that had to be provided for in the Fleet Ditch, in addition to the sewage let into it on both sides. This was a question which was considered now, but was not thought of years ago. Regarding the difficulties of dealing with rainfall he instanced India, where twelve inches of rain had been known to fall in twenty-four hours, and pointed to the enormous volumes which at times fell in Australia. How could such great volumes of water be dealt with in sewers? With regard to India, he would prefer to confine himself to dealing with the waste water from houses. Turning to the question of sewage, he said it contained all the ingredients from a large population, and was undoubtedly rich in manurial character. All chemicals that were used, in his opinion, polluted the sewage, and clarified sewage became stinking in spite of the clarification. Mr. Crimp had indicated that the sewage must eventually go to the land, and therefore he thought it a great pity so much money was to be wasted on the costly barges now in construction. He said that at the mouth of the Thames there was a splendid area of sand over which, if turned by conduits, the sewage might be allowed to run. Contracts might be made with farmers to take sewage for irrigation purposes, and he thought that if it could be obtained, farmers would pay a good price for it. In his opinion statesmen had made a great mistake when they took the dues off coal and wine, as coal had not been made any cheaper, and poor people had not consumed wine, and the dues might now have paid for the necessary outfall sewage works.

Mr. Santo Crimp (London County Council) said, in reply to the discussion, that his task was a light one, because Mr. Rhodes had answered many of the questions. With regard to the storm-overflows at Old Ford, these were placed upon a navigable canal, with a very slight current, and the effect was to convert the canal into a settling tank when the overflows were in operation. The arrangement was therefore not a good one. Of course the pumping down at Abbey Mills only affected the storm-overflows on the low level system, and not those at Old Ford. With regard to Col. Jones's remarks, they had experienced some trouble in pumping sludge through mains, some 900 feet in length, and he thought it would be rather risky to attempt to pump it as far as Canvey. One speaker had referred to the Berlin farms, no doubt these were interesting, but so far from sewage farming being played out in this country, we had at Birmingham the sewage of 600,000 persons applied to the land; at Nottingham, 213,000; at Leicester, 180,000; and nearer home, about 80,000 at Beddington, and 30,000 at Wimbledon, and sewage farms in this country were constantly being extended. With regard to London, the question was a very large one, but they had in Essex land that was unmanured and uncultivated, they had sewage that was unutilized, they had labour that was unemployed, and if the liquid and the labour could be employed upon the land without placing a burden upon the shoulders of the ratepayers, he thought it was a consummation devoutly to be wished.

LECTURES ON THE SANITATION OF INDUSTRIES AND OCCUPATIONS.

OCCUPATION AND MORTALITY.

By ARTHUR NEWSHOLME, M.D.Lond., M.R.C.P., D.P.H.
Medical Officer of Health, Brighton.

Read November 2nd, 1893.

The lecture which I have the honour to give is introductory to a course of six lectures, to be given by various specialists, which, although they cannot, of course, cover the whole range of the sanitation of industries and occupations, will, it is hoped, give a practical insight into some of the more important problems connected with this subject.

The importance of the subject.—A moment's reflection will show the enormous influence of a man's occupation on his health. At least one-third of each working day is spent under the conditions implied in this occupation, and it may therefore be credited with this proportion of the total influence exerted by the circumstances of life on health. The influence exerted by occupation is however much greater than this. Conditions of overcrowding are more deleterious during active work than when lying quietly in bed. Overcrowding implies an atmosphere loaded with the products of respiration, which are when re-breathed a fertile source of disease. Dr. E. Smith found that if the air inspired lying down be represented by unity, the amount inspired when standing erect is 1·33; when on a treadmill, lifting 196 lbs. through 1920 ft. per hour, 4·40; and when walking four miles an hour, 5. Not only is more air inspired during active work, but there is a corresponding increase in the amount of carbonic acid eliminated by the lungs. Thus during rest 13·11 grains of CO_2 are expired per minute; on a treadmill, under the conditions named above, 57·68 grains per minute. If, as in ill-ventilated warehouses and shops, the carbonic acid resulting from respiration is not quickly got rid of, the substance of the muscles becomes loaded with carbonic acid and their activity diminished. For this reason, if for no other, it would be economical for large employers of labour to provide an abundant supply of fresh air for their workpeople.

Conditions of overcrowding in insanitary factories and workshops are aided by the effects of inhalation of dust and irritating or offensive effluvia, or the absorption into the system of chemical poisons, or the effects of undue strain or over-exertion. These various considerations give to the industrial side of hygiene an importance which is secondary to no other.

Past Neglect of Industrial Hygiene.—Notwithstanding its importance it cannot be said that Industrial Hygiene is one of those "flat and flexible topics which have been beaten on by every hammer." There are scattered papers in the medical journals, and in the reports of factory inspectors, and a few papers contributed to the Royal Statistical and other societies, and three or four books, of which the most recent and at the same time the most accurate and exhaustive is Dr. Arlidge's *Diseases of Occupations.* These represent the whole literature of the subject in English. French and German hygienists have expended much more labour on the subject; they have published elaborate statistics which are very generally defective or fallacious in one particular or another; and under the different conditions holding good in this country but little use can be made of the data they have collected.

Legislation on Industrial Hygiene.—In saying that industrial hygiene has been much neglected in the past, the importance and value of factory and workshop legislation is not ignored.

A legislature, which, urged on by the pressure of public opinion, has passed the Factory and Workshop Acts, culminating with that of 1891, and has devised and arranged so many checks and curbs on unscrupulous masters and careless workmen; which has altogether prohibited the employment of women in certain industries, and curtailed their hours in others; which has raised the minimum age of employment of children in factories and workshops to eleven years, and insists on a previous medical examination of all children thus employed; which has by the Shop Hours' Act of 1891 prohibited the employment of young persons under eighteen in shops for a longer period than seventy-four hours, including meal times, in any one week; and which has by the Alkali Works Regulation Acts, the Coal and Metalliferous Mines' Regulation Acts, the Merchant Shipping Acts, the Canal Boats' Acts, &c., regulated other industries in a more or less efficient manner, cannot be said to have adopted the policy of national selfishness, which is embodied in the theory of *laissez-faire.* The majority of these enactments are still administered by Government Inspectors. These inspectors have in the past done work of great importance to the health of the community. The principle is however being gradually accepted that this work should be delegated as far as possible to Local Authorities. In the case of bake-houses this has been already done with good results, and gradual extension of such

decentralisation is desirable. If this work is placed more fully in the hands of Local Authorities, the appointment of inspectors should be made compulsory on these Authorities, and districts should be so combined as to ensure the appointment of skilled inspectors, with reasonable fixity of tenure of an office, which like other sanitary work implies interference in the interest of workers with wealthy proprietors.

What is rather meant, when I state that industrial hygiene has been neglected in the past, is that the opportunities afforded for investigating and elucidating the influence of various industries on the health of the workers in them, have not been fully utilised; and as sound progress in the prevention of industrial diseases must rest on medical and hygienic study of these diseases, valuable time has been to that extent lost.

Much of this neglect of investigation into industrial diseases is owing to the difficulties inherent to such an enquiry. The pathological material connected with our large hospitals has been utilised to a certain extent. The medical enquirer has, however, in investigating the relative prevalence of any disease in a given occupation, been beset by overwhelming difficulties.

Statistics of Occupations.—Correct statistics of any occupation can only be obtained when the deaths in that occupation are stated in proportion to the total number of persons engaged in it. An initial requirement is therefore an accurate statement of the number engaged in each occupation.

Difficulties in Classifying Occupations.—Classification is by no means an easy task. The number of distinct industries in this country is enormous. Most of these industries are sub-divided with great minuteness, thus further complicating the task. Twenty-four orders of occupation are described by the Registrar-General, which comprise eighty sub-orders or genera. The orders are grouped into six classes; viz., professional, domestic, commercial, agricultural, industrial, and non-productive. The lines of demarcation between these classes must not be supposed to be very definite, though the classification is convenient.

The number engaged in each of these six classes at the census of 1891 was as follows:—

	Persons.	Males.	Females
Total aged 10 yrs. & upwards..	22,053,857	10,591,967	11,461,890
Professional Class	926,132	597,739	328,393
Domestic Class	1,900,328	140,773	1,759,555
Commercial Class	1,399,735	1,364,377	35,358
Agricultural & Fishing Class ..	1,336,945	1,284,919	52,026
Industrial Class	7,336,344	5,495,446	1,840,898
Unoccupied Class	9,154,373	1,708,713	7,445,660

Whatever classification of occupations is adopted errors must occur, largely owing to *ambiguity in the nomenclature of occupations.*

A drummer may mean either a musician or a blacksmith's hammerman; an engineer may be either a maker or a driver of engines; a collar-maker may be a seamstress or a harness-maker. In these instances the confusion is only between two occupations. But the same name may apply to a larger number of different trades. Cotton, silk, wool, and flax factories alike have spinners, weavers, &c., and unless some further specification is added to these occupations, confusion must arise. Similarly, merchants, miners, mechanics, artisans, and labourers, are frequently returned as such without further definition, thus rendering their classification under special headings impracticable.

One great source of difficulty is the occurrence in the same individual of *double occupations.* The same person may be a farmer and a miller, a plumber and a gas-fitter, or a clergyman and a schoolmaster. The general rules adopted in the census * are that a constructive or mechanical handicraft is invariably preferred to a mere shop-keeping occupation; and that of two occupations, the apparently more important one is to be selected; or failing any special indication, the occupation first named on the census return is to be taken.

Another great source of difficulty is in *the separation of classes.* It is often very difficult to separate between masters and men in any given trade or manufacture. A watchmaker or tailor may be either a master or journeyman, the health conditions in the latter case being probably much more unfavourable than in the former; and similarly in other cases.

The difficulties in classifying the occupation returns of the census, which have been briefly indicated, apply even more forcibly to death returns. It is evident, therefore, that it is only in certain clearly recognised and well-defined groups of occupations that accurate occupational death-rates can be deduced. We must be satisfied, to quote the golden rule laid down by Joshua Milne, that "the population enumerated is precisely that which produces the deaths registered," the great desideratum being "to determine the number of annual deaths at each age which takes place among the living at the same age." These rules have been so frequently neglected, that a large share of the occupational statistics which have been published are untrustworthy.

Erroneous Forms of Occupational Statistics.—(1) Much of

* General Report of 1881 census of England and Wales, Vol. IV. pp. 27 & 28.

the earlier work on occupational statistics is invalidated by the acceptance of the *mean age at death* of men employed in different industries as a trustworthy indication of the relative salubrity of these industries. This is evidently fallacious. The mean age at death is governed by the mean age of the living, and it is as much affected by the ages at which people enter and leave any given occupation, and by the increase or decrease of employment, as by its salubrity or insalubrity. Mr. Ben Tillett in 1890 stated that the average age at death of workmen was 29—30 years, of the well-to-do classes 55—60 years. It is probably quite true that the prospects of life of the average workmen are less favourable than those of the average member of the well-to-do classes; but Mr. Tillett's statement, founded as it probably is on the experience of Trades' Union Societies composed largely of young men, by no means proves this.

In 1888 the Collective Investigation Committee of the British Medical Association reported, as the result of an elaborate inquiry, that of

122	Total Abstainers the average age at death was	51·22 years.
1529	Habitually Temperate	„ „	62·13 „
977	Careless Drinkers	„ „	59·67 „
547	Free Drinkers	„ „	57·59 „
603	Habitually Intemperate	„ „	52·03 „

This was seized upon by the brewing interest as proving that the prospects of life are diminished by total abstinence, while there was a corresponding fluttering and agitation in the temperance dovecotes. It is obvious that no valid comparison is made in the preceding statement between the two groups. The statement of age of the dying, the age of the living being ignored, can only mislead, as it did in this instance. It would be absurd, similarly, to draw any inferences from a comparison of the mean ages at death of bishops and curates, as men do not usually become bishops till they have passed the middle period of life. The low mean age at death of dressmakers has been adduced as a proof of the unhealthy character of their employment. Without denying the latter fact, the low mean age at death of dressmakers is no more a proof of their insanitary circumstances than is a low mean age at death among the pupils in a boarding school.

Mr. F. S. Neison, in a paper contributed to the Statistical Society in January, 1844, showed very clearly the errors following on the use of this method by comparing the populations of the districts of Bethnal Green and St. George's, Hanover Square. He found that

The number living—	Bethnal Green.	St. George's, Hanover Square.
Aged 23—25, was..	8·9 °/₀ of total.	14·2 °/₀ of total population.
„ 5 and under..	14·5 „	8·6 „

and he showed that were the population of Bethnal Green to be transferred to St. George's, Hanover Square, and submitted to the conditions of mortality of the latter, the mean age at death at St. George's, Hanover Square, would be reduced from 31·23 to 27·25 years (the mean age at death at Bethnal Green being 25·80 years). It is evident, therefore, that the population of St. George's, Hanover Square, at that time, instead of having on an average 5·42 more years of life, had only 1·45 years more than Bethnal Green.

(2). The proportion between the number engaged in and the number dying in any given occupation, expressed as a rate per 1,000, is also fallacious. As is well known, the death-rate in the general population varies greatly at different groups of ages. The death-rate among those engaged in any one occupation would similarly vary according to the relative number at the different ages engaged in it. In other words, it would depend on the *ages of the living*, which would vary in every occupation, (*a*) according as persons enter it early or late in life, and (*b*) according as the numbers that annually enter it increase or decrease. Dr. Farr, in his 14th Report, gives the following example of the mistakes which would follow the adoption of this method. The death-rate of all farmers over 20 years of age were 28 per 1,000, of all tailors 20 per 1,000; but when tested by a comparison of the death-rate among men of corresponding ages, farmers were much healthier than tailors, as seen in the following table:—

Death-rate per 1000 *at Six Age-groups of Farmers and Tailors.*

Age.	25	35	45	55	65	75
Farmers . .	10·15	8·64	11·09	24·90	55·30	148·62
Tailors . .	11·63	14·15	16·74	28·18	76·47	155·28

The only trustworthy method is to compare the mortality of those engaged in one occupation, and of a given age, with the mortality of those engaged in another occupation and *of a corresponding age.*

This is the method adopted by Dr. Ogle in his report for the decennium 1871—80, and it is his figures which will be chiefly quoted. The report of the decennium 1881—90 has not yet been issued, so that any figures which are given are necessarily to a certain extent out of date.

Sources of Possible Error.—Even supposing that occupational statistics are constructed by the correct method just indicated,

some sources of possible error still attach to them. These are pointed out by Dr. Ogle, who however rightly claims for his results a high degree of trustworthiness, on account of the width of his basis of operations, and the precautions taken to ensure uniformity in the abstraction of the figures on which the statistics are based.

These sources of error exist even when the difficulties connected with the classification of occupations have been overcome, and the fallacies connected with the paucity of data have been avoided.

Paucity of data often forms a difficulty in local occupational statistics, as the number engaged in any given industry is necessarily limited, and the observations of several years must therefore be collected, in order to remove variations due to accidental causes. The scantiness of material seldom however reaches the level of that of the parliamentary questioner who asked Mr. Stanhope if it was his intention to retain a British garrison at a post in Africa where the mortality had been 800 per 1000. The reply admitted this high death-rate, but explained that the garrison in question consisted of a corporal and four men, of whom one was accidentally shot when on a shooting expedition, one was eaten by a crocodile while bathing, a third died of sunstroke, and the fourth died as the result of lying out all night in a drunken fit!

For one difficulty pointed out by Dr. Ogle there appears to be no remedy, and it must always to some extent diminish the value of all calculations of the death-rate in different industries. Many trades, as that of a blacksmith or miner, require great muscular strength, and must be given up by men when they become weakly; and the latter may then raise the mortality of the lighter occupations to which they resort.

Another flaw in occupation death-rates, when taken as tests of the relative healthiness of different industries, is the fact that those who follow these do not start on equal terms as regards healthiness. A weakling will not become a navvy, but a shopman or tailor by preference. The occupations demanding great muscular strength and activity, to some extent then, consist of picked men, stronger at the commencement, and maintained up to a certain standard by the fact that weaklings are drafted into lighter occupations.

After making full allowance for the preceding difficulties, the death-rates of different occupations still furnish most valuable indications of their relative salubrity; and while small differences may be accidental, large differences must be taken as representing real differences of healthiness in the various occupations.

When we pass from a comparison of death-rates from all causes at different age-groups, to a comparison of death-rates from special forms of disease at the same age-groups, the subdivision is greater, and the danger of errors arising from scantiness of material is increased. There are, however, certain diseases concerning which there is abundant evidence of their special association with particular industries, and these will be further discussed shortly.

Outdoor and Indoor Occupations.—From a hygienic standpoint, a vitally important classification of occupations is into (*a*) out-door, and (*b*) in-door.

The following table, re-arranged from one given by Dr. Ogle,* brings out this point. It should be explained that the figures relate only to males between 25 and 65 years of age, the death-rates of men between 25 and 45, and between 45 and 65 having been in each case applied to a male population in which those under and those over 45 bear a fixed proportion to each other. The clerical profession, having the lowest death-rate, is taken as the standard and stated as 100; the death-rate of each of the other occupations being stated by a figure proportionate to this standard.

Comparative Mortality of Men aged 25 to 65 years, 1881-2-3.

OUTDOOR OCCUPATIONS.			
Gardeners	108	Fishermen	143
Farmers	124	Masons and Bricklayers	174
Agricultural Labourers	126		
MIXED OCCUPATIONS.			
Clergymen	100	Medical men	202
Lawyers	152	Carpenters	148
INDOOR OCCUPATIONS.			
Commercial Clerks	179	Tailors	189
Bakers	172	Shoemakers	166
Shopkeepers	158	Bookbinders	210

It is evident that in industrial occupations, the balance is very greatly in favour of outdoor work. With the exception of the clerical profession, those engaged in agriculture have the highest probability of life. Even fishermen, notwithstanding their exceptional proneness to fatal accidents, compare very favourably with those engaged in indoor occupations. In occupations where the evils connected with the inhalation of dust arise, the mitigating effect of work in the open air is felt.

* Transactions International Congress of Hygiene and Demography, Vol. X., p. 14.

Masons and quarrymen who work in the open air have a mortality from lung diseases, which is only from two to three times that of fishermen; while that of Cornish miners and potters, who work in more confined space, was in 1880—82 five to six times that of fishermen (Ogle).

Rural and Urban Industries.—The conditions of urban life involve a larger proportion of indoor occupations than those of rural life. The increased urban population in this country has been the result of an immense increase in manufacturing and mining industries. At the census of 1861, 37·7 per cent. of the total population of England and Wales was rural; at the census of 1881, this proportion had decreased to 33·4 per cent.; and at the census of 1891, to 28·3 per cent. Now the average urban death-rate was 24·8, and the rural death-rate 19·9 per 1000 in the decade 1861—70; 23·1 and 19·0 in 1871—80; and had become 20·3 and 17·3 respectively in 1881—90.* It is evident therefore that rural (*i.e.*, in a large measure outdoor) conditions of life are much more conducive to health than urban conditions. The real difference is greater than is shown by these uncorrected death-rates; for the age-distribution of urban is more favourable to a low death-rate than that of rural districts. Thus, as Dr. Ogle shows, if the annual death-rate in England and Wales at each age-period be applied to the respective urban and rural populations at the census 1881, the death-rate in the urban population would be 20·40 (instead of 23·1); in the rural population, 22·83 per 1000 (instead of 19·0). That is, assuming that the urban and rural populations were equally healthy, the death-rate of the former should have been 4·09 per cent. below, and that of the latter 7·33 per cent. above the mortality of England and Wales as a whole.

It will be noticed that urban death-rates show a greater decline than the rural. This cannot be explained completely by the increased afflux of young and healthy recruits from rural districts; it is an indication that in towns sanitary administration is more active, and the health conditions of life are improving more rapidly than in country districts.

It would be interesting to inquire how far the diseases of workmen with which we are concerned *are town made, and how far they are trade made.* The aggregation of workmen in towns implies a less pure atmosphere, a diminished freedom of access of this atmosphere to their homes and workshops; high rentals, with their concomitant evils of sub-letting and overcrowding of

* Stating the deaths in town districts to 100 deaths in country districts, out of equal numbers living, there died in towns in 1851—60, 124; in 1861—70, 126; in 1871—80, 122; in 1881—90, 117; and in 1891, 114.

tenements; an absence of gardens and cheap home-grown vegetables; a deficient supply of milk, too often "separated," for their children; and many other evils, which a comparison between country and town life renders obvious. Could our great industries be more widely scattered in small communities, there is no reason to doubt that occupational mortality would decline with increased rapidity. It is well known that miners living some distance from their work suffer less than those living near at hand; and we may reasonably hope that with cheap workmen's trains, enabling workmen to live beyond the outer circle of our towns, great improvement will be seen.

Consumption and Occupation.—Stress has been laid on the distinction between indoor and outdoor, urban and rural occupations. This is essential, inasmuch as impure air is one of the chief causes of disease. The langour, headache, and drowsiness which result from a temporary exposure to a vitiated atmosphere, are followed if the exposure is more chronic by a general lowering of bodily and mental vigour. The tendency to catarrhs is increased, and apart altogether from the provocative action of dust, "colds" and bronchitis are more common than among those living an outdoor life.

Phthisis, or consumption, is the most fatal disease of adult life. In the five years 1886—90, phthisis caused 8·7 per cent. of the total deaths in England and Wales. In the thirty-five most active years of life, from 20 to 55 years of age, phthisis caused 20·6 per cent. of the total deaths of males during the year 1891. In the same year, bronchitis only caused 5·6 and pneumonia 11·7 per cent. of the deaths from all causes at ages 20—55.

The close association between phthisis and indoor occupation has been long known. Dr. Greenhow, in most important reports to the General Board of Health and Privy Council in 1859—62, showed most conclusively from an analysis of the statistics of lung diseases in agricultural and manufacturing populations respectively, that "in proportion as the male and female populations are severally attracted to indoor branches of industry, in such proportion *ceteris paribus*, their respective death-rates from phthisis are increased." In indoor occupations involving much muscular effort, the amount of phthisis is less than in those of a more sedentary character. An examination of the history of 6,000 patients admitted to the Brompton Consumption Hospital showed that two-thirds had indoor occupations, the occupations of milliners, sempstresses, and tailors being specially predominent.

From the records of Millbank Penitentiary during the eighteen years 1825—42, Dr. Baly showed that the mortality

from tubercular disease was three or four times as great as it was in the year 1842 among persons of the same period of life in London generally. A sentence of imprisonment for fifteen years was then equivalent to a sentence of death by phthisis. If time allowed, even more striking instances of the evil effects of indoor occupations, under conditions of overcrowding and deficient ventilation in favouring the development of phthisis, might be given.

With advancing knowledge, heredity as a cause of phthisis has been pushed into the back ground. It is now known that the essential cause is the introduction into the system of the tubercle bacillus. Vitiated air, defective food, fatigue, inherited weakness, act as predisposing causes, by lowering the general health and originating catarrhal inflammations, and thus diminishing the resistance of the organisms to the infection, which is always introduced *ab extra.*

The infective material is inhaled in the majority of cases as dust, which contains the desiccated expectoration of phthisical patients. To diminish this danger, every workshop and factory should have a spittoon provided in each room containing some disinfecting fluid, and the dirty habit of spitting on the floor should be prohibited. By steady and gradual education of workpeople the centres of infection may thus be diminished, and the danger of predisposed persons acquiring phthisis minimised.

The following table given by Dr. Ogle* shows the influence of vitiated air in the production of phthisis and other lung diseases. Fishermen are taken as a standard, their mortality from these diseases being represented as 100.

Comparative Mortality of Males aged 25 to 65.

	Occupation.	Phthisis.	Other Lung Diseases.	The two together
Pure Air	Fishermen	55	45	100
	Farmers	52	50	102
	Gardeners	61	56	117
	Agricultural Labourers	62	79	141
Confined Air ..	Grocers	84	59	143
	Drapers	152	65	217
Highly Vitiated Air	Tailors	144	94	238
	Printers	233	84	317

* Op. cit., p. 17.

The essential cause of phthisis is the inhalation of dust containing the specific bacillus of this disease. Hence persons engaged in dusty occupations are much more prone to be affected than others who are simply exposed to a vitiated air. To quote Dr. Ogle again:*

Comparative Mortality of Males aged 25 to 65.

	Phthisis.	Other Lung Diseases.	The two together.
Fishermen (as standard)	55	45	100
Coal Miners	64	102	166
Carpenters and Joiners	103	67	170
Bakers	107	94	201
Masons and Bricklayers	127	102	229
Wool-workers	130	104	234
Cotton-workers	137	137	274
Stone and Slate Quarrymen ..	156	138	294
Cutlers and Scissor Makers ..	187	196	383
File Makers	219	177	396
Pottery Makers	239	326	565
Cornish Miners	348	231	579

The dust inhaled by carpenters and bakers appears to be comparatively innocuous. The dust from woollen fabrics, and still more from cotton, is much more prejudicial; while mineral dust, as shown in the later occupations given in the table, is highly injurious.

The metallic dust in file-making and cutlery causes a mortality from chest affections which is nearly four times that prevalent among fishermen, who are not exposed to dust. The death-rate from these diseases alone is almost equal to the total mortality from all causes (including accident) among fishermen.

The dust of stone is even more formidable than metallic dust. Masons and quarrymen work in the open air, so their mortality from phthisis is only two or three times as great as that of fishermen. Potters and Cornish miners work in more confined space, and their mortality from these diseases was, at the period to which Dr. Ogle's returns apply, five to six times as high as that of fishermen. There is reason to believe that, owing to improved and increased inspection, the conditions under which potters work and their resultant mortality have greatly improved since that date.

The mortality from phthisis and respiratory diseases among

* Op. cit., p. 19.

Cornish miners is appallingly high, forming two-thirds of their total mortality. On the other hand, coal miners have a remarkably low mortality from these diseases. This may be partly due to the excessive mortality from accidents, for it is evident that any injurious effects of coal dust may not have time to operate under such circumstances. Such an explanation, however, only very partially explains the comparative immunity of coal miners from phthisis. It has been supposed, therefore, that coal dust has some inhibitory power against the development of this disease. A more probable explanation is that in the scattered work of a coal mine, the opportunities of infection by desiccated sputa are less frequent than in most of the other occupations which have been named.

It is evident from the foregoing illustrations that the breathing of impure air, especially when the air carries with it irritating dust in addition to the specific infective material, is the chief cause of phthisis. Working in a cramped or constrained position, involving imperfect expansion of the lungs, strongly predisposes to phthisis. This is shown by the high phthisis mortality among printers and tailors, among women in the hosiery and lace trade, and in sempstresses and dressmakers.

The effects of variations of the temperature and moisture in workshops in favouring phthisis are only secondary in importance. Exposure to the weather is a preservative against phthisis. Variations of temperature only cause it when accompanied by an impure atmosphere and the inhalation of specifically contaminated dust, though they may, even in the absence of such dust, favour the production of bronchitis.

Cancer and Occupation.—The causation of cancer is obscure. That it is, like phthisis, more common in certain families is well known; but there is little doubt that, as in phthisis, this means an inherited vulnerability, rather than the actual transmission of potential disease. One thing is fairly certain that persistent local irritation has very commonly preceded cancer. In cancer of the tongue or lip, there is generally a history of a jagged tooth or the use of a clay pipe. As is well known there has been in the past an excessive amount of cancer among chimney-sweeps, particularly of the scrotum, due to the chronic irritation of soot. Workers in coal-tar and crude paraffin appear also to be subject to cancer in excess of the average amount. It has been suggested by Esmarch and Langenbeck that the relation of tobacco smoke and juice to the mouth is, probably, similar to that of soot, tar, and paraffin to cancer of the scrotum. Charcoal and coal-dust do not appear to have a similar effect in producing scrotal cancer. There is a general impression that chimney-sweep's cancer is declining, but such scanty figures as are available do not appear to confirm this impression. Dr. Ogle calculates from the figures of 1880—82 that "the liability of chimney-sweeps to malignant disease is about eight times as great as the average liability of all males." About one-half of these deaths from cancer among chimney-sweeps were from cancer of the scrotum and neighbouring parts.

Mr. Butlin, in a very interesting inquiry,* has shown that scrotal cancer in sweeps is almost unknown in the chief European countries and in the United States of America. The immunity of these countries is ascribable to the fact that hard or stone coal is not generally used, that open fireplaces are not common, and that consequently there is less soot, or a less irritating form of soot than in England. In Belgium, where hard coal and fires similar to those in England are in use, the almost complete immunity from scrotal cancer appears to be traceable to the care taken by the sweeps to prevent their bodies from contact with soot by special arrangements of clothing; and in North Germany, to the practice of daily washing the body from head to foot.

Accidents and Occupation.—Accidents cause a very high proportion of the deaths in certain industries. Happily they claim as time goes on a diminishing number of victims, as will be seen from the following data:—

Annual Death-rate from Accident and Negligence per Million persons living.

Three years	1858—60	653
Five "	1861—65	690
" "	1866—70	678
" "	1871—75	671
" "	1876—80	630
" "	1881—85	580
" "	1886—90	544

A decrease of 16·7 per cent. under this head in the period reviewed is very satisfactory. It has been impracticable for me to obtain the necessary data for showing the proportion of this gain which has occurred in adult life; but there is no doubt that a large share of the decrease is attributable to the more efficient supervision under the Acts for regulating factories, workshops, mines, &c.

The chief incidence of mortality from accidents at all ages may be gathered from the following data for 1891†:—

* *British Medical Journal*, June 25th, July 2nd and 9th, 1892.
† Fifty-fourth Annual Report of the Registrar-General for England, p. liv.

Deaths to One Million living.

Accident.	Persons.	Male.	Females.
In Mines and Quarries	32	65	—
Vehicles and Horses	86	155	22
Ships, Boats, Docks (not drowning)	5	11	—
Building operations	5	11	—
Machinery	8	15	1
Weapons and Implements	8	13	3
Burns and Scalds	77	74	80
Poison, Poisonous vapours	19	27	11
Drowning	93	161	29
Suffocation	78	83	74
Falls	89	114	65
Weather agencies	10	16	4
Otherwise or not stated	64	93	37
All forms of Accident	574	838	326

It will be noted that males are two or three times as subject to fatal accident as females. The excess is especially incident upon the working years of life, but an analysis of the death returns of the quinquennium 1878—82 showed that this excess begins much earlier* in life. Under one year of age the fatal accidents of boys during 1878—82 were 6 per cent. more numerous than those of girls—a difference closely corresponding to the relative number of boys and girls living at that age. In the second year of life the accidents of boys were 30 per cent. more numerous, in the third year 51 per cent., in the fourth year 61 per cent., and in the fifth year 75 per cent. more numerous than the accidents of girls. After this age the preponderance of accidents of males becomes greater, the influence of occupation coming generally into action. The higher male mortality from accident is an explanation of the higher general death-rate of males, the total mortality from violence being too small to affect the general death-rate to any extent, and the difference from this cause being partly counterbalanced by the mortality of females from childbirth and puerperal fever.

The occupations in which fatal accidents are most common will be seen from the following statement. The mortality from all causes among all males aged 25 to 65 years of age in

* Forty-fifth Annual Report of the Registrar-General for England, p. xx.

England and Wales is taken as the standard, and of this amount sixty-seven were due to accident.

Comparative Mortality of Males, 25—65 years old (Ogle).

	All causes.	Accident.
All Males (England and Wales)	1000	67
Miners (S. Wales and Monmouthshire)	1081	229
Miners (N. Riding & other Ironstone Districts)	834	206
Miners (Durham and Northumberland)	873	196
Miners (Staffordshire)	929	172
Miners (West Riding)	772	161
Fishermen	797	152
Stone, Slate Quarries	1122	148
Cab, Omnibus Service	1482	84
Plumbers, Glaziers, Painters	1169	71
Brewers	1361	64
Innkeepers	1521	45
Costermongers, Hawkers	1879	53
Butchers	1170	35
Farmers	631	30
Wool Manufacture	1032	27

The figure for fishermen is probably below the mark because of the number drowned, whose bodies are not recovered, and who escape registration.

The diminution of accidents as the result of efficient supervision and regulations has been very marked. In the majority of industries, the number of deaths from accident is now small in proportion to the total deaths from all causes. Among all males they form 6·7 per cent. of the total deaths; among Welsh miners, they only cause 22·9 per cent. of the total deaths at ages 25 to 65. The proportion is still much too high; and when the workmen themselves are more conscientious in their abstinence from smoking in mines, &c.; when they are better educated, and more thoroughly appreciate the importance of hygienic precautions; when the hours of labour have been so reduced that the neglect arising from fatigue will not occur, as in pointsmen on railway lines, the number of accidents will shrink still more.

Even now it is against the chronic diseases due to dust and to overcrowding and to defective ventilation that the chief fight needs to be waged; and it is in this department of industrial hygiene that the largest scope for the saving of health and life lies.

