

The Broader Context

An Occasional Series

British Occupational Hygiene Practice 1720–1920

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The first recognition of the profession of occupational hygienist was preceded by at least 200 years of developments in disease prevention practices in the workplace, many of which could readily be characterized as occupational hygiene. The nature and pace of adoption of these practices depended on the contemporary state of technology, science, medicine and social concern. At first it was a matter of individual initiative and did not depend on quantitative data, but by the second half of the 19th century techniques of measurement for both harmful effects and for exposure were being introduced and official bodies at both national and local level were active. People from a wide range of backgrounds made contributions to disease prevention at work and by 1920 most of the major concepts and practices of current occupational hygiene practice were in place, if only in rather limited settings.

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CREATION MYTHS

Myths about the origins of events and institutions abound and occupational hygiene is no exception. Sellers (1997), in his detailed study of occupational hygiene in the USA, suggests its birth there in the first two decades of the 20th century. He indicates that it was conceived out of the rather tense inter-course between the Bureau of Labor Standards, whose ethos was the creation of good working conditions, and the US Public Health Service, with its focus on examination to detect disease as the basis for action. Alice Hamilton, writing in 1929 does acknowledge the lead of European countries in relation to control of chemical poisoning (Hamilton, 1929). However, it is these American origins which are usually cited in the discourse of hygiene professionals as being the beginnings of their subject. This review points to the evidence which supports a much earlier origin than is generally acknowledged for most occupational hygiene concepts, an origin which

was closely intertwined with the industrial development of Britain and which also involved major innovations in other European nations.

DOWN THE MINE

The main social, legal and technical contexts for the development of hygiene practice in the workplace can be readily characterized by examining the world of mining. Like the rest of the developments reviewed, this examination will not be a comprehensive one but will look at examples to illustrate the origins, growth and fate of key concepts.

The world of miners, as presented by authors such as Agricola (1555), was one of largely self-regulating guilds, who supported standards of practice by apprenticeships, and supported members who became sick or injured by guild benefits. Harm due to work was prevented, where possible, by guild regulations, for instance about the timing of fire-setting in mines. It seems that many diseases were perceived as the inevitable consequences of a trade, a belief that has proved to be very persistent. The separation of capital and labour seen in the industrialization of Britain created a weak and readily exploited group of

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unskilled workers. The reforms in mine legislation from the 1840s sought to protect such groups, in terms of both their physical and moral welfare, and were in part engendered by the 1842 Royal Commission report on the Employment of Children in Mines, which included heart-tugging illustrations. This concern resulted in regulation of the mining industry and thus provided the framework for later actions to control health risks. Among the first of these risks to be recognized was the harmful effect of a technical innovation in mining, the pneumatic drill, known as the 'widow-maker' because the dust level was such that if quartz-containing rock was drilled silicosis set in within a few years (Hunter, 1975). This massive risk led to early attempts to quantify dust levels, especially in the Rand gold mines of South Africa. Speedy reductions in exposure as a consequence of wet drilling were soon followed by a measurable fall in lung disease (Hunter, 1975). However, one of the abiding problems of occupational disease prevention arose: the disease was termed 'miners' phthisis', a term normally equated with tuberculosis, but it was subsequently found to have a complex pathology, starting with the fibrosis of silicosis, which in turn makes the lungs more susceptible to tuberculosis bacterium infection. This illustrates how the characterization of risk and the measurement of the effectiveness of control both depend on a good understanding of the natural history of the disease risk in question, although prevention can often be improved even in the absence of full information on the pathology.

An overview of this high risk sector shows how the interactions between the organization of work, social and political attitudes to it, the development of technology, and the understanding of exposure, disease and their relationship all determine the recognition of risk and the response to it. This pattern of concern and investigation leading to action can be used to consider the significance of the range of examples of early hygiene practice which follow.

THE CONDITION OF ENGLAND

In the mid-19th century a series of books was written by authors such as the Brontës, Disraeli and Elizabeth Gaskell which brought the conditions of industrial workers and the tensions of industrialization to the attention of the reading public away from industrial areas. In *North and South* (Gaskell, 1855, p. 146) we find a young mill girl, Bessy, talking to the daughter of a vicar, Margaret, who had recently moved to a cotton town:

'I began to work in a carding room soon after, and the fluff got into my lungs and poisoned me.'

