occupational hazards and realize that each has a contribution to make towards the preventive methods which ought to be adopted. This applies equally in the field of research. Whilst the primary aim of most industrial research is quite understandably concerned with discovering new and improved methods of production, it is important that principles of hygiene should be fully understood and practised by research workers, so that the safest and healthiest methods and designs may be incorporated into new plant at the pilot stage. Joint consultation between those carrying out industrial research and those responsible for occupational health is essential before any new project is put into production.

It is self evident to those who study human problems that using our man power to the best advantage means a great deal more than just seeing that the right man is in the right job, important though that is. Above everything else, it means understanding men and women, understanding things that influence their attitude to their daily work and to one another. We want to know a great deal more than we do at present about the things that release the full measure of human resource and enterprise, about the relationship between incentive and environment, and the extent to which environment can enhance the effectiveness of the group—in short about those human factors which will be the particular study and concern of your Society. The field of your enterprise is very large indeed, and I am sure that you will have much to contribute to our present knowledge of the things that make for greater satisfaction and, consequently, greater happiness.

I have a special pleasure in being here today in that I can personally congratulate you on the choice of your first president, Dr. Bedford. He has long been known as an international authority in special fields of environmental hygiene. For many years he has advised the Factory Department of my Ministry, and many of my inspectors have had cause to remember his teaching in the sciences of heating and ventilation. Members of the House of Commons have a particular reason to be grateful to him. His work in balancing the heating and ventilating system in the House can only be appreciated by those who had previously to endure blasts of hot and cold air from all sections of the House with bewildering frequency.

Although this Society of yours with its special aims and objects is new to this country, there is a well known body in the United States, and I am sure that we are all delighted that the American Association is represented here today by Dr. Henry F. Smyth Jr. As is our custom, we accept innovations with caution until the need is evident. The founders of this Society have followed this principle and have given much thought to its constitution and to the qualifications for membership. Membership is not limited to scientists, as you know, but may include others with interests and responsibilities in the wide field of occupational health. In this way, scientists and industrial doctors and others may contribute their gifts and knowledge to the common purpose. In my Ministry, we have, in the Factory Department, direct experience of this sort of team-work between the various professions concerned, and I am convinced that it is the right way of working.

In the Ministry of Labour we shall watch your progress with lively interest and I wish you every success in the important tasks that lie ahead.

**Occupational Hygiene in Great Britain**

**THOMAS BEDFORD**

It is no new discovery that health is affected by occupation, nor is it only in recent times that occupational hygiene has been practised.

The writer of *Ecclesiasticus* described the work of various craftsmen. He wrote:

> "The smith also sitting by the anvil, and considering the ironwork, the vapour of the fire wasteth his flesh, and he fighteth with the heat of the furnace: the noise of the anvil is ever in his ears, and his eyes look still upon the pattern of thing that he maketh: he setteth his mind to finish his work, and watcheth to polish it perfectly."

He also gave a graphic description of the work of the potter. These passages reveal a clear realization of the stresses imposed by occupation.

Again, four centuries before the Christian era, Hippocrates alluded to the difficult breathing of the metal digger.

In the sixteenth century Agricola referred to the perilous nature of mining because of the dust which caused asthma, and at times produced consumption. On that account, in the Carpathian mountains there were women who had married seven husbands, all of whom miner's consumption had brought to an early grave.

Perhaps the first reference to the application of preventive measures in industry goes back to Roman times, when Pliny mentioned that men refining cinnabar enveloped their faces with loose bladders so that they could see without inhaling the fatal dust.

**Development in Great Britain**—The history of the application of industrial hygiene in this country in more modern times is largely reflected in the industrial legislation of the past 150 years.

The introduction of power-driven machinery in the latter part of the eighteenth century made it possible for a child to perform tasks which had previously required the strength of an adult. This encouraged the exploitation of child labour, particularly in the textile mills of the north. Very young children, especially those indentured under the Poor Law, were required to work long hours, and often at night, in unhealthy surroundings. Following an outbreak of fever in the cotton mills around Manchester towards the close of the eighteenth century, there was agitation for the regulation of the working
conditions of these children, and probably as the result of this there was passed the Health and Morals of Apprentices Act of 1802. This Act, an extension of the Poor Law, marked the beginning of factory legislation. It limited the hours of work of Poor Law apprentices to 12 a day and forbade night-work; and it required that factories should be whitewashed twice a year, and properly ventilated. Further Acts of 1819 and 1831, which applied only to cotton mills, prohibited the employment of children under 9 years of age, and applied the 12-hour day to all under 18.

