But the different species—that is, the different morphological forms of the disease organisms—far outnumber the different kinds of the defensive cells; hence the same defensive cell must be adapted to and must be able to resist the attacks of many kinds of disease organisms. Hence it becomes necessary that the individual cell should obtain new defensive powers by “use acquirement”—that is, by varying “intracellularly” in response to environmental changes as well as by “intercellular” variation. Farther, in view of the changing capacities and changing activities of the disease organisms, a moving equilibrium or equality of adaptation can only be maintained by losing vulnerability in some directions and gaining increased resisting powers in other directions on the part of the defensive cells and the disease organisms. We know that in the struggle between individual organisms adaptation has been brought about by retrogressive as well as progressive variations; in fact, in some cases the former have outnumbered the latter. It is probable, therefore, that retrogressive as well as progressive variation has occurred on both sides during the struggle between individual cells and cell parts.

It is probable, in fact, that the advantages—the increased adaptive capacities which have arisen as the result of variation amongst the disease organisms, and the increased adaptive capacities which have arisen in defensive cells as “use acquirements”—both equally owe their origin to progressive and retrogressive variations, in the one case largely in the intercellular, in the other case largely in the intracellular as well as the intercellular field.

As before indicated, the crucial difference between “innate variation” and “use acquirement,” between “inter-” and “intra-” cellular selection is this: in the former the new characters do not arise in the individual cells exposed to the change, for, these being unable to make the adaptive response, perish, but in related cells which possess the more suitable capacities, and which therefore survive.

In the latter case, although the new characters arise in more fit physiologically differentiated cell parts the discarding of the older cell parts exposed to the environmental change does not necessitate the death of the cell as a whole.

But while they differ crucially in the kind of units which vary and which are selected, both processes are essentially alike, inasmuch as both depend on variation and selection.

The old question which Lamarck and Darwin set themselves to solve in the world of species still confronts us in the world of the individual organism. They were struck by the sharply accentuated discontinuity between species on the one hand, and they were troubled by transitional forms on the other. They asked the question, How does one specific character arise out of, merge into, and give rise to another specific character? Lamarck answered the question in one way, Darwin in another.

Modern bacteriological attitude to the evolutionary process as it affects the different varieties and different capacities of defensive cells is still in the Lamarckian stage, and the problem, moreover, is rendered even more obscure and more difficult by reason of the very fact that in the case of the body cell and the disease organism we are dealing with component parts of the individual organism, which are themselves unicellular organisms, and in such organisms the continuity between cytoplasm and nucleus is much more perfect than the continuity between body cells and germ cells in the multicellular organism.

Hence in unicellular organisms, such as the defensive cells, environmental change exercises through the cytoplasm a much more direct influence on nuclear activity. Hence variation assumes a more directly adaptive character. Hence, also, the greater difficulty in distinguishing between “innate variation” and variation due to “use acquirement.” Hence the great probability that they are both a process of variation and selection—one *intercellular*, one *intracellular*—and the further probability that the one process has arisen out of the other.

But the analogy between the progress of evolutionary thought in the ontogenetic and phylogenetic field goes deeper still.

Confronted by the difficulties to be surmounted in

accounting for “spontaneous” variation—that is, in associating germ-cell variation directly with somatic-cell variation, the result of environmental change—Weismann fell back on variation and selection among the different ids and determinants which he had already assumed in the germ cells, as forming the material basis of variation and hereditary transmission—that is, he fell back on variation and selection of an intracellular kind.

In like manner Ehrlich, confronted with the difficulty of accounting for direct adaptational response in defensive cells, has assumed the existence of a complex machinery of “receptors” in the defensive cells to explain the manner in which the immunity response to disease organisms is brought about.

There is therefore some precedent for going a step further and assuming, as we have now done, as a working hypothesis, a process of variation among the physiologically differentiated parts which compose the cell itself, together with a selection of the more favourable of the variations so occurring.

The result of the foregoing examination into the conditions under which acquired immunity occurs tends to show that the process by which the defensive cells acquire new characters and new capacities of offence and defence is a process of variation and selection, partly of an intercellular and partly of an intracellular kind.

It tends to suggest, in fact, that “use acquirement” is a form of adaptation to environmental change brought about by variation and selection among intracellular units instead of among individual cells.