Alcohol and Occupation.—The influence of even moderate doses of alcohol is in most instances to diminish the capacity for work, and more especially to diminish the power of endurance. Excessive doses of alcohol not only produce the temporary incapacity for work, partial or complete, which is their most obvious effect, but when systematically imbibed, lead to increase of sickness and to premature death. Alcohol has been well described by Dr. Dickinson as the "genius of degeneration;" and the degenerative diseases produced by it are by no means confined to the intemperate; they are seen, perhaps, quite as frequently in those who, though never intoxicated, indulge in frequent "nips" between meals.

In certain occupations, the amount of alcoholic disease is very great. It is true that no man is compelled to drink; but in actual practice it is found that the constant exposure to the temptation to drink is almost as certain to produce chronic alcoholic poisoning, as is similar exposure to the fumes of mercury, or white lead, or yellow phosphorous, to produce the characteristic effects of these poisons. In fact, the pursuit of the occupation of a tapman or publican, in the majority of instances, implies a slow process of suicide. This will be abundantly evident from the following figures* :—

Annual Death-rates per 1000 *at Four Ages among Clergymen, Ministers, and among Publicans and Wine Merchants,* 1880-1-2 (Ogle).

Ages.	Clergymen and Ministers.	Publicans, Innkeepers, Wine and Spirit Merchants.
20—25	1·72	7·81
25—45	4·64	18·02
45—65	15·93	33·68
65 and upwards	83·96	85·81

There is no influence prejudicial to health in the life of publicans, &c., which can account for their excessive death-rate at each group of ages, as compared with the corresponding death-rates in the clerical profession, except the one factor of alcoholic excess.

The official figures of the Registrar-General give a very incomplete statement of the mortality caused by alcoholism. So long as the present objectionable method of requiring the medical practitioner to give the death certificate to the relatives (instead of sending it sealed to the registrar) is continued, there is little hope that the real facts as to alcoholism, or as to syphilis, will appear on death certificates. Were the truth known, these two great causes of disease and death would probably be found to be more fatal than all the specific infec-

* Dr. Ogle's Supplement to the Registrar-General's 45th Annual Report.

tious diseases put together; and they, especially the former, have this additional importance, that the deaths caused by them occur chiefly in the most useful periods of life. One of the commonest diseases due to alcoholism is cirrhosis of the liver; and as this is the chief cause of mortality under the head of "liver diseases and ascites," the latter may be taken as a more correct index of the amount of alcoholic excess in England and Wales than intemperance, alongside of which it is tabulated below:—

Period.	Death-rate per Million persons living from—	
	Intemperance.	Diseases of Liver and Ascites.
Three years 1858—60 ..	40·3	394·0
Five " 1861—65 ..	41·6	416·0
" " 1866—70 ..	35·4	417·6
" " 1871—75 ..	37·6	427·8
" " 1876—80 ..	42·2	423·6
" " 1881—85 ..	48·0	372·0
" " 1886—90 ..	55·8	324·8

The indication of decrease of intemperance furnished by liver diseases is confirmed by the falling off in the number engaged in the liquor trade, which was equal to 17·9 per cent. for equal populations between 1871 and 1881, and to 3·8 per cent. for equal populations between 1881 and 1891.

The figures contained in the following table tell their own tale:—

Comparative Mortality Figures in Men aged 25—65 from Special Causes (Ogle).

	Alcoholism.	Diseases of the Nervous System.	Suicide.	Gout.
All Males	10	119	14	3
	—	—	—	—
Innkeepers	55	200	26	13
Brewers	25	144	26	9
Butchers	23	139	23	5
Commercial Travellers ..	23	139	31	6
Cab, Omnibus Service ..	33	134	16	11
Costermongers	19	207	44	3
Tailors	11	144	16	4
Grocers	10	—	17	—
Painters, Plumbers ..	12	—	—	10
File Makers	—	262*	—	—

* Including deaths from suicide.

	Liver Diseases.	Diseases of the Circulatory System.	Diseases of the Urinary System.
All Males	39	120	41
	—	—	—
Innkeepers	240	140	83
Brewers	96	165	55
Butchers	96	132	55
Commercial Travellers	61	—	44
Cab, Omnibus Service	54	160	65
Costermongers	47	227	69
Tailors	48	127	45
Grocers	52	—	48
File Makers	41	180	123
Painters, Plumbers	48	143	100

Innkeepers head the list under three headings—Alcoholism, Liver Diseases, and Gout; and in the four remaining columns they stand third on the list. Were it not for the special incidence of renal disease from lead poisoning, on file-makers and painters, innkeepers would also head the list under this disease.

Phthisis has not been tabulated above, though there is good evidence that it is increased by alcoholic excess.

Under another head, that of Accidents, alcoholism is reponsponsible for a large increase in mortality. Excluding miners, fishermen, &c., whose occupations expose them peculiarly to fatal accident, the comparative mortality from accident is higher than in most other occupations among brewers, innkeepers, and butchers. The latter must be grouped among those who suffer severely from alcoholic excess, the effects of which are doubtless enhanced by excess of animal food. They are, as a class, among those who have been described as "digging their graves with their teeth."

Effects of Excessive or Too Protracted Work.—Time is only left to briefly touch on this subject. The excessive use of any part of the body inevitably brings in its train evil results. The deafness occurring in boiler-makers and riveters; the gradual loss of power of distinguishing the varying qualities of tea by tea tasters; the localised muscular cramps and spasms, followed by palsy, occurring in writers and violinists, and in hammermen, are instances of this law.

Muscular strain from over-exertion is a common cause of hernia; and the same cause, more particularly among smiths, porters, dock loaders, &c., produces aortic aneurism. In regard to the latter condition, it is noteworthy that Dr. Drummond, in his address in Medicine at the annual meeting of the British Medical Association in August, 1893, says that since he commenced his investigations on the subject, no indisputable case has come under his notice in which a history of syphilis was wanting in cases of true aortic aneurism. There is no doubt that, at least in a large proportion of cases, specific arteritis precedes the aneurism, and is an important determining factor in its causation.

The increased use of machinery must be beneficial by diminishing the necessity for sudden and violent exertion. The extension of work by machinery is the most prominent feature of the present century. Did time allow, it would be interesting to inquire whether the good derived from it more than balances the evils due to the increased monotony of occupation, to noise and uproar, and to the greater proclivity to accidents. As the increasing use of machinery is however inevitable, it may be more useful to congratulate ourselves that the general substitution of collective work in factories and workshops for the home handicrafts facilitates supervision of the conditions of work, and thus enables the evils arising from dust and vitiated air to be partially overcome.

The too protracted continuance of work which is not of necessity excessive, is an evil which is probably in the long run as detrimental to the interests of the master as it is to the workers. In occupations, like those of miners and railway employés, where the lives of others may depend upon the alertness and scrupulous care of the workmen, the legislature will have little hesitation in intervening between master and man. When Dr. Guy and other eminent men in 1848 advocated the case of the journeymen bakers, who demanded that they might have at least ten hours out of the twenty-four for themselves, it was objected in Parliament that "it was intolerable and impossible in a free country such as this, to apply to labour in dwelling houses and workshops a minute system of inspection and supervision such as was found practicable in our factories." The political economists were up in arms, and the continuance of "freedom of competition" without legislative restraints was advocated as the only way to sound commercial success. Much was said about "interference," and very little about humanity and justice. As Dr. Guy nobly stated the case for the journeymen bakers: "It is a bitter mockery to talk about grown-up men being able to make their own bargains. . . . The contest now going on . . . must ere long take a more definite shape between the natural feelings of a Christian man, and the cold unbending theory of a perfect freedom of human act."

Since that day the righteous sentiments of the country have

led to industrial legislation decade by decade, of extended scope and increased stringency. In the case of many shop assistants and others

> "Whose hard toil
> Doth scarce divide the Sunday from the week,"

overwork still exists, not on special occasions, but systematically and persistently, though the early closing movement is, especially in the larger shops, doing much to improve the conditions of labour. To say, as some masters do, "I can make better use of your leisure than you would," is an argument which is only fitting between the slave driver and the slave. Happily a large number of masters now realise that their relationship to their employés involves responsibility as well as profits. If they allow detrimental conditions, whether it be defective drainage, or defective ventilation or warming, or inefficient appliances for the removal of dust, or any other defect to remain, which it is within their power to remove, their responsibility for the ill-health of their employés is undoubted. One of the most important deductions from scientific teaching is that no event can be considered as *accidental*, or as the result of a mere concurrence of chances. Fixed laws co-operate in the development of every event; and given ill-health or actual disease in the employés in any shop, workshop, or factory, it is more than probable that the conditions under which they have worked for from one-third to two-fifths, or even half of every working day, have been largely instrumental in producing it.

With an increased sense of responsibility on the part of employers, we must look to the influences exerted by education, and by a higher development of the sense of responsibility on the part of workpeople, for the removal of that callousness and indifference which now form the chief obstacles to improvement. In certain occupations the production of unhealthy dust is unavoidable; and the refusal of workmen to wear respirators, or to wash themselves after exposure to deleterious dust, is a common cause of mischief.

The time is ripe for great improvements in industrial sanitation; and when the statistical history of the last decade of this century comes to be written, there is little doubt that it will record a lowered industrial mortality as the result of the present activity in improving the conditions under which the industries of this country are carried on.

MINERAL (NON-METALLIC) DUSTS, THE MANUFACTURE OF POTTERY, &c.

By J. T. ARLIDGE, M.D. & A.B.Lond., F.R.C.P.,

Consulting Physician to the North Staffordshire Infirmary, Stoke-on-Trent; Late Milroy Lecturer at the Royal College of Physicians, London.

READ NOVEMBER 16TH, 1893.

A NECESSARY prelude to Sanitary Science is to know what is insanitary.

This knowledge has now been the object of research by medical men for a long series of years, and this Institute has materially contributed towards its attainment.

All the old reputed *elements*—earth, air, fire, and water—have been scrutinised to discover what insanitary conditions are to be found in them severally. Fire comes scathless out of the ordeal and gets a place as a purifying agent, though at the same time harmful as excessive heat, and as often lending increased intensity to the action of what is insanitary in the other elements.

But earth, air, and water are ever present surrounding media often charged with health destroying energies, aroused by the play of chemical forces, and especially so when organic matter is present; and moreover acting prejudicially upon physiological structure and function by abnormal contact.

Ever extending exploration of causes inimical to bodily health opens up to our view new facts, and corrects old inferences. The ancient doctrines and theories of infection and contagion are, if not overthrown, vastly modified by microscopic research, by biological experiments respecting the minutest known organisms, and by pathological investigation coupled with wide observation of endemics and epidemics.

To students of Sanitary Science, and necessarily too of medical science, an illimitable field of study is opened out by the microscopical and biological problems thus raised. Hitherto they have rather restricted their study to more prosaic, yet most important, topics to be found in the material conditions of human existence and in the surroundings of men—especially those of man's own creation—existing in the dwellings they erect, in the ventilation provided, in the system of drainage adopted, in the food and drink they use, and in the mode of life they pursue.

But there is yet another factor in sanitation, which, in my humble opinion, has been greatly overlooked. I allude to the surroundings and conditions connected with occupation. We may secure the artisan good ventilation, good water, and watch over his food supplies assiduously, but we fall considerably short of our sanitary obligations to him, if we leave out of consideration the health aspects of his labour, and take little or no account of his workshop and its sanitation. As I remarked just now, this department of hygiene has been greatly neglected by sanitarians. And I must further add that, in the case of physicians when gathering the history of patients, small account is taken of the influence of occupation upon the health of the sufferers, and little knowledge or inquisitiveness displayed concerning the manufacturing process they pursue, or what may be their occupation. I hold, therefore, that great credit is due to the Council of this Institute for starting a course of lectures "on the Sanitation of Industries and Occupations."

It is now my privilege to bring under your notice the sanitary features of industries wherein mineral—non-metallic—dusts are generated, and to illustrate the subject by an account of the manufacture of pottery and of cement.

You will observe that in the programme issued the forms of non-metallic mineral dust selected for treatment are but few out of many. The enormous industry of coal-mining and iron-stone getting, the very large one of slate-quarrying, and the cognate occupations of stone and granite and plaster-of-Paris quarrying, and of raising and working clays for the manufacture of pottery, of tiles and bricks and other fictile products—all dusty employments—are matters outside the precribed scope of the present lecture. That which remains for examination—pottery and cement-making—is of two-fold character, and calls for separate discussion. For the methods of making china and earthenware differ entirely from those concerned in producing cement. So, likewise, do the materials used, the processes followed, the character of the dust evolved, and therewith the effects upon health.

Now scarcely any other manufacture has so strong a claim upon the attention of sanitarians as has that of pottery. It stands nearly at the head of the list of unhealthy occupations, and exercises its pernicious effects almost wholly upon the respiratory organs, by the production of bronchitis and of consumption. Thus it is found that whilst workmen engaged in other employments have a mortality from chest diseases of 7·86 per cent., potters exhibit one of 12·29. Likewise with respect to phthisis—non-potters present one of 9·27 and potters one of 12·90.

Manufacture of Pottery.—To understand the sanitation of the china and earthenware manufacture we must be acquainted with the materials employed, the processes to which those materials are subjected, and the methods of working, or the manipulations called for on the part of the artisans. Subordinate but accessory to these topics are the habits of the workpeople, the legal conditions under which they work, and the character and arrangements of the manufactories. Nevertheless, as I read the programme submitted to me for my guidance, the properties and mode of action of the dust arising from the industry in question must form the staple of my present lecture.

Bearing this limitation in mind, my observations will be first directed to the materials employed, which are all dusty or productive of dust in the processes they are subjected to.

It seems superfluous to inform my hearers that china and earthenware are made of clay; yet it is necessary to guard them against erroneous conceptions of what such clay is. It is not the familiar buff and brown aluminous substance which we daily encounter wherever we go. It is a prepared article got almost exclusively from Dorsetshire, Devonshire, and, above all, from Cornwall, and is composed largely of silica. The potter distinguishes several sorts of clay, differing in colour and in the relative proportion of alumina and silex, and which his technical skill teaches him to use in varying proportions according to the character and quality of the ware he desires to make. For instance, when he requires a larger ratio of the siliceous matter he adds what is called "china-stone." The ordinary ball and blue clay—the most akin to clay as ordinarily understood—enters more largely into the composition of common earthenware. The Cornish clays are white and like "Cornish stone" are the resultant of the action of air and water on granite rocks, producing disintegration and decomposition. This work of nature is pushed farther by human agency; the quarried material being submitted to the free action of water and air, promoted by oft repeated washings and stirring, and prolonged weathering. The product is a fine white powder resembling flour. Such is china clay, so-called because its principal application is to the making of china.

The first business of the potter is to mix the required clays together, to produce a homogeneous plastic mass—such as those who have not seen the substance in potteries may have met with in the studios of sculptors. It is familiar also as the material of which clay smoking pipes are made, hence called pipe-clay. It has the property of drying rapidly, and when dry of falling into powder.

We have got thus far:—that the basic matter for constructing pottery—the so-named clay—is very rich in silica, and that it is rendered more so by the addition of "china stone" and of flint. A strong magnifying glass or a microscope will detect in it the minute particles of silex, of irregular shape with sharp angles and points; and it goes without saying, that a dust of this description must powerfully irritate the delicate mucous membrane and epithelium of the lungs when it reaches it.

Clinical observation abundantly confirms this fact. For a considerable time the inhaled dust is arrested in its advance towards the lung tissue proper by the mucous secretion in the bronchial tubes, and by the expulsive energy of the cilia lining those tubes. But at length these resistant forces weaken before the constant entry of fresh dust, and in course of time the noxious material passes into the lymph channels, and also along the finer bronchi, until it reaches the intimate structure and the air-cells themselves. Here as a foreign substance it sets up inflammatory action; lymph cells spring up, the air-vesicles become choked with inflammatory products, the tissue around them gets indurated (lung sclerosis), and useless as breathing tissue.

The history of these pathological changes is reflected in the symptoms exhibited by the sufferers. In the primary stage little inconvenience is felt: there arises a desire to clear the throat of some impeding mucus at the end of the day's work, or upon transition to the outer air from the warm shop, and especially on rising in the morning. This expulsive act soon develops into a cough, and relief is obtained by the expectoration of more or less blackish viscid mucus. Presently there is a feeling of tightness in the chest, and the breathing grows less free and full. As time goes on these signs of disturbed lung function become more pronounced, and in the end the patient grows asthmatic—a victim of potters' asthma.

Until this advanced stage of disorder is reached, it is singular to notice how little attention and anxiety are bestowed upon the pulmonary derangements. This is because the general health is, for the most part, not seriously affected, and inasmuch as whilst the sufferer breathes a warm air in his workshop or home, his lung trouble is felt as little more than an annoyance; or as something which is to be taken as a matter of course, and like his wages, as an unavoidable incident of his calling.

As with chronic maladies at large, so with potters' bronchitis and asthma; the tendency is to grow worse and the lung lesion to extend, and soon the damaged respiration reacts upon the whole frame; the sufferer cannot get proper outdoor exercise, his appetite fails, his sleep is broken, the expectoration augments and grows muco-purulent, the body wastes slowly, whilst the increased effort to breathe entails strain upon the heart, leading not infrequently to disease of that organ, with the after-consequences in the shape of dropsical effusions.

We now have before us the fully developed disease known as potters' consumption or potters' asthma.

The shortness of breath sanctions the use of the term asthma; whilst the existence of cough, expectoration, and wasting, is suggestive of the appellation consumption. Still these terms are not rightly applicable to the actual lesion present. The morbid changes are not those of tubercular disease, and the symptomatology is diverse. At the same time, it must not be lost sight of that the tubercular lesion may be, and not infrequently is, a concurrent condition; nor that those predisposed to consumption are likely to have that malady lighted up by the dusty employment they follow.

To return to the processes followed in the making of pottery. The selected clays with the usual addition of a certain proportion of powdered flint, are mixed with the water to make a thick semi-fluid, called "slip." To render this fit for after processes, its excess of water must be got rid of. This formerly was done by evaporation in tanks aided by constant stirring. It is now effected in specially constructed machines, whereby the water is expelled by pressure. By either method a plastic material is produced, ready to the hands of the potter who moulds it as he sees fit.

We may reckon pottery to be the earliest industry pursued by man; vessels for eating and drinking were essential things; tenacious clay was almost everywhere accessible, and its readiness for modelling into any shape immediately perceptible to the simplest aborigines. Hollow vessels were a primary desideratum, and it needed but little observation to discover how easily these could be formed by a whirling or rotary movement with pressure about a fixed point. Hence soon arose the invention of the potter's wheel, a piece of mechanism that has come down to us from the remotest ages—modified little in detail, and ever the same in principle.

The artisan who works with the potter's wheel is called a "thrower," for he throws a mass of clay upon the rapidly revolving axis or central disc, and by skilful manipulation moulds it into the required shape. Owing to the mechanical features of the apparatus he uses, his business is the making of "hollow-ware," including cups.

Modern invention has greatly curtailed the work of the thrower by introducing the processes of "*pressing*" and of

"*casting*." Hence two new classes of operatives have arisen, known as *pressers* and *casters*—the former constituting the most numerous division of pottery artisans, and, what is regrettable, the greatest sufferers from their occupation.

They are divisible into two classes, called respectively hollow-ware and flatware pressers, according as they make hollow-ware, such as jugs and vases, or flatware, such as plates. Both alike employ a twirling disc, known as a "jigger," but in other respects their operations differ. The hollow-ware presser constructs his jug within a mould of the requisite shape, divisible into halves; whereas the flatware presser spreads a thin lamina of clay upon his flat mould resting upon his rapidly driven jigger, and proceeds to smooth the surface and edges. The mould used determines the shape and size of the article made, and also absorbs much of the moisture of the clay.

The article, as yet in a soft state, has next to be slowly dried. This is done in a closet situate behind the presser, the transfer being made by boys, who from their work are called "mould runners." In former years the jiggers were turned by hand, but at the present day are mostly driven by steam power.

The surface of ware as it leaves the hands of the throwers and pressers does not possess the smoothness required, and has to undergo other operations before it goes to the oven. These are sponging, friction with sand-paper, or turning. The first method needs no elucidation. The second, that of rubbing with sand-paper or some substitute, has grown, in the case of flatware, into an operation of considerable magnitude, and one of first-rate importance in relation to the health of the workers. Owing to "tow" having been first employed it acquired the appellation of "towing." It is done on a rapidly revolving "jigger," the tow or sandpaper being pressed by the hand on the surface of the flatware to be polished whilst in the biscuit state. It will be at once understood how great must be the dust thrown off by this proceeding. So great and fraught with injury was it, that regard to humanity and the health of the employed called for some provision against its patent evils. Happily the inventive genius of Mr. Turner, a manufacturer at Tunstall, suggested a simple plan of doing this work in a nearly enclosed box, provided with a strong current of air, produced by a fan, to extract and remove the dust as it arises, and thus prevent its diffusion on and around the workpeople. By this mechanical expedient this dusty process has, to a great extent, been rendered innocuous.

The operation of "towing" is specially applicable to flatware, plates and saucers. Where hollow-ware has to be duly smoothened, its surface is either sponged with a damp sponge, or otherwise is passed to a "turner," who finishes the surface by means of a lathe worked by a treadle, in the same fashion as a wood turner deals with the objects submitted to him.

The "pot-turners" constitute a special class of artisans, but not a numerous one. The treadles are worked by women and girls, who keep up a constant jumping action with one leg—a proceeding that is suggestive of evil to them, particularly when young and not strong. We, however, are justified in looking forward ere long to the displacement of this primitive way of giving motion to the lathes by the substitution of machinery. Indeed the change has already come about to a small extent in modern factories.

Here I am led to remark, that the application of machinery moved by steam power has, in the history of pottery, been of very slow growth. Forty years ago it was unknown, and up to the present time human labour contributes a very large proportion of the moving force required in many processes. The nature of the material, by its brittleness as it becomes dry, forbids indeed its application in many operations. Nevertheless, every year witnesses the extension of the use of machinery in the trade. Owing to the brittleness of clay in a dried or nearly dry condition, and its ready reduction to a pulverulent state, all who deal with it are exposed to its dust. And besides the larger operations previously alluded to, there are lesser ones falling to the lot of clay-workers. Principal among such are the handle and spout-makers, the sand-paperers, and the varied helpers whose special business is to clean off irregular and redundant fragments upon the ware. These cleaners are, in the language of the trade, called "fettlers." However, no special description of these people and their work is necessary; the primary agent for evil is the dust, and happily this evil is inconsiderable in the sundry minor divisions of labour adverted to.

Powdered flint is also largely used in the manufacture of pottery, though chiefly in china-making, where its main use is to pack the china within the boxes called "saggars," in which it is fired in the ovens. The filling in of the saggars with powdered flint is the work of the class of men named "placers." Their work is less continuous than that of flat pressers, and in consequence their exposure to dust is not so great, though, at the same time, the dust inhaled is even more harmful than that of clay alone. It is a common thing for placers to act likewise as oven-men and kiln-men, and so to incur the additional risk attendant upon the drawing of ovens and the emptying of saggars.

There is still another class of workers among whom flint dust is pre-eminently a cause of sickness and death. These are the china-scourers—all women. Their business is to brush off the flint which has adhered to the china in the operation of firing. The quantity is considerable, and in its removal by brushes a cloud of dust is thrown off, which, if not diverted from the respiratory orifices, enters the lungs and there works most serious mischief, setting up fibrosis and rapid consumption. Of all the operations pursued in the making of pottery, this one is the most destructive to health and life. Within a few years these scourers, if not dead outright, are broken-down women on the highway to the grave. Fortunately, compared with the whole number of hands in a china factory, they are few in number. The occupation ranks as about the lowest in the series of pottery avocations, for it is one that needs no special training, and, consequently, like other unskilled work, falls into the hands of the least instructed, and the least concerned with sanitary scruples and social considerations.

Another and far more important material used in pottery manufacture is *lead*.

This is employed in the form of the white carbonate or of the red oxide of lead; the former most frequently. These and other salts of the metal are most common constituents of colours used in decoration; whilst others, principally the chromates, are themselves actual colouring materials.

But the special use of red and white lead is—in conjunction with borax and china stone fired together in a kiln—to make an enamel to coat the ware, to give it smoothness, and to render it non-absorbent. The glaze or enamelling fluid is put on after the first firing of the ware, when it is in the condition known as "biscuit." In this state it is porous, absorbent and unfit for use.

The glaze is applied in a liquid state by simply dipping the ware in it; and the workmen occupied with this process are called "dippers." It very rapidly dries on the surface, some portion being absorbed. The very rapidity of drying causes much of the evil attending the operation; because it leads to the formation of a fine coating of dust readily diffusible. This fact in conjunction with the mode of working, wherein the hands and arms of the dippers are almost incessantly plunged into the glaze, will account for the prevalence of lead poisoning or plumbism in this class of workmen. For we cannot fail to recognise the inevitable absorption of the poison by the air passages in the shape of dust, and by the skin from immersion in the liquid.

A great effort is being made at the present time—promoted especially by the Home Office and the Factory Inspectors—to abolish if possible the use of lead in glazes; or, if this be not practicable, to diminish its employment and to guard against its poisonous properties. To attain these most desirable ends many glazes devoid of the metal, or nearly so, have been submitted to manufacturers, who, however, have not yet been induced to use them, in the absence of sufficient experiments and experience to justify them in so doing. A more practicable way of lessening the serious evils of the poison is suggested, viz., by the use of fused lead glaze only, without the usual addition of raw white lead. The value of the suggestion is now being fully tested, and it is to be hoped that a great reduction of the serious evils connected with the glazing of ware will reward the trial.

But even supposing the use of lead cannot be dispensed with, experience unmistakeably proves that its serious results may be very largely mitigated by greater attention, on the part of the artisans themselves, to cleanliness in person and in working. Men can be found who have been dippers for ten, twenty, and even thirty years, and have escaped the direful consequences of their occupation, entirely or nearly so. Such men are the careful and clean workers, and men who lead steady lives.

It requires personal observation to realize the carelessness and recklessness of workpeople who perfectly understand the danger of their calling, but who will eat food exposed to the contaminated air of the dipping-house, and this often with unwashed hands; or who will take little or no pains to cleanse themselves and their clothing on leaving work, or who will neglect to properly protect themselves from the bespattering glaze by suitable coverings. For such persons the interposition of factory regulations is urgently needed.

Much more might be said on this subject of lead as used by potters, and of the consequences attendant thereupon. But I forbear, knowing how fully and forcibly the subject of Plumbism will be placed before you by my distinguished colleague in this course of lectures, Dr. Oliver, who has made it a special study and employed the best advantages furnished in this country.

There is yet another ingredient that enters into the composition of china, not so directly chargeable with injury by its dust. I mean calcined bones of horned cattle. These are finely ground and mixed with the clay to form the "*body*" of china or porcelain ware. The bone gives transparency and lessens the brittleness. It is an expensive component, and on the continent is replaced by felspar.

This last-named substance is, in England, principally used in the production of "Parian" goods—mostly figures; but no facts are in hand to indicate how far its dust is prejudicial.

I have said that the powder of the calcined bones added to make the body of chinaware is of small consequence hygienically. Still it is but right to remark that bone dust proves very irritating to those who have to mix it, and that, besides its mechanical action, an annoyance often arises from a pungent offensive odour it gives off. Moreover, practical potters assure me that the compound of clay and bone dust, as used in china-making, exhibits a caustic and destructive quality not found in clay itself. It softens and destroys the wooden troughs of the throwers, which have in consequence to be faced with lead, and it is corrosive to clothing.

These mischievous properties one is inclined to assign to the nature of bone dust as a phosphate of lime; and as the dust of china-making is admittedly more noxious than that of the manufacture of earthenware, one cannot resist the impression that, over and above the harm attributable to a higher percentage of silex in china, additional injury arises from the calcined bone as an ingredient.

To justify this allusion to bone dust in the category of mineral dusts, it is almost needless to say that in pottery it is only the mineral element of bones, after complete calcination, that is dealt with.

To proceed. There is yet another mineral dust encountered in the pottery industry. I allude to Plaster of Paris, which is very extensively used in the making of moulds and models. But though readily diffused around the workers, it does not penetrate into the lung parenchyma as does ordinary potters' clay dust, and its pathological results are not nearly so conspicuous. It is conceivable that this circumstance is owing to its strong affinity for water, and its consequent arrest by the moist ori-nasal and bronchial mucous membrane, ere it can penetrate to the finer tissue of the lungs.

Having now passed in review the various mineral dusts connected with the manufacture of pottery—earthenware and china—and noted the processes wherein those dusts are evolved, it seems necessary, in addressing the members of a Sanitary Institute, whose primary purpose is to devise sanitary remedies, to say something respecting measures calculated to remove the evils of the trade, or at least to mitigate them. Those evils are very obvious, and unhappily their consequences are no less so. The business of the potter stands nearly at the head of the list of unhealthy trades, and it is an imperative duty to endeavour to give it a better position.

The insanitary factors are the mineral dust of clay, of silex, and of lead; subordinate to them are high temperatures, and the dusty and smoky atmosphere of a trade which demands a prodigal use of coal.

The dust of clay and flint operates directly on the breathing organs; hence our efforts must be directed to obviate its entrance into the respiratory passages by mechanical means. These means consist in, first of all, providing efficient ventilation in workrooms, and next in devising apparatus to prevent dust diffusing itself on and around the workers, and to withdraw it altogether from the shops. Until recent times such measures have been totally neglected, or attempted by very ineffective arrangements. Now pressure exercised by the factory inspectors and strongly seconded by aroused public opinion, has had the effect of rapidly introducing modern schemes of ventilation into factories, and also inventions to remove dust from the point at which it is generated. To accomplish these ends the chief instruments employed are ventilating and extracting fans. I cannot here enter into details of the mechanism adopted. Indeed, such a course is not called for, because present plans are but more or less tentative, and we may look for important modifications and improvements as the result of experiments. One drawback to the more general adoption of mechanical appliances, is the absence in numerous factories of motive power supplied by steam or gas or electric engines; an absence largely attributable to the smallness of the works and want of capital, and to the frequent irregular arrangement of detached shops and the consequent difficulty of conveying power.

Nevertheless, the future course to be followed to improve the hygiene of the potter's craft is sufficiently plain, and engineers and architects need give much more attention to the subject than they hitherto have done.

Respecting the subordinate factors of ill-health among potters little need be said. The regulation of the heat of workrooms is very much a matter of ventilation and of construction. The heat emanating from the closets wherein the ware is first placed can be moderated by care, and lessened by ventilation of the closets themselves; and that of the shops can be reduced by alterations in their construction and disposition, and by ventilating arrangements.

The introduction of steam and hot water pipes for warming the shops, in place of the old-fashioned stove pots, has operated injuriously upon the health of the operatives: because, for the most part, whilst securing warmth, it has been at the sacrifice of ventilation.

The enormous combustion of coal in firing pottery, and the dust and smoke attendant upon it, represent evils which we may yet hope to see removed, by the adoption of gas in place of the crude coal. Experience in America and elsewhere has proved the applicability of coal-gas for firing pottery, and nothing

more is now wanted than the inventive genius of engineers to contrive arrangements for substituting gas, which shall be both efficient and economical.

Another factor of no mean importance in relation to the occupation of potters is found in the habits of the workmen themselves. It is, as said before, particularly prominent in the instance of those who are brought into contact with lead, in whose case experience sufficiently proves to how great an extent care and cleanliness in work and dress, temperate living, and the use of some simple prophylactic expedients, will enable them to proceed with their task unaffected for a series of years.

All this is generally and equally true of every other department of the potter's business. In short, much of the sickness and mortality of the trade is avoidable by care, cleanliness and temperance; and without these qualifications, no mechanical arrangements and no official rules can be successful in obviating the evils of this calling.

The Manufacture of Cement.—This is a manufacture of no inconsiderable dimensions, although the numbers employed in it are not great.

The material made is known as Portland cement, and is an artificial product serving the same purposes as does Roman cement, which is a natural product found in volcanic deposits.

It has been a greatly persecuted form of industry, driven from the habitations of men to outside places, where, excepting the workers themselves, population is sparse, the surrounding land comparatively valueless, and the chances of prosecution for public nuisance and for destruction of crops are but few.

All this has followed from the malodorous and destructive vapours thrown off in the course of manufacture, and magnified by public sensitiveness and prejudice.

Let me first say what cement is in its composition. Chemically speaking, it is a mixture of carbonate of lime and silicate of alumina; or a double silicate of lime and alumina coloured by oxide of iron. The rough components are carbonate of lime (usually chalk), flint and clay, the last being of a selected tenacious character, and obtained from ancient lake bottoms, from river beds, and like places of past or present subsidence.

The first process is to grind the clay in a mill resembling a mortar grinding machine. After that the necessary portion of flint and lime are added and worked up together with water into a mud-like mass.

Formerly the amalgamation of the raw materials with water was done in tanks with the aid of heat, and after very prolonged stirring and time to allow settlement, the material was submitted to a process of wet grinding, and ultimately calcined in open-topped kilns.