'Fluff?' said Margaret inquiringly.

'Fluff,' repeated Bessy. 'Little bits, as fly off fro'

the cotton, when they're carding it, and fill the air till it looks all fine white dust. They say it winds round the lungs, and tightens them up. Anyhow, there's many a one as works in a carding room, that falls into a waste, coughing and spitting up blood, because they're just poisoned by the fluff.'

'But can't it be helped?' asked Margaret.

'I dunno. Some folk have a great wheel at one end o' their carding rooms to make a draught, and carry off th' dust, but that wheel costs a deal o' money – five or six hundred pound, maybe, and that brings in no profit; so it's but a few of th' masters as will put 'em up: and I've heard tell o' men who didn't like working in places where there was a wheel, because they said as how it made 'em hungry, at after they'd been long used to swallowing fluff, to go without it, and that their wage ought to be raised if they were to work in such places. So between masters and men th' wheels fall through. I know I wish there'd been a wheel in our place, though.'

Not many of the arguments now advanced for and against the control of health risks at work were missing from this passage written nearly 150 years ago! If thinking was by then so well formed and readily popularized how far back do we need to go to find the first examples of hygiene practice?

BENSON'S PATENT

Another myth tells how the observation of the fine white powder from calcined flint used in 1720 to treat eye disease in a Staffordshire potter's horse while travelling through Dunstable led to its widespread use to make white ceramics (Shaw, 1829). In less than 10 years calcined flint became a large scale ingredient of Staffordshire wares, with widespread lung disease in its wake. Thomas Benson, a painter and decorator working at one of the mansions near the Staffordshire potteries, heard of the problem and invented a solution based on the way in which paint pigments and fillers were ground. This he patented in 1726, stating:

... method hitherto used in preparing hath been by braking and pounding the stones dry, and after sifting the powder through fine lawns, which hath proved very destructive to mankind, occasioned by the dust sucked into the body, which being of a ponderous nature fixes so closely upon the lungs that nothing can remove it. ... (Benson, 1726)

His patent specifies grinding under water using balls, originally of iron, but later of chert because that did not add rust to the product (Fig. 1). The invention formed part of one of Erasmus Darwin's (Charles Darwin's grandfather) verses of 1789–91 celebrating

The grinding pan

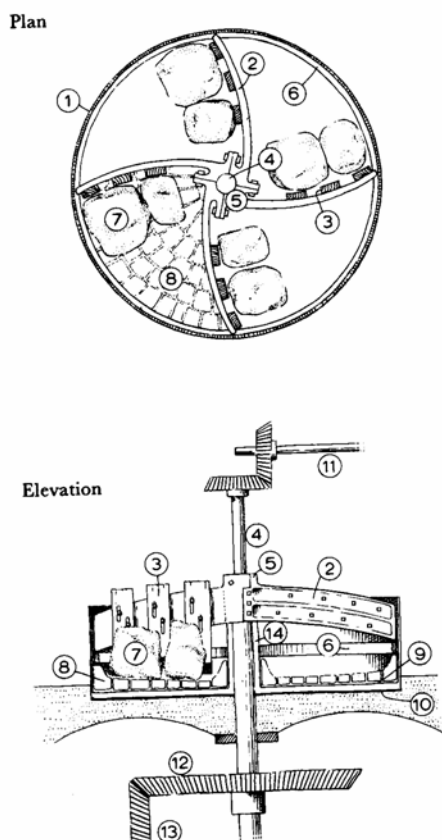


Fig. 1. Benson's device for wet grinding of flint (Benson, 1726).

progress, although Darwin, a doctor and close friend of Josiah Wedgwood, nowhere mentions the lung risks in his extensive medical writings:

Gnomes! as you now dissect with hammers fine
The granite rock, the noduled flint calcine:
Grind with strong arms, the circling chertz betwixt
Your pure ka-o-lins and pe-tun-tses mixt.
(Darwin, 1789–1791)

ARTS AND SCIENCES

Others were interested in both the origins of disease at work and their control. Thomas Beddoes in a publication of 1793 debated causation with William Withering, who introduced foxgloves (*Digitalis*) for the treatment of heart disease; the former was an admirer of Darwin and the latter something of a sparring partner:

Japanners are constantly breathing the vapours of resinous substances, but I never could observe that they were more or less subject to phthisis than others; caster of fine brass work very often die consumptive, much more so than other sets of artists in Birmingham. They dust their moulds with powdered rosin, the vapours of which rise copiously when the melted metal is poured in. But the mischief can hardly be attributed to this vapour, otherwise the Japanners would be affected; nor yet the flowers of zinc, which are copiously diffused through the work-shops, because the casters of large brass work are not peculiarly liable to become consumptive. I suppose the phthisis in these instances to be caused by the mechanical action of the powdery matter which float in the air in great quantities in these fine casting shops, and are necessarily taken in with the breath. Whilst flints for the potteries were pounded in mortars, the people so employed universally died consumptive, and the grinders of needles now often experience the same fate. (Beddoes, 1793)

Their final point, on needle grinding, pre-dated the description of this risk in Redditch, the hub of needle manufacture, by James Johnstone (1799).

However, much of the concern about work and health in the 18th century concentrated on the rather specific forms of poisoning associated with the heavy metals rather than the complexities of lung disease. Mercury poisoning was commonplace because mercury was about the only effective treatment for syphilis and familiarity with the symptoms meant that industrial poisoning, particularly associated with button gilding, ormolu manufacture and mirror silvering, all of which used mercury to amalgamate and spread gold or silver, was readily recognized. So much so that in 1778 the Society of Arts (later Royal) offered prizes for methods to control poisoning. Several devices for containment of vapours and usually also their recovery were developed, although it was not until the next century that electroplating and chemical deposition of mirror silver were introduced, thus eliminating these mercury poisoning risks (Wood, 1913).

Lead was the other widely used poisonous heavy metal. The risks, both to miners in the Mendip Hills of Somerset and to cattle in the fields around mines and downstream from sources of mine water, were noted by Samuel Johnson in the first edition of his dictionary (Johnson, 1755). It was lead in pottery glazes that caused most controversy. Some potteries, such as Coalport in Shropshire and Josiah Wedgwood's in Staffordshire, tried to remove it from their glazes. However, the latter also defended its use in his highly profitable creamware, and when challenged by Thomas Percival of Manchester and others gave the robust rejoinder 'that quieting one of these

gentlemen would only be lopping off one of the Hydra's heads' (Finer and Savage, 1965). Lead, then as now, was an issue for users of the ceramics as well as for the workers who made them and it is perhaps the threat to markets as much as to workers which led to these efforts to eliminate it.

VICTORIA'S CENTURY

The start of the 19th century saw a long series of wars with Napoleon and a general mood of austerity. It was not until the great reforming administrations of the 1830s that health and work again became a public issue, with the Factories Act and changes to local administration. The health of towns became a major public issue, especially following the 1831–1832 cholera pandemic. Thus the environment and disease became a prominent feature of scientific and medical debate leading to preventative approaches such as glazed sewers and clean water supplies (Porter, 1999).

Although medical authors such as Thackrah (1832) in Leeds and Darwell (1833) in Birmingham wrote about disease and work, the 1830s and 1840s were a time when both government and employers sought to minimize state interference with industry, and innovations in hygiene practice were largely a matter for individual enthusiasts. The wider public health debates did not intrude greatly into the workplace (Wohl, 1983). The needle pointers of Redditch were a group who illustrated the extent of informal action. Following medical recognition of the risk of death from lung disease after around 10 years work as a pointer, the Society of Arts offered prizes for 'contrivances' to prevent this harm. Several were commended, including a mask with magnets to remove the steel particles, then seen to be as likely a cause of harm as the silica dust from the grindstones. Holland (1843) of Sheffield and others developed local exhaust ventilation systems based on hoods around the grindstones with fans to extract the dust-laden air (Fig. 2). 'The Fan' became a cause of controversy in Redditch, with the pointers, an elite group who were paid a risk premium which made their wages several times higher than other workers, resisting its introduction because it would reduce their wealth and status, while the manufacturers supported it as a cost-saving measure! (A. Spurgeon, personal communication 2004).