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THE HULTON COLLIERY EXPLOSION.

BY

W. A. HATTON, M.D. DURH.,
SURGEON TO THE COLLIERY.

HISTORY OF EVENTS.

THE explosion, lasting about a couple of seconds, produced a dull, heavy roar, distinctly heard four miles away, occurred on December 21st about 7.50 a.m., when the men had been working about an hour. I arrived about 8.20 a.m., and found the manager, Mr. A. Tonge, and the mechanical engineer and officials busily engaged in rescue work. Some colliery proprietors and Sir William Hulton, on whose land the pits are situated, were already on the scene, endeavouring to find out what was the matter, and anxious to give every assistance possible.

Drs. Blakemore and Russell, Leigh and Racker, were soon upon the scene, and we remained throughout the day attending to casualties. Medical men from all the surrounding districts were soon present and ready to render assistance.

The engine-house was prepared as an emergency station, while the Miners' Union room, lent by Mr. Roughley, was used as a temporary hospital under the charge of Dr. Mallett of Bolton Infirmary. Stretchers, splints, and surgical materials and blankets were supplied by the colliery officials. The Westhoughton district nurses, Nurses Gallimore, Jones, and Green, several nursing sisters of our ambulance division under Lady Superintendent Caldwell, together with ambulance carriages, were in attendance, so that the medical arrangements left nothing to be desired, and we were fully prepared to deal with any emergency. There were, in addition, a good number of well-trained ambulance men soon on the scene, who did good work on that and the succeeding days.

Hour after hour of anxiety was passed by the enormous crowd, uncertain as to the extent and consequences of the explosion, and doubts as to whether any would be found living became the current feeling, especially when the condition of the first casualty, brought up between 10 and 11, was seen—a youth, Gibson, aged 15. He was entirely nude, not a shred of clothing left on him. He was badly burnt all over, and thickly coated with coal dust. He was just alive, unconscious, and breathing spasmodically. There were no fractures or wounds; the hair was completely burnt off. He lived but a short time, death being due to the shock of the explosion.

He was soon followed by Fountain Byers, aged 33 who was about fifty yards from the Yard shaft (with several dead around him). He was badly burnt about the head, chest, back, body, arms, and legs, unconscious, covered with coal dust, and with a severe scalp wound on the back of the head. After attention he was removed to the Bolton Infirmary, where he died the following morning from shock due to his injuries. He was suffering from asphyxia, but with no definite symptoms of after-damp.

Following him were some dozen cases of men, more or less badly gassed, and presenting the usual symptoms—staggering gait, difficulty of breathing, dizziness, and mazziness. They had all come from the Arley Mine. Most of the cases were treated in the engine-room, where they all recovered, artificial respiration in some cases having to be performed for some time.

Richard Clayton, a head fireman, was the next important case. He had gone to an air crossing in the Arley Mine to see that the ventilation was all right; he tumbled down and was found insensible, though there were no traces of any violent disturbance due to the explosion near him. Artificial respiration and every means of recovery were resorted to, without avail. On being brought to the surface a plug of tobacco was found lodged in his throat. It would be difficult to say whether it was the cause or the effect of death. He was certainly asphyxiated, which might very likely be caused by foul and impure air, of which a good deal had penetrated the Arley workings. Another unfortunate casualty was the death of William Turton, who was bravely engaged in rescue work in the Yard Mine (where the disaster occurred). A slight fire had broken out, and he and a companion, Stott, were sent to put it out; he dropped his lamp, and getting hold of Stott's he dropped that, saying "I am done for." Rescue men went down, and did what they could for him, but he never recovered. Death was due to asphyxia.

Both of these cases might have stood a better chance had they been hurried at once to fresh air. These were the only two unfortunate incidents occurring from beginning to end, apart from the effects of the explosion. Turton's death, sad as it was, may have been the means of saving several lives, as it showed the dangers lurking round and the need for caution.