Now the mud-like material is spread over the floor of large vault-like chambers, heated by a furnace at one end. After being there duly dried and subsequently calcined, the cement is ready for grinding between mill stones. The aim is to reduce the compounds to as fine a powder as possible.

Few manufacturing processes are more simple in principle. A semi-liquid mud is prepared and thoroughly mixed, then dried and calcined, and afterwards ground in a mill. Nevertheless, it presents possible causes of illness, both by heat and dust.

For example, a very high degree of heat is attained in the drying chambers or vaults, and when it has done its work, the residual dry cement has to be removed by shovels and sent up to the surface. As the excavation is piecework, and a speedy emptying of the chamber desirable, it is common for the labourers to descend into the chamber before the material has sufficiently cooled, and thereby to suffer exhaustion due to heated air conjoined with strong physical exertion, within a confined space, and some gaseous products not quite innocuous. As a matter of course, the excavation of the dry cement is attended by considerable dust; though to a less degree than the subsequent operation of grinding.

The dust generated in either way is highly irritating to mucous membranes, and causes heat and smarting of the eyes, and still more of the nose. In the case of the latter organ the irritation advances to local inflammation, and presently to ulceration, which especially attacks the septum of the nose, and ends by producing perforation. Farther destruction of tissue follows should work be continued and no efforts at treatment be made. This partial destruction of the *septum nasi* is a lesion well-nigh peculiar to cement makers. It is brought about by the irritating dust which clogs the nasal passages and provokes efforts to dislodge it by the finger nail, with consequent aggravation and extension of the ulcerative inflammation already set up.

The character of the dust cannot fail to prove highly irritating to the mucous membrane of the air passages, but thanks to protecting coverings of the mouth and the remarkable affinity of cement for water, almost the whole of it gets interrupted in the nose where it forms a plug, the expulsion of which is impelled both by the volition of the individual, and by automatic or reflex action. It must however be admitted that some of the finest particles do, in course of time, penetrate to the larger bronchial tubes, and eventually produce cough and shortness of breath, or a chronic bronchial asthma.

In this occupation of cement-making there does not appear to be much scope for sanitary appliances. Still something might be done in the grinding department to obviate the diffusion of dust. It may be urged that in the case of cement-mills the number employed is insignificant; but, if this be true, humanity imposes the onus upon proprietors to lessen, if not to altogether remove, a tangible cause of sickness; and the example of flour-mills, to some extent at least, indicates how it may be done.

In all dusty trades there is a simple expedient against dust inhalation found in the wearing of a respirator; and it is one that would seem to be well calculated to effect that object. In very many occupations, indeed, respirators are applicable, and would be far more so if improved and specially constructed to provide against the breathing of dust. Unfortunately this specially adapted character is not one commonly met with; for in their construction the principles necessary to make good respirators for sick folk who only want protection from cold and damp air, are those followed. The fine wire-gauze is not essential; it does not intercept fine dust, and the firm frame is only an impediment to the close adjustment of the dust-filtering material to the depressions about the mouth and nose.

The gauze with the inserted film of wool gets speedily choked with fine dust mixed with the moisture of the breath; and the whole apparatus impedes free expiration and inspiration, and when choked is not readily cleansed. A respirator must not be rigid, and its essential part to oppose the inhalation is a film of cotton wool, so stretched and supported over the mouth and nose, that it lies in immediate apposition with the cutaneous surface of the face around them. For a long series of years I and others have tried assiduously to get pottery workpeople exposed to dust to wear respirators, but with so little success that our endeavours must be accounted failures. The freedom of breathing is so embarrassed by them, and what seems of more account, if our female workers do not deceive us, the freedom of talk also, that they prefer to breathe dust rather than to wear them. Another objection arises from the inherent sense of beauty lodged in the breasts of all ladies; a sentiment seriously offended by the enclosure of the mouth by an ugly respirator, which is contemptuously called a muzzle, and which, in the presence of unmuzzled workers and their jests, only singularly strong-minded individuals can persevere in wearing.

Those who have favoured me with their attention to this discourse on the making of pottery will be disposed to ask, why I have said nothing, or next to nothing, of the ornamentation of ware by the processes of printing, gilding and colouring—

processes constituting the business of finishing or decorative department. The omission will seem so much the more glaring when the large number of hands employed in that department is taken into account; for the number so occupied equals, if indeed it does not surpass, that of those working in the clay-department. But the fact is, that the ornamentation of pottery by painting and gilding, is a form of work differing entirely from that of pottery making properly so called; though in almost all cases the two kinds of occupation are pursued in the same buildings, and those engaged in them get grouped together under the general heading of potters.

The hygienic features in common are: indoor labour, the use of lead, and, in the case of a small band of workmen, exposure to heat. Respecting the first-named no remarks are needed. In the matter of lead, the hands engaged in decoration are in injurious contact with the poison, in the form of colours in majolica painting, in "ground laying," and to a very small extent in ordinary enamel-painting. Lastly, as to exposure to heat, and omitting that experienced in working in hot shops, the two departments meet on common ground in kiln-work—a process of firing required to fix and make permanent the gold and colour decoration used for ornament. At the same time the conditions of labour in kilns and in ovens are not alike; those in the former being far less severe, considered in their hygienic bearings.

The sanitary features of the decorative and finishing department exist, however, in a pre-eminent degree, in the conditions more or less inseparable from sedentary labour. Such are the sitting posture with the body more or less inclined forward, the want of muscular movement necessary to healthy respiration and circulation and to muscular nutrition, and lastly, confinement in shops too frequently over-heated and under-ventilated, and fouled by the breath of numerous workers and by the products of gas combustion.

These factors are common to all sedentary occupations and need not be enlarged upon by me, although in the department of work in question they are the most weighty from a hygienic point of view.

I will now conclude by cordially thanking my hearers for the patient attention with which they have favoured me, and trust that I have succeeded in elucidating the sanitation of the pottery manufacture, as far as the compass of a single lecture would permit.

METALLIC DUSTS, CUTLERY, TOOL MAKING, AND OTHER METAL TRADES.

By SINCLAIR WHITE, M.D., F.R.C.S.Eng., D.P.H.Camb.

Lecturer on Public Health, Sheffield Medical School, &c.

READ NOVEMBER 23RD, 1893.

I HAVE selected the cutlery and file trades for my lecture, partly because they are industries which find employment for a large number of workmen in the district in which I reside, and I am thus able to speak of them from personal observation; and partly because they illustrate in several ways the need which exists for drawing the attention of the community in general, and the Legislature in particular, to defects in the sanitation of occupations.

These trades are of a highly specialised character, necessitating a long apprenticeship before proficiency is attained: and as in the majority of instances the callings have been handed down through many ancestors, the workmen may be said to possess hereditary qualities, whether for good or evil, incidental to their occupations. Then they are quite free from the adulteration of casual labour, and for this reason statistical evidences concerning them possess a relatively high value.

I propose to pass in review the special risks to health to which the workmen are exposed, the sanitary conditions under which they work, the evidence bearing on their health furnished by mortality and other returns, the factory legislation as applied to these trades, and, lastly, suggestions for remedying or ameliorating existing evils.

At the outset I gratefully acknowledge my indebtedness to the manufacturers and workmen of Sheffield for the uniformly courteous and frank reception they accorded me while gathering material for this lecture.

The manufacture of cutlery comprises a number of wholly distinct processes, each of which is interesting; but from a sanitary standpoint it is only necessary to refer at length to a few of these.

In the production of the best cutlery the first process is that of forging the blade out of a bar of heated steel. Inferior blades are frequently stamped or "flied" out of thin sheets of metal by means of machinery; while the lowest class of all is made out of a substance called "sow metal" cast in moulds.

Forging may be done by hand or by the aid of a steam-hammer. Hand forgers are a muscular, healthy class of workmen; and their calling, which is very similar to that of a blacksmith, presents nothing requiring special comment.

After the blade has been forged it receives the mark of the manufacturer, and is then tempered and hardened, these processes being commonly done by the forger. It is next passed on to the grinder, who reduces it to its proper shape and thickness and gives it its cutting edge. Grinding is done on circular stones, turned either by steam or water power. The stones vary in diameter from one or two inches to several feet, and are of different degrees of hardness, according to the nature of the work required of them.

From a sanitary point of view grinders may be divided into two classes known as "wet grinders" and "dry grinders."

Dry grinders are engaged in grinding steel forks, augers, gimlets, needles, and a few other articles. They form a comparatively small class of workmen, but owing to the excessive mortality which formerly obtained among them, they have long attracted the attention of the trade sanitarian. The attrition of the steel against the dry grinding stone gives rise to enormous quantities of steel and stone dust, which is very irritating to the lungs, and produces a pathological condition known as grinder's phthisis.

At one time dry grinding was, perhaps, the most unhealthy trade in the country. The late Dr. J. C. Hall, of Sheffield, in an admirable paper read before the Social Science Congress in 1865, stated "that, excluding boys, the average age of dry grinders was only 29 years." Of late the introduction of fans for carrying away the dust has greatly improved the conditions under which dry grinders work; and, as I shall presently show, this has been followed by a corresponding improvement in health and length of years, but the trade is still an unhealthy one.

Wet grinding is much the more important branch of the grinding trade, and gives employment to several thousand workmen in Sheffield. The grinding stone passes through a thin layer of water during its revolution, and the process is comparatively free from dry dust; but it is accompanied by other evils almost as great as those incidental to dry grinding.

The grinding stones are constantly throwing off water, which

soddens the floor and saturates the air of the grinding room. The damp atmosphere in which wet grinders work undoubtedly conduces to the appalling mortality from phthisis and other lung diseases to which they are subject. Two other factors must be mentioned which contribute to the same end. One is the stooping, constrained posture which many grinders assume as they sit astride their grinding stones with the elbows resting on the thighs; the other is the stagnant condition of the air of the grinding room, which in many respects resembles that of a damp cave.

Certain articles of cutlery are ground partly on a wet and partly on a dry stone. Thus the backs of razors and scissors and the bolsters of table knives are ground dry, while the rest of the blade is wet ground. The dry process is however of relatively short duration, occupying less than one-sixth of the entire time taken to grind the blade.

There is another process connected with grinding which gives rise to enormous volumes of dry dust. The grinding stones are received from the quarries in a rough condition, and the grinder, after mounting the stone on its axle, reduces its circumference to the proper shape and degree of smoothness by applying a bar of steel to it while it is revolving slowly. This process, which is known as "racing the stone," occupies less than half an hour; but while it is in progress, the air of the room near to the stone is almost unbreathable. All stones, whether for wet or dry grinding, require to be "raced" in the first instance.

Another danger to which grinders are exposed is the breaking of the grinding stone. These accidents are unfortunately common, and often cause frightful injuries and death. They are due to a variety of causes, such as departure from the circular shape owing to one side of the stone wearing faster than the other, flaws in the stone, allowing a portion of the stone to remain in water when not in use, fixing it on its axle by means of wedges instead of using plates and screws for this purpose, and permitting the stone to revolve too rapidly.

Most articles of cutlery after being ground are "glazed." This is done on a wooden wheel covered with leather, which has received a coating of emery and glue. The rim of the wheel is from time to time rubbed with a cake composed of emery, suet, and bees-wax. The glazer is used for the purpose of removing the marks left by the grinding stones, and, owing to the greasy nature of its surface, there is not much dust formed.

Behind the glazer, and in the same trough with it and the grinding stone, is a third wheel known as "the polisher," which is employed to give a highly finished appearance to certain blades. The polisher is also made of wood and covered with leather, but instead of emery a fine powder containing oxide of iron, and known as "crocus," is used with it. Polishing gives rise to a considerable amount of dust at a part of the room where the ventilation is especially bad. Glazing and polishing are usually done by apprentices.

The blades of pen-knives and many razors are subjected to a process called "lapping," which is done on a lead-rimmed wheel called "a lap." The process is of interest as being a possible source of lead poisoning; but I have failed to find anyone showing evidence of plumbism from this cause.

The next process is that of hafting, and this work is done by a class of men called cutlers.

The healthiness or otherwise of a cutler's occupation is to some extent determined by the class of work he does. Thus workmen who haft in ivory and tortoiseshell, work under more favourable conditions than those engaged on inferior material, such as wood and bone.

This difference is due to the fact that the former class do most of their work with a file, and produce little dust; whereas the latter shape the knife handles on an emery wheel, known as "a cutler's glazer," and produce clouds of dust, composed of steel particles from the rivets and tang, of emery from the dry glazer, and of bone or other material of which the handle is made. The cutler's glazer is a comparatively recent invention, having come into general use only during the last twenty years. Previous to then all handles were shaped with a file. It is most injurious when used for shaping the hafts of knives that have scale tangs, because the projecting portions of the tangs have to be ground down by it.

The cutlery manager of one of the largest firms in Sheffield assures me that cutlers, as a class, have become much more unhealthy since the introduction of the glazer. This opinion has been endorsed by other competent observers; and there is no difficulty in accepting it if we reflect that the modern scale tang cutler, when using a glazer, is virtually a dry grinder.

The bolsters of inferior knives are often made from an alloy of lead and zinc, which is cast on the blades and subsequently ground to the proper shape on an emery wheel. During the grinding process much dust is given off, and being inhaled by the workmen occasionally causes lead poisoning and death.

Files and rasps are largely manufactured in Sheffield and the surrounding districts. In Sheffield alone the industry gives employment to more than 4,000 workmen, besides a large number of females.

The principal processes in the manufacture of files are forging, annealing or softening, grinding on a wet stone, file cutting, and hardening. Of these file cutting and file hardening only need detain us.

File cutting may be done by hand or by machinery. Of late the proportion of machine cut files has steadily increased, but by far the greater number are still hand cut; and in this process more workmen are employed than in all the others conjoined.

Hand file cutters are exposed to two special dangers to health; one of these arises from the overcrowded and badly ventilated rooms in which they work, and will be fully considered when I come to discuss the sanitary condition of the workshops; the other is due to the employment of a lead bed on which the files are cut, and is a terrible scourge to the trade.

The teeth of a file are produced by means of a chisel and hammer; and to afford a firm bed for the file and reduce vibration, a block of lead is placed underneath the file. The non-elastic character of lead eminently fits it for this purpose, while its comparative softness prevents it from injuring the teeth of the file when the reverse side is being cut.

At each stroke of the hammer a fine cloud of dust containing much lead rises in the air, and as the file cutter sits with his face directly over the anvil he must perforce inhale some of this lead dust. Moreover, his left hand which holds the chisel is almost always resting on the lead block from which it receives a coating of lead, and in a great many instances some of this finds its way to his stomach at meal times. Nor is this all, a practice exists among certain file cutters of moistening from time to time the end of the left thumb at the lips, so as to secure a better grip of the chisel. This habit I am pleased to learn is dying out, but where it is practised it is a potent method of introducing lead into the body.

The ill effects resulting from the employment of lead in file cutting are only too well known. Colic, paralysis of the extensor muscles of the wrist and thumb, gout, and Bright's disease, are the most evident of its protean evils; but long before it produces these definite maladies its influence on the body is both seen and felt. The sallow anæmic countenance presented by the file cutter is almost characteristic of his calling, while enquiry will often elicit a history of constipation, indigestion, and bodily weakness, long antecedent to the development of more alarming maladies.

It is reasonable to suppose that file cutters who neglect to wash their hands before eating, and who are otherwise careless, will suffer from lead poisoning to a greater degree than those who are more careful in their habits.

But while this supposition is no doubt true as a rule, it admits of numerous exceptions, and one is driven to the conclusion that idiosyncrasy of constitution renders certain workmen highly susceptible to the pernicious effects of lead, while it enables others to effectively resist its power. In no other way can I explain some facts brought out during my inquiry. Thus a highly intelligent workman informed me that he was the oldest of five brothers, all of whom were file cutters and careful in their habits, yet four of these had died from the effects of their trade, and he himself had had lead colic. On the other hand, I have examined workmen who expressly stated that they were indifferent as to precautions, and yet were in good health after forty and in one instance after fifty-five years of file cutting.

These anomalous cases are serious stumbling blocks in the way of improvement, because they are sure to be quoted by file cutters when they are urged to take more stringent precautions against lead poisoning.

By way of sampling file cutters I examined one hundred men taken haphazard as I met them in their workshops. Their average age was thirty-seven years, and they had been working at their trade on an average for twenty-three-and-a-half years. Seventy-four had a lead line on their gums, twenty-eight had suffered from lead colic, and twenty had at some time been afflicted with paralysis of the wrist or thumb.

These figures, however, do not show the full extent of the mischief, because file cutters when they become seriously paralysed in the wrist are unable to follow their employment, and either take to some other calling, or too frequently become a burden to the community, until a life of decrepitude and disease terminates in premature death.

Although lead is well known to produce paralysis of the wrist and thumb, it would appear to be probable that in the case of the file cutter these affections may sometimes be partly due to the excessive use to which the muscles of the wrist and thumb are put.

The rapidity of a file cutter's movements is perhaps unsurpassed by that of any other handicraft, while the muscular energy produced in the heavier branches of his calling is truly phenomenal.

A deft workman will cut from 100 to 260 teeth per minute, using a hammer which ranges from nine pounds to a few ounces in weight, according to the size and character of the file. In cutting large files a workman will, in eight hours, develop in his right arm muscles alone sufficient energy to raise from 150 to 200 tons a foot high.

Machine cut files are frequently cut on lead or an alloy of lead and zinc, but there is little contact with the lead on the part of the machinist. I have examined a number of machine cutters in order to ascertain if they suffered from lead poisoning. The problem is complicated by the fact that many machine cutters were formerly hand cutters; but my observations lead me to the conclusion that machine cutting rarely, if ever, gives rise to this malady.

File hardening is most commonly done by heating the files in a coke fire and afterwards plunging them in a brine bath; but occasionally they are heated in a bath of molten lead, while a lead bath is universally employed for softening the tang of the file.

It is popularly supposed that the fumes arising from the molten lead are productive of lead poisoning, and I have had hearsay evidence of several men who it was said had died from this cause.

I have, however, failed to find direct evidence verifying this supposition. An examination of twenty file hardeners who used the lead bath, did not produce a single instance of lead poisoning. Three of these men had a lead line on their gums, but all three had formerly been file cutters. The point seemed so important that I deemed it advisable to examine the vapours given off from the molten lead; and I accordingly drew through water in a wash bottle several cubic feet of air taken from the surface of the bath while it was being used, and had the water analysed. Several experiments of this nature were conducted; but in every instance the water was found to be free from lead. Other investigations bearing on the same point yielded negative results; and it would appear to be fairly certain that the lead baths do not give off the vapour of lead or of its oxide, and are therefore unlikely to produce lead poisoning. It is only right to add that the molten lead is covered with a layer of fine coke; and to this agency the workmen attribute their immunity from lead poisoning.

I have now to describe the sanitary conditions under which these trades are carried on; but before entering on this subject it is desirable to mention the peculiar arrangement existing between workmen and the owners of the majority of cutlery works. The workmen are usually piece-workers, and, whether they work for the owner of the premises or for some one else, pay a weekly rental for their troughs or benches and the necessary motive power. They find their own tools, and are virtually joint tenants of the rooms they occupy.

Grinding may be done in separate buildings which are known as "grinding wheels," or on the premises where the other branches of the cutlery trade are carried on. In either case the grinding of heavy articles is conducted on the ground floor. The rooms or "hulls" as they are called are sometimes sunk below the level of the ground, and are, as a rule, bounded on three sides by blank walls, without adequate means for cross ventilation. The windows and door are in the fourth wall, and the former are usually devoid of glass, because the mud from the grinding stones would speedily obstruct the light.

The "hulls" are provided with fires for drying the blades after they have been ground; but the fireplaces are as a rule situated either in the front or in one of the lateral walls, and consequently their utility as ventilating agents is largely reduced. Each "hull" contains one, two, or more troughs which run from front to back, and in them are placed the grinding, glazing, and polishing wheels, in the order in which I have mentioned them. The floors are wet and dirty, and the atmosphere of the rooms damp and stagnant, particularly at the back where it is further defiled by dust given off from the polishing wheels. The cubical space per worker would as a rule be ample if sufficient ventilation were maintained.

Dry grinding and the lighter branches of wet grinding are carried on in rooms in the upper stories. Articles which are partly dry and partly wet ground are also as a rule ground in these rooms. Better ventilation exists here, but on the other hand the rooms are often overcrowded, and where dry grinding is done there is much dust generated. In the majority of dry grinding rooms an effort is made to remove the dust by fans, but occasionally these are absent. One fan is as a rule sufficient for several workmen. Attached to it are a number of tubes, each of which ends in an expansion or hood in front of the grinding stone. The tubes are put down by the owner of the factory, who likewise occasionally supplies the fans; but as a rule the fans and hoods belong to the workmen.

When properly constructed and looked after the fans act admirably for removing dust, and also aid in ventilating the workshops; but as several workmen commonly occupy one room and share responsibility for its sanitary condition, there is the usual failure to perform efficiently that which is the duty of no one in particular. For this reason the tubes are apt to become choked from not being periodically cleaned out, or a trivial defect, which a few minutes would remedy, is allowed to render the fan inoperative for days together. Again a careless grinder by neglecting to use a hood will seriously discount the effort of his more careful shopmates to keep down dust.

Hence it happens that in many workshops where dry grinding is done, the dust accumulates in large quantities on the floor, to rise in dense clouds each time it is disturbed.

The buildings in which cutlers work vary very widely in their sanitary aspects. Many of these places are as perfect as it is possible to make them, having regard to the nature of the work carried on therein. The rooms are lofty, well lighted, and provided with efficient means for ventilation, together with fans for the removal of dust where such is generated in large amount. But in the manufacture of scale tang cutlery where glazers are extensively used the atmosphere, under the most favourable circumstances, is charged with fine dust. This is especially noticeable where bone is employed for hafting. Moreover, manufacturers complain bitterly that the workmen will often block up ventilators and dispense with the use of fans unless strict vigilance is maintained. It may appear to be incredible that anyone should pursue so suicidal a policy, yet personal observation compels me to admit that these allegations are not altogether groundless.

But while I gladly note these superior factories, I am compelled to state that in a large number of cutlery works the sanitary conditions are utterly bad.

Dilapidated buildings, constructed in the first instance without due regard to the requirements of health, are sadly too common. In these, overcrowding, defective ventilation, and a dust laden atmosphere are the rule rather than the exception. Externally the condition of affairs is often no better, the factories being shut in by other buildings which exclude sunlight from the lower rooms, and interfere with the circulation of the air.

Fans exist in the majority of scale tang cutlers' shops, but by no means in all. When present they are sometimes useless owing to the choked condition of the outlet tubes. Another grave defect is the indiscriminate mixing of various classes of workers. Thus in a shop where a dozen men work, only two or three may be engaged in dust-producing processes, yet all are obliged to inhale the dust laden atmosphere.

Again a careful workman will provide a fan for his own use and still suffer from dust, because his shopmates work without fans. Such instances are perhaps rare, but they serve to emphasise the difficulties that arise in dealing with the sanitary evils of the trade.

The forging, grinding, and hardening of files are conducted on the premises of the manufacturer; but file cutting by hand, which gives employment to more than one-half of all file makers, is usually done by outworkers in shops which they rent for their use. These workshops are commonly one storied buildings, situated in courts and yards, and surrounded by dwelling houses. Many of them are in close proximity to middens, which receive the excreta of the surrounding inhabitants, and are nearly always wet and offensive. Occasionally the file cutters' shop is placed under the same roof with a midden, being separated from it only by a thin brick wall.

The workshops contain from two to ten or more workers, and are nearly always overcrowded—often much overcrowded.

I measured 21 workshops, in which 109 file cutters worked, and found the average space to be equal to 167 cubic feet per worker, and in one instance it was as little as 100 cubic feet. It should be added that these shops were not specially selected, and are probably a fair sample of what obtains throughout the older parts of the city. It is exceptional to meet with any special means for ventilation; and as the occupation is a sedentary one, the windows and doors are shut during cold weather.

Fortunately all file cutters' shops are provided with a fire, but as the chimney is always a low one, its aspirating effect is inconsiderable. Moreover, the faces of the workers are on a higher level than the chimney throat, and consequently the conditions for using it as a ventilator are bad. Occasionally one meets with a rude arrangement for washing the hands, but this is so exceptional as to be remarkable.

I shall now place before you the information which statistical returns afford us respecting the incidence of disease and death on these workmen.

Unfortunately, the trade societies to which the workmen belong exist only for the purposes of regulating prices, and of providing pay for them when they are out of work, or on strike: nor do the sick and funeral clubs furnish data sufficiently exact to be of any value for this purpose. The only significant fact I have been able to gather from this source is that most sick clubs decline to admit to membership dry grinders on the plea of their unhealthy calling.

But while we are cut off from the information which a well organised system of registration of sickness would afford, the registrars' death returns provide us with material from which it is possible to extract data showing the influence of occupations on the health and length of years of workmen.

Until quite recently in this country, if we except the valuable decennial reports of the Registrar-General, the task of working out mortality tables bearing on trades has been shamefully neglected, and yet I can conceive of no more useful work to which Medical Officers of Health could turn their attention; and I would respectfully and earnestly suggest to the Local Government Board the expediency of insisting on such tables being supplied for the chief trade centres in the country.

Following the example set by Dr. Ogle and his illustrious

predecessor Dr. Wm. Farr, I began in 1885 to compile the death returns for the more important trades of Sheffield. The work has been continued by my successors at the Sheffield Health Office, and through the kindness and generosity of Dr. H. Littlejohn, the present Medical Officer of Health, I am able to present to you mortality tables for grinders and file-makers which are perhaps unique.

An examination of death returns may be made to yield useful information in a variety of ways. By comparing the number of workmen in each trade, who have died during a stated period, with the computed number engaged in each trade, we ascertain the death-rate prevailing among workmen in various trades for that period. [Before this method can however be made generally applicable, the census returns will require to be much more detailed than heretofore. Thus at present the census returns give no information whatever respecting the number of grinders in the country, these workmen being classed with other trades.] By tabulating the deaths in each trade according to the diseases which occasioned death, we ascertain to what diseases workmen in any particular calling are specially liable. And lastly, by making a classification in which the age at death is the leading feature, we are able to indicate the length of life attained by workmen in various trades.

For the purpose of publication I have compiled mortality tables showing the number of deaths, the principal diseases which caused death, and the age at which death occurred among grinders and file-makers in Sheffield during the eight years 1885—92. Deaths among females, and boys under the age of 15 years have been excluded.

To make the figures readily intelligible to the ordinary reader, I have added a comparative mortality column compiled from the annual reports of the Registrar-General for the years 1887-88-89. This column shows the proportion of persons who died of various diseases at various age periods per 1000 deaths among the entire male population of England and Wales over the age of 15 years. It will afford at a glance the means of comparing the incidence of disease and death on the workmen I have mentioned with that obtaining among the entire adult male population of the country. The critical reader may observe a few minor inconsistencies, which are unavoidable owing to the smallness of some of the numbers dealt with.

For many reasons the mortality prevailing among the entire adult male population is the most convenient standard by which to compare that for various occupations; but as Dr. Ogle has pointed out it is not an ideal standard, because "it is contributed to by an enormous number of persons who are permanently enfeebled in health, and unfit for work of any kind;" and other things being equal, should be higher than the mortality among a body of workmen such as grinders, the majority of whom are healthy and robust when they begin their trade.

I will now briefly point out the most important facts brought to light by these tables. The most significant of these in connexion with grinders is the appalling death-rate which obtains among them from phthisis and other diseases of the respiratory organs. Phthisis causes 345, and other respiratory diseases 295, in every 1000 deaths among grinders, as compared with 144 and 182 in every 1000 among the entire male adult population of the country. In other words, these diseases are more than twice as fatal to grinders as they are to the entire male adults of the country. If we turn to the ages at death, a similar unsatisfactory state of things prevails. 458 grinders in every 1000 die between the ages of 35 and 55 years, as compared with 261 for the entire adult male community; and only 140 deaths in every 1000 occur after the age of 64 years, as compared with 391 in every 1000 for the entire adult male community.

The dusty nature of a dry grinder's occupation prepares us to accept these figures as applied to him; but it must not be lost sight of that dry grinders form a very small minority of the grinding trade, probably less than five per cent. of the entire number. Moreover, my investigations lead me to believe that dry grinders, although they still show an enormous mortality from phthisis and bronchitis, live to a much greater age than formerly. Thus I found the average age of twenty-two unselected fork grinders to be forty-three years, which is a marked improvement compared with the late Dr. Hall's estimate of twenty-nine years. Again, during the four years 1889—92, the average age at which fork grinders died was 45½ years. It is quite evident, therefore, that dry grinding will not account for more than a small proportion of the excessive mortality which prevails among grinders as a class.

If we except the processes of "polishing" and "racing the stones" wet grinders produce very little dust, but they have an equally potent agent for mischief in the damp, ill-ventilated atmosphere in which they work; and to this cause may be attributed their excessive fatality from pulmonary diseases.

The mortality column for file makers shows that 453 in every 1,000 deaths occur between the ages of thirty-five and fifty-five years, as compared with 261 for all adult males, and that only 198 in every 1,000 take place after the age of sixty-four years, as compared with 391 for all adult males.

The diseases which occasion the excessive mortality among file makers are phthisis and other respiratory disorders, which

DISEASES.	AGES AT DEATH.	Deaths registered in Sheffield during the eight years 1885-92. Grinders.	File Makers.	Proportion of deaths per 1000 due to various diseases at various age periods during the eight years 1885-92. Grinders.	File Makers.	Comparative Mortality Column, shewing in each 1,000 deaths of Males in England and Wales over age of 15 years, the number caused by various diseases at various age periods during the three years, 1887-89.
Diseases of the Nervous System.	Under 25 years	1	1	1	1	6
	25 and „ 35 „	3	3	3	4	7
	35 „ „ 45 „	9	26	11	36	12
	45 „ „ 55 „	15	18	18	26	17
	55 „ „ 65 „	12	28	14	39	26
	65 and over.........	17	25	20	35	61
	All ages	57	101	67	141	129
Diseases of the Respiratory System.	Under 25 years	10	6	12	9	7
	25 and „ 35 „	29	12	34	17	12
	35 „ „ 45 „	35	27	41	38	19
	45 „ „ 55 „	65	44	76	61	28
	55 „ „ 65 „	67	37	79	51	40
	65 and over.........	45	47	53	66	76
	All ages	251	173	295	242	182
Phthisis.	Under 25 years	26	19	31	26	28
	25 and „ 35 „	41	28	49	39	37
	35 „ „ 45 „	81	42	95	59	34
	45 „ „ 55 „	86	31	101	43	25
	55 „ „ 65 „	47	14	55	20	14
	65 and over.........	12	1	14	1	6
	All ages	293	135	345	188	144
Diseases of the Urinary System.	Under 25 years	2	0	2	0	2
	25 and „ 35 „	3	9	4	12	3
	35 „ „ 45 „	1	14	1	19	5
	45 „ „ 55 „	9	15	11	21	7
	55 „ „ 65 „	5	9	6	12	10
	65 and over.........	1	4	1	6	18
	All ages	21	51	25	70	45
Diseases of the Circulatory System.	Under 25 years	3	2	3	3	6
	25 and „ 35 „	7	9	8	13	8
	35 „ „ 45 „	12	15	14	21	14
	45 „ „ 55 „	14	16	17	22	21
	55 „ „ 65 „	16	15	19	21	31
	65 and over.........	11	11	13	15	63
	All ages	63	68	74	95	143
Diseases of the Digestive System, including Liver.	Under 25 years	5	2	6	3	4
	25 and „ 35 „	6	3	7	4	4
	35 „ „ 45 „	3	5	3	7	7
	45 „ „ 55 „	3	7	3	10	11
	55 „ „ 65 „	4	7	5	10	13
	65 and over.........	3	1	4	1	19
	All ages	24	25	28	35	58
All other Diseases.	Under 25 years	15	12	18	17	28
	25 and „ 35 „	17	17	20	24	24
	35 „ „ 45 „	27	33	32	46	29
	45 „ „ 55 „	30	32	35	44	32
	55 „ „ 65 „	22	17	26	24	38
	65 and over.........	30	53	35	74	148
	All ages	141	164	166	229	299
All Causes.	Under 25 years	62	42	73	59	81
	25 and „ 35 „	106	81	125	113	95
	35 „ „ 45 „	168	162	197	226	120
	45 „ „ 55 „	222	163	261	227	141
	55 „ „ 65 „	173	127	204	177	172
	65 and over.........	119	142	140	198	391
	All ages	850	717	1000	1000	1000

cause 43 per cent. of all deaths, as compared with 32·6 per cent. for all adult males; urinary diseases 7 per cent., as compared with 4·5; and nervous diseases 14·1 per cent., as compared with 12·9.