The limited resources of the early factory inspectorate were concentrated on the power mills of the textile industry and paid little attention to the specific health risks from work. The majority of workers were either in small workshops, often working very long hours and exposed to a wide range of risks, or working outside in agriculture, construction or other industries where some forms of contamination might be removed by natural ventilation but where, in the

absence of effective protection from the cold and wet, being soaked and chilled were everyday occurrences.

A LAMP IN THE WORKPLACE

By the 1850s the health effects of work had become matters of public interest. Other powerful creation myths surround Florence Nightingale, as both the reformer of army medicine and as the founder of the nursing profession. She was, however, a campaigner on all aspects of health protection by the improvement of the environment and the systematization of precautions. Writing at the same time as Mary Gaskell, she entered the debate with some robust polemics (Nightingale, 1859).

How much sickness, death and misery are produced by the present state of many factories, warehouses, workshops, and workrooms! ... Employers rarely consider these things. Healthy workrooms are no part of the bond into which they enter with their workpeople. They pay their money, which they reckon their part of the bargain. And for this wage the workman or workwoman has to give work, health and life.

... And yet the master is no gainer. His goods are spoilt, his own health and that of his family suffers, and his work is not so well done as it would be were his people in health. ... And the time will come when it will be found cheaper to supply shops, warehouses and workrooms with pure air than with foul air.

Work people should remember that their health is their only capital, and they should come to an understanding among themselves to secure pure air in their places of work, which is one of the prime agents of health. This would be worth a "Trades Union", almost worth a "Strike".

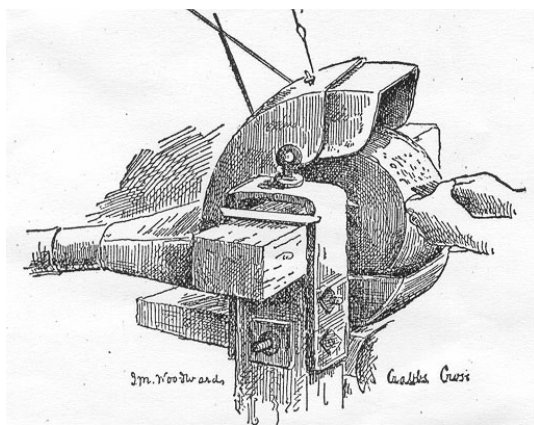


Fig. 2. An extraction hood for a grinding wheel.
From Heming (1877).

Surprising sentiments from someone who is now seen as a pillar rather than a scourge of Victorian values.

Awareness of harm to health from work was made apparent by the registration of causes of death which was started in 1836. This data came into its own with the work of John Simon, the Medical Officer of the Privy Council. His reports of 1860 and 1861 contained detailed supplements reporting the investigations of Edward Headlam Greenhow in those locations with high mortality from lung disease (Simon, 1860, 1861). He found that the highest risks were where many were engaged in dusty jobs, such as metal grinding, coal, iron, textiles and mining. Both reports contain reviews of this data and are rich in examples and astute observations, one at least anticipating the Tyndall beam by several years:

The occupation of needle pointing is still attended with injury to health. A small quantity of fine dust, only perceptible when the sun shines brightly, escapes the indraft of air produced by the fan.

The 1861 report included a hard-hitting account of the shortcomings in existing legal remedies and lack of concern about harmful contaminants in the workplace. The report was not in vain, as the 1864 Factories Act included the first provision for enforceable ventilation requirements. However, two important pieces of information were missing: the causes of common problems such as lung disease were poorly understood, and the levels of exposure which caused them were not known. This meant that ventilation was necessarily seen as a general good rather than a technique to be used in a focused way to remove specific contaminants.

About the only widely used measurement at this time was temperature, but this was being supplemented by techniques for the main atmospheric gases. The study by Lethbridge (1862) on the poisonous effects of carbon monoxide exemplifies the new interest of chemists with their quantitative methods. His report includes the results of quantitative studies of the relationship of concentration and time to harm in animals and links these findings with details of a series of accidental exposures in people.

