HEALTH HAZARDS OF COAL-MINING

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From the point of view of the industrial medical officer coal-mining is a rich and interesting source of study offering a variety of medical and surgical problems, which, if they are to be solved satisfactorily, must all be tackled in their natural setting. Medical questions involving illumination, ventilation, temperature, dustiness, posture and movements during work, can be weighed only by careful observation of the working place itself, and by talking there to the men. The difficulties of attending an injured man and transporting him outbye to the surface can be appreciated only by those who have helped to do it.

There is no industry which has had to suffer gladly the views of the uninformed as much as the coal-mining industry. These people, occasionally fortified by an underground visit, have not hesitated to state their opinions on the effect of underground conditions on the health of the miner. In time of peace these views, which calmly ignore the efforts made to combat the industrial diseases of mining, the causes of accidents and the difficulties and successes met with, are of passing interest, but in time of war their effect has proved serious. The result is that the general community has come to regard the entry of young men into mining as a horror hardly less vivid than that of a dangerous military operation and quite devoid of the glory of military service. This attitude, which is as misleading as it is fantastic, has added greatly to the difficulties of obtaining willing man-power to work in the mines.

Working conditions below ground have been less affected by the war than other industries on the surface. Blackout has not interfered with ventilation, nor have workers been exposed to the risk of tuberculosis due to overcrowding and the entry of tuberculous patients. Arrangements are being made for strict clinical examination of all new entrants, and in South Wales radiological examination is also to be used.

Far be it from me to suggest that working underground in a mine is not 'war work' or a 'man's job'—indeed it is so much so that a youth brought up in other spheres of life may well be proud of having done it. No two mines are alike; they vary in size, some employing less than 10, others 3,000 and in a few cases even more. The depths range

from several feet to well over 1,000 yards and the distances inbye to the working places may be from two to three or more miles, sometimes extending under the sea. In a few deep mines wet bulb temperatures reach and exceed 85° F. but this is exceptional.

In 1939, 1,955 mines were working and they produced over 231 million tons of coal. The average number of persons employed was 759,921, of whom 13,460 were boys under 16 and 2,320 were females. Approximately five times as many persons work underground as on the surface.

Women and girls, when employed (see Fig. 1),

FIG. 1.—Scottish pit girls.

mostly work on the screens sorting 'rubbish' from the coal as it passes along the screening belts—a job which they do carefully. Their employment underground in this country has been prohibited since 1842; but it was not until 1935 that underground working by women was universally prohibited by an International Convention at Geneva. Special rules have been made to govern wash-places, mess-rooms, and sanitary conveniences. At some mines the girls have their own up-to-date shower baths and rest lounges. Minor injuries are usually dealt with by a senior girl who has some first-aid training; more serious injuries, which are rare, are dealt with at the

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ambulance room of the mine. In this case a girl is always accompanied by a friend.

Mining hazards fall into two groups : accidents and industrial diseases. In both groups the whole-hearted co-operation of employer and employee is necessary in order that the risks may be reduced.

Accidents

The accident rate in mines is high, both for fatal and non-fatal cases ; mines medical officers, even more than other industrial medical officers, should therefore be familiar with the fundamental principles of early accident treatment. One of the main duties of the newly established Mines Medical Service is to advise on and encourage the most efficient first-aid organization both underground and on the surface, and follow this up by taking an active interest in modern schemes of accident rehabilitation.* The value of efficient early treatment at the mine cannot be overstressed. The highest proportion of underground accidents are caused by falls of roof and sides and they occur at or near the coal face. The patient therefore must often depend upon the services of his comrades for the immediate treatment of his injury. We thus find that in every mine a large body of men have studied the subject of first aid with the sole purpose of helping their mates in case of accident. Quite apart from the bravery which is shown in difficult situations, the standard of work is often high. It is by no means unusual for a doctor at the mine, or for the surgeon who receives the case at hospital, to comment favourably on the excellent manner in which a fracture has been put up.

