all other values. This is particularly so in the case of the health of the workers, since all other material and spiritual values are created by them or through their labour. Loss of health due to the harmful influence of the working environment cannot be compensated by money. Legislation must therefore make it compulsory to adopt comprehensive measures to prevent pollution of the working environment by substances harmful to health. It should be compulsory to keep a complete, detailed and continuous record of the effects of pollution on the health of workers of either sex and of every age. In view of the harmful effect which a number of agents may have on the genetic function, and hence on posterity, there is particular need for regulations governing the work of women and adolescents.

Maximum allowable levels of air pollution in industrial premises are of special significance and should be an integral part of safety legislation. It is still too soon to talk of international standards for maximum allowable concentrations, since many countries have as yet no experience concerning the application of any particular method of approach or limit values. To start with, every country should define by legislation the maximum allowable concentrations of harmful substances in the atmosphere of the working area, regardless of any differences that may exist in the scientific criteria by which these limit values are established. Such figures are extremely important for the practical protection of the working environment. They are a measure of the degree of danger which the environment presents for workers' health and also of the effectiveness of protective and preventive measures.

The values indicated for maximum allowable concentrations should not be considered as having been fixed once and for all. As new scientific data become available and research methods are improved, such standards should be revised in every country.

The fact that it is difficult to ensure that maximum allowable concentrations are respected in all processes in no way detracts from their tremendous significance. If they are scientifically well founded they stimulate engineering and technical innovations and lead to the production of equipment and machines and the adoption of technological processes that are more compatible with contemporary health notions. In this way the technical difficulties involved in implementing maximum allowable concentrations can be systematically overcome. Many examples could be cited of ways in which such difficulties have, in fact, been solved. What cannot be achieved today may easily be achieved tomorrow.

Unfortunately, the great difficulties hampering the implementation of maximum allowable concentrations are sometimes considered to throw doubt on the advisability of defining health standards, and are taken as sufficient reason for abandoning efforts to improve the working environment and for replacing the expensive technical measures required to make it safer by monetary compensation to workers whose health is impaired.

It is also greatly to be deplored that certain health specialists consider that such strict safety standards and the heavy expenditure they entail are unnecessary, arguing that human beings will be able to adapt themselves to the harmful effects of their industrial environment and that this adaptability will develop still further in the course of evolution. Such a view is devoid of scientific basis. Health standards should be fully able to preserve the workers' health. To invoke " technical impossibility " or " cost " is merely to replace the scientific approach to the problem by subjective considerations that hamper the fight against industrial pollution and its deleterious effects on the workers' health.

With growing experience in applying health standards in all countries and the further development of scientific research it will eventually become possible to draw up international standards for maximum allowable concentrations of harmful substances in the environment. In the meantime every possible encouragement should be given to scientific and practical work aimed at fixing maximum allowable concentrations, since industrial health has been unable to keep pace with the development of chemistry and a considerable number of new substances have come into use without the prior establishment of any standards at all. The standards fixed should be constantly improved and should not only take into account the interests of the present generation but ensure protection of generations to come, by totally eliminating delayed harmful effects, i.e. carcinogenic and mutagenic effects. It will be especially important in the next few years to establish standards for all carcinogenic substances used in industry, the number of which increases from year to year.[1]

[1] In the USSR the maximum allowable concentration for the most active carcinogenic substance, 3,4-benzpyrene, which is formed in the course of numerous processes by the thermal decomposition of oil and other organic products, has recently been fixed at 0.00015 mg/m³.

The fight against industrial pollution cannot be effective if legislation fails to provide that any chemical substances and materials destined for use in industry or agriculture must first be submitted to experts for assessment. It is on the basis of this preliminary assessment that the competent authorities should decide whether and in what conditions the substance may be used. The same applies to the prior examination by health experts of the plans for new plants or alterations to existing undertakings; it is precisely at the design stage that the fullest provision can be made for the use of all available modern techniques for the prevention of workplace pollution.

Legislation must of course clearly establish the responsibility of directors of undertakings and of employers to ensure that the working environment complies with health standards; it should also make it obligatory for the workers themselves to observe safety regulations, and should provide for trained specialists to instruct them in methods of preventing the dangerous effects of industrial pollution.