One badly gassed case from the Arley—that of G. Partington—is interesting; in his own words:

I was getting coal, when my light went out. I thought I would go and get it lit, but changed my mind, and waited for a few minutes, when I heard a great clap, and the air currents veered to and fro, and the air was thick with fog and mist and dust. Several of us went to G. Byers, a brother to Fountain (who lost his life), who was dazed and prostrate himself, and also gassed, and, as he wouldn't answer, lost their tempers with him. However, he rallied a bit, and told them to go round another way, as the fog was so thick you could cut it. Then I went mazy—my head swam—and I fell down; when I woke up I saw the doctors round me bringing me round.

Pneumonia commenced the next day; it ran the ordinary course, and terminated on the tenth day. For three days previously he was violently delirious—a condition noticed in several cases recorded by Dr. Shaw Lyttle in the Albion Colliery explosion as a result of after-damp. He made an uninterrupted recovery, except that he suffered from shock for a long time.

Another badly gassed case was that of Sharples, who was in the Arley Mine. He heard the roar, his lamp went out, and he was knocked down and remembers nothing more until he found himself in the Bolton Infirmary. There were no injuries, but symptoms of shock and asphyxia and unconsciousness. He recovered so well in the evening that he was on the point of being sent home, when he developed a severe attack of pneumonia, which ran the usual course. Davenport, the only injured man from the Yard Mine now living, had no recollection of anything—heard no roar, saw no flash. He was found partly in or near a manhole unconscious, severely burnt about the head and body, arms and left leg, his appearance as regards parts burnt exactly resembling that found on those who had lost their lives. The hair was all burnt off. He is making a good recovery, and undoubtedly owes his life to being near the manhole, where there was sufficient air to keep him going till he was found.

In addition to Clayton, Turton, and Gibson, three bodies

were brought up the first day; death in each case resulted from explosion.

Gangs of rescue men, with latest rescue apparatus and electric lamps, in batches of six, worked heroically on that day, when required, and subsequently for four to six hours, in parts reeking with after-damp and other poisonous fumes and impeded by tremendous falls of roof, and it says much for good management and carefulness that subsequently there was not a single casualty or case of injury. This reflects the greatest credit on the leadership of Mr. Alfred Tonge, who worked heroically from the going down of the first cage till all the roadways were made safe, and till nearly every body was recovered. In addition to being partly gassed once or twice, he himself had an alarming experience on December 23rd, when, after sending a rescue party up—and he was all alone in that dreadful mortuary of nearly 350 bodies—his lamp went out, and he had to stumble about in the absolute dark through blocked up and confused passages, when twenty minutes seemed like twenty years. Fortunately, he eventually reached the shaft. I may mention, to show Mr. Tonge's interest in his men, that I showed him a few weeks back Dr. Elworthy's article in the JOURNAL on miners' nystagmus,¹ and he intended following out some of the suggestions. He was ably assisted by Mr. John Bullough, Mr. Llewellyn Williams, under-managers, firemen, workmen, and by a host of neighbouring colliery owners and experts, prominent among them being Messrs. Gerrard and Harrison and Roscamp, H.M. Inspectors of Mines, who, in addition to their official duties, ably assisted in the actual work of rescue.

I was asked to organize the many willing ambulance helpers, and had no difficulty, getting teams of twenty for day and twenty for night duty for over a week, about 500 in all. Their services were not needed for the living, so they cheerfully aided in the grim and, later on, unpleasant task of bearing the bodies to the mortuary and assisting in many other ways. They all did their duty well and cheerfully, and showed the great advantage of having skilled and trained ambulance men attached to every colliery district. Our nursing members assisted day and night in the mortuary in getting bandages and disinfectants ready, and made themselves useful in several ways. The ambulance men and nurses should be sent for in any great disaster at once; they should work under the orders of a recognized and authorized medical man, and he would be responsible for the entire charge of that department, their comfort and feeding, the drawing up of a time table, and the prevention of overlapping. We had a few boy scouts, who were exceedingly useful, carrying messages to and fro. They served a very necessary part.

A good photographer should be at hand to assist in the work of identification. After the first four days or a week the features become indistinct, and later on absolutely unrecognizable, and identification is only possible by bits of clothing, clogs, and other property and articles.

Two mortuaries were available, the first for washing and laying out bodies, and the other where they awaited identification. There was a good supply of buckets of hot and cold water, sawdust, carbolic soap and disinfectants, and cloths and linen, and india-rubber gloves for all touching the bodies. Though nearly 350 bodies were carried, undressed, and washed up to the end of six weeks after the explosion, not a single case of blood poisoning or other illness occurred, notwithstanding the advanced state of decomposition in which a good many of them were.