All types of fracture are met with and long stretcher journeys over uneven roads are often necessary. A clear understanding of the significance of shock is of primary importance. At a number of mines specially selected and trained ambulance men are allowed to administer morphine from ampoules-syringes ; this use of morphine however is strictly controlled.

In addition to first-aid men who deal with accidents in ordinary circumstances, there are Rescue Corps and Rescue Brigades. The men who form these units must be physically fit and specially trained for heavy work underground. They wear self-contained breathing apparatus. One of their main tasks is to enter and explore parts of the mine where it would be dangerous for other men to go, either because of the possible presence of carbon

monoxide or because the percentage of oxygen is low. In the past the most dreaded hazards of the miners' calling were explosions, and sometimes underground fires from spontaneous combustion, but these occurrences are now happily much less common, and when they do occur they are usually of smaller dimensions. An explosion is usually due to ignition of 'fire-damp' the chief constituent of which is methane—CH₄. This gas explodes when it is mixed with air at percentages ranging between 5 and 13 approximately. The explosion may then be propagated along roadways by the combustion of fine coal-dust which is raised by the force of the explosion. The medical results of an explosion include burns, injuries due to violence, and asphyxia from the carbon monoxide of the 'afterdamp.' Experience has brought out two vital points in treatment: (a) every effort should be made to prevent a man who is suffering from burns, even if these seem to be of small degree, from walking outbye; (b) a mixture of 93 per cent. oxygen and 7 per cent carbon dioxide should be administered as soon as possible in order to hasten the dissociation of carbon monoxide from the haemoglobin. The possibility of these disasters gives further emphasis to the value of efficiently trained ambulance men and the importance of a liberal supply of first-aid requisites in the mine.

Existing statutory first-aid requirements include three main provisions: (a) arrangements below ground extending to the working face—these consist in the provision of sterilized mine dressings, splints, and stretchers; (b) a properly equipped and staffed first-aid room on the surface—the man in charge of this room should be specially trained in casualty work, and the appointment of an industrially trained female nurse for the supervision of this part of the organization has much to recommend it; (c) facilities for transporting the patient promptly by motor ambulance from the mine to his home or to hospital.

Industrial Diseases

Industrial diseases in the mining industry form an impressive list and their prevention calls for continued study. It is worth noting that all mining industrial diseases are to a greater or less extent preventable. Just before the war the incidence of these diseases, with the notable exception of pneumoconiosis, was tending to fall; on the other hand, spirochaetal jaundice (Weil's disease) was insidiously making its appearance.

It may be of interest to enumerate and briefly describe the diseases for which compensation is payable to those who are disabled. In the year 1939, when 759,921 persons were employed, the percentage of cases for which certificates of disablement were given is noted in Table 1.

TABLE 1
CASES IN WHICH CERTIFICATES OF DISABLEMENT WERE GIVEN IN 1939

Silicosis (New cases ¹)	Nystagmus	Beat hand	Beat knee	Beat elbow	Inflammation of wrist	Dermatitis
0.06 per cent. (465)	0.147 per cent. (1033)	0.13 per cent. (980)	0.56 per cent. (4276)	0.09 per cent. (721)	0.05 per cent. (406)	0.04 per cent. (305)

N.B. The figures in brackets represent the actual number of cases.

¹ This does not include death certificates granted to men who have previously been certified as disabled.

* Rehabilitation Centres for miners are now established in the various coalfields. These centres are controlled by a Rehabilitation Advisory Committee under the chairmanship of Mr. R. Watson-Jones. This committee was set up by the Miners' Welfare Commission.

Miners' Nystagmus. Much remains to be determined about miners' nystagmus. It would seem to be an affection of the nervous system, the most marked sign of which is a rotary oscillation of the eyeballs. Behind this physical sign, which itself is not finally accounted for, lie hidden a series of even less understood 'nervous' symptoms. These range from headache, insomnia, and photophobia to marked mental depression. Indeed it is mental depression which is the main cause of disablement, for on careful examination many workmen who are quite unaware of it show oscillation of the eyeballs.