The limitation of the hours of work of children was extended throughout the textile industries by the Act of 1833. This Act also provided for the appointment of Government factory inspectors, and for certificates of age to be given by medical men—the first suggestion of certifying surgeons.

Up to 1842 women and children were employed in mines, often under bestial conditions. The Mines and Collieries Act of that year prohibited the employment of women or of boys under 10 years of age, and provided for the appointment of inspectors of mines.

Two years later women factory workers were included in the limitation of hours of work, and later legislation extended protection to workers in other industries and imposed some further limitations of hours.

In 1844 there was enacted the first requirement for the fencing of mill-gearing and shafting, and more than 20 year later, in 1867, the safety provisions were extended to require the fencing of machinery.

The year 1864 saw the first provisions for the prevention of industrial poisonings. The taking of meals in certain rooms where noxious materials were handled was forbidden, while employers were given power to make special rules for dangerous trades; and in 1867 the removal of dangerous dust by mechanical means was first required.

Lead poisoning was dealt with in an Act passed in 1883. In 1891 power was given to control dangerous trades, to prohibit dangerous processes until they were made safe, and to prohibit or restrict employment in trades certified to be dangerous. In 1895 medical practitioners were required to notify certain industrial poisonings.

In 1889, and later, provision was made for regulating humidity and ventilation in cotton cloth factories.

The Consolidating Act of 1901, which remained in force until 16 years ago, brought further advances. From this it is clear that the emphasis in the early years was on the protection of children, and later of young persons and women, from the evils of gross overwork. Such conditions had played havoc with the health and physique of the industrial population. Yet the protective laws were not made without a struggle, for during the first half of the last century there was bitter controversy, even after Orders in Council had restricted the hours of labour of slaves, adult and child, in British possessions overseas.

Attention to safety from injury, and from industrial poisonings, came later, and the progress in that direction was due to the initiative and devotion of the Factory Inspectorate.

From the standpoint of occupational health, a notable event in the history of the Factory Department was the appointment in 1896 of a medical man, Dr. Whitelegg, as Chief Inspector of Factories. This was followed, two years later, by the appointment of the first Medical Inspector of Factories, Dr. (later Sir) Thomas Legge, to whom industrial hygiene in this country owes an immeasurable debt.

The Factory Department waged war on industrial diseases which had earlier killed many workers. Thus, while research on silicosis was yet in its early stages, great reductions were effected in the death-rates from grinder's phthisis and potter's rot through the application of industrial hygiene measures.

There was still no agency for research in occupational hygiene, however. Such research as was accomplished was done by various people, including factory inspectors, who were already laden with other duties.

Then came the first World War. Early in 1915, the Ministry of Munitions was set up to combat the serious shortage of war supplies. Meanwhile, in the effort to make good the shortage, factory workers worked for such long hours, over so long a period, that output declined, and the health of the people suffered. Not uncommonly people were working 80 to 100 hours a week. These effects caused much concern, and the Minister of Munitions appointed the Health of Munition Workers Committee to consider and advise on questions of industrial fatigue, hours of labour, and other matters affecting the health and physical efficiency of munition workers.

In its Interim Report, published in 1917, the Committee said:

"Our national experience in modern industry is longer than that of any other people. It has shown clearly enough that false ideas of economic gain, blind to physiological law, must lead, as they led through the 19th century, to vast national loss and suffering."

In its Final Report, issued in 1918, the Committee stressed that efforts to protect the health of workers had been based mainly on the need for mitigating or removing admitted evils as they arose. The Committee expressed the view that it was necessary to make arrangements without delay for a national scheme of industrial medical research, and to accord fuller recognition to the importance of industrial hygiene.

Shortly after the dissolution of the Health of Munition Workers Committee in 1918 the Industrial Fatigue Research Board was set up under the joint auspices of the Medical Research Committee and the Department of Scientific and Industrial Research to study the relation of methods and conditions of work to functions of the human body, having regard both to the preservation of health and to industrial efficiency. The appearance of the word "fatigue" in the title of the Board is a reflection of the importance then rightly attached to the problems of hours and methods of work. In 1921 the Board was taken over entirely by the Medical Research Council, as it had then become, and later, when the emphasis on
the various aspects of its work had shifted, its title was changed to the Industrial Health Research Board.