And, lastly, I would like to add a word for the numerous bands of medical men from all the surrounding districts, leaving their own private work day after day, anxious to help their fellow-men, and placing their talents and knowledge just where they might be useful, and emulating the quiet and modest heroism of medical men in every previous colliery disaster, among whom Dr. Morris of Tylorstown, Dr. Turner of Darran, and Dr. Harris at Whitehaven are shining examples, often risking their lives in rescue work. Four among us went down into the dangerous workings on the call of duty on this occasion, and relays of medical men every twelve hours for three weeks put their names down for duty till the work was done.

A suggestion occurs to me: where so many human lives are at stake, and so many medical considerations, respecting expert treatment, pathology, and medical assistance

in tracing the cause and other considerations of the explosion, as shown by the causes of death in various groups of men, in various districts, and the position in which they are found, a medical expert from some neighbouring university would be of good assistance to H.M. Inspector of Mines and the local medical men, and should be appointed.

Statistical Summary.

Number of bodies recovered to February 16th	...	343
Causes of Death:		
Carbon monoxide	...	224
Explosion	...	53
Explosion and CO	...	63
Asphyxia	...	2
Unstated (probably explosion and CO)	...	3
Died in infirmary (shock and burns)	...	1
Bodies charred and scorched by flame	...	92
Bodies uninjured	...	312
Bodies injured by violence (including those under falls)	...	31
Bodies unidentified	...	19

DEATHS BY VIOLENCE.

Of the 343 cases, this was the cause of death in 53, or 15 per cent.; violence with evidences of carbon monoxide poisoning in 116, or 34 per cent. To those exposed to the full blast of the explosion death must have been instantaneous; they would be immediately stunned and rendered unconscious, and found where they fell. One man had died in the act of eating a meal of bread; several with hands raised as if getting coal. The blast on haulage roads was very severe, but at some of the faces the men had had a little warning and were able to proceed a short distance.

In 312 of the 343 cases there was no disfigurement. The features were peaceful and placid as if sleeping peacefully, and the limbs in repose; in no body examined was there any expression of agony or pain. In all these cases the bodies were thickly and uniformly coated all over with coal dust from head to foot, which was easily washed off, and which had probably fallen on them at the time of, and after, death, and had also penetrated the air passages, nostrils, etc. Examined in some few cases under a lens, no evidence was seen of it being coked or fused, as was noticed on the pit props and timber. From the uniform layer there was no evidence of the track of the explosion or flame. In some bodies there was a thick covering of grit and flakes of coal between the clothing and the skin. In no single instance was there any coal driven into the body. I examined a few cases to see if the drum of the ears had been damaged, but failed to find any instance.

Thirty-one bodies showed evidences of injuries, more or less extensive. There were fractures of face and jaw in 4, of the skull in 10, of the ribs and sternum in 12, of the thigh and leg in 8, of the upper limbs in 6. Limbs were torn off bodily at the joints in about 20 cases. There were several dislocations, chiefly shoulder and ankle. I did not see any sign of extensive hæmorrhage in any of these cases. One man was hit by a violently hurled missile which had severed the blood vessels of the neck, from which he had bled profusely, though probably he did not survive the force and sudden shock of the explosion. In some 10 cases the injuries were extremely severe; in 4 nearly every limb was fractured, the skull torn off, brain absent, and chest and abdomen laid open; in 1 case the liver and heart were laid upon the ribs; 1 man was blown bodily about forty yards, and then fell another 135; 3 found blown down the sump hole were youths engaged in haulage work within fifteen yards of the pit shaft.

It may be of interest to inquire how sudden shock causes death. Cases of sudden death without any mark on the body are numerous in works on forensic medicine, and are sometimes difficult to explain even on the hypothesis of violence without mark; of such we had in this instance about 22 cases. Death may occur naturally suddenly as well as slowly (F. J. Smith). Many instances are recorded of sudden death by fear alone, lightning, fear of operation, fancied snakebite (Neale), great mental emotion, or fright;² in diseases, instances are common in angina, heart and other organic disease, status lymphaticus; in poisons, as in prussic acid and cyanide poisoning, the cause probably being sudden paralysis of the nerve centres controlling brain or heart primarily. Savory suggests that "death from shock is nothing more than tem-

porary exhaustion of nerve force, the result of a violent sudden excessive expenditure of it."