THE FIRST LIMITS

The general requirement for ventilation had only a limited effect, no doubt for the reasons portrayed by Mrs Gaskell, but it was the cotton industry which saw some of the earliest atmospheric standards being set. The general appointment of Medical Officers of Health (MoH) to boroughs from 1872 created a local focus for investigation of disease risks. In 1887 Dr Stevenson of Blackburn surveyed the town's health

and concluded that 'the poor ventilation and heavy steaming in the cotton mills was injurious to the health of those who work in them' but would not be with proper attention to ventilation. The Cotton Cloth Factories Act 1889 set maximum humidity levels and a limit for carbon dioxide levels of nine volumes for every thousand volumes of air (Wheatley, 1902). This led to both a general interest in the techniques of ventilation (Casmey, 1901), including the different forms of fan and their economy and effectiveness (Carter, 1907), and to the development of sampling devices. Dr Scurfield, the MoH for Sunderland, patented a system of indicator tubes for carbon dioxide, using a weak solution of barium hydroxide with phenolphthalein as an indicator of acidity. The indicator changed colour as the solution was acidified by the carbon dioxide in a measured amount of air being drawn through the tube as a vessel of water emptied (Sutcliffe, 1900). All these developments were based on observations showing non-specific increases in mortality without any clear links between specific risks and particular diseases.

GERM THEORY

From the 1860s the bacterial causes of infectious illness started to be recognized. This revolutionized public health, as specific remedies could be applied to particular diseases. The concept of specific links between risks at work and harm also came to dominate thinking, well shown in the work of the Home Office Dangerous Trades Committees, which devised sets of precautions for a range of occupations. It is even more clearly seen in the response to the recognition that woolsorters' disease (lung) and malignant pustule (skin) in the wool workers of Bradford were linked to the anthrax bacillus, a disease brought to the town in wool imported from countries where it was endemic in flocks and herds (Laforce, 1978). Anthrax in man was never more than a locally important condition with some tens of work-related deaths a year, trivial by comparison with the effects of dusts on the lungs, but it occurred in defined groups of well-organized and skilled workers such as woolsorters and could be rapidly fatal. Action was initiated by Bradford Borough Council (1884), which issued a set of precautionary rules. These prescribed a comprehensive occupational hygiene management system which did much to reduce the inhalation risks.

- ... The sorting rooms for all classes of Mohair, Camel Hair, Persian, Cashmere, and Alpaca shall be provided with extracting ventilation so arranged that each sorting board [hurdle] shall be independently connected with the extracting shaft, in order that the dust arising from the

material being sorted may be drawn downwards and thus is prevented from injuring the sorter.

- The dust collected by the fan must not be discharged into the air, but be received into properly constructed catchments and must be afterwards burnt. This must be attended to at least twice a week. The sweepings from floors, walls and from under the hurdles shall be similarly treated. All pieces of dead skin, scab and clippings or 'shear-lings' must be removed weekly from the sorting room, and must not be dealt with or sold until they have been disinfected.
- All bags in which wool or hair has been imported shall be picked clean and not brushed, and such bags shall not be sold or used for any other purpose until they have been disinfected.
- No sorter having any exposed open cut or sore upon his person shall be allowed to sort.
- ...The sorting rooms shall be well ventilated. ... The sorting rooms shall be warmed during cold weather.
- ...The floor or the sorting room shall be thoroughly sprinkled with disinfectant so as to allay dust. ...

- ...Proper provision shall be made for the sorters to wash in or near the sorting room.

A notable innovation was the use of tables ventilated by downdrafts for sorting wool as the prime means of dust control (Fig. 3).

The specificity of anthrax meant that many other aspects of hygiene practice were pioneered here. Extensive studies were undertaken, from 1906 by Dr Eurich of the Bradford Anthrax Investigation Board, into the risks of different wools and, jointly with Duckering of the Factory Inspectorate, into the scope for control by disinfection (Bligh, 1960). Case notification was introduced and trends in different industries used to assess the effectiveness of control (Legge, 1934). Case fatality was reduced by the use of a newly developed antiserum (Carter, 1999). When the incidence in the wool industry failed to come down a major governmental enquiry was launched (Departmental Committee on Anthrax, 1918). This led to the building of a disinfection station in Liverpool based on Duckering's work and a not entirely satisfactory requirement that certain