Research bearing on occupational hygiene was also carried out by other organizations, including the Safety in Mines Research Board, the Building Research Board, the National Physical Laboratory, and, of course, the Factory Department and some university departments.

The Second World War gave a further impetus to research in occupational hygiene, partly in connexion with the war industries, and partly on behalf of the fighting services; and since the war ended there have been further developments. Many research units of the Medical Research Council are working on problems in this field, and much research effort is being put forth by the National Coal Board and the Ministry of Fuel and Power. Some of the industrial research associations also include hygiene problems in their research programmes.

The Scope of Occupational Hygiene.—It is well for us to look backwards sometimes and to appreciate and acknowledge the work done by our predecessors, who accomplished much in spite of great difficulties, much discouragement, and less powerful research methods than are now available. Yet this is a new Society. We are concerned with the present, and with the future, wherein lie our hopes, and I must turn to discuss the scope and objects of modern occupational hygiene.

Hygiene is " that branch of knowledge or practice which relates to the maintenance of health ". Health, in turn, is defined as " soundness of body : that condition in which its functions are duly and efficiently discharged ".

Occupational hygiene is not concerned only with the prevention of recognizable diseases, whether of specific occupational origin or otherwise. Its business is the maintenance of full bodily efficiency, well-being, and safety.

Of course, the prevention of industrial diseases is an extremely important part of occupational hygiene. These diseases are preventable and they should therefore be prevented. Indeed, to a large extent they are prevented, for without the vigilance and control that are already exerted their toll would be far heavier than it is today. But even so, that toll is by no means insignificant. The pneumoconioses alone annually cost the community large sums by way of compensation, and much loss of production, while to the victims and their families they bring misery.

The bulk of industrial sickness does not find its origin in the so-called dangerous trades. Most trades are not dangerous, in the sense in which the expression is commonly used, but there is the strongest evidence that rates of sickness and mortality are materially affected by occupation. It is one of the tasks of occupational hygiene to seek out and remove the causes of this excess of sickness.

Besides the prevention of recognizable illness, occupational hygiene is concerned with the application of physiological laws to the management of work. It includes the study of the effects of the working environment, and is thus concerned with the control of temperature and humidity, and the ventilation of the workplace; with lighting and noise, and, nowadays, with the control of exposures to radio-active materials. It also includes the application of physiological and anatomical principles to the arrangement of industrial tasks, the design of machines, and the arrangement of work-spells. Health and efficiency are greatly influenced by psychological factors, such as fatigue and boredom, especially in repetitive work, and maladjustment of the worker either to his vocation or to his working group. Such psychological matters as these must therefore be regarded as falling within the scope of occupational hygiene.

I should here refer to the reason for the use of the expression " occupational hygiene " in the name of our Society, instead of " industrial hygiene ", which term has been commonly used in the past.

Agriculture is our oldest industry, but one often hears the expression " agricultural and industrial workers " as though agriculture and industry were separate divisions of labour. Especially in these days when toxic insecticides are widely used, agriculture has its own hygiene problems, and it should be within the power of this Society to help in their solution. Moreover, the fighting services have their hygiene problems, some similar to those of industry and others peculiar to the Services, or to a particular Service. We wanted to be free to discuss Service problems insofar as the requirements of security permit, and it was therefore logical to use the adjective " occupational " instead of the more restrictive " industrial ".

Teamwork.—Occupational hygiene requires the employment of many skills, embracing those of the various branches of medical science, the physical sciences, and engineering. Its research problems call for the work of highly skilled chemists, physicists, petrologists, engineers, psychologists, and sociologists, as well as that of physicians and pathologists; and most of these need to acquire much of the skill of the statistician.

The practical application of the results of research work in industry also calls for skill, insight, and often ingenuity, on the part of the industrial health engineer or other person on whom that duty falls.

In both research and its application occupational hygiene calls for teamwork. That is quite evident, for men are not omniscient. There are occasions when an individual worker can get along very well under his own steam. But neither the physician nor the lay scientist will get very far without the cooperation of the other, and for work on major problems persons trained in various disciplines will be needed.