Technical measures

One of the fundamental principles of prevention is to forbid the commercial production of particularly dangerous chemical substances and to replace highly toxic substances by others that are either non-toxic or of low toxicity. The ban on the production of 2-naphthylamine and benzidene has eliminated cancer of the bladder from the aniline dye industry. The substitution of solvents of low toxicity for benzene, dichloroethane and carbon tetrachloride in the manufacture of lacquers and paints has completely eliminated occupational poisoning by these substances in many branches of industry. Many similar examples could be given.

Health standards for chemical products and raw materials are vital. For instance, limitation of hydrogen phosphide additives in acetylene, of arsine in sulphuric acid, of aromatic hydrocarbons in methyl alcohol and of benzene in furfural and other alcohols has removed the risk of poisoning from many industrial processes.

If a toxic substance cannot be entirely eliminated from an industrial operation, it is vital to take adequate preventive measures by organising suitable technological processes and adapting the industrial equipment concerned. Examples of such measures are: comprehensive mechanisation and automation of processes using remote control, or the use of uninterrupted instead of batch processes to preclude leakages in enclosed production systems or to avoid manual operations; the sealing of equipment and pipelines; automatic control of the technological process; systematically planned preventive maintenance of equipment and pipelines to preclude leakages or defects.

Workshops should be planned and equipment designed so that chemical substances and aerosols cannot penetrate from one room to

another, and walls and floors should be covered with materials that do not absorb poisonous substances and are easy to clean.

Under industrial conditions the above-mentioned measures are not always fully effective; that is why it is also essential to use ventilation to purify the air of the working environment. In processes involving intensive dust formation, spraying with water has proved highly effective (wet-drilling in the mining industry, wet sandblasting of castings, etc.).

In cases where this combination of measures does not fully eliminate atmospheric pollution by dust and toxic substances it is essential to use personal equipment for the protection of the respiratory system, eyes and skin.

Medical measures

In order to ensure the success of the fight against chemical and dust pollution of the working environment and their harmful effect on health, it is important to introduce compulsory recording of all cases of occupational disease and investigation of their causes accompanied by full documentation. The results of such investigation serve as a basis for specific measures to preclude new cases of occupational disease.

Another essential measure is pre-employment and periodic medical examination of workers who come into contact with harmful environmental agents.

The purpose of pre-employment medical examinations is to prevent the admission of persons suffering from a condition that would be aggravated by contact with industrial pollution. Any decision to admit a person or exclude him on medical grounds should be based on the fullest data available in the field of industrial toxicology.

The purpose of periodic medical examinations is to detect at the very earliest stage symptoms of reaction to industrial pollutants so that preventive and curative measures can be taken promptly with respect to the individual worker (transfer to different work, medical treatment), as well as with respect to the premises and the work process as a whole. Periodic medical examinations can be effective only if they are properly organised and carried out: all workers who come into contact with pollutants must be covered; physicians must be fully trained in occupational pathology and safety and must be provided with adequate laboratory facilities and instruments for diagnostic purposes; consultations should be held with medical specialists wherever necessary; examinations must be carried out at regular intervals; and full records of their results must be kept.

Pre-employment and periodic medical examinations are also important because they provide an opportunity of identifying persons with a greater sensitivity to harmful substances and of taking essential additional measures in their case.

Over and above these direct uses of medical examinations, their special significance lies in the fact that they provide the basis for epidemiological surveys of the effect of environmental pollution on the health of the workers and of the population at large. It is precisely this kind of survey and subsequent epidemiological and statistical work that made it possible to detect the carcinogenic risks involved in asbestos, nickel, oil refining products, ionising radiation and many other chemical and physical agents. Statistical and epidemiological examinations of workers in various occupations provide a reliable measure of the effects of the various industrial pollutants on their health and serve as a basis for fixing health standards for the various factors entering into the working environment and for general prevention campaigns.

Scientific research for preventive purposes

Thorough protection of the working environment depends on the development and use of safe techniques satisfying the requirements of occupational health, physiology and psychology. This can be achieved only with the help of thorough and far-reaching scientific research. For instance, research might lead to the discovery of a way of producing lacquers and paints without organic solvents, thus eliminating an extremely widespread source of atmospheric pollution in industrial premises by highly toxic substances. Similarly, if methods were found for the prior elimination of sulphur from oil, this would practically solve the problem of air pollution by sulphur dioxide in the combustion of fuel oil. Wider use of new methods of smelting steel directly from iron ore, bypassing the production of pig-iron (cokeless metallurgy), would greatly reduce the use of blast furnaces and coal coking and hence the extremely harmful pollution of the environment by coke oven emissions. Putting into practice a scientifically sound system of manufacturing artificial and synthetic fibres in an enclosed, airtight process would provide a radical method of preventing pollution of the working and the general environment by chemical contaminants and would entirely eliminate occupational poisoning by carbon disulphide and hydrogen sulphide, which is at present the most prevalent form of poisoning.