As to the cause, I agree with the conclusion of the Third Report of the Miners' Nystagmus Committee (Medical Research Council 1932) which is stated thus:—'The present Committee, however, have seen no evidence or criticism which would entitle them to withdraw from the conclusion arrived at by the first Committee, viz., that the fundamental cause of miners' nystagmus in the narrower sense of the term (i.e. oscillation of the eyes) is the low illumination under which miners in general work.'

The effect of low illumination on the eye is that

mittee are strongly of opinion that the practical treatment of the disease . . . should consist in the elimination of a hopeless dependence on compensation, by the provision of opportunities for work of some kind, the end in view being complete restoration to full work underground, under conditions of proper illumination, even if this has to be preceded by a period of work in daylight.' An aid to better illumination is also provided for by regulations which require certain parts of the mine (where the total number of persons employed exceeds ten) to be effectively whitewashed.

Pneumokoniosis. The presence of this disease in South Wales has recently excited much interest and led to an extensive investigation. Just as in South African gold mines several years passed before the existence and cause of pulmonary fibrosis (in this case, silicosis) was recognized and subsequently dealt with, so in South Wales as time went on a new type of x-ray picture began to be observed. Silicosis, by which is understood a type of pneumokoniosis characterized by nodular fibrosis, had already been acknowledged, and compensation

FIG. 2.—Nystagmus Patient, showing 'Tilt of the Head' (Photophobia).

(By kind permission of Dr. T. Lister Llewellyn.)

the function of the retina is maintained by the peripheral field; in other words the central part of the retina—which is composed only of cones, is associated with acute vision, and needs good light—is thrown out of action; vision is taken over by the larger, but less acute, peripheral part of the retina, composed mostly of rods which function in conditions of poor illumination. Oscillation of the eyeball arises in order that the image shall be thrown on the peripheral part of the retina. In order to avoid this change-over from central to peripheral vision, a minimum standard of light for safety lamps has been specified in the Coal Mines Regulations (Lighting) 1934.

It is essential that the desired standard of illumination should be kept up *throughout the working shift*. A hint as to the nature and cause of the 'nervous' manifestations is contained in a note on treatment, by the same Committee, which states 'The Com-

FIG. 3.—Reticulation. Man aged 39 years. 21 years underground, South Wales, haulier and collier.

schemes were drafted to meet the liability. The disease was diagnosed among men who bored in siliceous strata, such as Greys in Somerset and Penant in South Wales. Cases were, however, coming forward for examination which, although showing various degrees of disablement, did not conform to the standard required for the condition designated as silicosis owing to the absence of nodulation. This led to the—now well known—Medical Research Council's exhaustive investigation of 1936.

This investigation showed that cases of lung fibrosis occurred among colliers who had never worked in rock with boring machines. The x-ray picture of a large proportion of these men showed a fibrotic network to which the name 'reticulation' is given. The recognition of this fact led to a widening of the compensation term from silicosis to pneumokoniosis so that this form of dust fibrosis was

included as well as silicosis. In coal-miners' lungs where there is nodulation or consolidation there is mostly reticulation, but reticulation can, and in a great many cases does, exist without either nodulation or consolidation. Moreover, there is no

FIG. 4.—Collier. 36 years. Emphysema around coal nodules.

(By kind permission of Dr. Gough.)

definite evidence that reticulation must inevitably lead to nodulation or consolidation, but it would seem that it may do so particularly if the man goes on breathing harmful dust, and the more dust he breathes the more likely it is that reticulation will develop.

One of the most constant symptoms of pneumoconiosis among coal-miners is dyspnoea. Further clinical study is necessary in order to determine the exact cause of the dyspnoea. It has been noted that marked pulmonary emphysema is a common sequel to fibrosis, and Dr. J. Gough of Cardiff has demonstrated to me a fine type of emphysema in and

FIG. 5.—Collier. 39 years. Emphysema around coal nodules.