As my friend Professor Hatch put it in his Cummings Memorial Lecture to the American Industrial Hygiene Association two years ago, one can think of occupational hygiene as a joint field of specialization. The activities of the various specialist professions engaged in it are characterized by interdependence, mutual support, and
teamwork. And, Professor Hatch added, in importance these transcend the separate skills and special techniques, valuable as they are.

In that admirable lecture Professor Hatch gave a brilliant exposition of the concept of teamwork in industrial hygiene, and I commend it for your earnest consideration.

The cardinal point is that we are primarily concerned with the reactions of man to his environment. Broadly, the physician, the medical scientist, and the psychologist are concerned with man, while the disciples of the physical sciences, including the engineer, are for the most part concerned with the environment. It is from the linking together of the two sides of the work that one arrives at an understanding of the man-environment relationship.

In an occupational hygiene team, as in any other, mutual understanding is necessary for success. Aside from personal relationships, those working together must know something of each other's work. Each must understand the language of the others, and be aware of the potentialities and limitations which confront them. The physicist and the engineer must appreciate the lack of precision which is often inherent in biological assessments, whether these are clinical appraisals or estimations of biological samples, and in turn the medical man must know the difficulties which beset the physicist or the chemist in sampling, or the engineer in effecting desirable controls.

Although each member of the occupational hygiene team should know something about the work of his colleagues, and may on occasion find himself having to undertake work which might more appropriately have been done by others, there is much to be said for the cobbler sticking to his last.

Here I feel constrained to hazard a word about education in industrial hygiene as far as this country is concerned.

There are in Great Britain university departments which have provided courses of study for the medical post-graduate Diploma in Industrial Health. In some of these departments short courses of lectures have been given which non-medical people could attend. Yet there is no university in this country which offers a full course of instruction in occupational hygiene for engineers and other non-medical people comparable with the teaching provided by some American universities, and notably those of Harvard and Pittsburgh. It seems to me that this is a serious lack.

Nor do I feel that all is well with respect to the training of medical men for work in industry. The Diploma in Industrial Health is a valuable qualification, which calls for a sound knowledge of industrial medicine, but I doubt whether it requires an adequate knowledge of methods of assessing and controlling the working environment. Dr. Merewether has said that the industrial doctor should learn about industrial health as a whole. His training must bring him knowledge of the working environment and of industrial processes.

Responsibility in Occupational Hygiene.—There can be little doubt that from the material standpoint the general standard of living has been raised since the Industrial Revolution, but has that brought more happiness? Too often in this mechanized age men find themselves mere cogs in a massive and unfeeling machine.

Marvelous advances have been made in the development of machinery and industrial processes, but often at the expense of no longer needing skilled craftsmen and requiring instead just "hands". Man-management has been found wanting, and men tend to rebel against what, rightly or wrongly, they regard as a soulless machine. Surely enlightened and understanding management can remove some of these difficulties. Indeed, it has done so in some large undertakings.

Frequently, success in the application of occupational hygiene cannot be measured in terms of increased output per man-shift, important as that may be from the standpoint of industry, but rather in terms of improved health and happiness. The tendency to measure success in terms of output may give an impression of complete callousness.

Some years ago, in a paper on mechanization in coal-mines, there appeared a discussion of the basis of the calculation of accident frequency rates. The author advocated the use of rates showing the number of accidents per million tons of coal mined, and said that, provided the rates so calculated declined, he would not object to increases in the rates calculated on the basis of man-shifts worked or persons employed. It is cold comfort to the individual miner that the compensation costs per ton of coal are reduced if, while that result is achieved, the risk to him is increased.

There are various statutory requirements of employers in connexion with occupational hygiene. But industry should provide higher standards than the bare minima which will just suffice to avoid prosecution.

The industrial worker should be able to earn his daily bread without undue risk of physical injury and without risk of poisoning through the inhalation of toxic substances or other contact with them. I have said earlier that industrial diseases are preventable and should therefore be prevented. They should be prevented even though the necessary measures may be costly; and the safeguards should not impose hardship or serious and prolonged discomfort. Thus, it is iniquitous to demand of a worker that he wear a respirator as a matter of routine unless other safeguards are quite impossible. The wearing of a respirator in this way constitutes a confession by management that it has failed to deal adequately with the situation. The worker should not be exposed to unnecessary risk in order that the product of his labours may be sold more cheaply. Life is not cheap.