The Registrar-General's estimate for file-makers, although compiled on a somewhat different plan from that which I have adopted, shows similar results. His general mortality figure for these workmen is 1,667, as compared with 1,000 for all males at corresponding age periods, while his special mortality figure for phthisis and other diseases of the respiratory organs is for file-makers 783, as compared with 402 for all males. Moreover, he shows that the mortality from lead poisoning among file cutters is more than twice as great as that among any other class of workmen.

The deaths registered as being actually due to lead poisoning, together with the excessive mortality from diseases of the urinary and nervous systems, may be properly referred to the lead bed used by file cutters; while the abnormal mortality from phthisis and other respiratory diseases is accounted for chiefly by the overcrowded and badly ventilated workshops n which they work.

Had it been possible to compile a mortality column for file cutters only, there can hardly be a doubt that it would have shown a higher mortality still.

Owing to the ambiguity which exists respecting what constitutes a cutler, the Registrar's returns for this trade are comparatively worthless, and I have been unable to compile a trustworthy mortality table for these workmen; but there can be little doubt that scale tang cutlers suffer greatly from diseases of the lungs.

The Registrar-General's estimate for this class of workmen shows a general mortality figure of 1309, and a special mortality figure for phthisis and other respiratory disorders of 760, as compared with 1,000 and 402 respectively for all males at corresponding age periods.

But before accepting the figures I have prepared as showing the unhealthy nature of the callings pursued by these workmen, it is desirable to enquire if there are other factors than their occupations which may specially influence their health for good or for evil. In other words, do their habits of life and the conditions under which they live outside their workshops materially contribute towards the results which statistical evidences yield? This is an exceedingly complex question, and yet on its solution depends the value to be attached to statistics when they are offered as evidence of the unhealthiness or otherwise of any trade. A calling may of itself be a healthy one, and still show an excessive mortality among its workers owing to their dissipated habits. The same result may accrue owing to the workmen spending their nights and unoccupied hours in unsanitary houses, or in districts that are from their position unhealthy. On the other hand the incidence of unhealthy trades will be less felt by workmen who live prudent lives under favourable hygienic conditions when not at work, than by others less prudent or less favourably situated.

Briefly it may be taken that the habits of life and the houses occupied by the workmen I am discussing are, from a sanitary point of view, neither better nor worse than what obtains among the other artisan classes in Sheffield. There are no data which would enable us to form an accurate estimate of the mortality prevailing among this class, and the most we can do is to fall back on the evidence afforded by the mortality figures for the entire city.

Without wearying you with tedious details, it may be stated generally that the average death-rate for Sheffield is somewhat higher than the average for the other large towns in England, and distinctly higher than that for the entire population of the country.

We must therefore remember that, in comparing for the purpose of my lecture the mortality prevailing among Sheffield workmen with that for the entire country, the Sheffielder starts somewhat handicapped. A part of this handicap, it is true, is the result of unhealthy trade influences and should not count, but the greater portion is undoubtedly the outcome of other causes. The total amount however is not sufficient to seriously influence the results arrived at, and if we take the mortality among all adult males in Sheffield as our standard, it will still be found that the trades under review are distinctly unhealthy according to this standard. Thus the death-rate for all males over the age of fifteen years in Sheffield during the eight years 1885—92 was 19·1 per 1000 per annum, while that for file makers during the same period and at corresponding age periods was 22·1 per 1000 per annum.

Owing to defects in the census returns it is impossible to calculate the annual death-rate for grinders, but it is quite certain that it also is largely in excess of that for all adult males in Sheffield.

The legislature of this country has done much to improve the conditions under which workmen pursue their various callings, and although local peculiarities and unforeseen contingencies sometimes frustrate the beneficent intentions of our legislators, there can be no doubt that the Factory Acts have been and will continue to be productive of an enormous amount of good.

The most important portions of these Acts, from a sanitary point of view as applied to the trades I am dealing with, are Clauses 3 and 36 of the Factory Act of 1878, and Clause 8 of the Act of 1891.

The first of these enacts that "a factory shall not be so overcrowded while work is carried on therein as to be dangerous or injurious to the health of persons employed therein, and shall be ventilated in such a manner as to render harmless, so far as practicable, all gases, vapours, dust, or other impurities generated in the course of the manufacturing process or handicraft carried on therein that may be injurious to health." The second provides that "If in a factory or workshop where grinding, glazing, or polishing on a wheel, or any process is carried on by which dust is generated and inhaled by the workers to an injurious extent, it appears to an inspector that such inhalation could be to a great extent prevented by the use of a fan or other mechanical means, the inspector may direct a fan or other mechanical means of a proper construction for preventing such inhalation to be provided within a reasonable time."

The third clause provides that when the Secretary of State certifies that any trade is dangerous or injurious to health, the Chief Inspector may serve on the occupier of the factory or workshop a notice requiring the observance of such special rules, or the adoption of such special measures, as appear to the Chief Inspector to be reasonably practicable, and to meet the necessities of the case.

The Acts further stipulate that the occupier shall be responsible for carrying out the various provisions which they contain.

At first sight it would appear that these enactments leave nothing to be desired, but when we examine their application to the cutlery trades it is found that they work badly, owing to the difficulty of bringing home responsibility for their observance.

Commander Hamilton Smith, Factory Inspector for Sheffield and the surrounding districts, has been good enough to give me his views on this and other defects in the Factory Acts. He points out that "many grinding wheels and cutlery works are the property of companies who let off rooms and power to workmen, and successfully repudiate responsibility for sanitary control." It would appear that the same irresponsibility can be claimed by cutlery manufacturers who let rooms or parts of rooms to their own workmen; and that if the Inspector insists on fans or other needful appliances being provided, he must proceed legally against the workmen.

The outcome of all this is that it is difficult or impossible to apportion responsibility for sanitary requirements, the Inspector's work is enormously increased, and often rendered excessively irksome, while the amount of good he can effect is proportionately lessened.

There is but one remedy for this state of things. Sooner or later the Legislature will have to fix on the individual who lets off rooms and power to workmen the responsibility for carrying out the provisions of the Factory Acts. We shall be told that an enactment of this kind would disturb long established trade usages, and be unfair to the manufacturer; but apart from the fact that it is the only feasible way out of the difficulty, it would merely place cutlery manufacturers on the same footing as that occupied by most other employers of labour in the country. Moreover, some of the best cutlery firms already recognise their moral responsibility in this respect, and provide for the use of their workmen fans and all other contrivances of a sanitary nature.

The Factory Act of 1891 transferred the sanitary control of workshops from the Factory Inspector to the Local Authority. Under its provisions all new workshops must be registered, and a register of such places is kept by the Medical Officer of Health. The period which has elapsed since the passing of this Act is not sufficiently long to enable one to pronounce final judgment on its working, but at least one defect has already come to light. The Act did not make it obligatory on the part of the Local Authority to provide efficient machinery for the proper supervision of these places, and the Sheffield Local Authority have not availed themselves of the optional power they possess in this respect, but have handed on to the already overworked Sanitary Inspectors the duty of inspecting workshops. Up till the present time there has been no systematic inspection of these places, nor has any serious attempt been made to deal with the overcrowding and other sanitary defects which abound in them.

It is calculated that there are altogether 2,000 workshops in Sheffield, and to efficiently control these at least three special inspectors should be provided.

The law at present stipulates that the occupier of a workshop shall within one month of the date of commencing to use such workshop notify the fact to the inspector, and supply him with details respecting the nature of the work, &c., carried on therein. This requirement is so far so good, but it does not go far enough. It would be much better if the legislature insisted on inspection and approval as preliminaries to the registration or licensing of premises as workshops.

In this way, as Commander Hamilton Smith points out, "no license would be granted for undesirable places, the license would state exactly the conditions required. The occupier and landlord knowing what to do would do it; and when it was found necessary to prosecute, the inspector would present to the Bench an actual offence, instead of what is now considered the technical offence of not having given notice of occupation."

Having regard to the unhealthy character of the work done by grinders, file cutters, and certain classes of cutlers, the Home Secretary should direct the Chief Inspector of Factories to draw up special rules under Clause 8 of the 1891 Act, containing requirements to be observed in places where these trades are carried on. The rules should specify the minimum cubical space per worker permissible, together with the special means to be provided in each case for the removal of dust and impure air.

A notice should be exhibited in each room showing its cubical capacity and the maximum number of workers who may be employed therein at any one time, together with the special rules to be observed. Before however special rules can be made effective, it will be necessary to shift the responsibility for their observance from the workmen to the person who lets off the rooms.

The sanitary condition of rooms in which grinders, particularly wet grinders, work admits of much improvement. These rooms should always be above the level of the surrounding ground, and so situated in regard to surrounding buildings as to allow of free entrance for fresh air and sunlight. The floors should slope to the front, and be composed of concrete or some other impermeable material so that it would be impossible for pools of water to collect, as is frequently the case at present. Better means for ventilation are urgently required, especially for the back part of the rooms. The fire-places might with advantage be placed at the back, so as to secure a thorough current of air. Another excellent plan would be to have an exhaust fan for each room connected with a series of tubes ending in front of the polishing wheels. In this way a thorough current of air from front to back would be secured, while the tubes would carry away the dust generated in polishing.

To minimise the danger arising from the breaking of grinding stones it should be obligatory to use plates and bolts instead of wedges for fastening the stones on their axles.

Dry grinding should be done in separate rooms, and not as is sometimes the case in the same room where wet grinding is carried on. When stones are being "raced" the workmen should use some form of respirator. In the absence of a special appliance an ordinary woollen muffler drawn over the mouth and nose answers very well.

In cutlers' shops there ought to be ample air space, and the means for ventilation should, as a rule, be beyond the control of the workmen. The glazing wheels used by scale tang cutlers should always be provided with fans for carrying away the dust. Fans might likewise be extended to other dusty processes with advantage, as in addition to removing dust they are very efficient ventilators. Where practicable dusty and non-dusty processes should be carried on in different rooms.

Where file hardners use a lead bath, there should always be a flue for carrying away the fumes given off from the bath. Apart altogether from the possibility of these baths giving off the vapour of lead, flues are required for the removal of other noxious gases.

Bearing in mind the poisonous nature of a file cutter's trade, ample air space should be insisted on—not less than 300 cubic feet per worker; and this should be conjoined with suitable means for ventilating the workshops.

File cutters' shops that are placed in close proximity to foul middens, or so surrounded by buildings that ingress of fresh air and sunshine are impossible, should be closed as unfit for habitation.

A lavatory with water, soap, and nail brushes, should be provided for washing the hands after work, and workmen should be discouraged from eating or storing their food in the workshops.

I need hardly say that attention has been repeatedly directed to finding a substitute for the lead bed on which the files are cut. Unfortunately the peculiar physical properties of lead, which render it so suitable for this purpose, are not met with in any other non-poisonous metal or alloy. After having devoted much time to this point, and having had trials made of nearly every substance which appeared likely to answer the purpose, and after calling in the aid of several experts, I can only confirm the opinion formed by previous enquirers that there is no known substance other than lead, or an alloy of lead, that will meet the requirements of the file cutter.

But while we are unable to suggest a substitute for the lead bed, there can be no doubt that its evils may be to a large extent prevented by adopting well recognised precautions. The most important of these are, to wash the hands and moustache before eating, to frequently remove all the dust that has collected around the anvil, and to avoid as much as possible contact of the left hand with the lead. The lead block should be made as narrow as possible, and a strip of clean paper might be placed over that part of it which comes in contact with the hand.

In conclusion, let me impress on you the supreme importance of trade sanitation. It has its sentimental side, but in this eminently practical age the value of sentiment is apt to count for little. We cannot however afford to ignore the practical bearings of the subject. Each skilled artisan represents a certain amount of wealth to the nation, and his premature death or disablement from preventible causes is a direct and unnecessary loss to the country, while indirectly it leads to the same result by swelling the burden of providing out of the public purse for those who are dependent on his labour for sustenance.

Strangers from other lands when they come to this country are much impressed with the manner in which we care for the sick, the destitute, the demented, and even the felon. Let it be our aim to make the sanitary condition of our factories and workshops also a source of national pride, and in accomplishing this we shall not only add to our wealth, but likewise brighten and better the lot of our toiling fellow countrymen, who are the life blood of the nation, and who have done so much to make England the workshop of the world.

TEXTILE MANUFACTURES, SILK, COTTON, WOOLLEN AND LINEN INDUSTRIES.

By J. T. ARLIDGE, M.D. & A.B.Lond., F.R.C.P.,

Consulting Physician to the North Staffordshire Infirmary, Stoke-on-Trent; Late Milroy Lecturer at the Royal College of Physicians, London.

READ NOVEMBER 30TH, 1893.

IT was at rather a late period before the date fixed for this Lecture that I had the honour of being asked by the Council of the Institute to undertake the subject of the Sanitation of Textile Industries. I solicit therefore some indulgence on the part of my audience when they come critically to examine the facts and opinions I advance. These, I may say, are for the most part the fruit of my own observations made in textile factories in different parts of the country. At the same time they have the disadvantage of being the observations of one who professes to be no expert in textile operations, or in the comprehension of the intricacies of the most complicated and elaborate machinery therein employed.

Happily I do not feel called upon to describe that machinery, and need only refer to it in its relations to sanitation and to the materials submitted to its operation.

Of the textile manufactures, it may be safely stated that they rank first among the industries of this kingdom, by the number of persons engaged in them, and by the value of their products. They were also the first to assume a national importance, and to elevate this country to its pre-eminent rank as a manufacturing one.

Moreover, from their rise and development, and from the outcome of sanitary, social, and moral conditions, they were the first to call into existence factory legislation and the intervention of the State in the conduct of private enterprise; the first, in short, to make an inroad upon the principle of individualism.

The extent of the textile industries is a well-known fact. It will render it still better understood if I quote figures from the last Return of the number of textile factories, and of that of the persons employed in them, made to the House of Commons in 1890. From this document it appears there were 7,190 such factories in Great Britain and Ireland, together employing 1,084,631 individuals. Of these 428,082 were males, and 656,549 females. A further analysis of the Return shows that of these 86,499 were working half time, and consisted of 40,558 males and 45,941 females. Owing to comparative stagnation of trade in textiles since 1890, I fancy these figures about represent the numbers of the employed at the present day.

A glance at the statistics shows at once that the textile industries give employment to many more women than men, the former exceeding the latter by nearly 230,000, which number is little short of one-fourth of the total of the employed.

The transition from hand-spinning and hand-weaving (due to the introduction of steam-power) to machine-spinning and weaving, was very rapid, and its immediate consequence was the origin of associated labour on a scale hitherto unknown, and a development of trade theretofore undreamt of. From this flowed remarkable changes in the social conditions, and in the distribution of the industrial population; and co-ordinate changes charged with important sanitary consequences.

But it remains a remarkable fact that those consequences of employment upon health have attracted very little attention from the medical profession. For excepting stray communications in medical periodicals, the almost only source of information respecting the hygiene of textile factories is to be found in the "Blue books" issued by the medical staff of the "Local Government Board," and of the medical department of the Privy Council Office that preceded.

Of all official writers on the diseases and mortality of textile operatives, we are most indebted to the late Dr. Headlam Greenhow, who acted under the direction and supervision of Sir John Simon.

What especially is still needed are careful clinical observations on the disorders of textile workers, and minute investigation of the lesions associated with them; not omitting a concurrent judicious examination of the sanitary conditions of the labour pursued.

In no country in the world are larger and better opportunities for such study to be found than in the United Kingdom; and I hope to arouse the attention of medical practitioners in textile towns to the subject, and to the wide field it opens out for original research.

The *textile industries* are divisible into several branches according to the material used. Such are the silk, cotton, woollen, linen, and jute and hemp manufactures. Subordinate branches are represented by carpet-making, lace-making, and hosiery-making, by blanket and flock-making, by the weaving of cocoanut fibre, and by the making of cordage and of horse-hair tissue.

The mere enumeration of textile trades suffices of itself to show that the materials employed have very diverse origin; some coming from the animal and others from the vegetable kingdom. Indeed, the list would be incomplete were the mineral kingdom forgotten, seeing that asbestos is a substance that can be woven into a tissue.

The textile materials derived from the animal kingdom are silk, wool and its congeners, mohair and cashmere, and horse-hair. Those coming from the vegetable kingdom are cotton, flax, jute and hemp, and cocoanut fibre and straw. There are indeed other fibrous substances brought into use for weaving materials suitable for clothing and other purposes; but of them no account is called for in the present lecture on the textile industries of Great Britain.

The various manufactured products of these several substances differ widely in economical importance and commercial value. Likewise the manufacturing processes and machinery concerned in elaborating them, differ among themseves in character and in various incidental and accidental features; add to these the distribution of the sexes and of the ages of the workers engaged in them. Yet amid all the diversities obtaining between the several forms of textile industry, these have certain features in common. The most marked are the processes required for spinning the material into "yarn" and its subsequent weaving into "cloth."

The machinery employed in all textile works presents a general similitude in principle, although it differs in detail according to the material dealt with, and the form of tissue to be evolved from it. Moreover, it is perpetually undergoing modifications aiming at greater simplicity or efficiency, or at greater cheapness of production.

Again, noise and vibration are inseparable from machinery, and must operate as sanitary factors not to be ignored.

Further, machinery moved by steam or other power, collected within a common building, and having its purposes directed to various ends, implies associated labour. Also in certain measure, although common employment prevails, the intricate working of machines leads to a great sub-division of labour, and along with this a remarkable monotony of work.

Its speed likewise demands unremitting attention, and causes strain upon the organs of sense.

Another incident attaching to many machines is, that they entail a standing, and often too a bent position, or it may be a greater weight or strain upon one part of the body than on another, leading to distortion; others again involve a sitting posture with its drawbacks to health.

Yet another widely prevailing incident is the production of dust by machines in connection with the material operated upon. In this matter we recognise a most important health factor; one, in fact, occupying the foremost place in textile work at large.

What the amount of dust diffused shall be, is mainly determined by the physical nature of the substance acted upon, and the possibility of guarding against the evolution of dust by mechanical means. Again, machinery though universal in textile trades, has to be modified by special arrangements in some of them, for the supply of moisture, or steam, or oil, and to these substances its consequences to health are attributable in no small degree.

Such, in general terms, are the sanitary incidents accompanying the use of machinery, and to be found in varying degree in textile works at large.

A description of the machinery in use for spinning and weaving I am not competent to give. To attempt it, one would require the technical knowledge of a mechanical engineer, and if accomplished, few of my audience would derive instruction therefrom.

In fact, it is not a little embarrassing to comprehend and bear in mind the special appellations given to particular divisions of labour and to those who follow them; for these differ in different textile occupations and in different localities. Besides, such special knowledge is not necessary for the understanding of sanitary conditions.

Another circumstance not to be overlooked is, that the complicated machinery of textile factories is fraught with danger to life and limb; and this peril is far too frequently exemplified. Considering, however, the thousands of rapidly revolving wheels in machine-rooms, and the array of shuttles in the weaving sheds, the extent of "shafting," and the multitude of "belts" twirling in all directions, the marvel is that many more accidents do not happen; and the more so, as a very considerable proportion of the hands employed are young persons and children, among whom care and caution are not common characteristics. Injuries to hands and fingers from being pinched between wheels, or pricked by sharp points, are frequent; whilst now and again a female worker is caught by her hair by a belt, or her loose dress gets entangled between wheels, and a serious accident is the consequence.

There is, moreover, a special kind of accident connected with looms, arising from the detatchment and flying off, with almost electric speed, of "shuttles." When this happens, owing to the elevated position of the shuttle, the usual disaster is the destruction of an eye. The ingenuity of mechanicians has greatly reduced this accident in frequency, but not extinguished it.

On this matter of accidents, it is painful to state that many of them are due to the carelessness of the artisans themselves.

Other sanitary factors common to the textile trades are sedentary labour, heat of workrooms, neglect of ventilation, rebreathed air, unnecessary consumption of gas, and, as before noticed, monotony of work and constrained posture of the body.

These conditions may be termed incidental; but over and above them are many others truly accidental, and for the most part attaching to the workers themselves and in a very large measure avoidable; such are, the neglect of proper clothing, unnecessary exposure to cold by passing from heated rooms into the outer air, improper food, irregular living, dissipation and unhealthy homes. All such insanitary conditions are too well known to need enlarging upon in a lecture devoted to a particular group of manufactures. I now come to the consideration of the *diversities* which exist between the processes of manufacture of the several textile materials. These are far more numerous and of more importance hygienically than their characters in common.

They chiefly have their origin in the physical characters of the materials used, and of the dust evolved from them. Viewed in ascending order from the least injurious we have, silk, wool, cotton, flax, jute, and hemp.

Again, the nature of the material regulates that of the processes pursued in its manufacture, as well as the kind of machinery requisite.

Bearing in mind what a textile tissue is, it is evident that it must be constructed of animal or vegetable fibres, intertwisted and interlaced more or less minutely; and as a further requirement, that those fibres shall be capable of resisting tension, torsion, and twisting without fracture. These qualities exist in very varying degrees in the different materials employed, and even in various specimens of the same textile substance.

When subjected to the microscope, the intrinsic structure of the fibres of the several materials is seen to differ widely. Thus, the fibres of silk are recognised by their unbroken continuity, their soft outline, and the absence of a central cavity, and when in masses, by their extreme softness and flexibility. Those of cotton exhibit a harder outline and a hollow interior.

Again, those of wool presents a still harder outline, and like common hair, have a figured variegated surface, and are really hollowed cylinders.

Lastly, the fibres of linen have a firmer appearance than those of cotton, are less tubular in aspect, and marked at distances by transverse septa. They likewise fracture more readily, the broken ends being frayed.

These structural peculiarities necessarily infer a different adaptability of the fibres to the processes of spinning and weaving—an inference the truth of which experience amply demonstrates.

It is above all in the first or preparatory operations on the raw material, that the greatest differences in connection with sanitation between the several textile substances exist, and that the most serious conditions adverse to health are met with.

To properly illustrate this fact, it is necessary to take each kind of textile substance in turn; though I shall omit horse-hair, cocoanut fibre, and asbestos as of inconsiderable importance in comparison with the rest.

1. *Sanitation of the Silk Manufacture.*—Beginning with silk, there are several qualities of this article, each of which requires a somewhat different method of preparation before it reaches the spinning machines. The trade distinguishes between silk, and silk waste. The best qualities of the former come from China and Italy in a nearly fit state for immediate use.

Reeling from the cocoons immersed in warm water is the primary business. After this follows the cleansing of the fibres from a gummy matter that invests them, by means of boiling in an alkaline solution. In the case of silk waste, these preliminary operations are attended by a nauseating smell. In the next stage wherein the entangled mass is torn apart in cylinders armed internally with steel teeth, a great amount of dust is produced; but happily is rendered of small account by the operation being conducted within an enclosed box or case.

A carding or combing process also performed in enclosed machines next follows, whereby particles of dirt that have escaped previous operations are removed, and a clean bright silk turned out ready for immediate spinning.

But notwithstanding that the operations concerned in manufacturing silk are, at the present day, little chargeable with ill consequences to the health of the operatives, it was not so some years since when, in 1861, Dr. Headlam Greenhow made a special investigation of the causes and prevalence of chest diseases and consumption in the manufacturing towns of the kingdom. At that date the mortality of silk workers from those maladies exceeded that of most other artisans; whilst various bodily deformities prevailed, due to unhealthy modes of working.

Indeed, the entire sanitary history of the silk manufacture goes to show that its unhealthiness followed largely from preventible causes, and that its former high ratio of sickness and mortality was less attributable to the actual processes of the trade than to accidental conditions of labour—a group of health-destroying agents by no means peculiar to the silk trade, but pervading formerly every textile manufacture. These agencies are now greatly reduced in number and intensity, mainly by the sanitary provisions of the Factory Act, which protect children from too early and laborious work, curtail and regulate the labour of all hands, young and old, directly and indirectly, and successfully further better hygienic conditions in the case of all factories and workshops. Co-operating with the Factory Laws in accomplishing the like salutary ends, has been the advance on the part of the public of a superior knowledge of sanitary science, the improvement of the homes of the working classes, and the better provision made for their out-door amusements, and for their intellectual and moral advancement.

But if these avoidable incidents of the silk manufacture are to a great extent removed, one of the unavoidable kind persists, viz., the sedentary nature of the work, and it is one unfortunately of very destructive energy.

Moreover, as things stand, another injurious incident remains in action, though greatly reduced in degree, I refer to the dust generated in some processes, and to which the prevalence of bronchitis and asthma must be assigned, together with the comparatively shortened duration of life noted among silk workers.

Nevertheless, when everything is taken into consideration we cannot fail to recognise an improvement all round in hygienic conditions, and are entitled to anticipate ever advancing progress in the sanitation of our industries.

2. *The Sanitation of the Cotton Manufacture.*—Turning next to cotton; there are many commercial varieties of that product, the differences between which are due chiefly to the length, tenuity, and strength of the fibres, and the more or less dirty state in which cotton is sent into the market. Here again, from a hygienic point of view, it is, for the most part, in the preparatory processes that circumstances obnoxious to health are to be found.

The opening out of the bales and the sorting of the cotton as it first comes to hand, is a dusty business. So likewise is the ensuing one. This consists in freeing the cotton from seeds and accidental foreign particles by the aid of scutching machines, which tear apart the mass and beat out the dirt, before it reaches the blowing apparatus and passes onward to the carding machine. The combing action of the latter finally cleanses it from all extraneous substances, and delivers it in a filmy cord-like shape called a "sliver," for the further action of the elaborate apparatus of the machine shop for its conversion into yarn. The earliest stages of sorting, mixing, and scutching are the special occupation of women, who suffer from the dust and "flue" thrown off in those operations, and become the most frequent victims of the peculiar bronchitis and asthma of cotton workers.

The amount of dust, and its greater or less irritating effects on the breathing organs, depend upon the quality of the cotton, being greater in the case of the inferior brands.

Within a brief period the steel teeth of the carding machine become blunted and choked with refuse cotton. Hence it is requisite to clean and sharpen them. This business is the work of a special class of men known as "strippers" and "grinders" —a class particularly subjected by their work to the inhalation of dust, and among whom a high ratio of chest disease prevails. To remedy the disasters, ingenious self-cleaning and sharpening machinery has been invented, and been attended by considerable success.

In olden time the carding machines were worked without enclosing boxes, and therefore with sad results to the operatives by reason of the vast quantity of dust they threw off. Their enclosure put an end to this evil.

In the several stages of spinning the yarn little dust is encountered, though in the after operation of winding a more perceptible amount is given off.

However, dust is not the only insalubrious agent in a cotton mill. A high and moist temperature is needed in the spinning rooms, and the more so where inferior cotton of short and brittle fibre is being spun. This state of things cannot be held as wholly accountable (acting as it does in conjunction with indoor confinement and the want of exposure to the free outside air and sunshine) for the washed-out, weakly appearance of most cotton spinners, and for the gradual sapping of their vitality and the progressive degeneration of the manufacturing population so generally observed.

The same conditions are met with among weavers, who work in an equally hot and still moister atmosphere. So serious to

health of these operatives did these abnormal conditions become, that it was deemed imperative to limit the degree of heat and of humidity in weaving sheds by a special Act of Parliament, passed in 1889.

Yet another incident of great sanitary importance occurs in the business of cotton-cloth weaving. I allude to the so-called "sizing" of the warp before weaving. This business is done by a small body of men before the "beam" is placed in position; but the weavers are the persons most exposed to the ills attending it.

In former years the materials used for sizing were of innocent quality, consisting of fermented flour and tallow; but these have almost everywhere been replaced by a compound of china clay and certain mineral salts, among which are chlorides of zinc, magnesium, and calcium, with a good proportion of sulphate of magnesia. These salts were added to the dressing, primarily with the view of preventing the formation of mildew on the cotton-cloth, especially where it had to travel long distances and to hot countries.

I do not know that the addition of these salts to the sizing is a source of special disease to the weavers; but obvious mischief to health resides in the combined china clay by the dust arising therefrom; for as those who have acquired some information respecting potters and their maladies will know, the so-called clay is a silicious material, and its dust most destructive to lung function and lung integrity.

Though diffused through a very vaporous atmosphere (and it so happens that the heavier the sizing the greater is the degree of heat and moisture required for the work in hand), the dust will find its way into the lungs, and there set up chronic inflammation in the air-tubes, and eventually in the lung tissue and cells themselves, followed by bronchitis and asthma, and finally by lung fibrosis—a lesion which symptomatically closely resembles pulmonary consumption.

The heavy sizing of cotton-cloth must be looked upon as a mischievous adulteration. The buyers of the most inferior cloths—chiefly the ignorant dwellers in eastern lands—actually buy in weight much more china clay than cotton; and I am assured by the clay merchants in the potteries, that far more china clay is consumed in weighting cotton cloth than in the manufacture of earthenware and china. In like manner, chemical manufacturers report that they make more sulphate of magnesia (Epsom salts) for the cotton mills than for the doctors.

Besides heat and watery vapour, and cotton and clay-dust, those other insanitary factors already described as common to all textile mills are to be taken into account in estimating the effects of labour upon the employed. There is yet one other minor process not to be passed by without notice; I allude to the operation of "gassing." This belongs to cotton and silk alike. It consists in running the fibres with great velocity through a small jet of gas by the aid of machinery. By this proceeding, the irregularities and ragged sides of the fibres are burnt off, rendering them more suitable for fine spinning.

This process is productive of very hot shops, of air fouled with a large proportion of gas, and with no inconsiderable escape into it of carbonized dust, at once detected by the smell of combustion of organic matter, and by its irritant action on mucous surfaces.

Gassing rooms consequently are far from healthy places, and engender languor, sweating, and more or less anæmia from their heat and closeness: and on its part the diffused dust generates asthmatic breathing and cough, and leads to progressive disablement for work.

Reviewing the manufacture of cotton as a whole, in relation to its sanitary position, it must be called an unhealthy one.

Statistics demonstrate a high ratio of chest disease and consumption among its work people; shortened life, and a history of physical deterioration.

Apart from the habits of the people, both when at work and when absent from it, and which are open to very great improvements, visitors to cotton mills generally cannot fail to perceive sanitary defects, most of which are preventible. The prime sanitary agency called for is ample ventilation. Accompanying it must be reduction of temperature of work-rooms by avoiding, as far as practicable, its artificial elevation, by steam and hot-water pipes, and by the extravagant use of gas.

The abolition of this last-named incident awaits only the general adoption of electric lighting for its attainment.

Circumstances have occurred during the past twenty or thirty years which have greatly hurried onward material changes for the better in the construction and ventilation of textile mills—for what I am about to say applies to textile factories of every description. Those circumstances have arisen from the pressure of public opinion, from clearer views of sanitary requirements, from the operation of the factory laws, from the keenness of competition, from the improvement of machinery and of factory buildings containing it. This last result may be attributed to the dimensions and enormous value and weight of modern machinery, which alike demands space and sound building. Hence the erection of the almost palatial structures met with in textile districts, particularly noticeable in the instance of cotton mills.

Linen Manufacture.—But I must hurry on to find time for examining the sanitary aspects of the remaining manufactures to be examined—the Linen and Woollen.

The health aspects of the linen manufacture have been best described by the late Dr. Charles D. Purdon, of Belfast, who enjoyed unusual opportunities for observing them, by his position as certifying surgeon for that great centre of the linen trade, and by occupying several posts in connection with its medical institutions; and it was my good fortune to make myself acquainted with the details of the manufacture under his guidance.

Each of the processes, whereby flax is converted into yarn, and afterwards woven into linen cloth, possesses sanitary features of its own. A general sketch of them is all that I can venture on.

When flax is in-gathered, it is first steeped in water, and left for a lengthened period, so as to allow decomposition to set in, whereby the woody fibre decays, leaving the superficial strong fibres beneath the epidermis intact. This simple, crude proceeding gave rise to the exhalation of fetid gases, to the detriment and annoyance of persons they happened to reach. It is now more common to secure the like results in tanks, with the help of hot-water, in a much briefer space of time. This process is known as "retting." On its completion, the fibrous mass, when dried, was formerly subjected to a vigorous pounding action in the "scutching mill," whereby the fibres were separated from the decayed woody matter in a tow-like form. At the present day, the use of revolving cylinders, between which the flax is crushed, is largely substituted for the beaters of a scutching mill. The rude processes noticed, and particularly the scutching, were, by reason of the clouds of dust driven off, potent causes of ill health and lung disease. After scutching, the material passes to the "rough combers," who rid it of much dirt and waste by hand combs. Its next destination is in the "heckling" machines, wherein an active combing process proceeds, and which, when completed, evolves the flax in the shape of a clean, fine, fibrous, filmy rope—the "sliver," which passes on to the machine rooms, to be spun into yarn or "line;" just as is done in the case of cotton. With "heckling," the preparatory stage terminates. The manufacturing one is accounted to begin when the flax reaches the drawing and roving frames; and to end with the production of yarn or line ready for the weavers.

The mechanism, whereby all this is effected, is far too complicated for description alone, and its sanitary features are unimportant when compared with those of the preparatory stages.