(By kind permission of Dr. Gough.)

around the 'coal nodule' which in his opinion is closely connected with dyspnoea. This condition will doubtless be described in detail by Dr. Gough when he has completed his pathological research work.

So far as present knowledge goes the incidence of the disease among colliers is confined to South Wales; it is relatively low in the bituminous mines of the south-east of the coalfield but extends progressively higher to the anthracite mines of the north-west. It is noteworthy, however, that the incidence of pneumoconiosis is very low in some anthracite mines. Another point is that, even in 'high incidence' mines, a large proportion of workers do not develop abnormal fibrosis, whilst a large proportion do not seem to go beyond the stage of reticulation.

Much attention is being directed to prevention. Various methods of dust suppression are being experimented with and the results noted and correlated. It is hoped that facilities for long-term medical research will soon be provided which will include clinical, radiological, pathological and other branches of investigation.

Inflammatory Diseases of Hand, Knee, Elbow and Wrist. The diseases popularly known as 'beats' are compensable under the Workmen's Compensation Act, 1925, and are scheduled under the following descriptions: subcutaneous cellulitis of the hand (beat hand); subcutaneous cellulitis or acute bursitis arising at or about the knee (beat knee); over the elbow (beat elbow); inflammation of the synovial lining of the wrist-joint and tendon sheaths.

Mechanization at the coal face facilitates the working of thin seams in which workmen are particularly liable to develop the 'beat' diseases, and may be one of the causes of the rising incidence of beat knee and beat hand. Furthermore, during recent years, workmen have been strongly encouraged to take care of even minute abrasions and it may be that more cases are now being reported.

Beat Hand. This condition arises when the primary injury is caused by repeated jarring of the hand by the pick followed by the entry of pathogenic organisms. The infection may enter by the most minute abrasion, cut or crack in the skin. Hard manual labour usually makes the skin of the hands tough and resistant, but if the hands have become soft by a period of off work, and especially if the pick handle is rough or thick, injury is likely to follow. Experienced miners realize this and smooth their pick handles with a knife, emery paper or even a piece of glass. The pick should not be held too tightly, especially if the coal is very hard; much care should be taken to keep the pick handle free from gritty particles; and the workman should see that it is not splintered or split. If the skin of the hand has become soft it may be toughened by the application of spirit. Cuts or cracks on the palm of the hand should receive immediate and careful first-aid attention.

Beat Knee. In this case the inflammation is due to injury and subsequent infection caused by working for long periods in a kneeling position, or moving about and pivoting on the knees whilst shovelling. The first sign of the condition may be a pimple or pustule on the part of the knee which is longest in contact with the floor, but later on the whole knee may become involved. Cases of beat knee usually occur in men who work in seams between 3 feet 6

inches and 2 feet 6 inches in thickness ; in these circumstances special care should be taken. In seams of greater thickness kneeling can often be avoided, while in thinner seams the worker is constrained to lie on his side, i.e. his body is mainly supported by the elbow, hip and leg. The danger of infection is increased if the working place is wet because the skin of the knee becomes sodden. The hardness of the floor is also important. At one mine more cases occurred where the floor was of hard fireclay than where it was a carbonaceous shale.

Protection of the knees usually takes the form of knee-pads. Four types are used: (a) pads which are strapped to the leg; (b) pads which are sewn or fitted into the trousers; (c) several folds of stocking over the knee; and (d) small mats, usually of rubber, on which the miner can kneel when necessary.

These pads need not be very thick. The essential precaution is to prevent particles lodging between the skin and the inner surface of the pad, so the pads should be thoroughly freed from particles from time to time.

First-aid treatment of small scratches or cuts, especially if there is redness, swelling or pain about the knee, is important. Boils and pimples on the knee should receive early attention at the first-aid room. They should not be squeezed. Poultices should not be applied except on a doctor's instructions because they tend to cause spread of infection.

Beat Elbow. Beat elbow, like beat knee, is an acute inflammation affecting the subcutaneous tissues and the underlying bursa. It arises through using the elbow as a support whilst 'hand holing' in a thin seam. It usually occurs in miners who work in seams thinner than those which are associated with cases of beat knee. Swelling and pain are noticed over the elbow.