Methods of work, machines, and the working environment should be such as not to impose undue strain. The intelligent application of the results of physiological research can do much to ease the load on the worker, and to improve his efficiency.

Understanding management, which gives leadership
and treats the worker as a person and not merely as a productive unit, can do much to bring contentment and at the same time increase production.

The worker, also, has his responsibilities. Where means of protection against personal injury are provided he should use them. Where certain acts are prohibited in the interests of safety he has a strong moral, as well as a legal, duty to refrain from them. Otherwise he may endanger the lives of others as well as himself.

Without the full cooperation of the worker full success is unlikely, but the major responsibility rests with the employer. In that connexion I quote two axioms laid down many years ago by Sir Thomas Legge:

(1) "Unless and until the employer has done everything—and everything means a good deal—the workman can do next to nothing to protect himself, although he is naturally willing enough to do his share.

(2) All workmen should be told something of the danger of the material with which they come into contact and not be left to find it out for themselves—sometimes at the cost of their lives."

The scientist should not offer industry new processes or materials, nor should industry accept them, without first ensuring that they are unlikely to cause injury to health.

The full cooperation of the trade unions is necessary. They should seek for good conditions of work rather than for "danger money" to compensate for bad.

The full achievement of the aims of occupational hygiene calls for the devoted work of scientists, cooperating with each other and with industry, in seeking for a fuller understanding of the relation between man and his environment, and in endeavouring to remove any hazard to health with all speed, once it has been recognized, even though the perfect method of assessing the hazard may not yet have been found. Such research is likely to be arduous and often prolonged, and it may not bring resounding fame to the researcher but he will be making his contribution towards the welfare of mankind.

Finally, a yet stronger sense of mutual obligation is needed, so that employers will seek to provide healthful conditions as a moral duty, while employees will readily use the means of protection provided, as a duty to themselves and to their fellows.

So, health and happiness may be promoted, and, I believe, material prosperity increased.

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DR. HENRY F. SMITH, President of the American Industrial Hygiene Association, conveyed formal congratulations and best wishes and presented the Society with a gavel on behalf of his Association.

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Measuring the Workers' Environment
S. A. ROACH

From the Pneumoconiosis Research Unit of the Medical Research Council, Llandough Hospital, Nr. Cardiff

Although harmful materials may enter the body by ingestion with food or by absorption through the skin, in many industries their most important mode of entry is by inhalation. The material may, like poisonous gas, be immediately dangerous, or its effects may be the result of the accumulated exposure of a life time. The problems arising in determining the risk to health by means of measurements of the environmental conditions may appear at first sight to be very different, but I hope to show in this paper that they are actually very similar, if not identical.

The Period of Accumulation

A substance may enter the respiratory tract in the form of solid particles or liquid droplets or as a gas. Solid particles and liquid droplets are deposited on the upper respiratory tract, the coarser particles being deposited first and the finer particles sedimenting out in the deeper parts of the tract. If they are not immediately dissolved the coarser particles are removed by ciliary action and may subsequently be swallowed. The finer particles which have been deposited in the alveoli may remain in the lungs indefinitely if they are insoluble, so that the amount of dust in a man's lungs is roughly proportional to the product of his age and the average concentration of dust to which he has been exposed since birth.

On the other hand a relatively soluble dust such as lead is absorbed in the lungs so that it fairly rapidly accumulates in the blood, tissues, and skeleton, and is eventually excreted. The rate of solution increases with the amount of material deposited in the lungs and the rate of excretion of the material increases with the amount in the body, so that under exposure to a constant concentration a level of equilibrium will eventually be reached when the amount in the body is such that the rate of excretion just equals the rate of deposition in the lung.

In contrast to coal and silica, the lead in the body is slowly excreted when exposure ceases and the lead content usually reaches normal values within about 18 months (Kehoe, Thamann, and Cholak, 1933). Thus the amount of lead in the body is determined by the level of exposure over the previous 18 months and, to a great extent, by that within the previous few weeks.

The period of accumulation is even shorter in the case of harmful gases. Both absorption and elimination take place in the lungs, and, once the blood becomes saturated, accumulation in the rest of the body (when it takes place to any significant extent) is dependent on the concentration in the blood. For example, with a vapour such as benzene, saturation of the blood is reached within a few minutes; and saturation of the tissues is reached in two or three days (Schrenk, Yant, Pearce, Patty, and Sayers, 1941).