The sudden impact of a huge volume of air travelling at a rapid rate would knock a man down senseless (Haldane), and when we consider the evidences of the tremendous explosive force in every direction in this disaster, the huge falls resembling hills some 200 yards in length and weighing thousands of tons, the smashing up into fragments of a huge fan weighing some four tons, and also the heavy haulage wheels, the smashed tubs, together with the extensive injuries seen in some of the bodies, it is not difficult to understand that the explosion itself, without considering the great onrush of preceding air and subsequent developing by after-damp, would kill instantly all where they stood; human beings would be like a leaf or a straw in a violent hurricane. The suddenness and completeness of this explosion in practically every part of the workings—the longest diameters of which were 1,920 × 1,750 yards, separated in the centre by the pit shaft—and its apparent simultaneousness are appalling.

BURNING.

Of the 343 bodies, 92 were burnt or scorched. This must have occurred either at the time of the explosion or immediately after it. It was very extensive and marked, but in all cases save two superficial; the flame must have been intense and of not long duration, leaving huge volumes of carbon monoxide in its wake, which, with the temporary absence of oxygen, would probably put out fire and stop any further burning. The hair was burnt to within half an inch of the scalp in all cases except two, where it was completely burnt away, and there was charring of the skull; the eyebrows, eyelashes, and the hair on backs of forearms and chest were burnt away and scorched, and in many places on the upper part of the body and upper limbs the skin was hanging off like scorched rags; the hair and skin of the lower limbs was untouched even where bare, showing unmistakably that the course of the flame was along the upper and not the lower part of the galleries. In many cases clothing round the chest and mufflers round the neck were burnt; straps round the neck, used by drawers to hang their lamps on, so as to leave their hands free for pushing their tubs, were in two cases burnt, but very rarely was the clothing on the lower limbs, trousers, drawers, stockings, or clogs burnt at all. In three cases not a stitch of clothing was left on the bodies, as in the first body brought up; this can only be accounted for as due to the extreme violence. In deaths by lightning the body is sometimes stripped of its clothing. That the clothes were not burnt away is proved by the fact that the bodies were not more charred. In one case only was the body badly and deeply burnt, one leg being burnt to a cinder. In one case only was there any evidence of burning before death—a large blister round the neck, together with some surrounding congestion, which might have been caused by a piece of burning coal or wood; neither the clothing nor moustache was burnt; there was marked evidence of CO poisoning, which must have been the cause of death.

In no instance was death due to burning, and only in one case was there any evidence that it caused suffering; in this the clothing had caught alight; the man had taken off his clogs so as to take off his trousers, which were found in a heap of ashes; his body was found about fifty yards further on.

Whether the body was burnt or not seemed to have no influence on the rate of subsequent decomposition.

CASES OF CARBON MONOXIDE POISONING.

Carbon monoxide poisoning accounted for 287 deaths, or 81 per cent. In 224 cases CO alone had caused death; those with signs of explosive force also numbered 63; this tallies with the latest estimates that CO accounts for 80 to 90 per cent. of all deaths in the majority of colliery explosions. Probably to the 287 cases may be added a few more, for CO was probably the cause of death in those unstated, and several of the bodies brought up early showing signs of violence.

After Dr. Haldane's complete and classical report on the Tylorstown explosion, 1896, unfortunately now out of print, containing an exhaustive analysis repeatedly confirmed by all subsequent observers, there is nothing to be added to the description of CO poisoning. We had here

343 deaths, a larger number than in any previous colliery explosion since that at Barnsley in 1866, yet nothing can be added to the description of the *post-mortem* signs. The dark carmine-red tinge could be found everywhere when looked for; at the first glance it was most noticeable on the cheeks and down the lower limbs; on more careful examination it was seen on the tongue, lips, and mucous membranes everywhere, owing to the thinness of the skin; where the epidermis had peeled off, as in the palms, or the nails of hands or feet had got loosened from heat or decomposition, the bright redness was very marked. It was just as noticeable in bodies brought up at the end of eight weeks as in the first week; it would be interesting to know how long it would be evident—probably till the blood cells became absolutely disintegrated.