Heckling is attended by clouds of dust, but being done in enclosed machines the greater part of the dust is kept from escaping into the workroom. However, some does so, and especially when for one reason or another—such as refilling with new flax—the enclosing-box is opened. Unfortunately, flax-dust is excessively irritating to the respiratory passages and lungs, and leads to chronic illness, assuming the form of wasting or consumption, with remarkably severe dyspnœa. In fact, the dyspnœa is out of proportion to the amount of dust inhaled, and points to some specific property of the flax itself specially obnoxious to the nervous system. The dust of flax is locally known as "pouce," and the sufferers from it in the early stage are termed "poucey." Its first symptoms are dryness of the respiratory passages, with huskiness in the throat, which soon increases and sets up cough and oppression of breathing. This dyspnœa, or asthma with cough, is the leading symptom, and assumes a a paroxysmal character, which in the later stages causes vertigo and staggering. The persistence of the symptoms induces debility, painful anxiety of the face, rounded shoulders, emaciation, and the well-known signs of consumption, soon ending in death.

The second stage of manufacture included under the general appellation of spinning, is not without some insanitary consequences. These happen especially in "wet spinning," in which the line, or "roving," traverses small receptacles containing hot water, whereby the rooms become filled with more or less steam, and the women's clothes considerably wetted.

There is a difference of opinion among flax spinners how far this heated and moist atmosphere is necessary to the successful production of yarn; and the belief gains ground that much freer ventilation of the shops than usual may be permitted, and that without detriment.

The wetting of the clothes is, in a measure, preventible by mechanical means directed to obviate the dispersion of the hot water; and the Factory Act provides that special protective coverings be supplied to the workwomen.

Wet spinning possesses this advantage—that it lessens the production and diffusion of dust, which is more pernicious than watery vapour. Nevertheless, as watery vapour, accompanied by heat, is productive of lassitude and sweating, and a cause of general debility with derangement of the digestive organs, besides increasing the liability to taking cold and to rheumatic affections, it is an imperative duty to devise means for its abatement.

In the weaving department the evils to contend against are excessive heat, unhealthy postures, confinement, and want of physical exertion out of doors—a category of insanitary conditions needing no illustrations.

A subordinate branch of the occupation in which few are employed is that known as the "dressing" department. Here the workers are exposed to a temperature of 100° and upwards. Moreover, so fatal is this division of work regarded, that it is restricted to adults. Dr. Purdon calculated that the average duration of life among those who enter upon this occupation was little over sixteen years.

The account of the sanitation of the linen trade would be incomplete without some remarks upon certain subsidiary phenomena.

The principal of these are a temporary acute disorder known as mill fever, and the production of cutaneous eruptions. The fever attacks new hands within a few days of beginning work, and passes away spontaneously in less than a week without necessary medical treatment. The usual skin eruption is papular, and has been called by some lichen or eczema, and regarded by others as a folliculitis. It produces a prickly sensation, and is confined usually to young hands who have recently commenced work. Its cause is assigned to the flax-water by some, but by others, and with greater probability, to the oils freely used for lubricating the spinning machines.

Another form of eruption of more serious consequence to health is occasionally seen. It assumes a pustular character, not very unlike that of small-pox, and seems connected with the use of Russian flax, a circumstance suggestive of septic matter, when viewed in connection with what we know regarding Russian wool and horse-hair.

The Sanitation of the Woollen Manufacture.—Wool is turned to a variety of uses by different manufacturing operations, which, though varying among themselves, present a general similitude in principle, and happily are chargeable with few ill consequences to health; occupying in this respect a better sanitary position than those concerned in the production of cotton and linen; the dust of the animal fibre of wool seeming to be less obnoxious to the breathing organs than that of vegetable materials.

The woollen manufacture among those pursuing it is recognized as of three branches: known severally as the woollen, the worsted and the "shoddy" trade. In the last named previously used wool is the principal constituent, and it is chiefly concerned in the making of cloth and tweeds for male attire.

The operations antecedent to the passage of wool to the machine-rooms for spinning and its cognate processes exhibit the more important hygienic features. The first operation is that of "sorting." This is done by men at large tables, who pick out the different qualities of the wool, and put aside what is unclean or otherwise unsuited for the purposes in view. This business, as I shall more particularly refer to by-and-by, is one attended by considerable danger to the workers, in the case of certain wools imported into this country; and I may at once add that the wools in use differ considerably in physical character in sources of origin and in the state of cleanliness in which they reach the factories.

However, at all times, wool as received requires preliminary cleaning from accidental dirt and from a copious normal amount of grease. The fatty matters have to be removed by repeated washings with hot water containing alkali. The intermingled solid particles of dust are got rid of by the "willying" or "winnowing" machines, which beat and shake them out whilst they, at the same time, divide the fibres. This purifying stage is completed by "carding machines," of like pattern and working as those used in cleaning cotton fibres.

These early operations are necessarily productive of dust, but this evil is very materially reduced by the employment of enclosed machines with extracting currents of air produced by ventilating fans.

Again, in the subsequent processes in the spinning-frames the fibres of the wool are lubricated by oil, usually the Galipoli oil, and thereby the production of dust obviated. And not only is spinning thus deprived of its injurious consequences as a dust-generating process, but the artisans themselves believe the constant contact with oil to be a positive health benefit and a help to nutrition. However this may be, the health of wool workers is far superior to that of cotton and linen hands, and certainly not inferior to that of silk hands.

Another superiority in sanitary position belongs to the woollen manufacture, arising from the intrinsic characters of wool. For instance, its fibres are stronger and longer, and therefore less liable to break. Hence it follows that they require less watching in passing through machinery, and there-with less strain on the attention and sight. Moreover, wool does not call for the heat and moisture needed in dealing with cotton and linen. Again, its fibres do not fray as do those of the other textile materials named, and consequently are less fragile and dusty.

The *making of shoddy* is more complicated and is attended by more dust and heat.

At least a very considerable proportion of the cloth woven for male attire is a resuscitation of former apparel, with some addition of fresh wool and cotton. The materials used are rags collected at home or imported from abroad, and are of a very miscellaneous character, and too often dirty and offensive. Hence the first business is to steam, wash, and cleanse them from dirt, and the next to sort and tear them up. The sorting is done by poor women, and the tearing up by a machine known as the "devil." Into this they are thrown and there exposed to a rapidly revolving apparatus of teeth, whereby they are divided into small fragments, which pass on to a "scribbling" or grinding mill, and are there reduced almost to a fine powder preparatory to the operation of carding.

The sorting of rags is a dusty business, and the reception of rags from all sources might be considered as a dubious proceeding, likely to spread contagious diseases. Such an accident has happened, chiefly in bygone years; but a special inquiry made some time since proved how very seldom a misfortune of the kind occurred in sorting rags, whether for shoddy or mungo mills, or for paper factories. The tearing up of the rags was formerly almost wholly done by hand, and was attended by many evils from the resultant dust; but now the machine "devils" have supplanted that proceeding, and the dust from the process, which is very great, is prevented diffusing itself in the air by the enclosure of the apparatus, and by a strong extracting current of air, which withdraws and carries it away along a flue to the outside of the place of work.

The wool fibres having been reduced to a powdery mass, are next freely besprinkled with vegetable oil, and then subjected to the "willying" and roving machine to produce a "sliver." In the next place they are spun into yarn, and eventually woven into cloth. In these proceedings the addition of oil happily controls the rising of dust from the disintegrated wool, and must be reckoned a salutary proceeding.

When the cloth leaves the weaver it has to undergo the operations of "dyeing," of fulling and dressing, of raising the pile, shearing and pressing, and afterwards of exposure to steam. The hygienic features however that attach to these proceedings need not here detain us. Heat is the chief factor noticeable, and these final processes, as a whole, occupy but few workers.

When Dr. Greenhow visited the shoddy-mills he met with a febrile complaint among the employed, known as "shoddy fever," due principally to the action of dust from the grinding apparatus, which at that period was commonly unenclosed, and consequently emitted clouds of dust. My enquiries at cloth factories failed to discover the prevalence at the present time of this disorder, but further investigation is needed.

It fell to the lot of newly employed hands to suffer this shoddy fever; and Dr. Parsons, of the medical department of the Local Government Board, who, a few years since, investigated the health conditions of the manufacture of "Flock," describes the occurrence of "flock fever" similar in all respects to "shoddy fever," and like it affecting only those who enter anew upon the business, continued occupation begetting tolerance of this unhealthy consequence.

It will be remembered that a febrile disorder seizes on those who enter upon flax-working, and it appears clearly that the conditions of mill-life are calculated to engender such attacks: and, in my belief, this malaise occurs whatever be the material in course of manufacture. For even in cotton mills, novices at work where unnatural heat and closeness exist, and where dust is generated, have to pass through a seasoning process of constitutional disturbance of short duration. We can, indeed, well conceive that the dust inhaled plays an important part in the matter, though it be not the only agent. On entering shops devoted to the preparatory stages of manufacture, a visitor encounters a feeling of oppression and general discomfort connected with the heat, and with the peculiar odour of the manufactured article and of that coming from machinery.

Other manufactures in which wool is the chief constituent are hosiery-making, blanket and carpet-making. These, though differing more or less in the nature of the processes passed through and of machinery employed, have no such pronounced sanitary incidents that I need linger upon them in this lecture.

But I cannot quit the subject of wool in its sanitary bearings without adverting to the serious consequences that attend, now and then, the primary operations of opening out the bales and sorting their contents. For in these it is that the workers encounter the malady known as "wool sorters' disease," which is in reality anthrax.

The precise nature of this malady was not at first realized, whilst the mortality arising from it caused it to be viewed with terror. But ere long its true character as anthrax was detected, and this "wool sorters' disease" was further identified with a like malady that happens to horse-hair workers and to those handling infected hides and skins, mostly those received from foreign parts—especially from Russian Asiatic territories.

At the same time its manifestations differ, for anthrax will at one time display its virulence, especially as a local lesion; whereas at others—as happens with the wool sorters' malady—it exhibits its presence chiefly by malignant fever without furuncular abscesses.

A review of the whole subject of the Sanitation of Textile Industries will show that their leading health features are to be found, firstly, in the conditions of associated labour, in confinement within rooms or shops which may be deficient in space, badly ventilated and overheated; secondly, to a lesser degree, in the circumstances, inseparable from the use of machinery, among which are vibration, noise, monotony of work, and the strain of watching the minute and very rapid movements of the machinery; thirdly, in the dust evolved in the course of manufacture from the material used, an evil principally attaching to the earlier operations, but varying greatly in degree according to the nature of the substance dealt with; fourthly, in special auxiliary conditions this or that manufacture may call for, such, for instance, as the presence of a hot steamy atmosphere, the employment of oils, or of substances introduced in dressing, foremost among which is the china-clay employed in cotton-sizing; fifthly, in the accidental presence of noxious or poisonous matter in the rough material to be manufactured, as illustrated in wool sorting.

Add to the foregoing incidents those common to all sedentary occupations, constrained positions of the body, and want of physical out-door exercise, and we cannot fail to recognize a series of hygienic conditions and surroundings which must sap the health, lower vitality, engender constitutional weakness, and deteriorate the race, besides being accountable for setting up active present disease, and thereby increasing in every direction the rate of mortality, and lessening the value of life.

On a retrospect, however, this consolation reveals itself, that the major part of the insanitary conditions are more or less remediable, and justify the expectation that, in course of time the enlightened efforts of employers, better instruction of the artisans in sanitary knowledge, coupled with due attention thereto, and the genius of engineers, will concur to very materially diminish the unhealthiness of the Textile Industries.

THE METALLIC POISONS LEAD & ARSENIC, AS MET WITH IN OUR INDUSTRIES.

By THOMAS OLIVER, M.A., M.D., F.R.C.P.,

Physician to the Royal Infirmary, Newcastle-upon-Tyne; Professor of Physiology, University of Durham; late Goulstonian Lecturer, Royal College of Physicians, London.

READ DECEMBER 8TH, 1893.

WHEN I accepted the invitation of the Council of The Sanitary Institute to deliver one of the lectures of the present course, I did so with misgiving, for I felt that not only was I a stranger to a London audience, but that I had little or nothing to say that could either interest or instruct you. It was suggested, however, that as I had given some attention to the subject of lead poisoning, it might serve as a useful text from which to address you.

Lead poisoning is of greater importance than people generally imagine. It is a subject of almost national importance, for have there not been within our experience several epidemics of plumbism in many of the large towns in England, owing to the faulty conduction of the water supply, and several cases from the poisoning of food cooked in tin utensils? Besides, lead is known to be a dangerous metal, and thus it is that those who are engaged in the manufacture of its compounds, such as the white lead worker—those who manipulate them like the house painter or the dipper in the potteries—or those who are employed in enamelling, too frequently suffer from inhalation of the dust.

I am not here to-night to discuss the dangers attendant upon the conduction of drinking water into our houses through leaden pipes, or to show you how water that has trickled through peaty soils, rich in decaying vegetable matter and iron, dissolves out lead and thus becomes a source of danger to the consumer. It is sufficient to be reminded that drinking water should never be stored in leaden cisterns. Water used

for drinking or culinary purposes should come straight from the main and every morning should be allowed to flow for a few minutes, so that what has lain over night in contact with the leaden pipes may be allowed to escape. The consumption of this water has long been recognised as a source of danger. The same is true of malt liquors. Barmaids who lap up the beer that has fallen on the leaden slab on the counter, and barmen who have indulged in the first swill of beer drawn from the tap in the early morning, have to my knowledge forfeited their lives through their indiscretion. It is stated that the extensive use of foreign lead for pipe-making in this country, and from which the silver has been extracted, is more apt to be acted upon by fluids of all kinds than the native lead which is poor in silver, and therefore not worth the trouble of extracting.

The entrance of lead into the system in infinitesimal quantities—no matter the channel by which it gains admittance or the form in which it is absorbed—cannot go on without serious impairment to health. Thus do we seek to explain the rapid breakdown of the constitution of the lead worker, the colic of the house painter, and the extreme headache and anæmia of the lady of fashion, who tries to deceive herself and her friends by obscuring the whitening touch of age by the use of certain hair restoratives.

I am here to-night to deal with lead poisoning in its relation to certain trades, and particularly in regard to lead making itself. Lead mining in this country is an old industry. It dates back to the Roman occupation and has been constantly carried on since 1401. Its home is the North of England. The profits derived from lead mining contributed in no small measure to the revenue of the Prince Bishops of Durham, and whilst the industry has enriched several of our county families, it has given employment to several people in the thinly populated dales of Durham and Cumberland. What is called the "lead country" is limited to the upper reaches of the rivers that arise on either side, and to the south, of the Pennine Range. Lead is also found in Cornwall, Wales, and the Lake District. The surface of the country is generally heather-clad moorland, 1000 to 2000 feet above the level of the sea. The miners live in the villages lower down and have thus frequently to walk from two to four miles from their homes to the mine. Dr. Robinson, of Stanhope, has in an interesting paper, "Lead Miners and their Diseases," told us how the miners and their families, shut up in the deeper recesses of these dales, and removed from centres of civilisation have seen little of the life that lies beyond. They have migrated but seldom; they have intermarried much amongst themselves and in this way they have become not only one family industrially, but socially. To circumstances such as these must be attributed their predisposition to certain diseases such as phthisis—a morbid condition to which they are peculiarly susceptible. Like the Irish peasantry, they cling with a wonderful tenacity to the mountain sides and dales inhabited by their ancesters for generations. The wages of the men are seldom more than 10 or 12 shillings a week, and yet unless they are compelled by sheer necessity, they will hardly leave "the badly paid, disease producing, and life-shortening employment of a lead miner for more lucrative work in the coal pits and iron works of central and eastern Durham." As a class, lead miners are intelligent, religious, and temperate.

Metallic lead occurs as "veins" in the rock, varying in thickness from 1 inch to 15 feet. In this country the ore is found principally as galena, or lead sulphide, in which silver and sulphide of antimony may be present, or in the form of carbonate or white lead ore. The ore that is imported from New South Wales is largely carbonate, and it is owing to this fact that lead mining in that colony is productive of greater risk to health than in this country. Saturnine poisoning is practically unknown amongst our miners, owing to the ore being non-volatile and insoluble. In lead mining there are fewer risks than in coal cutting and coal raising, but the lead miner is exposed to risks from which the collier is to a large extent exempted. The free ventilation of coal pits insisted upon by Government, has removed many diseases from which miners in the early part of this century suffered. Not so, however, with the lead miner. He has to get the ore out of the veins in the hill sides, and in order to do this a shaft is sunk as in an ordinary pit, or a drift is driven into the hill side. Whichever method is adopted, one is no better than the other, ultimately, so far as ventilation is concerned. Frequently a lead mine may extend one or two miles into the side of a hill and may reach a considerable depth, exit from the bottom of which can only be accomplished by climbing a series of ladders. Ventilation of such a mine is not only difficult but expensive. At all times it is faulty. In the deeper recesses of the mine the air may be so contaminated that the tallow candles which the miners carry cease to burn. Ordinary atmospheric air contains 21 per cent. of oxygen and 79 of nitrogen, with just a trace of carbonic acid; but in the air removed from lead mines, Dr. Angus Smith found in 110 analyses, that in 12·7 per cent. it was pure or nearly so, decidedly impure in 24·5 per cent., and extremely bad in 62·7 per cent. In one instance the oxygen was as low as 18·27 per cent., and the carbonic acid reached 2·26 per cent., a high

percentage when it is remembered that an atmosphere above ground is bad when it contains ·1 per cent.

Carbonic acid is one of the great dangers to the men, and there is a tendency for it always to be present in excess as it is given off from the lungs of the miners in respiration, and the combustion of the candles as well as from the strata in which the men are working. Add to these facts the deterioration of the air of the mine by the use of dynamite and from the explosions of gunpowder, and you have an atmospheric condition in the mine which frequently obliges the men to retire to the mouth of the pit in order that the needs of respiration may be satisfied. What with impure air and the inhalation of the dust and grit from the limestone rock, the lead miner is exposed to risks that are in constant operation during the whole period he is at work. When to these are added the fact that the mines are warm and the men on leaving are overheated, owing to the exertion required in scaling the ladders, and are obliged to trudge home two or three miles across a bleak moor exposed to biting winds and in all kinds of weather, we can readily understand how it is that many of them succumb to such acute illnesses as pneumonia, or how the neglected cold or pleurisy, acting in conjunction with a family predisposition, too frequently throws the miner into consumption.

It was to diminish some of the inconveniences necessarily connected with the distances that separated the homes of the lead miners from their field of operation, that "Lodging shops" were built by the proprietors, and where for three or four nights a week the miners reside. Dr. Robinson states that in Weardale 166 miners make use of these buildings. Without a fireplace, or any means of ventilation, the bed-rooms, which are in a filthy condition, are crowded to excess—twenty men will occupy a room with breathing space for only eight or ten. Inhaling for forty hours every week (five shifts of eight hours) the vitiated atmosphere of the mine, and sleeping in a room the beds in which are so close to each other that there is scarcely room to pass between them—beds which are almost continually occupied, for the mattresses have scarcely got cooled ere they are lain upon by the succeeding shift; with conditions such as these I ask how is it possible for these working men to be healthy? When we know that the air of the "lodging shop" fairly reeks with the effluvia from the bodies of the inmates, that thorough ventilation is impossible, that the miner who is in the early stage of consumption takes his place amongst the rest, and that with each expectoration he spits upon the floor, myriads of tubercle bacilli are possibly liberated, then we have an atmosphere not only poisoned by excess of carbonic acid, but ladened with micro-organisms, which are believed to play an important part in the causation of consumption. No wonder therefore that we learn of pulmonary diseases, acute and chronic, being the lot of the lead miner. They shadow him at his work in the mine, in the lodging shop when asleep, and in the long, cold walk across the moor.

Setting aside these risks, it may be repeated that the lead miner in this country never suffers from plumbism. There are fewer men engaged in the mines to-day than formerly. Many of the lead mines in the North of England are closed and have been for years. The importation of lead from Spain and Australia, richer in silver and thrown cheaply into the English market, has largely lessened the output of native ore. Lead mining is with us therefore a declining industry. Foreign competition has practically strangled it. Whilst the lead mines in this country are free from saturnine poisoning it must not be inferred that this holds good all the world over. In the Report presented to the New South Wales Government by a committee appointed to enquire into the prevalence and prevention of lead poisoning at the Broken Hill Silver Lead Mines, it is clearly demonstrated that several of the miners have suffered from plumbism; also that whilst the getting and working of the ores composed of sulphide of lead or galena are attended with little risk to health, those that contain carbonate are dangerous, a danger that increases in proportion to their friability and dustiness.

I have always maintained that the special dangers incidental to the manipulation of lead are not met with in the getting, but commence with the smelting of the ore. Smelting of the metal is not a large industry in this country. It is an occupation attended by a certain amount of risk. Lead is volatile at high temperatures. Inhalation of the fumes of the molten metal by the smelter was in days gone by a frequent source of poisoning. In one instance that came under my own observation four sons in one family—all strong healthy men—died at an early age, under 30, from chronic lead poisoning. At present the risk to the smelter is practically nil. Owing to the hood which is placed in front of the furnace, the draught carries the fumes all up the chimney. Lead smelting can scarcely be regarded therefore as a dangerous occupation. It is absolutely necessary however that the chimney stalk should be high, so that the fumes may be widely dispersed by the wind. The lighter dust thus floats away, and is carried a great distance, but the heavier particles necessarily fall close at hand, and become a source of danger. Cattle grazing in the fields near lead smelting works have suffered from colic—they are said to be "bellond," an old

French word, the interpretation of which is briefly "belly-bound." Horses, sheep, and oxen, that have eaten of the contaminated herbage have died, and, in the processes of litigation that followed, farmers have succeeded in obtaining compensation from the factory owners for the damage thus inflicted upon their flocks. In Germany an interesting circumstance was noticed by Schroeder and Reuss. In close proximity to some of the forges they noticed that the red berries of the mountain ash trees were regarded as a favourite food by the thrushes and finches in the autumn, as well as by nearly all the birds that remain there over the winter. Below and close to these trees they often picked up birds sickly or dead. Those that were alive had their extremities contracted, and their power of flight appeared to be paralysed. Some of them died in a few days, powerless in their attempt to flutter. The birds had eaten the berries upon which were deposited the particles of oxide of lead, and had thus poisoned themselves. Plumbism was not confined to the small birds, for the wild animals that roamed in the woods close by also suffered from paralysis, the stags amongst other things exhibiting a peculiar defect in their antlers. On meadow hay taken from the neighbourhood of the Altenau forges, Freÿtag found a deposit of lead oxide equal to ·0027 per cent.

I have alluded to the Broken Hill Mines. As illustrating the poisonous nature of the fumes emitted from their chimneys, I need only mention that a child aged five years died from lead poisoning. She had been in the habit of plucking flowers and putting them in her mouth, the flowers bearing visible particles of flue dust which had fallen upon them from the smelter stack under the shadow of which she resided. Cows, horses, dogs, and fowls died close to the mines. The soil surface on being analysed was found to contain a percentage of metallic lead varying from ·05 to 4·81. In my own neighbourhood I have known dogs that had slept upon the jackets of their masters when engaged in the smelting shops, licking the sweet dust or that had lapped the water trickling from lead works, suffer from colic or exhibit a peculiar form of nerve symptoms due to the effect of lead upon their brain. Wherever lead smelting is carried on to any extent, there is a risk of the pasturage becoming contaminated. Whilst the risk to the smelter has been greatly diminished by the hood placed in front of the furnace, nearly all the men thus engaged are pale and exhibit a well-marked blue line along the margin of their gums. One danger however still remains, and that resides in the flue itself. The smoke that issues from the chimney of a smelting furnace is composed of two parts, one the ordinary fume from the metallic vapour arising from the molten metal and mixed with atmospheric air, and the other the heavier part or flue dust in which lead is sometimes present to the extent of 20 or 40 per cent. These flues have to be cleaned out, and in some instances men have told me when thus engaged they have been obliged to come out, suffering from dizziness and a splitting headache, and have vomited freely.

English pig lead contains very little silver—seldom more than eight or ten ounces to the ton—so that it does not pay the manufacturer to extract it. In the Spanish lead there is from forty to eighty ounces to the ton, and in the Greek eighty ounces, whilst in the Australian metal the silver is very variable. It may be as low as sixty ounces to the ton or it may range from 400 to 500 ounces, and in some exceptional instances I am told it may run 1,000 ounces to the ton. Under these circumstances the silver is worth extracting from the lead, and on Tyneside desilverization is largely carried on, so that we send to the mint and the buyers in London several tons (upwards of fifty tons) of silver every year. The silver may be extracted by what is known as the Zinc or Parkes' process, the principle of which depends upon the fact that when silver-lead ore and zinc are melted together at a suitable temperature and allowed to cool slowly, the zinc alloys itself with the silver and rises with it as a crust which floats on the molten mass and can be skimmed off from it. By repeatedly melting and concentrating these rich crusts, and the adoption of certain processes to recover the zinc, it is easy to obtain pure silver. Workmen employed in desilverizing do not appear to suffer. I have never known of a case of lead poisoning amongst them. In all the works that I have visited I have always found the men thus employed very healthy, well developed, good specimens of the British working man.

The manufacture of red lead is an easy, and on the whole not a very harmful, process. Pig lead is placed in a furnace, and when molten a workman keeps stirring the mass by means of a long iron rake. By degrees the metal becomes oxidized, and is removed from the furnace as a yellow powder, known as Massicot. This is subsequently returned to the furnace, and again raked up and down so as to allow of its complete oxidation. When this is accomplished it is drawn out, and it is noticed that the yellow colour of the Massicot has been replaced by one of a dark raspberry red. This on cooling and on exposure to the air gradually assumes the colour of the ordinary red lead of commerce. It is an oxide of lead, and in its manufacture, whilst we admit that the work is hard—something of the nature of the puddling of iron, though not so severe—any

danger to the individual from lead poisoning is minimised by the free ventilation in front of the furnace, and by the draught carrying away all the fumes. The danger arises when the manufactured article is removed from the furnace. It is a coloured powder, and as the heat at which it is drawn off is considerable, there is naturally given off a certain amount of fume, and later on, red dust. When a sunbeam slants through one of these shops you can see the red particles floating in the atmosphere. As the dried red lead is frequently packed into casks in the same part of the factory where it is manufactured, there is disseminated a large quantity of dust through the air, inhalation of which may cause colic. Colic and wrist-drop, or paralysis of the hands, occurs amongst red lead workers, and are due to inhalation of an atmosphere charged with red lead dust. Careful attention to the raking-out of the furnaces and the packing of the dried red lead in closed chambers, along with scrupulous cleanliness on the part of the workmen, would tend still further to diminish risks to health.

So far as we have gone it cannot be said that lead making is a very dangerous employment to the individual engaged in it. When we come to consider the manufacture of white lead, we observe that at certain stages of the process a good deal of dust is evolved. It is the inhalation of this fine penetrable dust, and the fact that women are largely employed in the trade, that have gained for this industry a bad name. We believe that women are much more susceptible to the influence of lead than men. This statement, for which I am largely responsible, has been disputed, but an increasing acquaintance with the subject, an extensive hospital experience of plumbism, and renewed experimental investigation upon animals, lend weight to the opinion that women are not only more susceptible than men but they are so at an earlier age. In addition there is a greater tendency for lead poisoning to assume its most serious form, in which headache followed by convulsions and coma are the most prominent symptions. Such an illness is frequently fatal within three days after its development. It is because several young females engaged in the white lead works have died rather suddenly, that the Home Secretary, influenced by public opinion, nominated a few months ago a commission to enquire as to how far their fatal illness could be attributed to the special nature of their employment and how far it is preventible.

White lead is made in considerable quantity in this country. On Tyneside alone the annual out-put is about 15,000 tons, and were trade good, there is a productive capacity for two or three thousand tons more. English white lead has to compete with that of foreign manufacture, and were it simply a question of quality, *e.g.*, purity of colour, covering power and durability, educated opinion would at once decide in favour of the home-made article. No method of manufacture can touch that which is generally in use in this country and which is known as the old Dutch process. There are two other, the "chamber" and "precipitation" processes. On the Continent white lead is largely made by the precipitation process, but the quality of the article produced does not compare favourably with ours. The Dutch method has long been in use in this country. Thin sheets of metallic lead placed in a chamber spoken of as the "blue bed," are exposed to the vapour arising from acetic acid. The acetate of lead so formed becomes the subacetate, and is subsequently converted into carbonate of lead from the carbonic acid arising from the tan in which the jars containing the acid are deposited.

After describing the Dutch method the lecturer said, so far as this process is concerned the first element of danger to health arises when the metallic lead is converted into carbonate. This occurs in what is known as the "white bed." Manufacturers generally allow thirteen weeks for this process to be accomplished. It is believed by some that if the conversion of the acetate into carbonate is incomplete, and the stack or "white bed" is opened too soon, that the girls sent in to strip it suffer more from headache than on other occasions, owing to the acetate of lead floating in the air with carbonate being a finer dust and more soluble, and therefore more readily absorbed than the pure carbonate. It is advisable that the stack should not be opened too soon, that when stripping a "white bed" the surface should be sprinkled with water, and that those who are stripping, but not those who are carrying the white lead, should wear respirators. No respirators, however, can keep out all the dust. They are certainly preventives. Without them a larger quantity of fine lead dust would doubtless be inhaled, but they are not an absolute protection.

It is after the white lead has been washed and ground and the wet pulp placed in the stoves for a few days that the principal danger arises. It is the drawing or emptying of the stoves that tells hardest upon the girls. A few hours in the stoves every week may, if excessive care is not taken, very quickly develop symptoms of saturnine poisoning. The wearing of overalls and respirators, careful cleansing of the hands and teeth before eating, a good meal before starting the work of the day and a bath at the end of it, and only one day's work a week in the stoves are precautionary measures, the value of which cannot be over-rated. A better procedure, however, would be the abolition of the present stove or drying chamber and the substitution for it of one that could be filled and emptied mechanically.

In addition to this if female labour was abolished in this department and the "white beds," we should hear little of white lead-making as a deadly industry. It is only on financial or economic grounds that females are employed, the wages of women being less than those of men.

I need scarcely waste your time over a description of the chamber and precipitation processes.

There is no better preventive against lead poisoning amongst operatives than working upon a full stomach. Lead enters the system by the lungs during respiration by inhalation of the dust, or it is swallowed with the saliva and enters by the stomach. Some time ago I proved experimentally that during the processes of artificial digestion, if food were being digested at the same time as lead, only the smallest quantity possible of the metal passed into solution—only the smallest quantity therefore became capable of absorption. If, on the other hand, gastric juice was allowed to act upon lead alone a much larger quantity passed into solution. What I demonstrated experimentally is confirmed by experience amongst the workpeople themselves. Safety for them consists in their having a good meal before beginning work. Employers recognise this fact and of their own accord provide them with a free breakfast.

The compounds of lead are all more or less dangerous according to their solubility. They produce their baneful effects upon animals as readily as they do upon men, and amongst them it is noticed just as in the human subject, that females are more readily influenced than males. Lead strikes a deadly blow at the reproductive powers of the female. If pregnant she miscarries. In the human female, miscarriage not only occurs once, it may be repeated time after time. Should a child be born when a woman is following her avocation at the lead works, too frequently it is dead or dies shortly after birth from sheer exhaustion, or it dies a few weeks or months after from convulsions. These are facts that have been placed beyond all shadow of doubt.

What I have said of white lead applies equally to orange lead: it too is a carbonate. When administered to animals it causes albuminuria, paralysis of the limbs, and death.

Whilst recognising that the manufacture of white lead is a dangerous employment, we must admit that the fault is not altogether on the side of the employers. To my knowledge many of the owners of the factories take a warm interest in their workpeople. They recognise that the making of white lead is not without risks and they do all they possibly can to diminish them. Of their own accord, and at their own expense, many of them provide breakfast for the hands, whilst the wearing of respirators and overalls, the taking of baths and the drinking of acidulated beverages are insisted upon. In addition the services of a doctor are gratuitously supplied. It is just in those factories where all these points are attended to that we seldom hear of cases of lead poisoning. Many of the females employed belong to the lowest grades of society and are extremely poor. Many of them are intemperate, whilst others are bravely struggling with adversity, and owing to the death or ill-health of their husbands, are tempted by the good wages of the white lead factory. Poverty from some cause surrounds most of them and it is to the improper feeding, the scanty clothing, the imperfect housing, and to intemperance in alcohol that must be attributed a large part of the lead poisoning met with in this industry.