Preventive measures consist in the use of elbow pads. Nothing elaborate is needed. The author has seen a simple mat made of several folds of thick material answer the purpose. As in the other 'beat' conditions, it is essential to avoid rubbing small gritty particles into the skin. With all three conditions, beat hand, knee, and elbow, work should be suspended and a doctor consulted at the earliest sign of inflammation or pain of a throbbing character.

Synovitis of the Wrist. This is brought on by over-exertion and jarring of the wrist. The onset is usually accompanied by tenderness or pain on movement, together with swelling. The symptoms may clear up after a short rest, or the case may become chronic. The use of wrist straps, which used to be common, is now rare; they might be worth trying again, especially by men who have just recovered from the complaint, and are about to resume work. Their use reduces the excursion of tendon movement. The wrist straps should be padded and well-fitting but not fastened so tightly as to interfere with the blood supply to the hand. Again, small cuts or scratches on the hands, wrists, and forearm should be attended to in order to avoid infection.

Infective Jaundice. (Spirochaetal Jaundice: Spirochaetosis Icterohaemorrhagica: Weil's Disease.) This disease is caused by the micro-organism *leptospira icterohaemorrhagiae* found in rats. It has been notifiable in Scotland since 1924, but not in England and Wales. Nevertheless it has been recognized for some years in many countries. Compensation is

now payable provided that the diagnosis is confirmed by bacteriological or serological examination. As far as the coal-mines of Great Britain are concerned cases have been reported in Scotland, North of England, and South Wales.

When investigating the disease among coal-miners, it has been noted that the presence of rats is nearly always established and the working places in the mines are wet. It has been shown, at certain mines where men who have contracted the disease have worked, that rats caught in the mines have harboured the leptospira, and in one case the organism was isolated from the jelly-like slime which clung to the timber. Moreover, the workings are usually shallow, and they nearly always communicate with the surface by a drift or level. This fact may be of importance, for not only may rats enter the mine, but they can easily leave it and go, for example, to a river, farm, or dwelling-house, and then return to the mine. Surface water, which may be contaminated, penetrates into shallow mines with comparative ease; for instance, a definite increase of water is sometimes noticeable at the time of a thaw following a heavy fall of snow. On the other hand rats are present in many mines, both shallow and wet, at which no cases of infective jaundice are known to have occurred.

Diagnosis.—Certain manifestations are usually associated with the disease, namely, fever of sudden onset, severe pain and muscular tenderness, congestion of the conjunctivae, jaundice, and haemorrhages under the skin and the mucous membranes. The disease may be fatal, or it may be so mild as to be missed owing to the absence of jaundice; in fact, blood specimens from a number of men working in the same part of a mine were found to be positive although some of the men had shown no clinical signs of the disease; the incubation period is said to average about ten days.

The diagnosis of the disease can be confirmed with some certainty by means of bacteriological or serological tests, and this confirmation is necessary to support a claim for compensation.

Transmission.—The organism may enter the body through abrasions in the skin, through the alimentary tract from contaminated food, or through the mucous membrane of the nose. One miner with whom I spoke attributed his attack to water which he had splashed up from the road in the mine into his face and mouth. As it is the general opinion that the disease is transmitted from rats to men, the first and most important preventive measure in mines is to rid them of rats. This matter is receiving attention with the collaboration of the Infestation Branch of the Ministry of Food.