The dry and yellow parchment-like skin on legs and arms was very noticeable, and in most cases decomposition was markedly delayed. The last body brought up on February 14th—just eight weeks after the explosion—was in a good state of preservation, not at all decomposed, and the evidence of CO poisoning perfectly plain.

All bodies were of the same uniform tint and were evidently saturated with CO; in many cases the dull red colour could be discerned beneath the coating of grime and before the bodies were washed. We had no opportunity of testing any treatment for CO poisoning, as not one man lived, but in his paper on the Darran explosion, 1909, Dr. Llewellyn has ably summed up the treatment for this condition.⁸ To one point that he and other observers emphasize our experience also directs attention, and that is, all "gassed" cases must be brought to fresh air at once; no attempt at artificial respiration is of any use in vitiated or poisoned air, or any air not absolutely fresh, even if non-poisonous. It is just possible that Clayton and Turton might have been brought round had they been brought out to fresh air at once. Another essential point is to keep the patient as warm as possible. "Several cases collapsed more than once after coming round, and were quickly revived by warmth."

Poisoning by CO is a very merciful death; there is no pain or distress; the person simply feels tired and sits down. Dr. Turner, the medical hero of the Darran disaster, who was decorated by the late King for his noble rescue work, "had no symptoms until he exerted himself in trying to rouse his companions, he then felt tired, wanted to lie down, falling down several times, and finally losing consciousness."

An interesting point is that though it forms so stable a combination with haemoglobin, blood may be freed of its CO both by oxygen and also by fresh air; artificial respiration should therefore always be well and persistently tried whenever there is any chance of success. Of the various methods, Schäfer's is probably the best. I noticed that in four cases that died from carbon monoxide poisoning, and in which the intestines were exposed, they did not present the usual and easily discerned carmine-red, probably for the reason just mentioned.

In none of our cases was there evidence of carbon dioxide or other asphyxiating gases producing cyanosis and congestion.

It is interesting to note that though of the 343 victims a great many probably died instantly by the tremendous explosive force, immediately followed by huge volumes of after-damp, there are evidences that a great many were not killed instantly, though probably none of them lived more than ten to twenty minutes. In their cases there were no signs of suffering beyond the mental anxiety, no marks of abrasions or injury by hurry or panic, no handkerchiefs over mouths. For some cause or other the explosion did not kill them, but they would certainly hear the report, their lights would be put out, and they would proceed in the darkness with great difficulty towards the pit shaft, when the oncoming after-damp overtook them. They were all found to have been killed by carbon monoxide, few were injured, though one of them was badly scorched. Roberts was found killed by CO, with his clothes in his hand, endeavouring to escape. One other case also had walked a short distance—the man already recorded, who had shed his burning clothing. Of all who had gone down the Yard Mine that ill-fated morning only Staveley and Davenport are alive.

THE RESCUE WORK.

Several members of the Committee of the Howe Bridge Rescue Station were quickly on the spot, and Mr. Arthur Ellis, the secretary, at once took over the organization of the rescue work, and arranged the sequence of the descent of the teams. Everything went off without a hitch. There were no casualties among the many hundreds of

rescue men, although they were continually plunging into danger, and their work was most arduous owing to the numerous falls and tremendous damage everywhere.

The apparatus used was the Fleuss, the design of which has been much improved by the Howe Bridge Committee, with the assistance of Sergeant-Major Hill and the makers. Dr. Arnold Greene, Medical

Fig. 1.—The Modified Fleuss, as used. (By courtesy of Sergeant-Major Hill.)

Officer of the Rescue Station, writes to me as follows:

Every man trained has to pass through my hands as being medically sound. I pay special attention to certain points which in my opinion are essential to oxygen breathing and the apparatus.

As regards the accident itself, we had some 150 local rescue men at work, and during the whole time I was there I never had an accident of any sort brought to my notice as regards the rescue men. All the men I examined, both at the time of the disaster and subsequently, showed no signs of the hard work they had undergone, not only as regards the oxygen breathing, but as regards their physical condition. It was a severe test for oxygen breathing, but everything came out all right, and only proves that oxygen breathing in the way we use it does no harm to the men.