You cannot examine a sample of white lead made by the old Dutch process without being impressed by its whiteness and purity. I know nothing equal to it. As a pigment there is nothing that surpasses it in colour, covering power, or endurance. In expressing this opinion I am supported by a large amount of evidence given by experts before the Home Secretary's Committee. There has been thrown upon the market as a substitute for it the white sulphate of lead. Its process of manufacture has so much improved that it is being run as a rival to the carbonate. The makers claim for it that it stands exposure to the air better than the carbonate. Opinion is perhaps not yet quite ripe for a complete settlement of all the points in dispute—viz., colour, covering power, and endurance—but the answer will come in due course from the paint mixers themselves. The manufacture of white sulphate of lead is simple. It may be made by the precipitation process, or Galena is thrown into a furnace along with coke, with the result that the sulphide of lead becomes oxidized at once into sulphate, the white fumes of which can be seen passing off into a chamber, where they settle in water. The sulphate of lead pulp is subsequently dried, ground, and mixed just as is done with the carbonate. Sulphate of lead is not so dangerous a compound as the carbonate; it is less soluble. On no account, however, can it be claimed for it that it is absolutely free from danger. No compound of lead is perfectly harmless. Animals to whom I have given the white sulphate in their food have died from lead poisoning. They became paralysed, and after death lead was found in the liver. It takes, however, a very much longer time for the sulphate of lead to destroy life than does the carbonate.

Some have proposed oxide of zinc as a substitute for the carbonate of lead, and whilst the opinions of house painters are divided upon this point, it is admitted that for internal decorative purposes, such, *e.g.*, as the painting of ceilings and the woodwork of rooms, oxide of zinc or zinc white is a very serviceable pigment. In several instances, ceilings painted with zinc white have kept their colour for a longer time than those painted with white lead. It has been urged against the employment of zinc white that it is too readily discoloured by ordinary linseed oil, and that it takes too long to dry even if you use a refined linseed oil. Mixed, however, with boiled pale linseed oil, Mr. J. S. Macarthur, of Glasgow, says this drawback is overcome; that with judicious management and the proper proportions of turpentine, it makes a far nicer surface of paint than does the carbonate of lead. The difference in price between the two substances is at once a barrier to the general employment of zinc white. Genuine zinc white sells for £19 a ton, carbonate of lead for £15 or £16, and the white sulphate for £12 or £13. There is too another objection, and it is that the manufacture of oxide of zinc is not a home industry. The mines from which it is taken are in Silesia.

Lead enters largely into very many of our industries. Chromate of lead, for instance, is used as a dye. Dr. Scott, of Tollcross, near Glasgow, was the first to show how yarn, dyed with chromate of lead, might seriously affect the health of operatives. Several of the hands, particularly the women, employed in a wool factory in his neighbourhood suffered from attacks of colic and vomiting, and were anæmic—the cause of which was for some time obscure. It was not until Dr. Scott had seen the peculiar yellow vomit of one of the sufferers that his suspicions of lead poisoning from the chrome dye were aroused—a suspicion unfortunately too soon confirmed by the rapid and unexpected death of a young forewoman in that factory. It then became clear that from the yellow yarn stained by means of lead chromate a very fine dust was given off, which impregnated the atmosphere of the carding room, at that time very badly ventilated. Believing that this was the source of the trouble, Dr. Scott suggested the introduction of a fan into the room, by means of which not only was fresh air drawn into the room, thus diluting the poisoned atmosphere, but removal of the chromate of lead dust also accomplished. The result of the introduction of the fan was that for two years not a single case of lead poisoning occurred in that factory. Shortly after this however a very cold winter set in, and the girls complained that since the introduction of the fan the carding room had become so cold that it was impossible to work therein. Out of consideration for the complaints of the girls, and from ignorance of the circumstances upon which their safety depended, the manager closed the fans, and then came such a rush of cases of lead poisoning that not only were the fans once more successfully put into operation, but the validity of Dr. Scott's opinion was amply confirmed.

We are continually being reminded of the keenness of competition in commercial circles by the numerous advertisements that we see everywhere. The walls of our railway stations are now nothing but a series of sign boards whereon in black and white or blue and yellow, manufacturers seek to laud their own special wares. Out of this method of advertising has grown, practically speaking, a new industry, viz., the enamelling of iron plates. It is an industry chiefly confined to Wolverhampton and Birmingham. The making of these enamelled plates is not without some risk to health. At first lead and arsenic were employed but the use of arsenic has been almost entirely dropped. Lead, however, is still made use of either in solution or in the form of a very fine grit like ground glass. Roughly speaking, there are two methods of enamelling, the "wet" and the "dry." In the wet process the prepared iron plate is swilled with a solution which may or may not contain lead. The plate is placed for a few minutes in a furnace; removed and allowed to cool. It is again swilled. The solution this time may contain lead. The plate is again placed in the furnace and enamelled. In the third coating or laying-in as it is called there is generally a large quantity of lead in solution, sometimes as much as 20 to 30 per cent. The plate is not, after this coat has been put on, placed immediately in the furnace but is allowed to dry by exposure to the air. It is then taken to another part of the factory where girls place upon it stencils cut out of paper or very thin metal—the letters of the stencil being those that are subsequently to appear as the advertisement on the finished plate. The girls leaning over these plates, and with small brushes in their hands, brush off the last coating exposed through the cut letters of the stencil, and in doing so raise a cloud of coloured dust. This dust, strongly impregnated with lead, not only falls upon their clothing and their hair—to say nothing of their bare arms and hands—but is inhaled. At Wolverhampton we found that this enamelling of iron plates was not altogether free from some risks to health. With proper precautions however the dangers can be minimized by the introduction of fans so as to drive the dust downwards from the plates as they are brushed by the girls, by the wearing of respirators, by a thorough washing of the hands and face before eating, and by the operatives taking breakfast before commencing work in the morning.

I have dwelt at such length upon the employment of lead in

our industries that I have left myself little time to discuss the question of arsenic. A short while ago public opinion was unduly aroused by articles in the daily press indicating the risks to health incurred by those engaged in the manufacture of emerald green. Arsenic is an escharotic, *i.e.*, it has the power, if the skin is broken, of causing ulceration and it was maintained that those who were employed in its manufacture suffered from open sores on various parts of the body. I have visited the large colour works in this country and examined the operatives, and I must admit that I saw nothing of the horrors that are attributable to arsenic, although the men admitted that if great care and cleanliness were not exercised there was a risk of the skin becoming affected.

In the manufacture of emerald green, white arsenic or arsenious acid, soda, sulphate of copper and acetic acid are used. The sulphate of copper is dissolved in water. A solution of arsenite of soda is made by boiling together arsenious acid and a solution of soda. This is added to the fluid containing the copper sulphate and after a time acetic acid is also added. Emerald green forms and falls to the bottom. It is well washed by being stirred up several times with water. Up to this stage there is nothing deleterious to the health of those engaged in the manufacture. The men employed are not exposed to any noxious influence. The remaining operations, however, are dusty and must be carried out with caution.

The washed emerald green is drained from the water in cloth filters, and this moist clay-like mass is placed on wooden racks, covered with paper, and dried in a stove. When dry, it is removed and "shot" into large iron drums or kettles. This may give rise to considerable dust. Having been "shot," the colour is mixed in a revolving drum and sifted in a sieve with all the currents arranged so as to carry off the dust. The emerald green is then taken to the packing room to be put into self-closing tin cans. Little dust is generated during this operation. The draught is so arranged as to carry away any dust that may be created.

Certain precautions must be attended to. The men work in this particular department only one day in the week, respirators and overalls are worn, and baths are provided. Cleanliness of the person and of the hands before eating, and above all, avoidance of exposure to the green dust if there is the slightest abrasion of the skin are to be insisted upon. The usual ill effects are redness and soreness of the skin chiefly round the nose and mouth where the edges of the respirator fit. These are due to the skin at this particular part being kept moist by the expired air, and are also to be attributed to friction of the respirator against the skin. If the men do not wear respirators, they suffer from vomiting.

Emerald green is used as a pigment, but in addition large quantities of it are exported to Colorado to put an end to the destructive beetle.

We are frequently reminded that disease treads closely upon the heels of civilization. It would appear as if ill-health followed in the trail of some of our great industries. Can we prevent it? New industries are no sooner developed than upon the operatives are exerted some of their morbid influences, and it is surely for us as sanitarians to diminish or abolish these attendant ills. We live in a humanitarian age. In no epoch in the world's history has the life of man and woman, quite irrespective of their station in society, had a higher value assigned to it. In spite of the perplexing doubts that surround modern life and the increasing number of social problems that await solution, the answer to the question "is life worth living" is found in the expressed desire of the majority to have it prolonged when it is assailed. The better housing of the working-classes and the means given them of obtaining more wholesome food, have done much to prolong life. Whilst the aim of modern Sanitary science has been to develop health in the home; let us not close our eyes to the necessity of promoting health in our industries.

MANUFACTURE OF ALKALIS AND ACIDS.

By WATSON SMITH, F.I.C., F.C.S.

READ DECEMBER 14TH, 1893.

INTRODUCTORY.

HAVING very much to crowd into this one lecture, I shall not waste your time or add to my own embarrassment by commencing with anything worthy of the name of an introduction. As far as any further movement towards legislation is concerned in connection with the question of the hygiene of processes and occupations involved in the manufacture of alkalis and acids, since such manufacture consists of a series of chemical operations on a large scale, it was absolutely necessary in the first instance *to make inquiry*. But the recent inquiries at first instituted by our Government, as well as by certain of our newspaper commissioners, owing to the fact that scientific and expert knowledge had been overlooked, only led to the raising of a general dust or fog. Only one instance is necessary to illustrate the depth and thickness of that fog, and as it is an instance both brief and amusing, I will give it you. During the Government inquiry in November of last year, a workman gave the alarming information that sometimes the Bleaching Powder Chambers were in a red hot condition when the packers were required to enter them. When I tell you that bleaching powder chambers are almost invariably made of thin sheet lead supported by light woodwork, and that heat is the ruin of bleaching powder, that a red heat and bleaching powder—or even a bleaching powder chamber, are nearly as incompatible as a red heat and iced cream, you may imagine the wrong feeling or confusion such false statements would create. However, whether the truth is finally arrived at by the process of *reductio ad absurdum* or direct reasoning, makes little matter so long as darkness or fog is at length dispelled and the light shines. When that desirable stage is at length arrived at, then we can all look back and smile at our errors and wanderings when in the dark.

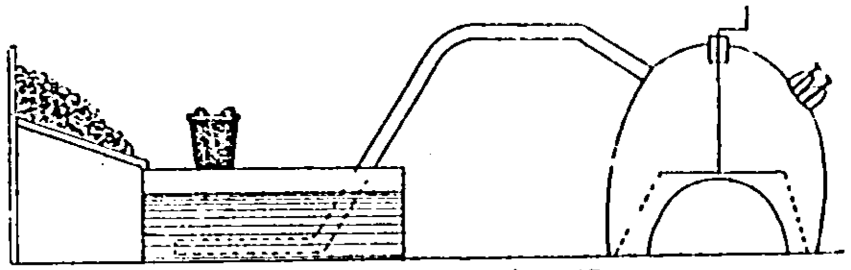
Now on the subject of the physiological action of the materials, products, and surroundings of factories, especially chemical factories, on the workpeople, and the collection of accurate scientific evidence, I may tell you the Germans stand foremost, and therefore you will not be surprised that I quote largely from the observations of German authorities. Of the Alkalis we shall now consider, I shall begin with

Ammonia, and it will be best under the head of ammonia to commence with its sulphate, the commercial Sulphate of Ammonia.

Ammonia Industry.

Sulphate of Ammonia.—In very many branches of chemical industry it has been found by the manufacturer that the method of working which is the most profitable and the most economical is the very one which also secures the healthiest conditions for the workpeople. Let us trace the collaterally improved economic and hygienic conditions of the process for manufacturing sulphate of ammonia since 1868, and I will give you here the result of my own personal experience.

In 1868 sulphate of ammonia was made by heating in wrought-iron boilers or stills ordinary gas-water or tar-water from our gas works along with slaked lime, a pipe from the top of the still leading the gaseous ammonia into diluted sulphuric acid,



Original Sulphate Tank (1857).

contained in an open cistern made of wood, lined internally with sheet-lead. Now tar-water, which by the way was once used as a remedy—perhaps I had better say was a *nostrum*—for a variety of ailments, and taken internally too, may be defined as a watery solution of a variety of ammonium salts, with a small quantity of coal-tar bases, and generally a little film of tar floating on the surface. Chief as to quantity among these ammonium salts, are the carbonate and sulphide. On boiling with milk of lime, especially at first, along with free ammonia, a certain and a considerable quantity of carbonic acid and sulphuretted hydrogen escaped from the acid cistern. The ammonia was absorbed by the sulphuric acid, the vigorous action causing the mixture in the tank to get warm, whilst carbonic acid gas

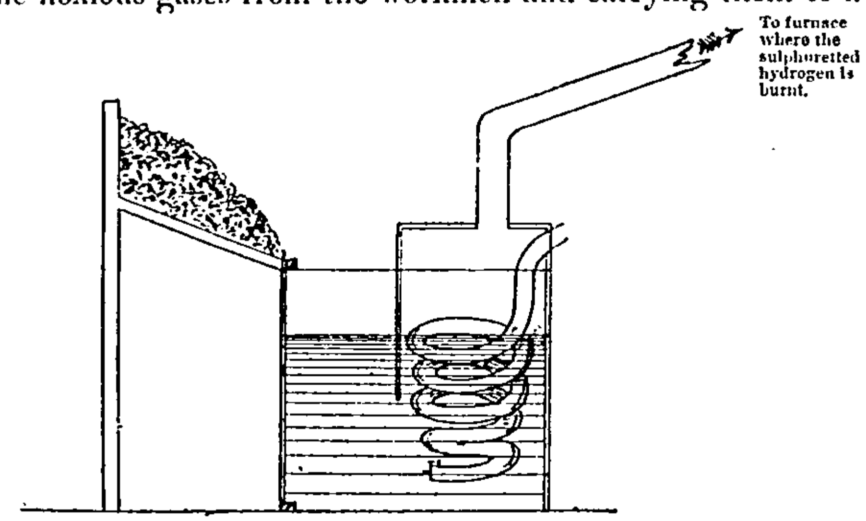
"Gassing" in 1868.

and sulphuretted hydrogen passed off into the air. Sulphuretted hydrogen gas is one of those singular chemical substances which smells worse the more dilute it is, and hence, as you may imagine, it was a difficult thing for the manufacturer to keep out of "hot water" with his neighbours in those days. The factory workmen generally knew how to dodge the fumes, but new hands, or strangers, were occasionally overpowered and rendered unconscious, and I recollect on one occasion a plumber

who endeavoured to repair the leaden side of one of the cisterns during a dinner hour, was found afterwards with his boy assistant lying quite dead by the side of the cistern. Some of you would no doubt like to ask if they would suffer any pain. Absolutely none, I reply; no more than you do in going to sleep. Men who had been "gassed" at the sulphate tank in those early days told me that if ultimately favoured with a choice of deaths, they would not fail to choose that by "gassing" at the sulphate cistern or tank, it was so uncommonly like being overcome by sleep. A man so partially "gassed" as to feel unconsciousness commencing to creep over him would often run ten or twenty paces away before falling, and I never knew or heard of a case where such feeling of alarm had been occasioned as to cause a man to run away for fresh air, in which he did not ultimately fall, and lie unconscious for at least a brief period.

Rough remedy adopted.

The remedy adopted in the tar distilleries in those days was to lay the man with his abdomen over an empty petroleum barrel, and one man taking his head, and another his heels, they would draw him backwards and forwards over the rolling barrel. This remedy, though rough, was by no means irrational; it was a mechanical process for at once expelling the irrespirable gases, and of restoring normal respiration, and was always effective, except in very bad cases. The after-effects of unconsciousness through this "gassing" simply lasted for the day or over-night; the man feeling, as he would put it, "rather light-headed" for a time. However odourless the carbonic acid might be, the sulphuretted hydrogen mingled with it, and "scenting" it, gave rise to much trouble and many fines for the manufacturer, who at length constructed another kind of sulphate cistern, in which was an arrangement for cutting off the noxious gases from the workmen and carrying them to a



Improved Sulphate Tank (1872).

furnace flue, generally the steam boiler furnace. Thus, at all events, the workmen were spared; and I have seen this kind of sulphate cistern in full operation and the still too, under cover, and in the large room of an old cotton factory, in the north. However, the nuisance to the neighbourhood, though abated, still remained, and so the manufacturer's troubles, for sulphuretted hydrogen, mingled with so much carbonic acid, was apt to be carried away still to a considerable extent, unburnt.

Government Inspection.

Ultimately, the Government stepped in, and committed the matter to the care and supervision of the General Inspector of Alkali Works, and he now insists on the removal of sulphuretted hydrogen gas from the "sulphate gases" by means of an oxide of iron purifier, similar in principle to the oxide purifier employed in gas-works. In the meantime, the German Sulphate and Ammonia Manufacturers, Dr. Grüneberg, of Cologne, and Herr Feldmann devised improved stills, by which a certain proportion of ammonia, hitherto lost in the waste liquors and spent lime mud, was recovered, and these inventions far more than covered any expense incurred in the nuisance-abating purifiers, the use of which the Alkali Inspector had enforced. But a direct value arose in these purifiers for the manufacturer, for the oxide of iron therein in decomposing the sulphuretted hydrogen becomes itself converted into sulphide of iron, and this on roasting in suitable shelf-burners yields sulphurous acid, and in the leaden chambers, sulphuric acid, which can then be used over again in producing fresh sulphate of ammonia.

In England both the Simon-Grüneberg and the Feldmann stills are much used, as well as modifications of them.

Present condition.

At the present time, I consider the hygiene of an ammonia and sulphate of ammonia works, under the supervision of the Alkali Inspector, is as perfect for the workpeople as need be. With regard to any injury or danger from ammoniacal gas (ammonia) itself, when we consider that the whole attention of the manufacturer is concentrated upon the most perfect condensation of the gas that is possible, and the most effective storage of the aqueous liquid, and that any annoyance to a workman's respiratory apparatus means loss of money to his master, you may imagine that the master's interests and the man's comfort in that respect coincide with most particular completeness. In short, workpeople in such a properly conducted works and with the best plant, are not exposed to any debilitating effects arising from small escapes of injurious gases or vapours.

Having said this of ammonia works, I may add that just the same remarks apply to the large factories where soda is manufactured by the Ammonia Soda process.

Accident thro' workman's neglect.

I cannot close my account of the history of sulphate of ammonia making, without telling you a singular accident which occurred in 1870 in a works near Manchester, entirely owing to the neglect of a workman on the night shift. It had been thought in a still larger factory quite possible to distil the gas-liquor and expel ammonia into the sulphuric acid so as to form sulphate without any addition of lime in the still. The smaller factory determined to stop the use of lime and follow the same course, and the night-men were warned not to neglect to keep the fires going regularly under the stills. During one evening, however, the attractions of a public house not far distant proved too much for the night workman, and he left the premises and let the fire burn down under the one still he was in charge of. On his return that fire was nearly out and the pipes were cold. Alarmed at the result of his foolish neglect, he commenced to fire up vigorously. Now what had occurred during the cooling process? At a given period, when ebullition was but feeble, a condensation of ammonium sesquicarbonate took place, vapours of that substance commencing to deposit in the pipes, eventually filling them and choking them up. On re-firing and re-starting the still then, that man was actually heating up a boiler absolutely closed and with no pressure gauge! The final result was naturally a terrible explosion which killed him and another man, and the rent still was carried up in the air over a row of cottages and deposited in a pond about 100 yards off. I may tell you that to dispense with the use of lime was not only a primitive process now never thought of, but a losing game for the manufacturer, since a careful analysis of the residual still-liquors would certainly have demonstrated the presence of an amount of ammonia that should never have been thrown away. Of course the apparatus used was of the primitive type I have already referred to. But the moral for many chemical factory men is as good to-day, and as necessary, as then!

Ammonia.—In the manufacture of pure ammonia, or *Liquor Ammoniæ*, the health of the workmen is not affected at all, unless by such accidents as are analogous to a case say, like that of the fracture of the fly-wheel in the engine room of a large mill, such for example as the breaking of a carboy of strong ammonia and the accidental inhalation of its vapours. It is a case of loss to the master and pain to the man.

But let us now ask, "What is the physiological action of ammonia vapour?"

Physiological action of ammonia.

The investigations of Dr. Kar B. Lehmann, of Munich, on this subject are most reliable. Those of Hirt seem on the whole quite untrustworthy, so far as estimations of quantity, are concerned. Lehmann shows that there is extraordinary similarity in the action upon the respiratory apparatus of animals, between gaseous ammonia and gaseous hydrochloric acid. In experiments upon himself, this investigator exposed himself for half-an-hour in atmospheres containing 0·20, 0·30, and 0·33 per 1000 of ammonia, and two further experiments of twenty minutes each, in air containing 0·3 per 1000. The following were the principal symptoms:—Respiration strongly nasal, slow and careful; rather strong stinging sensation in the nose, frequent sneezing. The deep inspirations by the mouth, excited during sneezing, caused some smarting in the trachea (windpipe). The eyes tingled so painfully that they could not be kept open, one after the other, long enough to read off a scale divided into half millimetres. Some lassitude and headache, the head becoming flushed, and perspiration excited, although the day was a cool one. Considerable secretion of saliva. Symptoms for the first five minutes especially unpleasant; however, gradually the experimenter grew somewhat inured to the effects. Nevertheless, the continuance in the room was attended with much discomfort, and though a further concentration appeared safe, yet it also seemed as if it would be unendurable. After leaving the room, the smarting in the nostrils and the headache continued for a time, gases were frequently got rid of by eructation, and then the normal conditions of bodily comfort returned. Another person in the room, with 0·3 per 1000 (0·3 °/₀₀) of ammonia, suffered in addition a slight pain in the breastbone, but ten minutes after leaving the room normal conditions returned. Still another person suffered neither the headache nor the sweating, and instead of sneezing, he complained of a painful feeling of swelling in the neck and throat, and also of feeling of great cold in one hand.

Now ammonia vapours are often pretty strong in the purifier house of our gas works, and Dr. Lehmann accordingly determined the amount of the volatile alkali present in the atmosphere of the purifier house of the Munich gas works, when the purifiers were being emptied. On one day the amount was 0·07 °/₀₀, and on another when the odour was even stronger, 0·11 °/₀₀. Such doses, he says, are on the verge of decided unpleasantness. However, it seems that larger quantities of ammonia than this were often present in the case of this gas works, for one of the workmen was suffering somewhat acute chronic *conjunctivitis* (inflammation of mucous membrane of the eye), or some *ectropium* (eversion of eyelids), the cause of which he attributed to his work.

Finally, Dr. Lehmann states it as his belief that with a little practice 0·3 to 0·5 °/₀₀ of ammonia in the air can be borne a considerable time without sensible injury, and he is of the opinion that quantities of from 1 to 2 per 1000 can be endured for brief periods without injury. In any case, however, quantities over 0·5 °/₀₀ in working spaces where men are confined for considerable periods, are decidedly to be condemned as injurious.

When Hirt therefore speaks of animals that have lived for a day in air containing 100 °/₀₀ of ammonia and are none the worse, and of air containing 40 °/₀₀ as being a respirable and the proper atmosphere to be artificially created for workpeople engaged in "silvering" mirror-glass to protect them from the mercury vapours, then I say such workpeople would be in the position of the proverbial fish in the frying-pan, with a protector who, to save them from the pan, suggests a jump into the fire! Lehmann says he knows indeed of no reliable investigation or data to show that the pouring of *liquor ammoniæ* on the floor of the mercurialising rooms of mirror factories is of actual benefit, but it appears to him actually ludicrous that Hirt should give a solemn warning against tincturing the atmosphere of such rooms with more than 4 to 5 per cent. of ammonia! (Hirt, Gewerbekrankheiten, Handb. der Hyg., Bd. 2, Abth. 4, page 28.)

Lehmann gives some very valuable experiences of chief engineer, Herr Pitzner, formerly a colleague of Prof. Linde, whose ammonia ice-machine is so well known. In bringing this machine to perfection, Linde with Pitzner were engaged for nearly three years, and through faulty stuffing-boxes, &c., and various needs for repairs in the more primitive apparatus, considerable escapes of concentrated ammoniacal vapours took place. No real or lasting injury was ever noticed, and during Pitzner's eleven years' experience with ammonia ice-machines, he never knew of a single death taking place that could be recorded as caused by the action of ammonia. When working with the incomplete machines the workmen were often ailing, but almost invariably with transitory ailments—bronchitis, conjunctivital catarrhs, &c. Of chronic complaints traceable to ammonia vapours, Lehmann could find none; the catarrhs were mostly not of chronic character. Two workmen engaged as above he did not examine. They had been in the business many years, and were perfectly sound and healthy.

Pitzner himself often worked in rooms which he was compelled to leave every half minute or so for fresh air. He suffered from no eye troubles. It seems that nature has provided for such dangers in the case of the eye, for so plentiful is the secretion of tears, that the cornea is preserved thus from attack. Another observation as to the action during brief periods of strong ammonia vapours is of interest, it is that a tendency to vomit always arises, and sometimes actual vomiting takes place.

Of course now, either in the construction or use of ice-machinery of the kind referred to, scarcely a trace of ammonia is perceptible, so perfect are the adjustments. For the medical expert it is, however, useful to know what the essential tendency of strong ammoniacal vapours absorbed internally, is. It is this: To attack and destroy the more delicate portions of the epithelium, laying bare places in which at once inflammation is set up. The curious thing is, that placed in contact with concentrated ammoniacal fumes, another service of nature prevents such fumes reaching the lungs, a cramp or stricture of the epiglottis taking place. On several experiments by Lehmann, the trachea and even stomach had become inflamed, whilst the lungs had remained intact.

An interesting, although a painful case, of choking with ammonia, and almost to the death, came under my notice in 1867. A boy, who had brought a sample into the laboratory of the works where I was then engaged as chemist, took up a beaker glass half-full of the strongest ammonia, and, thinking it was water, flung the contents full in the face of my laboratory boy and ran out of the room. I entered the room as the first boy left it. My laboratory boy was evidently in a paroxysm of distress; some of the ammonia had entered his mouth, and some his nostrils. He advanced towards me like one in a semi-cataleptic state, the back was unnaturally bent inwards and the abdomen outwards; also owing to a cramp-like contortion of the legs and ankles, he seemed to stagger along on the toes alone. He raised his hands to my face, as I thought to scratch me, but his fingers were bent and cramped, and scratching was out of the question. After this he seemed to sink into himself and collapse, falling to the ground. Of course we sent for a doctor, and did all we could for the lad. I observed no tendency to vomit, but when on the ground, he commenced a singular gyration of himself whilst lying on his side, by the action of his legs and feet. Now it is a singular thing that Lehmann observed just the kind of symptoms I have described, in the case of small animals he had subjected to the action of rather large quantities of gaseous ammonia. Especially the gyratory motion he specifies as characteristic of ammonia. The lad I have referred to lapsed into a comatose state, and was found pulseless by the doctor. Whilst apparently strong cerebral action had been set up, he had also choked through stricture of the epiglottis, which had closed and protected his

lungs. The doctor administered a mixture of warm milk and alcohol, and in an hour the boy was restored to consciousness. He complained of sore mouth and throat, but after lying-up for a few days with a kind of slight bronchial catarrh, he returned to work apparently none the worse for his adventure.

Ammonia Soda Works.

Turning to our great Ammonia-Soda factories, let me remind you that all the movements of skilled engineering employed there, are in the direction of exclusion of the workman from any but traces of ammoniacal gas, for ammonia in that process is looked upon as we regard money stored in a mercantile concern and producing a given rate of interest upon which interest the investors are living. To let ammonia leak away or get lost during its circulation, would be like letting some of the capital sums invested dribble away. The whole genius of the ammonia-soda process is to continually circulate the same ammonia, or as nearly so as possible, and not lose it by leakages, &c. I think I may safely predict that no reason or cause will ever arise for inspecting works and factories for the sake of preventing injurious escapes of ammonia.

Soda ash.

Soda Ash.—Whilst upon the subject of ammonia, and before concluding it, with also the ammonia-soda industry, I should like to say that there is nothing in this latter industry that I call injurious or dangerous, in the sanitary sense, in any properly conducted works. Of course, with soda ash, the crude carbonate, which, by the way, in the case of the ammonia-soda process, possesses very little if any crudity—the dust of the ash in packing is no doubt irritating. The irritation is chiefly to the nostrils, and violent sneezing is induced. This result alone is sufficient to compel the workmen to muffle their mouths and nostrils, and in the case of a well defined dust, there is no difficulty then in avoiding the introduction of soda dust into the mouth or throat. I have never known any injury to health to arise in the case of packing ash, even finely ground ash; a man is compelled to muffle up and protect his respiratory apparatus, by reason of the inordinate fits of sneezing induced if any attempt were made to dispense with them. I think we may say that the very solubility and immediate acridity of the fine particles of soda ash, form the best means of protecting the men who handle it from injury to their respiratory organs.

Caustic soda.

Caustic Soda.—This is the hydrate or hydroxide of sodium, and is obtained on the large scale by boiling the dilute solution of the carbonate with slaked lime, which, possessing greater affinity for the carbonic acid of the carbonate of soda than the soda has, appropriates that carbonic acid, leaving in solution the hydrate or caustic, the insoluble carbonate of lime settling down, and leaving as a clear liquid the dilute caustic, which is eventually evaporated down, at increasing heats, until it is brought to igneous fusion. With regard to sanitation, caustic making is as healthy a process from beginning to end as soap boiling or brewing. I will tell you the only accident that ever came under my experience. When the prices of alkali reached a very high figure in 1873, some persons sold up their own businesses, and launched into small concerns for soda making, though without any knowledge of the subject, still less of the elements of chemical science. One such person, whom I assisted chemically for a brief period, set his caustic pots almost quite level with the platform on which the men stood, and insisted on their commencing work without supplying proper lights for the sheds at night. At last one man dipped his foot into strong, hot liquor, and was taken home with a bad burn; tetanus set in after about a week, and the man died. But you see I am only telling you here what might occasionally happen in the case of badly or insufficiently arranged plant, in the way of accident. However, there is no danger now, or probably ever will be again, of alkali prices being such as to tempt strangers to go into the Leblanc alkali manufacture! I shall, therefore, venture to place the simple manufacture of soda ash and caustic, as regards sanitation, on a par with soap making, and indeed, soap manufacturers largely use both soda ash and solid caustic.

Soda—or alkali-waste.

Soda—or Alkali-Waste, and the Recovery of Sulphur therefrom.—In older times, the alkali waste (an insoluble sulphide of calcium, mingled with a little carbonate of lime, cinders, etc.) was thrown out upon waste land, and beaten down as closely as possible. It thus gradually suffered an oxidation process, which resulted in the evolution of sulphuretted hydrogen in the neighbourhood, which meant two things: the loss of the sulphur to the manufacturers, and a nuisance, in the shape of ill odours, to the neighbourhood. However, I must deny that even this state of things affected appreciably the health of workpeople, for I can in this matter talk about my own health, after living and working for some six years in the thick of the vapours of Runcorn and Widnes, in Lancashire, and I simply say that my health was in every particular as good then as it is now that I am living in Hampstead. I do not deny, however, that a stranger coming, say from Hampstead, and pitching his tent in Widnes or Runcorn, or similar neighbourhoods, for the first time, would suffer some nausea, and thus encounter what is described as a general "lowering of the system;" but I do say, that after a short time people become inured, and get the nervous system, shall I say "attuned," to these odorous conditions. In this connection I will indeed add

my own personal confirmation to the statements of Mr. Cooper, of Widnes, Dr. Ballard, the Alkali Inspector, Dr. Robinson and Dr. Mouritz, of Runcorn, as given by Dr. J. T. Arlidge in his work on "*The Diseases of Occupation*," pages 497–498; that, except to workpeople already suffering from lung troubles, the vapours show no ill effects, not even in the intensification of maladies. However, a great revolution has been effected since then, in the introduction of a process for recovering the sulphur from alkali waste, known as the Chance-Claus process. By this process the waste is mixed with water, brought to the state of a cream, and then treated with carbonic acid gas from lime-kilns, so as to set free the sulphuretted hydrogen gas, which is subsequently half-burnt in an ingenious manner, and in an ingeniously contrived kiln, so that whereas in the ordinary way of burning in the air, $H_2S + 3O = H_2O + SO_2$, in this case $H_2S + O$ only gives H_2O, and S is left, and this sulphur is then deposited in a suitable chamber, collected and sold or used as brimstone, or the H_2S can be burnt, and the SO_2 passed into the sulphuric acid chamber, to make sulphuric acid or vitriol.

Recovery of sulphur from soda-waste.

At first, however, nuisances were caused by the new process, which had not been thoroughly brought under control. In the Government Alkali Inspector's Report of the year 1889, he confessed that "While the public and the Inspectors under the Alkali Act may be congratulated on the partial removal of one source of nuisance by the application of the Chance-Claus process, unfortunately that process itself is liable to be the source of a similar evil."

The Chance-Claus process.