Dermatitis. Dermatitis attributable to working conditions is less frequent than might be expected in an industry which is dusty and in which the workers are brought into contact with so many different objects. The factors which have been put forward as causes of dermatitis (A) and the preventive measures (B) which have been suggested are as follows:—

A	B
(a) Tinea pedis among users of pithead baths.	Thorough drying of feet after bathing. Dusting between toes with a powder, e.g. mixture of zinc oxide, boric acid and starch, swilling out of

A	B
	baths by an antiseptic solution, e.g. IZAL, excluding workers affected from use of baths.
(b) Ringworm contracted from pit ponies.	Medical treatment of both pit ponies and persons affected.
(c) Strong acid or alkali solutions among lamp room attendants.	Possibly a 'barrier' substance; careful washing in running water.
(d) Grease and oils.	do.
(e) High wet-bulb temperatures (over 75° F.).	Improvement of ventilation if sluggish.
(f) Handling of wet cement (e.g. when sinking shafts).	Thorough washing and drying of hands and arms at end of each shift.
(g) Water rich in chlorides; on floor or from roof.	Measures determined by circumstances.

As many cases become disabled through secondary infection men with any type of skin lesion or abrasion are encouraged to make early use of the surface ambulance room at mines. A large proportion of cases must be due to non-industrial causes for it cannot be expected that miners are immune from skin diseases such as scabies, eczema, impetigo, and psoriasis.

High Temperature in Mines

The effect on workers of natural high temperatures in mines is largely one of economic importance, but it must also be considered from the point of view of health. Much work has been done on high temperatures in mines, but up to the present no enforceable standards of wet- and dry-bulb temperatures or of ventilation have been recommended.

The problem of fixing legal standards is difficult because several factors are interdependent. It is agreed that the dry-bulb temperature is of less importance than the wet-bulb temperature, because it is the continuous cooling of the skin by evaporation of sweat which is of significance.

It must be recognized that there is a fundamental difference between a man and a thermometer. For a given set of conditions a thermometer always gives the same result; but man has the power to adapt himself to environment—a phenomenon known as acclimatization. In hot mines this manifests itself by control of body temperature through increase in the amount of sweat given off, so that an acclimatized miner does not show the rise of body temperature which might occur in an unacclimatized man; he sweats sufficiently to allow his skin to remain comparatively cool by evaporation, provided that an adequate air current is available.

It may be observed that where men sweat in an atmosphere of high wet-bulb temperature, and where sluggish ventilation minimises the evaporation of sweat from their bodies, there is a tendency for men to develop skin rashes and boils. This is noticeable from 75° F. wet-bulb upwards. To render conditions in a hot mine as healthy and comfortable as

possible, suitable limits of wet- and dry-bulb temperatures and rate of air current passing over the workers should still be sought. Heavy sweating and drinking large amounts of water may cause muscular fatigue and even severe cramp. Most men who are inconvenienced in this way can improve their condition by drinking less water and by adding a little salt (half a teaspoonful to a pint of water) in order to restore the normal chloride concentration. This is being done at some mines.

Mines Medical Service

It was in 1927 that the first Medical Inspector of Mines was appointed, but for some years it has been evident that a single medical officer stationed at headquarters could not be expected to cope with the many and varied problems peculiar to the coal-mining industry. The Mines Medical Service now consists of a Chief Medical Officer and Deputy Chief Medical Officer stationed at headquarters, and eight Mines Medical Officers stationed in the regions. It owes its origin to the White Paper on Coal (1942) which laid down that as part of the re-organization of the mining industry, and with a view to checking wastage of labour, there should be established a medical consultative service for the mines.

The mines medical officers have to survey the main hospital, clinic, and rehabilitation services used by coal miners, and make professional contacts with the organizations and doctors in charge—with the object of ensuring that the miners gain full value from hospitals and the Emergency Medical Service. For these purposes it is necessary for them to establish close relations with the local medical officers of the Ministry of Health. The effectiveness of this part of the work depends very largely on professional contacts and influence. A war-time addition to their duties is to act as a link between National Service Officers and Medical Referees in the case of men who apply to leave the industry on medical grounds.

It is hoped that this paper has indicated, although briefly, something of the various health hazards in this vitally important industry, and the problems with which the new medical service therefore has to deal. As time goes on its study of the preventive measures of mining industrial diseases will develop and will help to spread knowledge of special hazards and encourage the mining community to avail themselves fully of the facilities which are being provided to protect and rehabilitate the workmen. The service will thus become one of the many medical teams engaged in raising the general level of public health.