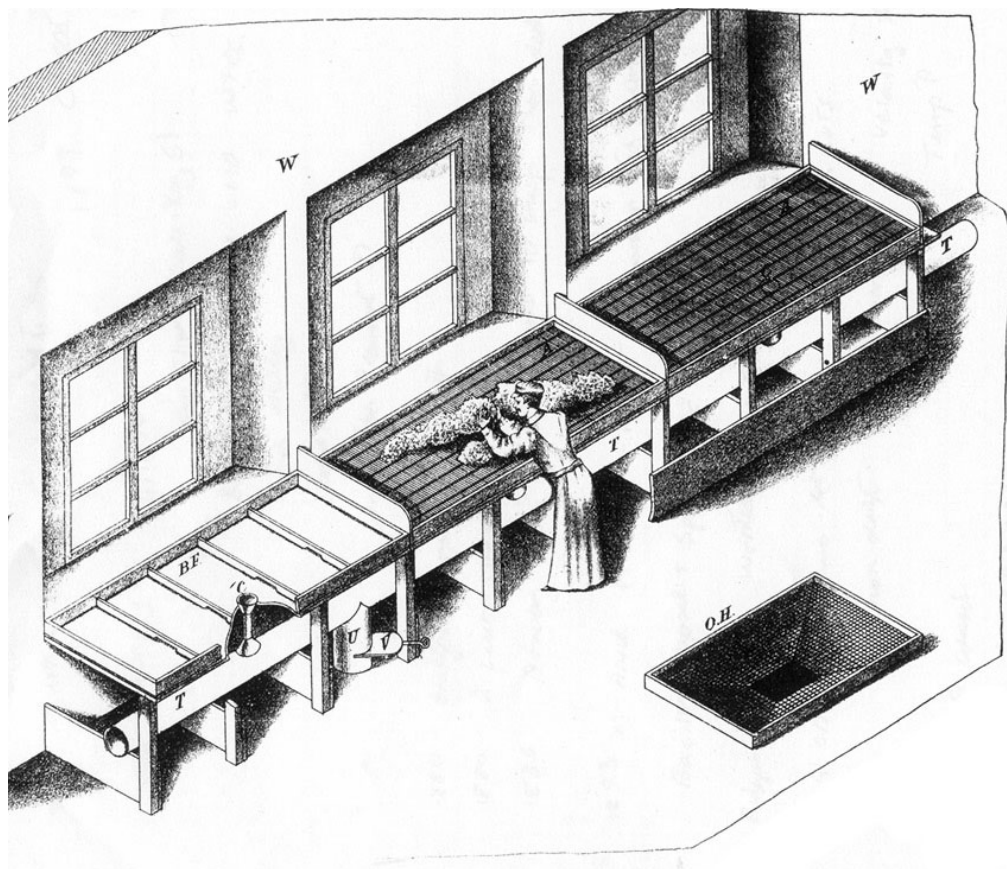


Fig. 3. An 1897 downdraft bench used for anthrax control in fleece sorting.

wools were disinfected on import (Mortimer and Melling, 2000).

MEDICAL INSPECTOR

The appointment of Thomas Legge as Medical Inspector of Factories in 1898 opened a new era in occupational disease prevention and the development of hygiene principles. His two most enduring areas of work were anthrax and lead. Counting cases of lead poisoning to justify action was much more complicated than for anthrax because of diagnostic uncertainties. As the Annual Reports of the Chief Inspector of Factories show, he did achieve a degree of consistency and realized that better science was essential to make the case for prevention. There was considerable controversy about whether lead entered the body through the skin, by ingestion or by inhalation, with manufacturers favouring the first two routes as they could lay the blame on workers failing to take precautions. Legge demonstrated conclusively that lead entered mainly by inhalation and therefore prevention was in the hands of the factory owners: backing this up with advice and regulations on ventilation. However, skin decontamination was not ignored and washrooms were also required. Chemistry had by this time advanced to the stage where the rate of intake of lead required to produce poisoning could be calculated and used to form the basis for risk criteria (Legge and Goadby, 1912).