This was for 1889, and since then, through the unflagging efforts of the manufacturers, notably of Mr. A. M. Chance, the inventor, and the friendly criticism of the Inspectors, so much improvement has been wrought, that in the last report of Mr. Fletcher, the Chief Inspector, dated 1893, he states: "There was great difficulty, 'at first,' in preventing the escape of sulphuretted hydrogen, and for about six months before the minor difficulties were overcome, much nuisance was occasioned near the works. *This is now, however*, passed, and the presence of that noxious gas is no longer perceived. The points of danger are now well understood and carefully watched." The last time I was in Widnes and was shown over a Chance-Claus plant there, I could perceive no odour of sulphuretted hydrogen whatever about it. If any friend from Widnes, or Runcorn, or St. Helens, be present, he may ask, "Then, why do we yet perceive occasionally odours of sulphuretted hydrogen on arriving at those towns"? I reply, those odours are from the old heaps of waste of years ago, in which the oxidation is not yet complete.

Physiological action of sulphuretted hydrogen.

However, now we have reached the subject of sulphuretted hydrogen, let me tell you something of the physiological results obtained by Dr. Lehmann, of Munich. He says (Arch. Hyg. 14, 135), as the results of his experiments on the *Toxic action of sulphuretted hydrogen*, he concludes to set 0·7 to 0·8 per million as the limit which must be drawn concerning an atmosphere, the remaining for a few hours in which begins to threaten some danger of injury to health. An amount of 0·15 per million of air appears, even after many hours' duration, not to effect such damage, but from 0·2 per million down to 0·15 is sufficient after some hours, to produce unfavourable symptoms. To give you an idea what these figures mean, let me say that if you go now to Widnes or St. Helens, choose the most fragrant waste heap to be found, set up a tent upon it on a damp still day, when the fragrance is greatest, and after closing the tent door you test the air of the enclosed space, you will not find anything approaching Lehmann's minimum figure, viz., 0·15 per million of sulphuretted hydrogen. Lehmann's figures will no doubt be very useful to Medical Officers and to our Inspectors of Works.

How alkali men have sometimes cooked their food

Use or custom is said to be "second nature," and I may tell you I have seen workmen cook a chop and boil up their tea by scooping a hole in the side of a waste heap partly on fire, until a red-hot portion was reached. The food was placed on a clean spade and the latter pushed into the hole and kept there till the chop was grilled and the tea boiled. The hole thus served as an oven, and spite of a slight odour of sulphurous acid and a tincture of sulphuretted hydrogen, chop and tea respectively, were at length eaten and drunk with appetite and relish.

SULPHUROUS ACID.

This gaseous substance (sulphur dioxide, popularly known as "fumes of burning sulphur") is principally employed for manufacturing sulphuric acid or vitrol. It is also used in bleaching wool, silk, and straw, and in the sulphite wood-pulp process. It is produced in the purest condition by allowing sulphur to burn in the air in suitable kilns, the oxygen of the air supplied by a slow draught, combining with the sulphur during combustion to evolve sulphur dioxide. A cheaper source of this gas is iron pyrites, the bisulphide of iron, which easily parts with one-half of its sulphur, and at a red heat and in presence of the oxygen of a sufficient supply of air, with the final half as well, and leaving oxide of iron (ferric oxide). If the iron pyrites be of a cupreous nature, so much the better for the manufacturer, as the copper left with the oxide of iron is easily extracted in a subsequent process by roasting the ground

ore with common salt at a dull red heat, and then lixiviating the cooled charge in vats, with water and dilute hydrochloric acid. The green copper liquors are treated with scrap iron in separate precipitating vats, when the iron dissolves and the copper is precipitated as a metallic powder to take its place.

Manufacture of sulphuric acid.

In making sulphuric acid, the kilns, whether brimstone kilns or pyrites kilns, are so arranged that their flame or hot gas passes through an additional kiln in which are cast-iron pots containing nitrate of soda, or Chili saltpetre, mixed with sulphuric acid, which must be in slight excess. The heat causes nitric acid to be driven off, which the sulphuric acid has already set free from the nitrate of soda, and its vapours mingling with those of the sulphurous acid not only assist the oxygen of the air in oxidising this sulphurous acid to sulphuric acid or vitriol, but convert that oxidising process, otherwise a very slow one into a quicker, and also into a continuous process. Still the process is a comparatively slow one, and hence large spaces are required to accommodate such immense volumes of gas, and for this purpose large oblong chambers are built of light woodwork and lined internally with sheet lead, which dips into a bottom constructed like a huge dish of stronger sheet lead, so that the whole is something like a large tea-cup inverted in its saucer, but prevented by outer supports from resting its weight and mass quite on the bottom of that saucer, or like a huge oblong shaped gasometer which does not rise and sink, but is always as high up as possible. You will say, "yes, but the gasometer is luted at the bottom in water." I say, "just so," and the sides of the Vitriol chamber also dip into vitriol always present at a sufficient depth in the dished bottom so as to lute the bottom of the "*curtain*" of lead, as it is called. Just at the place where the sulphurous and nitrous acids enter the chamber, steam is also turned in. Inside those chambers a shower of rain is always falling upon the bottom and running down the sides, and that rain is sulphuric acid—it is a vitriolic shower. At the end of the chamber system is a leaden tower called the Gay Lussac Tower, the purpose of which is to catch and retain the costly nitrous fumes—a red choking vapour which would certainly injure health, but which the manufacturer has no intention whatever of allowing to escape. Gay Lussac discovered that cold strong vitriol easily dissolves nitrous fumes (nitrogen trioxide), and from this discovery arose the device called the Gay Lussac Tower. It is packed with hard cokes, and downwards from a cistern above, strong sulphuric acid trickles in all directions. This shower meets the ascending gases from the last of the system of sulphuric acid chambers, and absorbs all the nitrous fumes from them. Strong vitriol thus charged with nitrous fumes really forms a compound called nitro-sulphonic acid, which is easily decomposed by water or dilute vitrol, especially if hot, the red nitrous fumes being set free for use over again. Now this description, though incomplete, will suffice for my purpose.

Hygienic conditions.

We have brought together in this remarkable process several acids and acid vapours, and so we will study their hygienic bearing on the workpeople together. Do not think that sulphuric acid is only made by the Leblanc Alkali manufacturer, manure manufacturers, tar distillers, dye and colour makers, indeed all who want much sulphuric acid, often make it for themselves.

The question to which I now hasten is this: Is the manufacture of sulphuric acid injurious to the health of the workmen engaged? I answer without hesitation, "*No, it is not.*" It is not the object of the manufacturer to build expensive plant to generate gases and vapours, afterwards to be wasted by leakage into the air, a proceeding which, besides loss of money, would mean stoppage of his process by the Alkali Inspector, with a probable fine on a repetition; but it is his object to manufacture sulphuric acid, and so to confine and utilise to the utmost those noxious vapours engaged in its formation. The small quantities of sulphurous acid you may sometimes smell in Vitriol works are distinctly not injurious; that I say after a twelve years' experience in such factories. But there are special occasions, which however only rarely occur, when great care is necessary, and when the men perhaps need some authoritative protection from their own ignorance and often downright obstinacy. Such occasions are the cleaning out of the chambers, or of a Gay Lussac Tower.

Dangers in cleaning chambers and Gay Lussac Towers.

Let me say, at once, that when accidents occur through inspiring too much of the gases left in a chamber or a Gay Lussac Tower, to be cleaned out, the *first cause* is generally attributable to men entering too soon. But the *second cause* is not usually the sulphurous acid vapours present, but the residual nitrous fumes, and I think I cannot do better than direct attention to this fact. There is a number of noxious gases, all of which, if not too largely admixed with air, at once make you aware of the peril of your position in respiring them by certain unpleasant symptoms, but nitrous fumes form a notable and an insidious exception. Hence, even in the admirable book of Dr. Arlidge, I notice that the occasional accidents occurring on cleaning out the chambers, are evidently attributed to the sulphurous acid present. No doubt, as to odour, the sulphurous acid completely masks the much smaller quantities of nitrous gases, but there lies the danger.

To convince you, in the first instance, that sulphurous fumes, of course in very small proportion, are by no means so insidious or injurious as they have sometimes been represented, I would merely remind you that in times of cholera and other epidemics, you may expect, if need be, to be disinfected with burning sulphur fumes, which are sulphurous acid, and that sulphurous acid in a liquid form, and in the form of bisulphites, forms a most valuable antiseptic and disinfectant. But I will give you also the results of the experiments of German investigators, and especially of Ogata. Ogata, with several others, found that 0·5 to 0·7 parts of sulphurous acid, per 1000 of air, act seriously upon small animals, such as rabbits and guinea-pigs, in two hours inducing incipient destruction of the cornea, bleeding of the lungs, emphysema (distension of tissues with gases), &c., 2 to 3 per cent. sufficing to kill the animals in a few hours. Lehmann draws attention to the fact that Hirt's figures for sulphurous acid are 150 to 200 times higher than these, and since Hirt is an authority known in England as well as Germany, I beg to warn sanitarians that, whilst symptomatically Hirt is no doubt correct, Lehmann shows that most of his figures are terribly in excess of the truth.

Physiological action of sulphurous acid.

This simply means that a totally irrespirable atmosphere is sometimes put down by Hirt as one that a man might safely pass a day in! But an atmosphere anywhere in a sulphuric acid works, which contains 0·5 part per 1,000 of SO_2, could never be found under normal circumstances.

Sulphurous acid in Underground Railway tunnel at Gower Street

It may be interesting to know that the atmosphere of the Metropolitan Underground Railway tunnel at Gower Street is sufficiently charged with sulphurous acid to make that tunnel act something like a sulphuric acid chamber. Droppings from the roof which taste acid are continually falling on to the platform, which is whitened and corroded by the weak vitriol, which these droppings certainly consist of. If you ask me as to injury to health caused by such an atmosphere, I say at once I don't believe there is the slightest, except in the case of delicate or diseased lungs. I don't know what escape there is from the conclusion that that tunnel is efficiently and cheaply disinfected against cholera and influenza, though I certainly deprecate the presence of the solid particles of carbon of the smoke and any carbonic oxide of the fuel gases.

Gases of chambers and towers.

But I spoke of the insidious nature of the mixed sulphurous acid and nitrous vapours of the Vitriol Chambers and Gay Lussac Tower. This character is almost entirely due to the nitrous vapours. In the *Chemische Industrie*, 1889, p. 317, there is reference to a workman who died after cleaning out a Chamber through the nitrous fumes, but a *post-mortem* proved that he had a very diseased heart. A case is also given in the *Chem. Ind.*, 1892, p. 284, of the death of a man who had assisted in cleaning out a Gay Lussac Tower in which stoppages of draught had occurred. Although the tower had been, as was thought, thoroughly freed from acid and nitrous vapours by washing out with hot water, running down soda solutions and several days' airing, and the workmen, previous to their descent into the tower, had bound wet sponges over their mouths to act as respirators, nevertheless, one of the men, known as a sickly and weak man, was soon so affected by the dilute nitrous vapours, that after walking about a mile of his journey home he could go no further, and he died before the following morning. Yet the other workmen of stronger build had worked for hours in the same atmosphere without apparently any injury whatever. In such cases it is recommended that special respirators should be furnished, with tubes, and a supply of air from outside. The best form of respirator for such a purpose as recommended by German authorities is that of König, known as the Patent Respiration Apparatus, to be obtained from Gustav Kleemann, Engineer, of Hamburg.

Nitrous fumes form an insidiously noxious gas, and I must explain what this means. If a workman, or even a chemist, unaccustomed to its mode of action, try to judge of the influence of air mixed with a small proportion of it upon their respiratory organs, by closely observing how they feel whilst respiring such atmosphere for a short time, they may find themselves woefully deceived. To put it briefly, one of the principal symptoms, and that most characteristic of nitrous fumes, is the peculiarly deferred but alarming *dyspnœa* that after a time sets in. But it is *dyspnœa* of a special order, for whilst the inspirations are comparatively unimpeded, the expirations become more and more difficult and painful.

You will be astonished when I tell you however that the vapours of nitric acid, like those of hydrochloric and sulphurous acid, are not to be compared with those of nitrogen trioxide (red nitrous fumes) for danger, nor is that danger to be found except very seldom in either alkali works or nitric acid factories. There is a case given in a German report from the *Chem. Ind.* 1892, p. 283, and it is typical of perhaps the only kind of serious occurrence in our modern nitric acid works. A workman who had the job of filling a pressure-cistern in the open air with an acid for nitrations, upset the vessel he was carrying, and apparently fearing a severe reprimand, he endeavoured to remove the spilled acid by washing it away with water, without saying anything about the mishap. He trusted that the vapours in the open air would become so quickly diffused as to

Accidents in nitric acid works

become uninjurious. Such an acid would, however, generate volumes of nitrous fumes in contact with all organic matter it came in contact with. The man died in nineteen days after, from the effect of the fumes. For this class of work and such emergencies, that factory had respirators for the men, but what could a firm do in such a case as this?

Vitriol chamber plumbers.

Before leaving the subject of Sulphuric acid manufacture and going on to Nitric acid manufacture, towards which I have been steadily advancing, let me say a word about the Vitriol chamber plumber. Dr. Arlidge in his work, page 463, says, "The evils of lead are more severely felt by the plumbers, who find constant work in making and repairing pipes, funnels, and chambers, and are exposed to the fumes of the solder they use as well as to the metallic lead itself." But the use of soft solder for cementing sheet lead is out of date, and plumbers now always use strips of soft lead, which metal is used with a blow-pipe flame, somewhat as sealing-wax is in sealing a parcel. I do certainly not believe the plumbers suffer so much from lead fumes, for they need no such high temperature for their process as would cause appreciable lead fume, but they will use in their hydrogen gas-generators exceedingly impure spelter, and impure sulphuric acid, and both of these containing arsenic, they thus obtain hydrogen in their blow-pipe apparatus, containing considerable quantities of arseniuretted hydrogen, which must be injurious. I have myself pointed the false economy of this to them, but plumbers are rather difficult persons to convince of the errors of their ways.

German rules in cleaning Gay Lussac Towers.

In conclusion of this subject of sulphuric acid manufacture I have just learnt that the German Government has issued certain directions or prescriptions with respect to the discharge or clearance out of the packing of Gay Lussac Towers in sulphuric acid works in Germany. The document is headed, "*Besondere Unfallverhütungsvorschriften für das Auspacken von Gay Lussac Thürmen.*" These directions are recognised and passed by the Imperial Insurance Office, and were printed in the *Reichsanzeiger*, of 27th November last. Let me say that the German Chemical Industries are represented in Berlin by special committees, and I understand that any regulations proposed by the Imperial Government are submitted to these committees before being passed, and once passed they have to be adhered to. Thus the manufacturers practically control, to a great extent, and under a wise Government supervision, their own affairs, and those matters relating to the health of their workpeople. I will now give you the recent German rules with regard to the Gay Lussac Towers.

A. Precautions and Directions for the Employer of Labour.

1. Before beginning to clear out the towers ((Gay Lussac), which must only be done under supervision, every connection of the Gay Lussac Column with the chambers and other apparatus, must be cut off.

2. The Gay Lussac Tower still connected either directly with the chimney, or indirectly through the medium of an intervening Gay Lussac Tower, so that the through-draught is maintained, is now washed out, first with sulphuric acid and then with water or steam, until the exit washings only show a specific gravity of 3° Baumé.

3. After this washing-out, the connection with any intervening Gay Lussac and the chimney must be cut off, and the Gay Lussac to be cleared out must be closed up gas-tight. Then, where it is possible, a connection of the Gay Lussac with a chimney or a mechanical ventilator is made, and is maintained throughout the operation of clearing. If the tower is to be emptied from below, then exhaustion from above, with closed cover, is to be effected; if from above by descent into the tower, then exhaustion from below must take place. In the latter case the cover of the tower must be removed. If exhaustion be impossible, the cover should be removed and one large hole should be made below. Only after the tower is sufficiently freed from noxious gases should the clearing out of the packing materials commence.

4. Towers packed with coke, or similar material, should be cleared out from the outside. In the case of high towers, or towers with several internal arches, arched supports, or gratings, several holes at various altitudes in vertical line from above downwards, should be made following the progress of the work, or the emptying process is to be effected step by step ("etagenweise"). Stone, or such like packings, are to be removed by the workmen by passing them out by hand, or hoisting them out by suitable winding-gear. All the packing material is at once to be carried out of the building, *i.e.*, out of the neighbourhood of the Gay Lussac Tower. The workmen should, according to necessity, or, at all events, expressed desire, be at once absolved from further continuance in the work.

5. The workmen should be supplied with good mouth sponges (as respirators), respirators, and proper coverings for their hands, such as india rubber gloves, hand wraps, &c.

6. Before getting out the mud accumulated at the bottom of the Gay Lussac, water should again be caused to play upon it and be stirred well up amongst it from outside. If nitrous fumes arise, the liquid must be removed from outside, and the stirring up with water continued.

7. Workmen known to be affected with lung or heart affections, ought not to be employed in any of this clearing-out process.

8. Every manufacturer is directed to make known these "Measures of precaution against Accidents" (*Unfallverhütungsvorschriften*), by a printed notice set up in a suitable place in the factory. Besides this, these precautions must be impressed upon the workmen, and the dangers of the work be made clear to them, before they commence operations.

B. Precautions and Directions for the Workmen.

9. If, during the clearing out process by entering the tower from above, and thus operating, nitrous vapours in large quantity are generated, the workman must at once leave the tower and acquaint his overseer or superior with the fact.

10. Workmen affected in heart or lungs, who are employed for cleaning out Gay Lussac Towers, are bound to communicate such fact to their overseer.

C.

11. Here follow a few penalties, the proceeds of which go to the Workmen's Sick Fund, in case of disregard of the rules prescribed as above. A member of the Society has to pay double subscriptions for his omission, whilst an insured person pays, for each offence, some penalty not exceeding 6 M (six shillings).

Probable effect of stringent military discipline on chemical workmen.

As I have already said, during all my entire connection with alkali and sulphuric works, I do not remember a single fatal accident in clearing out chambers or Gay Lussac Towers, through inhalation of nitrous fumes. We must also observe that all the men in Germany, workmen and others, are soldiers, and the workmen class are those who will have a lively recollection of the "*Unteroffizier*," or otherwise of the stringent military discipline conveyed in that single word, unquestioning instant obedience demanded, &c., &c., and it may be that such workmen have been ordered heretofore to clean towers and chambers by foremen still mindful of the office of *Unteroffizier*, and the men without word or question, have exposed themselves to the gravest perils, which in English factories *could not thus happen*.

Nevertheless, the precautions mentioned are good, and what of good there is in them I am convinced our friends, the British Acid makers, will at once recognise. So far as I recollect, the vital portions of these regulations are already observed in this country.

Nitric acid: manufacture and uses.

Nitric Acid: Manufacture and Uses.—It is not seldom the case in the chemical industries that whilst sanitary difficulties or dangers do not specially arise in connection with the manufacture of a particular chemical, they may arise subsequently in the use of it. Nitric acid may be placed in this category.

The reason is not difficult to find. (1) The particular substance to be made must be condensed, restrained from escape in any form, for it has to be turned into money, and all skill and delicacies of appliance are, as it were, concentrated upon this object, and so too a maximum of experience is gained. (2) Then, the modes of application by users of the substance will mostly entirely differ from those of its preparation; and (3) in the application, the substance may be chemically decomposed, and then give rise to decomposition-products—which we designate by-products—that may be more noxious than the original substance used.

After a good deal of thought on the subject I have come to the conclusion that it may be very hard both upon the manufacturers and the men, to use one term, such as "*Noxious gases or vapours*" indiscriminately for all irrespirable gases; for whilst the accidental inhalation of a certain amount of one gas or vapour, *A*, may produce symptoms which are transient, or which will at once serve as a direct evidence to the person affected, of its dangerous character, another gas or vapour, *B*, may not do so, but induce slighter symptoms at first, which become aggravated later on, even when the arena of mischief has been abandoned for some time; whilst a third gas, *C*, may speedily induce narcotic symptoms, like the gas from the old sulphate of ammonia plant. Thus I should be inclined to separate such vapours and gases hygienically, and classify them as

Proposed classification of noxious gases.

GROUP 1.—*Non-irritant irrespirable gases,* such as nitrogen and carbonic acid.

GROUP 2.—*Irritant noxious gases,* such as hydrochloric acid, sulphurous acid, nitric acid, ammonia, chlorine, bromine and iodine vapours.

GROUP 3.—*Insidious irritant noxious gases,* such as nitrous acid (nitrous fumes).

GROUP 4.—*Insidious non-irritant noxious gases,* such as bisulphide of carbon, carbonic oxide, and sulphuretted hydrogen.

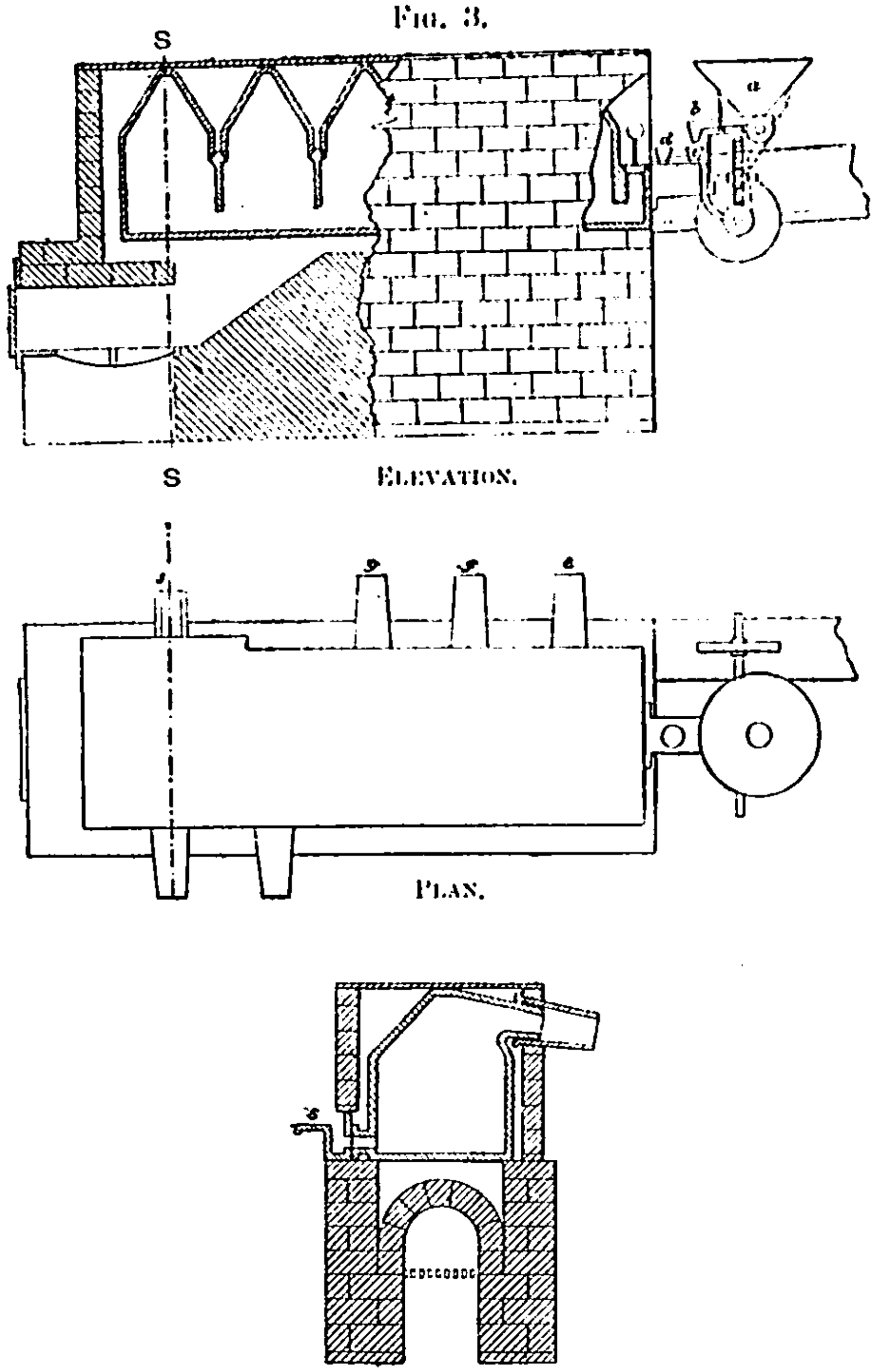
I should thus consider group 2 as the least dangerous, since giving immediate and adequate warning to the senses; whilst groups 3 and 4 are the most dangerous, as most immediately deceptive to the senses.

I shall say little about the nitric acid manufacture. In order to make a comfortable profit the manufacturer must *condense* the vapours, and not lose them to the detriment both of himself and his workmen. The older cylinder plant, as formerly worked, presented most danger of slight escapes in the preliminary mixing stage of the nitrate of soda and sulphuric acid, but very little of such danger is presented in the perfect apparatus now set up, and connected with excellent modern condensing arrangements. I have recently visited a factory where an admirable continuous process is at work for making nitric acid, and I should like to make as clear to you as mere words can do, what this apparatus and process are like, and the advantage of continuous working when possible. The apparatus and process are the device of Mr. Manning Prentice, of Stowmarket, and he kindly showed them to me in full operation, and answered all my questions. The older and well-known nitric acid cylinders require opening and closing, and charging with materials, and discharging of the crude bisulphate of soda, and though with care, and with such admirable modern improvements, as, for example, the Guttmann apparatus with Lunge Rohrmann condensor, or similar plant, most perfect condensation may be effected, yet a continuous process (always supposing equivalent economy), with continuous automatic feeding-in of materials (nitre and sulphuric acid), continuous mechanical firing, with a constant and even evolution of acid vapours and acid, and continuous and steady out-flow of liquid residual bisulphate of soda, must always from the hygienic point of view be considered the most advantageous. The drawing annexed will illustrate the apparatus of Mr. Prentice, with its agitated charging funnel (*a*), delivering in a thin stream at (*b*) the powdered nitre into a smaller lead funnel (*c*), which leads direct into a mixing chamber, and thence into the still. Another funnel (*d*) receives a constantly flowing and thin stream of sulphuric acid, which only meets the nitre inside the small mixing chamber, and under cover of the still. The mixture constantly generating nitric acid vapours in the hot still, flows on in zig-zag fashion from one compartment of the still to the other, towards the fire, and so that mixture becomes continually hotter. As it reaches the fire-end of the apparatus it consequently contains continually less and less nitric acid, and the residue on emerging at (*s*) is bisulphate of soda. From the first compartment, with its outlet (*e*), a weaker nitric acid is obtained than that obtained at further outlets (*f* and *g*.) These outlets are connected with separate condensing pipes, and furnish very constant acids; the less condensable fumes pass to a small Gay Lussac coke tower, where they are absorbed by a down-flowing spray of strong sulphuric acid. The fireplace is an ingenious one: such, that by a well regulated

Continuous nitric acid process.

draught and mechanical stoking arrangement, as nearly as possible a constant heat is maintained. The whole apparatus

Fig. 3.



Elevation.

Plan.

Section at S S.

is under cover, and the little fume I could perceive, only came from the receiver, containing the manufactured acid, ready to be drawn off.

Nitric acid fumes.

In a nitric acid works, as my friend Dr. C. Otto Weber says, "the workpeople may be exposed to the vapours of nitric acid and nitrous acid. To the former by escapes or accidents, to the latter by accident. Nitric acid vapours form an irritant noxious gas, which gives immediate and full warning to the senses, and so I do not regard it under normal working conditions as dangerous, but nitrous acid is both insidious and deleterious. It is a red gas, and its fumes are always abundantly generated when nitric acid comes in contact with organic substances through some accident. Take the usual case in a nitric acid works. A man breaks a glass carboy of nitric acid, which escapes into the straw of the hamper in which it is packed." Volumes of nitrous fumes escape around. The workman can easily beat a retreat, but not unfrequently, though against the rule, he may desire to hide the consequences of carelessness, and remain on the spot endeavouring to sweep up the spilled stuff. His lungs and life in such a case are in immediate peril, and I will try to explain how. The smell of the fumes is disagreeable rather than pungent. A slight choking sensation ensues on inspiring the mixed air and fumes, with a decided fit of dyspnœa if a little strong gas assail the nostrils. However, for a time the man gets over these symptoms by running away and breathing a little fresh air. After, say a quarter-of-an-hour, during which slight dyspnœa and tightness in the chest are felt, accompanied with nausea, new and alarming symptoms set in, of which I can speak from personal experience. These are as if a valve had been introduced into the throat, allowing tolerably free though spasmodic inspirations of air, but gradually closing against expirations. This at length becomes very alarming, and if presence of mind be lost may lead to violent coughing, and then vomiting, accompanied by swelling of the body. Blood may even be vomited in such cases. Such accidents as these, I may say, place the masters in almost the same peril as the men. But in processes where nitric acid is used for oxidising purposes, unless special draught and condensing arrangements are fixed up, the men are undoubtedly exposed to much peril.

Accidents in nitric acid works producing nitrous fumes.

Of course the accident of breaking a nitric acid carboy may occur not only in a nitric acid works, but also in the other factories where such acid is conveyed. In such other factories this acid is mostly used for oxidations, and in these, nitrous fumes are liberally disengaged. Examples of them are, the manufacture of the so-called "nitrate of iron liquor," of stannic chloride, in the oxidation of "white paste" (ferrous-ferrocyanide) into prussian blue, in the manufacture of all nitro compounds, &c. A manufacturer informs me that in some small works at

Oxidation and nitrating processes, and their dangers.

the present time only insufficient means exist for the removal and condensation of this dangerous gas, and that he recollects several cases in which inhalation of strong nitrous gas by workmen led immediately to fatal results. In two other cases the men succumbed on pneumonia supervening.

Nevertheless, let me say here that I have known many cases in which I greatly sympathise with the small manufacturer, who starts with the most humane intentions towards his employés, and necessarily must exert great economy to make a profit. He is often put to ridiculous and unnecessary expense by a certain class of inspectors of machinery and apparatus, who in very ignorance insist on vexatious and trivial, but costly, alterations of the plant and so squander the man's money fruitlessly, and leave him unable to effect for the time additions which might greatly improve the sanitary conditions of working for his men. The manufacturer would hail with delight a substitution of the visits of the inspector who is a scientific man, such as, *e.g.*, the inspectors under the Alkali Act, but they are very averse to those of the ignorant and unsympathetic faddist, who merely worships his own petty authority.

Action of nitrous fumes on vegetation.

In large works where nitrous fumes are given off in more or less continuous processes, the recovery of this gas, by means of a smaller or larger Gay Lussac Tower, is a matter of economic importance. Dr. C. Otto Weber informs me of a curious fact which he has observed. It is this. Although nitrous gas has such a deleterious action upon living organisms, plants and trees are remarkably indifferent to it. I may remind you too that in the case of hydrochloric acid vapours, the sensitiveness lies just in the inverse direction, minute quantities stripping the trees and killing plants, whilst animals with a little practice can breathe moderate quantities of it. We have thus an inverse sensitiveness to the two gases in plants and animals. Dr. Weber tells me that he recollects that a "nitre shed" in Silesia (Verein chemischer Fabriken) was surrounded with a remarkably fine set of trees. In the shed mentioned the manufacture of nitrate of iron liquor was carried on, and frequently red clouds of nitrous fumes escaped and spread right amongst the trees, but only one of these, which almost overhung the short chimney through which the vapours passed, showed a few branchlets bare of leaves. The remainder of the tree, with all the others, exhibited not the slightest sign of injury, although this factory had been at work for sixty years.

Inverse action of hydrochloric acid.

Dr. Weber says of the manufacture of nitric acid itself, "Nitric acid vapours very seldom escape into the atmosphere of the factory." He only knew of such an occurrence when one of the condensing tubes from the muffle to the condensing plant had become fractured. He confirms my statement as to the perfection of the best modern plant. He says, "Such escapes very rarely occur now, owing to the very superior quality of the earthenware tubing for condensers now produced. But at one time such accidents were very common, and the heavy vapours of nitric acid quickly filling the room at once acted upon the respiratory organs of those present, and compelled them to beat a hasty retreat. The symptoms produced after an inhalation of the dilute vapours were quite similar to those produced by hydrochloric or sulphurous acid. Only when a workman exposes himself repeatedly to these vapours as, for example, in the attempt to draw the fire from the furnace after rupture of a tube, a severe affection of the respiratory organs can occur, no doubt as with hydrochloric acid and chlorine. At the present time, the stoke-holes of nitre furnaces are mostly so arranged as to be inaccessible to any vapours caused in the working of the process, either incidental to it or purely accidental." Dr. Weber adds, "As far as vapours are concerned in the nitric acid manufacture, I have no hesitation in saying that it is not so much nitric acid as nitrous acid fumes that have to be guarded against." However, in manipulating liquid nitric acid, especially the new workmen, need to be informed of its instantly destructive action on the skin, burns and ulcers being formed. These wounds heal slowly and often cause much suffering if at all severe. It is greatly to be recommended as a safeguard against such burns and corrosions that a moderate supply of vaseline be allowed to the men, so that they may keep their hands well greased. Vaseline is inert to nitric acid and resistant to liquids, but the mistake should not be made of substituting animal or vegetable greases, which are attacked by this acid. Dr. Weber remembers that the attempt was once made in Austria to replace the fragile glass carboys, used for the conveyance of nitric acid, by strong earthenware jars. The dangers of breakage were thus greatly diminished and the railway companies willingly carried the acid packed in these vessels at reduced rates of freightage. However, the weight of the jars was so excessive in comparison to their capacity, that in spite of the reduced rates, the carriage in such stoneware proved too costly.