Mr. Gerrard, in his evidence, said that he desired to remark how well owners, managers, and officials of the mines, and workmen came forward and offered and gave their services night after night, and day after day, without hope of reward. He could not call to mind such a rapid recovery of a mine. In one day 123 bodies were brought out, and in five days 270. The men worked splendidly. They had to carry rapidly decomposing bodies under their noses, pushing them and hauling them over falls, "and sometimes they were their brothers." He continued as follows:

Next I must allude to the work done by rescue teams—the men with the breathing apparatus. We have one of the finest stations in the country established at Howe Bridge by the coal-owners of Lancashire and Cheshire, and we have got one of the finest men that could possibly be obtained as instructor in charge of that station, and he, Sergeant-Major Hill, arrived at this mine at 9.10 a.m. Immediately he was followed by Mr. C. Fletcher, one of the owners of Fletcher and Burrows, himself a trained and qualified user of the apparatus, and by others. By 11 a.m. there were forty men on the spot ready to do anything in the way of rescue work with their apparatus, and during the day eighty altogether arrived. It should be noted that they came from Burnley, Accrington, Rishton, St. Helens, Leigh, and Bickershaw, and distant places, and they were here day after

Fig. 2.

day and night after night, with an established rota, waiting their turn to go into the mine.

Mr. Gerrard gave instances of their admirable and courageous work. On one occasion they went 100 yards in foul air, and they recovered a body 40 yards in the deadly fumes. Poor Eccleston's body lay day after day, 36 yards in gas, and it was fetched out of the place by the men with the breathing apparatus.

To recover the bodies lying in after-damp a small apparatus called the "Salvator" (on the same lines as the Fleuss) was used. It consists of a breathing bag and a small cylinder of oxygen; it weighs about 7 lb., and lasts a man travelling at a moderate speed about two hours; it is also extremely useful in reviving anybody gassed.

CONCLUSION.

After thirteen days' patient hearing of about a dozen expert witnesses, the jury brought in the verdict "that the explosion was caused by an accidental ignition of gas and coal dust, probably from a defective or overheated lamp." The views of the experts were varied, and hardly any two agreed.

Professor Galloway suggested that it originated at No. 1 jig, North Plodder, from an electric sparking.

Mr. Alfred Henshaw: That it started above the jig wheel in No. 1 jig from a defective lamp, one being found with a broken ring, leaving a space below the glass.

Mr. A. H. Lush: At the top of No. 2 jig, North Plodder district, where there were evidences of great force, and all the men were found dead at their places and burnt.

Mr. Jesse Wallwork: No. 2 jig, North Plodder, owing to a damaged lamp igniting gas, the explosion traversing all the workings by means of coal dust.

Dr. Thornton (Newcastle) thought it highly probable that it started at the conveyor switch.

Sir Henry Hall, after a very careful examination: That it originated from gas in the Three-quarter Seam.

Mr. Gerrard (H.M. Inspector) and Dr. Cadman expressed the opinion that it originated from the burnt lamp found in the North Plodder, No. 1 jig (86). It showed signs of overheating, and the meshes of the gauge had very fine coal dust; it was near the conveyor face, where there would be a good deal of inflammable coal dust, together with some gas. Evidently the jury accepted this as the most probable explanation.

It is of importance, in an endeavour to trace the cause of the disaster, to know which bodies had been subjected to flame and, if possible, the cause of it. The mine (see plan) is divided into five districts—the North Plodder, South Plodder, Three-quarters, Top Yard, Downbrow Yard; the last had a subdivision—the East Jig. Of the 345 persons who descended the mine on December 21st only two now survive; one (Davenport) was found in a recess or manhole by the side of the Downbrow, leading to the Downbrow Yard, near body 190. The other (Staveley) was found in a pump-room place near No. 4 Shaft, but, strange to relate, his companion lost his life by CO, owing to his being slightly in advance of Staveley, the CO clearing off quickly, by proximity to the shaft.