A HUMAN CANARY

The causes of collapse and death from atmospheric conditions in mines, vats, wells and caissons were mysteries for much of the 19th century, but the work of J.S. Haldane put these risks on a rigorous and well-quantified footing. He both investigated accidents and undertook experimental studies, many on himself, which sometimes ended in unconsciousness in his exposure chamber! From these he derived dose–time plots for severity of discomfort and risk (Haldane, 1895, 1902), as well as showing that the prevalent belief that there were specific toxins in exhaled air was without foundation (Haldane and Lorrain Smith, 1893). Clearing away this misconception did much to direct attention away from generalities about vitiated air and focus on specific and remediable risks (Carter, 1981). Haldane's work is still with us in the widely reproduced graphic representation of carbon monoxide poisoning showing the severity of harm from a matrix of times and concentrations for a miner and, sometimes, a canary. It is also worth noting that in the canary he proposed a near personal sampling device which integrated exposure and had a directly readable output, although with some errors in the response curve as a predictor of human risk.

The elegance of late 19th century occupational hygiene practice can readily be seen in his studies of the atmosphere in the Metropolitan Railway in London (Board of Trade, 1898). Passenger complaints about smell and smuts and their effects, not only on clothes but on health as well, led the Board of Trade to commission an enquiry. The main atmospheric gases and exposure times were measured. It was concluded that the major risk was from carbon monoxide, but that this was only relevant to a few railway workers who were in the tunnels for most of their shifts. It was, however, easier to measure carbon dioxide, and as the ratio was constant this could be used to assess risk. The nuisance came from smuts and sulphur dioxide. These could be controlled with low sulphur coal and careful firing of the engines. Like so many studies, this one became irrelevant because electric traction was introduced a few years later (Oliver, 1902). It remains a model of good investigation to this day.

Haldane's interest in mine gases was a major spur to effective respiratory protection. 1900 was in the era of rag masks and any breathing apparatus was a land equivalent of the diving suit. However, by 1914 self-contained breathing apparatus was available for mine rescue workers, with considerable benefits in terms of overall safety in the mines.

THE GREAT WAR

The challenges of war production led to both disruption and damage to health, nowhere more so than in munitions manufacture. Long hours were worked, often by inexperienced female workers drafted in to replace men who were fighting. TNT shell filling led to deaths from liver necrosis, and control became a national priority as production of essential munitions was threatened. A high level of expertise was brought to bear and solutions involving automation, exposure reduction, medical surveillance and job rotation were introduced (Legge, 1917). More widely, it was recognized that the harsh conditions of work were responsible for a decline in safety and productivity. Detailed investigations by the Health of Munitions Workers Committee (1917) laid the ground for many subsequent practices in ergonomics, psychology, welfare and shift-work regimes.

CONCLUSIONS

This survey has necessarily been both sketchy and eclectic. Examples have been used to show how the recognition, measurement and control of health risks at work developed in the 200 years before the discipline of occupational hygiene became conscious of itself. The examples cited indicate that there are relatively few fundamental occupational hygiene principles that were not in existence prior to 1920. The

frameworks of recognition, evaluation and control were well established and methods were advancing in response to new science, technology and social concerns.

Most of the examples cited, at least after 1850, had a major element of governmental involvement, and this reflects the huge expansion of the state into public health and industrial activities. Hygiene practice during this period can be seen as part of a larger pattern of state intervention which sought to improve conditions by imposing duties on others. Governmental intervention was less dominant in the 1920s–1930s, and hygiene skills were widely used within productivity- and welfare-orientated businesses of America and later Europe to both reduce harm and increase efficiency. Was it this ‘privatization’ which created the new self-aware brand which called itself ‘occupational hygienist’ rather than any new science or the need to control new problems?

It is interesting to consider two recent appreciations of classic papers by occupational hygienists in the light of a longer perspective. Cherrie (2003) gave Jerry Sherwood’s work on personal sampling in the 1960s the accolade of ‘The beginning of the science underpinning occupational hygiene’. In a similar vein Stan Roach’s work on exposure patterns, body burdens and the risk of harm has been cited as a first (Rappaport and Flynn, 2003). However, similar issues were investigated and demonstrated, although with poorer techniques and less mathematical rigor, by Haldane (1895) for carbon monoxide and by Legge and Goadby (1912) for lead. Is it that, after a long period dominated by assumptions that protecting the average worker was the basis for workplace hygiene, these pioneers of the 1960s were simply rediscovering that individual variation mattered? Florence Nightingale would have approved; this aphorism of hers could be seen as the foundation for good hygiene practice in any age, whether or not it is the province of someone called an occupational hygienist:

There are two habits of mind often equally misleading:– (1) a want of observation of conditions, and (2) a habit of taking averages.

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