Vaseline, to protect skin from burns.

Hydrochloric acid.

Hydrochloric Acid.—Hydrochloric acid is to-day the most valuable product of the alkali manufacturer by the Leblanc process, though at one time it was a most troublesome by-product. It represents the sole advantage at the present time which the Leblanc process possesses over the ammonia soda process, for it is the source of the valuable chlorine gas, which duly combined with lime and oxygen, gives bleaching powder or chloride of lime of commerce, used both for bleaching purposes and for disinfection. The first step of the Leblanc process consists in the treatment of common salt with sulphuric acid in cast-iron pans or pots connected with long blind-furnaces. Over the pots, dome-shaped arches are built surmounted with a short shaft soon turning at right angles in the direction of tall flag towers, packed with hard cokes, and down which water is kept trickling. From the short shaft over the salt-cake pot, a line of earthenware pipes proceeds and enters at the foot of the flag towers, first as a rule dipping into flag cooling cisterns. The gas from the furnace into which the half decomposed salt is pushed from the pot by the workman, is led into the towers by another line of pipes. In these towers a solution of the hydrochloric acid gas from the pots and furnaces is produced, that gas being very soluble in cold water. Thus, liquid hydrochloric acid is formed.

Gaseous hydrochloric acid is also produced in the Hargreaves' process, by passing sulphurous acid gas (sulphur dioxide) along with air over heated cakes of common salt, whereby these cakes are converted *in situ* into sodium sulphate, and hydrochloric acid gas escapes and passes on to the flag condensing towers to form liquid hydrochloric acid. The vapours of hydrochloric acid in anything approaching the concentrated form are corrosive and very irritating to the mucous surfaces and respiratory passages, more concentrated still they are quite irrespirable. In minute quantities in the air, though very destructive to vegetation, I must entirely dispute the statements so often made, that this gas (except in the presence of already existing lung disease), is injurious to health. In my own case I have invariably found as the principal effect, a wonderful whetting of the appetite for food. Of course minute quantities of free hydrochloric acid occur in the gastric juice, but whether there is any connection here I cannot say. Nevertheless, the fact remains.

Hydrochloric acid gas an appetiser.

Whilst resident in Manchester I used to visit with my classes in Chemical Technology, year by year, the Alkali Works of Widnes and its neighbourhood, and I observed invariably, after consulting the students who accompanied me, that the concensus of opinion was that the appetite was greatly increased. Pictures have also been drawn of the woes of the salt-cake men exposed to the vapours of hydrochloric acid, or as it is called, "salt-cake gas." These are mostly exceedingly overdrawn. For sore finger-tips and exposed parts, vaseline should be used, or rather, the parts should have been protected with vaseline, which is inert to hydrochloric acid gas. Whilst I have observed no cases such as have been pictured, I will tell you what I have seen, for years together, practised in the Lancashire and

Cheshire Alkali Works: Women of the poorer classes, and even of the tradesman class, used to bring their infants troubled with whooping-cough, sometimes called "chin-cough" in the north, and beg to be allowed to carry them into the salt-cake sheds when the charges were being drawn. The inhalation of small quantities of hydrochloric gas was regarded as a specific against whooping-cough. If absolutely no result followed such administrations, or if the complaint became on the contrary aggravated, it is not likely such a practice would be continued from year to year; but I have been assured by parents that the beneficial results were most marked. Certain it is that women accompanied by small children, and often carrying infants in their arms, regularly bring their husbands' afternoon meals into the salt-cake and black ash sheds, and usually wait until the meals are over before returning, regardless of the vapours issuing from iron barrows full of freshly drawn salt-cake, or being filled with the material drawn from the furnace. Of course, they take care to keep to the off-side of acid vapour. The men themselves, when drawing the charges, are well bandaged around the mouth and neck. I like the German plan of using as a rough respirator a piece of damp sponge bound over the mouth, and I would recommend it for a trial.

Continuous hydrochloric acid processes.

I have already pointed out the sanitary advantages of continuous and almost automatic processes and apparatus for the preparation of ammonia and nitric acid, and also that, as such improvements are made, the profit to the manufacturer and the comfort to the workmen increase *pari passu*. You will naturally ask if there are similar methods for making hydrochloric acid. I at once reply, Yes; certainly there are. There are the Jones & Walsh and the Mactear revolving furnaces, in which salt is continually charged in through a hopper in one place, vitriol run in through a pipe, and agitation caused by either revolving scrapers, or a revolving bed with fixed scrapers. Whilst salt-cake (sulphate of soda) is continually discharged at its proper outlet, hydrochloric acid continually escapes and is drawn by the chimney draught to the flag towers for condensation, to form liquid hydrochloric acid. But the most beautiful and sanitary process to this end is that of Hargreaves, a fine plant for which, is at work a tthe factory of the Alkali Union, Ltd., known as the British Alkali Works, in Widnes, which is carried on on such a gigantic scale, and worked in such gradual detail, as to constitute a veritable continuous process, though in its details it is intermittent.

Physiological action of hydrochloric acid.

Let us now hear the results of Dr. Lehmann's physiological experiments with hydrochloric acid gas. But here, at the outset, I must again quote Lehmann on Hirt's researches, and the figures he adduces for what he considers permissible quantities, or insignificant quantities of such gases as ammonia, sulphurous acid, and now hydrochloric acid. Says Lehmann, "Woe to the workmen! who should be in a works in which such quantities of those gases contaminated the air." I lay stress on this matter—firstly, because many of our medical men, physiologists and sanitarians, in this country have quoted Hirt, and seem to rely on his statements, mostly correct as to symptoms, but wrong as to figures; secondly, because I recognise a great possible wrong done to our manufacturers if those figures be relied on, in leading physiologists and others to pronouncements on the characters and sanitary properties of these gases in air, that may be extremely wide of the mark, and, thirdly, I could conceive it possible that, relying on those figures, some might quote them as indicating that our Government Alkali Inspectors were unnecessarily severe and stringent in the low figures and high efficiency of condensation they insist upon. Lehmann finds the effect upon the lungs and respiratory apparatus in the case of hydrochloric acid gas, and of ammonia so similar, that he considers them together. So thoroughly has he made his experiments, that not content with torturing to death a number of cats and guinea-pigs, that he might *post mortem* examine their lungs, &c., he subsequently operated upon himself and a friend. Of course he and his friend spared their own lives!

As Lehmann was unwell, the experiments on himself were scarcely useful, but those with the friend, a strong man of thirty years of age, are valuable. With air, in a close chamber, containing 0·05 per 1000 of hydrochloric acid gas, symptoms of irritation to the larynx and nostrils were experienced, causing continual sneezing; instinctively breathing was effected through the nostrils alone, and by means of small and superficial draughts of the acidified air. Gradually, a certain degree of smarting at the chest was felt, and some hoarseness; also there arose a certain choking sensation in the throat. No acid taste could be perceived, and no smarting of the eyes. The man, a stranger to such fumes, declared that to work in such an air-space would be intolerable, and begged, after twelve minutes, to be let out.

After more experiments on himself and others, Dr. Lehmann states that he thoroughly believes that people of sound lungs, after a certain degree of practice, may become accustomed to breathing small quantities of hydrochloric acid, even stronger doses than that mentioned above, without any too great difficulty or danger; but that the limits for any considerable stay in such atmospheres ought to be drawn at 0·1 as minimum or

0·2 $^{0}/_{00}$ at the very outside as a maximum. Hirt specifies 5 to 10 $^{0}/_{00}$, *i.e.*, 50 times as much as for a small dose, which, I confess, I should like to see him try for five minutes!

The appearance of the lungs of the animals experimented on, that had inhaled considerable quantities of ammonia and hydrochloric acid gas, Lehmann describes as almost exactly resembling those of such animals as horses and dogs that have been found in stables which have taken fire accidently, the animals having been choked to death with smoke and empyreumatic vapours.

Chlorine Gas.

This gas is prepared for the manufacture of bleaching powder (chloride of lime) or for the manufacture of bleaching liquor, which might be termed bleaching powder solution, by subjecting hydrochloric acid to the action of such an oxidising agent as manganese peroxide, or as in the Deacon process to the action of the oxygen of the air under special conditions. The hydrogen of the hydrochloric acid is thus separated to form water whilst chlorine remains as a greenish yellow heavy gas of peculiar odour which is greedily absorbed by slaked lime, milk of lime, or alkaline solutions. On the large scale, hydrochloric acid is run into stills made of flag-stone containing manganese peroxide, or if manganese mud be employed as recovered by the Weldon process, this is run gradually into hydrochloric acid contained in these stills, which are suitably heated with steam. The chlorine gas generated, passes through short removable arms of stoneware or lead to a gas-main which conveys the gas to leaden chambers resembling small vitriol chambers, sometimes set on the ground, sometimes mounted on pillars. In the latter case the finished bleaching powder can be more safely, quickly and comfortably shovelled through suitable openings in the floor into the powder casks placed below the chambers. These chambers are supplied with windows, one on each side, and by looking through from one to the other, little more than traces of chlorine can be distinguished by the colour communicated to such a thickness of air. Chlorine is an irritant noxious gas, and its odour is very characteristic. It is more choking than hydrochloric acid gas, and more difficult to get rid of from the respiratory apparatus when inhaled, for it is not so soluble in aqueous liquids, and hence, in the salivatic and mucous discharges the flow of which it excites. Nevertheless it is a gas to some extent soluble in water, and the solution in contact with air and light, rapidly becomes changed into one of hydrochloric acid. So great is the affinity of chlorine gas for fresh slaked lime, arranged as it is in ridges resembling a ploughed field, so

Chlorine gas.

as to give increased surface, that advantage is taken of this fact, to clear a finished chamber of residual gas, by simply connecting it by a light leaden movable pipe with a neighbouring chamber containing fresh lime, and leaving an air-hole or opening in the finished chamber. The attraction for the chlorine by the fresh lime soon sets up a draught, and fresh air is drawn in at the openings of the finished chamber and thus it becomes ventilated.

Bleaching powder.

Before 1886 a bleaching-powder man going to a chamber, and judging as to the complete absorption of the chlorine gas by a mere rule-of-thumb process, would proceed to open it, not unfrequently to find the gas only partially absorbed, sometimes still with a content of 100 grains of chlorine per cub. ft.; often with 15 or 18 grains of chlorine. The result of finding such a choking atmosphere was a rapid retreat for fresh air. Such rule-of-thumb or guess-work process was often due to negligence in keeping the glass windows or "sights" clean. Now, *i.e.* since 1886, these errors are prevented (except of course in cases of sheer wilfulness) by a rule made obligatory by the General Inspector in 1886–87, viz., that no doors shall be opened until, by a suitable test, the internal atmosphere is found to contain something below *5 grains of chlorine per cub. ft.* The amount I understand that is usually kept to is 1 grain per cubic foot. A simple automatic test is provided for this purpose. To show how willing the alkali manufacturers are to meet the Inspector in any devices for the sake of the health and comfort of the workers, let me mention that Mr. Brock *(the Chairman of the Alkali Union)* himself introduced an additional rule and a process for more quickly removing the chlorine, viz., by a final diffusion of lime-dust through the chamber space. As it settles, this dust absorbs the residual chlorine gas, and a harmless atmosphere remains, which the packer can enter with safety and comfort.

Advances in sanitation of the bleaching powder industry.

It is a singular thing that the profession of bleaching-powder packing and chlorine-still working, seems to be almost entirely in the hands of Irish workmen, and this perhaps accounts for the further suggestive fact, that the one desire of these men, with but few exceptions, is to find any excuse for claiming monetary assistance for the libations, "*the dhrop of Irish whiskey*," which form their invariable specific for all "gassing" ailments. No helmets, waterproof clothing, or respirators would last a week, if worn at all, in the majority of cases, if it were known that the whiskey money must be stopped. Bright exceptions to this general rule are to be found, but they are comparatively scarce. The packers prefer to bandage their legs well with folds of cheap cotton and brown paper, and also their necks, mouths, and nostrils with cotton folds, before enter-

Alcoholism, an obstacle to improved sanitation.

ing the chambers. This it is quite as necessary to do on account of the dust of the powder as on account of chlorine gas. Of course the eyes are protected with large goggles, the lime-dust, nevertheless, sets up conjunctivitis from time to time. The preparation and sieving, as well as spreading of the lime in the chambers, is a trying piece of work; but the painfulness of it might be much reduced if the men would only accept the helps and defences that are offered to them, and especially abstain from whiskey drinking. The skin is generally greased by the men who enter the chambers. Vaseline ought to be used here again. I would also recommend the use of mouth sponges covering both mouth and nostrils under a less heavy cotton bandaging. The sponges are readily removed, and easily washed and wrung out from time to time. The bandages are often worn until both dirty and very acid, and when pressed against the teeth are likely to set up corrosion of them.

Lehmann says that there is not the least doubt that gradually certain individuals amongst the workmen can get accustomed to inhalation of moderate quantities of dilute chlorine gas, but there are some individuals too who cannot acquire this habitude. The work's proprietor himself through repeated visits into the factory acquires some of this faculty. One manufacturer of bleaching powder told Lehmann that some workmen will occupy spaces for a day together which he himself would have to quit after only ten minutes duration. Christison, speaking of bleach works, states that the chief result of habitual exposure in the chlorinated atmosphere, is that the men get acid in the stomach and other stomach disorders, which they try to remove by taking chalk. These men never become stout, and if stout at first as other men are soon reduced to leanness, Christison finds that many of these men grow old, and he sees no reason for considering the work unhealthy.

Dr. Lehmann On acquired hardening against chlorine.

Dr. Frank has also noticed the tendency to leanness in workmen exposed to bromine vapours, which are more trying than chlorine. He recommends plenty of fat food, and the utmost abstinence from spirits.

Dr. Frank opposed to whiskey and spirits.

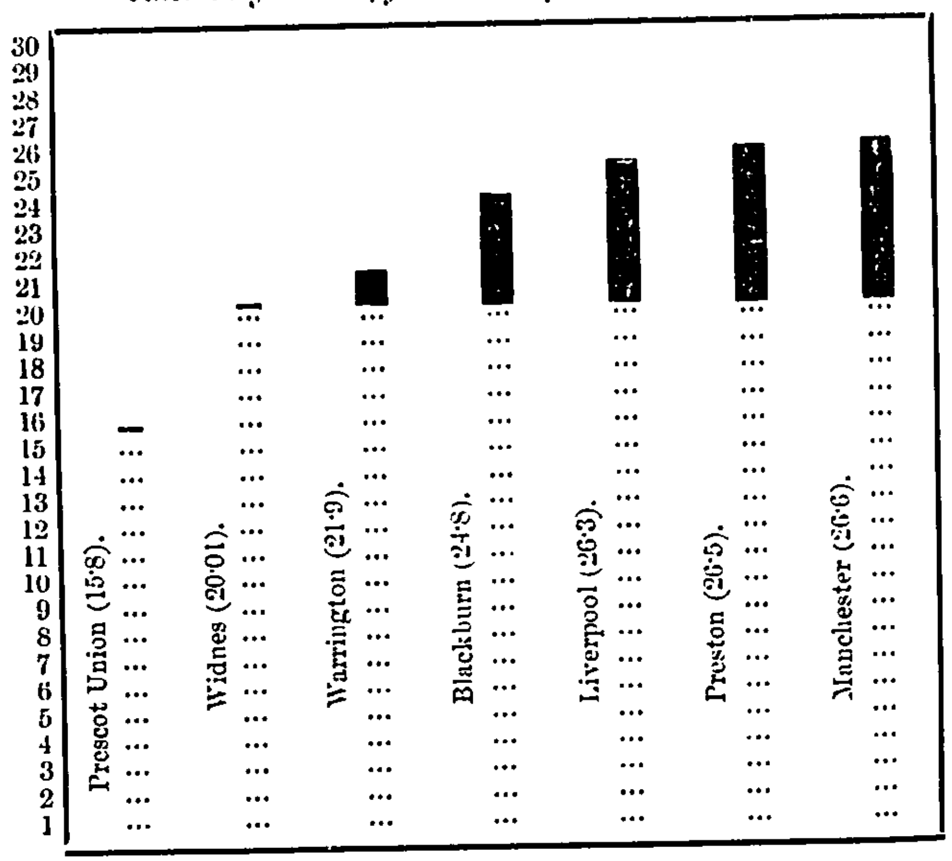
This abstinence from spirits of course applies similarly in the case of chlorine, and yet we find the workmen insist upon drinking it as a remedy! I have known a man "gassed" with chlorine to take hot whiskey and water, and subsequently to become for the time stark mad, six or seven men being required to hold him. The statement that workmen exposed to chlorine atmospheres are predisposed to phthisis thereby, is contradicted by recent authorities. I myself have drunk small quantities of weak sulphuretted hydrogen water when gassed with chlorine, and with immediate relief. Renk, who studied the condition of

Incompatibility of chlorine and whiskey toddy.

Weak sulphuretted hydrogen water an antidote.

the workmen in paper mills, where rag bleaching with chlorine takes place, could trace no injurious action of the chlorine at all. In the Bleachworks of Freiburg in Silesia, Hirt noticed the low rate of mortality of 1·25 per cent., and the high average longevity of from 56 to 58 years. Statements have been made as to the terribly unhealthy condition of Widnes, the great Lancashire alkali centre; my experience was dead against that, and I have here the death-rate of this town compared with those of larger towns, such as Warrington, Blackburn, Liverpool, Preston, and Manchester, showing that it is considerably below all these; indeed, the statistics I have here are those specially prepared for the Labour Commission, and they contain some very remarkable testimonies of workmen who have grown old in the alkali manufacture, and have also grown hale and hearty, because moral, steady, and temperate.

Diagram showing average death-rate of Widnes compared with other large towns, for the ten years, 1881–1890.



I now append the testimonies of several bleach packers and a "burner" man, employed by the Alkali Union, which speak for themselves.

Testimonies of workmen.

John Darlington was prepared to declare that:—He is a saltcake man at the Weston Alkali works. His age is 45 years. He has been employed at this work for 26 years. His general state of health is good. He has never known any men suffer in health in consequence of "gas." His hours of labour are 50 hours one week and 84 hours the other. The men, as a rule, are temperate. He, himself, was teetotal for five years, and now only takes liquor occasionally. The men, on the whole, are not improvident. He does not believe that the teeth of the men in the saltcake department are affected by the "gas," but that in cases where men suffer in this respect, it is a result of using dirty cloths in their mouths. The men have ample time for meals, and have half an hour to rest every two hours.

Thomas Percival was prepared to declare that:—He is a burner man at Messrs. Wigg Bros.' Works, Runcorn. His age is 58 years. He has worked (pyrites) burners for 17 years, and has been employed in a chemical works 44 years. He has enjoyed general good health. He does not consider that burner men suffer in health as a consequence of the conditions of labour. Although the hours on duty are long, the work is light, and only occupies about half the time. He has never seen any workman rendered insensible from the effects of gas.

Thomas Barnes was prepared to declare that:—He is a bleaching-powder packer at the Weston Alkali Works. His age is 53 years. He has been employed in packing "bleach" for 34 years. His general state of health is good, and he has only lost one day's work during the past 18 years through illness, which was in no way connected with the nature of his employment. He has never seen anyone insensible from the effects of chlorine gas. He does not believe that the work affects his health, but considers it a healthy employment. He does not consider it necessary to drink rum to enable him to perform his duties, but believes that he can work much better without intoxicants of any kind, which he thinks are injurious. He works from five to six hours per day.

John McLeod is prepared to declare that:—He is a "bleach" packer at Messrs. N. Mathieson & Co.'s Works, Widnes. He is 49 years old. He has been a bleach packer for 30 years, and has been employed in chemical works altogether about 33 years. He has never lost any time through illness in connection with his work, and has had very good health. He has never been rendered insensible from the effects of chlorine gas, nor has he ever seen anyone else insensible from this cause. He has been practically teetotal for the last 13 years, and does not consider it at all necessary to take intoxicants to enable him to perform his work. He thinks the ordinary flannel muzzle the best means to adopt in packing a chamber. He has never found it necessary to complain of any of the conditions under which he is obliged to work. He works about 36 hours per week.

James Campbell is prepared to declare that:—He is a bleaching-powder packer at the Widnes Alkali Co.'s Works. He is 36 years old. He has been packing 16 years, and has been employed in chemical work about 20 years. His health has been on the whole very good. Has never seen or known any man to be rendered insensible from the effects of chlorine gas. Does not consider it necessary to take stimulants to carry on his work. Does not consider men employed in chemical works exceptionally intemperate. He does not consider the "Denayrouse" apparatus suitable for bleach packing. He has heard of it being used by a man at Muspratt's Works, but it was found to be impracticable. He would not be disposed to use it for this work himself, preferring to use the ordinary flannel muzzle. Has no complaints whatever to make regarding the conditions of his work.

The great bane of the alkali and bleaching powder worker is his usual partiality for spirits as a beverage. I have observed, and believe it to be generally true, that when syphilitic or scrofulous taint exists, the drinking of spirits brings such taint to the surface, and then very slight external influences suffice to bring forth eruptive diseases.

Strong cerebral action of Cl. and Br.

It may be well to remember that both with strong chlorine and bromine, a sudden exposure may result in a sudden lapse into unconsciousness with falling to the ground.

Chlorine does not attack the cornea and eyes, nearly so quickly or painfully as bromine does. With the latter vapours, spasms of the eyelids of a very painful kind soon set in, the lids becoming tightly and spasmodically closed. The attack on the skin and mucous membrane, as Lehmann shows, is rapid with bromine but scarcely noticeable with chlorine, and of course it is still more rapid with iodine, and here we observe as in many of the other properties of the three halogens, this curious increase or diminution of affinity as the atomic weights rise or fall. Bromine acts with special vigour on the hair or fur of animals. Lehmann determined as nearly as possible the amounts of chlorine and bromine respectively, necessary to kill a small animal like a guinea pig. On calculating out the results, I find that the

Pathologic action of Halogens, a periodic function.

average numbers representing the respective weights of chlorine and bromine, are as nearly as possible those bearing a ratio to each other of 80 : 35·5, *i.e.*, inversely as the atomic weights of these halogens. Hence the power destructive of life in these two substances, is in the direct ratio of the atomic weights. Probably iodine may be safely included in this law.

Lehmann considers that an atmosphere containing 1 to 2 millionths (0·001—0·002 °/$_{oo}$) of chlorine or bromine is quite uninjurious and very little troublesome, whilst 0·003—0·004 °/$_{oo}$, 3 to 4 millionths, are very irritating and cannot long be endured advisably. 0·005 °/$_{oo}$ should be perhaps regarded as the maximum amount that can be safely tolerated for a brief period. Larger proportions than the above, for periods of a few hours, can only be inhaled with danger of injury.

In his experiments on small animals Lehmann could detect no action on the heart that could be taken into account, also the action on the eyes, mouth and mucous membrane of the nostrils was comparatively insignificant, but bromine distinguishes itself greatly over chlorine in its action on the hair and epithelium of the stomach, whilst the kidneys, liver and other abdominal organs were not much affected in the case of either gas. The curious distinction between the action of the halogens in vapour-form and that of their hydrogen compounds, hydrochloric and hydrobromic acids, was observed to be, that the halogens exhibit a much stronger cerebral action, if indeed any cerebral action at all in the case of the hydrogen acids can be spoken of. It is interesting to note that Lehmann after his experiments in a closed chamber, went to a German paper works and examined the bleaching departments and its conditions. He found that the average amount of chlorine in the vicinity of the souring vats during the process varied between 0·001—0·004 °/$_{oo}$ of chlorine, *i.e.*, 1 to 4 millionths. He observed that the workman at the period of strongest gas stood in the doorway to get as much fresh air as possible. This individual told Lehmann that at first the gas gave him a severe catarrh with expectoration of much mucous, &c., but that gradually he had grown accustomed to the gas, and ceased to become affected. He seemed to be a thoroughly healthy man.

Noteworthy distinction between actions of halogens and their hydrogen acids.

I quite agree with Lehmann as to the possibility of becoming hardened to the action of small quantities of the pungent gases mentioned, which are not what I have described as *insidious*, but I would ascribe a great deal of this so-called "hardening" to a kind of acquired skill gradually taught by instinct, and which cannot be adequately described. Nevertheless, I believe it can only be acquired by persons with sound lungs. I myself have often breathed with a fair degree of comfort in atmospheres

Acquired skill in breathing in chlorinated atmospheres.

containing hydrochloric acid or chlorine, in which I have observed a novice almost choking. The kind of acquired respiration necessary, I can only describe as one in which a larger number than usual of cautious but superficial (*i.e.*, not deep) inhalations are taken, not through the mouth, but through the nostrils. With one or two deep breaths through the mouth the novice is placed "*hors de combat!*"

Injuries caused by contact with Gases and Liquids—Prevention and Treatment, &c.

I notice in my reading of the great German organ of the Chemical Industries, "*Die Chemische Industrie*," that the large number of accidents which occur to workmen appear to arise through various intricacies of the apparatus in German factories, and through what seems to me as I read, the nervous desire to show an over-hasty obedience, combined with a lack of personal observation and independent judgment and self-reliance. I put a great deal of this down to the effect of hard military discipline, and say without hesitation that a good sturdy Irishman would know how to protect himself a great deal better, and yet do his work. If we add to the disability named, the greater complexity of German apparatus, already mentioned, and the increased minutiæ, I do not wonder at the records of so many injuries caused by men falling down ladders here with jugs of vitriol in their hands, and turning wrong taps on there, and in violent haste to set things right, getting hold of other wrong taps, and injuring the face and eyes with something yet more noxious. I trace these accidents in great measure directly to stringent militaryism, which has converted men into so much unself-reliant machinery, and I say, let not readers of the journal quoted think that British workmen thus suffer, because I can assure you it is not the case, nor do the manufacturers here need such an excess of bye-laws, restrictions, and precautions. We have our own peculiar faults, but we are not over-drilled!

However, we shall do well to hear of the means of preventing injury, remedies, etc., compiled by the German firm, K. Oehler & Co., Offenbach-a-M., on "*Corrosion and Burning with Inorganic Acids and their Treatment.*"

I should like, on perhaps another occasion, to give the text of this interesting and valuable pamphlet, but will now content myself with a summary.

1. In the case of any burn with strong acids, the chief measure of importance is as quickly as possible to dilute and remove the acid from the part affected by copious affusions of water.

2. The neutralisation of any remaining acid by means of weak solutions of alkaline carbonates, is desirable.

3. A corrosion is simply a burn, and must be treated as a burn: air-tight bandage, with goulard water compression.

4. With extensive burns, it is highly desirable to avoid, in every possible way, a loss of heat or chill in the subject under treatment, by administration of a warm bath; warm lead-water compressions, &c. Nevertheless, it is perfectly evident that the quickest possible dilution, and washing away of all acid, must be regarded as the first duty to the man.

In the case of burns and scalds, we in England are almost invariably supplied with a stock of the good old linseed oil and lime water, and this is highly spoken of too in Germany as a safe palliative in unprofessional hands. But a better remedy still is one devised by the large German firm, Bayer & Co., of Elberfield, for use for their workpeople in case of burns and scalds. This consists of an organic preparation called "*Aristol*," an Iodo-thymol compound, which is used in the form of a 10 per cent. lanoline or vaseline salve, or even in the form of powder, to be laid upon the wound. A subnitrate of bismuth, as prepared by a South German firm, is also very warmly recommended for burns. Either of these preparations much diminishes the pain of the wounds.

In all places where dangerous work is carried on likely to bring about burns or scalds should accidents occur, it is recommended that plentiful supplies of water should be close at hand.

The use of suitable spectacles is strongly recommended by Lehmann and by the various authorities, and great fault is found with some spectacles that are already in use. It also appears, that like their English brothers, many of the German workmen will not wear these spectacles if they can help it, or even respirators. The kind of spectacles most recommended are those devised by Stroof, and patented by him. These have means for the circulation of air through them, and thus the eyes are kept cool. Use of spectacles.

Another kind of spectacles obtained the first prize recently from the *Association des industriels de France contre les Accidents du Travail.* This prize was won by Simmelbander, of Montigny, near Metz. It is made with trapezoidal glasses (J. Soc. Arts, Aug., 1893, 876), surrounded by wire gauze; does not heat the eyes, and is specially useful in cases where corrosive liquids may be thrown about in spray as the result of accident or otherwise.

Protective mask.

Dr. Lehmann most strongly recommended the use by workmen and others of a protective mask, invented by Herr Pitzner, Engineer in Chief of the Seydelmayer Brewery in Munich. Lehmann has worn this mask himself in all kinds of noxious atmospheres and thoroughly experimented upon it. It appears actually to be a kind of light helmet made of soft indiarubber, which loosely encloses both head and neck, whilst the eyes are protected by two large circular glasses. In the neighbourhood of the mouth is a strong indiarubber tube passing out into the fresh air and connected with a powerful bellows. Whilst the workman operates in the noxious atmosphere, a strong stream of fresh air is blown to his mouth, the loose soft rubber around the head and neck expanding or contracting as the excess of air increases or diminishes. Also any openings through the loose fastening of the helmet are of no detriment, the escaping air preventing return of obnoxious gas. Lehmann's exhaustive experiments with the mask show how effective it is, at all events, for a man not attempting any hard work in it.

Formerly used noxious respirators in Germany.

It appears from Lehmann that, at one time in Germany, sponges moistened with aniline were recommended as respirators for men working in atmospheres containing chlorine, and these he properly condemns, since aniline vapours are more noxious than chlorine itself! It may be interesting to refer to a paragraph written by Lehmann on the attempts that have been made to disinfect human beings in cases of serious epidemics, with chlorine and bromine vapours. He points out that the experiments of Fischer, Proskauer, and others, demonstrate the futility of any such method of disinfection, since it was found that for the destruction of the organisms it was necessary that the moist atmosphere of the sterilizing chamber should contain 3 per 1000 of chlorine, or 2·1 per 1000 of bromine, and the exposure should continue for three hours, or there might be used an atmosphere containing 0·4 per 1000 chlorine or 0·3 per 1000 bromine, with a twenty-four hours' exposure. Lehmann very pertinently, and somewhat humorously, says: "The micro-organisms would, under the above conditions, be very effectively slain, but so also would the patients!" Besides many pathogenic bacteria can easily withstand the action of an atmosphere containing as much as *4 per cent.* of chlorine for an hour together.

Disinfecting human beings with chlorine and bromine.

Before concluding, I should like to refer to one or two facts of great interest:—

Chemical workmen with scrofulous taint.

The first is the predisposition, as already mentioned, to eruptive complaints shown by a certain class of workpeople of scrofulous or syphilitic taint. Dr. Arlidge in his work mentions the occurrence of skin eruptions in the case of bleaching powder workers, through the action of the chlorine. Such eruptions I have never observed, but I can say this, that men who inherit scrofulous taint, are quite liable to such eruptions in chemical works at the slightest provocation. Such persons, as well as those with lung diseases, or even with heart disease, should, if possible, choose other work to do.

The second is the curious fact that in some chemical works in which a variety of products is manufactured, it is found that the influence of the conditions of one department acts as an antidote to those of another in which some injury is contracted, and accordingly the men are changed about from one place to another.

Are our alkali and acid manufacturers humane masters and employers?

In conclusion, and in view of some hard things that have been said of the chemical manufacturers in their relations to their workmen, I should like to mention two facts which have recently come to my notice, and after mentioning them I am content to leave it to the public verdict, whether the chemical manufacturer, and more especially in this connection, the alkali maker, does not possess his share of humanity.

The first fact is that at a recent meeting of the Liverpool Section of the Society of Chemical Industry, two of the chief magnates of the Alkali Union set forth the advantages and spoke entirely in favour of, an eight hours day for the alkali men. The second is what I call a beautiful testimony to the same good feeling. During the late coal famine, when many of the Alkali works were brought to a standstill, especially in and around St. Helens, the principal officials of the United Alkali Co. started a relief fund for their out-of-work hands.

A strong committee was formed, with a secretary and treasurer, and this committee had received promises of weekly contributions amounting to £150. It was estimated that these sums would provide 2s. 6d. per week for each single man, and 5s. for each of the married men, thrown out of work through the scarcity of fuel. The first distribution of relief was made on Nov. 20th, when 742 workmen, representing 2,500 souls, participated. But numerous outside applicants for relief presented themselves, and an appeal was made for public support.

Hence, the hearts of this Alkali Union Committee were good for their own men, and large enough to take in the woes and distress of a famine stricken population outside them.