Those in the Three-quarters, the Top Yard, the Downbrow Yard, and the subsidiary district, the East Jig, were in great part subject to CO; those in the South Plodder were largely killed by CO, a few having received burns and violence. In the North Plodder the greater number had received burns and were subjected to violence, although a number died from CO. Around the shafts all had died from violence, and were burnt. In the North Plodder at the No. 1 conveyor face near the conveyor, three bodies (87, 88, 89) were found, where they had been working, on the east side; whilst on the west side bodies were found apparently fleeing from the conveyor. These facts led to the supposition advanced by some that the origin of the disaster was at or near the mechanical conveyor on the No. 1 North Plodder face.

It was in the Downbrow Yard district that the men were found to have walked the greatest distances from their working places. From the northern side of this district thirty persons (192 to 221) had travelled 260 yards, and to within 300 yards of the shaft; these were found in a group, some in a sitting, some in a lying position, some had got inside wagons which had been blown on to their side or upended. In appearance all these were as if they had fallen asleep; they had travelled without light to this point, where the foul after-damp prevented their going further; possibly they were waiting for the atmosphere to clear when they succumbed to CO. Other groups were found in similar poses, not having been able to travel so far (222 to 239). At two or three other places in this district—notably in Nos. 2 and 3 jigs—were similar

groups, having travelled some distance from their working places. Also in the Top Yard district were found several groups, having travelled some distance.

In the East Jig subdistrict—to a less extent, perhaps—the men had warning, and were able to leave their working places. In these districts it was unanimously agreed that the explosive force and the burning coal-dust had travelled inbye along the haulage roads. In the Three-quarters district also almost all the men had left their working places and were found in the roadways.

REFERENCES.

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TWO CASES OF SEVERE INJURY NEAR THE KNEE.

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I.—Hospital Gangrene: Condition Twenty Years After.

A MAN, aged 33, was injured on April 17th, 1890, by the fall of a large iron plate, extensively wounding his left thigh above the front of the knee. He was brought to the Liverpool Royal Infirmary, and was attended to by the house-surgeon, who put in stitches and dressed the wound.

The temperature rose on the second and third days to nearly 102°, and on the fourth to close upon 104°; by this time the skin around the wound had become deep red, and the region swollen and painful. Under an anaesthetic the stitches were removed by Mr. Parker, the wound explored, found largely to involve the knee-joint and extensor muscle, and to be bathed with foul dark-brown purulent discharge. After hot antiseptic washing and removal of pieces of lacerated muscle, the wound was lightly packed with cyanide gauze. The patient felt better after this, but the temperature reached 102° in the afternoon, falling at night and early morning to 100° or less; the pulse was about 90 for some days, during which chloroform was inhaled at each change of dressings.

On May 7th, the twenty-first day, the wound was found covered with a greyish-yellow exudation, and its margins much raised and thickened. This was judged to be the almost obsolete condition known as "hospital gangrene." Nitric acid was then freely applied, under chloroform, to these morbid surfaces. Three days later, the tissues having in the main become more healthy, but still showing patches of the greyish exudation, Mr. E. R. Bickersteth was consulted as to the diagnosis of hospital gangrene, which he fully confirmed, from experience dating from the days when this scourge was rife. At his suggestion the thermo-cautery was freely applied to the exudation that had re-formed. Obvious improvement followed the cautery, and each application of the nitric acid, which was preferred on all other occasions; the wound in most parts assumed a healthier look; but as the knee obviously needed a good fixing apparatus, the anaesthetic was again given, and the whole limb thoroughly steadied in a Thomas's knee splint. About the twenty-eighth day nitric acid was again applied, under chloroform, to recurrent patches, and some four days later all signs of hospital gangrene were gone, and the temperature had become normal.

About the thirty-fifth day great pain was felt below the knee on the outer side, attended with loss of sleep. On the fortieth day an incision was made and 1½ oz. of sweet green pus evacuated. The bleeding in the skin was stopped by acupressure with common pins. After this the patient became more comfortable and slept, but a few days later he had a return of pain, with burning, in the knee, this time on the inner side, followed by increased discharge from the incision on the outer side, with consequent relief.

Although great local improvement had occurred, these drawbacks were a great tax upon him, as he was greatly emaciated and short of resisting power. The outlook became so serious that, to save his life, amputation appeared inevitable, and with the consent of himself and parents it was arranged for a couple of days later. On the intervening day, however, things looked better, and this procedure was abandoned.