It can be safely said that if thorough scientific research is not used to eliminate a harmful aspect of production, the risk in question is not eliminated radically and occupational disease will follow. For instance, attempts to suppress dust in coal mines using modern cutter-loaders as well as spraying and exhaust ventilation will not give the desired result until entirely new methods of coal getting and extraction or of agglomeration of coal dust are discovered.

In the manufacture of viscose fibre, attempts have been made for many years to reduce the concentration of carbon disulphide in the air of work premises with the help of ventilation. The result achieved is

insignificant compared with the heavy cost of ventilation. What is needed is fundamental research into ways of replacing carbon disulphide by other substances. So far no satisfactory non-toxic substitute has been discovered and, for want of a better solution, an enclosed system of production is used.

Many similar examples could be mentioned. All of them show convincingly that without special scientific research carried out in modern conditions it is not possible to protect the working environment effectively from pollution. This is even more apparent when considering the fight against such harmful agents as noise, vibration, ionising radiation, microwaves, ultrasound, and laser radiation.

Together with the search for appropriate technology and machinery it is essential to base the fight against environmental pollution on prevention, and research of a similar nature should be carried out with the help of physicists, chemists and other specialists aimed at evolving the necessary preventive techniques (purification of the air, ventilation, enclosed systems, etc.).

As for medical and hygienic research, including epidemiological research into the effects of the working environment on health, the experience of many countries points to the fact that this should be carried out in special institutes and laboratories by staff specially trained in industrial medicine. These institutes can solve the problem of early diagnosis, treatment, expert assessment of disability and rehabilitation in cases of occupational injury to health due to pollutants in the working environment. But the main aspect of their work is to evolve a combination of protective and preventive measures for application at the place of work geared to the needs of each branch of industry. Unfortunately, except in a small number of countries including the Soviet Union, this branch of occupational health is still in its infancy and is not yet equal to the task with which the development of industry has confronted it.

Such institutes should also have central responsibility for scientific research into such problems as health standards in respect of the chemical and physical environmental pollutants, labour physiology and psychology, and ergonomics.

The final purpose of all research in the field of occupational medicine should be the prevention of occupational disease and fatigue, and the adoption of preventive measures against occupational hazards.

Inspection of the working environment

The working environment cannot be allowed to remain uncontrolled, since a number of pollutants are highly dangerous to the health of the workers and their offspring. Inspection should be both constant and thorough and should give an accurate, continuous picture of variations in the composition and level of pollution.

Inspection of this nature requires excellent material facilities (laboratories, instruments) and should be carried out by specialists with thorough training. Regulations for the systematic measurement and recording of pollution levels should be detailed and should take account of the particular circumstances of each branch of industry. The undertaking is the best location for an industrial health laboratory, which should be adequately financed by the undertaking itself. It is not enough to monitor the environment at regular intervals; what is needed is a dynamic and continuous record of the concentration levels of toxic substances or dust as well as of physical hazards, providing an accurate and extremely detailed picture of the degree of possible risk from the environment. Records of this sort can be obtained by the use of analytical equipment which, thanks to modern technology, can now be specially designed and mass-produced. In the absence of such facilities it is essential to carry out regular monitoring closely related to the various stages of the technological process and to record fully all conditions under which air samples or other measurements are taken (ventilation, aeration of the building, etc.). A highly qualified government inspectorate, independent of any undertaking, should supervise the proper and systematic monitoring of the environment. Small-scale undertakings, too, must be fully covered by such observation and control.

In all this, it is particularly important to monitor and control the effectiveness of preventive measures.

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Man's environment is of paramount importance to his life and health. The working environment is part of the general environment. In it man performs his work, which is the basis of his material and spiritual welfare. Whether work is a source of health and of satisfaction of his vital needs depends to a great extent on the environment in which it is performed. The working environment cannot be polluted and altered without becoming a source of disease, stress, fatigue and diminished capacity. The battle to safeguard the environment is a very difficult one, requiring tremendous resources, and may even turn out to be more arduous than was the fight against the many non-occupational diseases that have now been conquered. But if we make environment the primary object of our concern and attention and systematically apply a suitable combination of the essential measures, we shall win this battle too.