REPORT

OF THE

Miners'

PHTHISIS COMMISSION.

1902=1903.

With Minutes of Proceedings and Minutes of Evidence.

PRETORIA:

PRINTED AT THE GOVERNMENT PRINTING AND STATIONERY OFFICE.

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Mr. E. Perrow.

Mr. J. R. Williams.

Dr. C. Porter.

Mr. J. Stratford, *Secretary.*

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REPORT

OF THE

Commission Appointed to Enquire into and Report on the Disease commonly known as MINERS' PHTHISIS.

TO HIS EXCELLENCY THE RIGHT HONOURABLE ALFRED, VISCOUNT MILNER, *of St. James's, in the County of London, and of Cape Town, in the Colony of the Cape of Good Hope, in the Peerage of the United Kingdom, a Member of His Majesty's Most Honourable Privy Council, Knight Grand Cross of the Most Honourable Order of the Bath, Knight Grand Cross of the Most Distinguished Order of Saint Michael and Saint George, Governor of the Transvaal, and His Majesty's High Commissioner for South Africa.*

MAY IT PLEASE YOUR EXCELLENCY,

1. The Commission was appointed by your Excellency's Commission, dated December 19th, 1902, public notification whereof was given by Government Notice No. 579 of 1902, which was published in the *Government Gazette* on November 7th, 1902. By Government Notice No. 619 of 1902, the powers, jurisdiction and privileges conferred on the Commission known as the "Insanitary Area Commission" were likewise conferred upon your Commissioners.

2. On the 19th December, 1902, your Excellency was pleased to appoint Dr. Charles Porter, Medical Officer of Health to the Municipality of Johannesburg, as an additional member of the Commission.

3. The terms of reference were as follows :—

(*a*) To enquire into the extent to which Miners' Phthisis prevails.

(*b*) To ascertain the cause of the disease.

(*c*) To make recommendations as to the preventive and curative measures which should be adopted either by legislation or otherwise.

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4. The first meeting was held on December 4th, 1902, at which the procedure to be adopted was settled. At all subsequent meetings, extending to March 25th, 1903, evidence was heard in public, and your Commissioners have endeavoured to obtain all information possible on the matters referred to them.

The evidence which has been taken has been partly oral and partly in the form of written statements submitted in person by the witnesses tendering them.

5. In addition to the evidence taken at the meetings of the Commission, it was decided to send forms to each mine manager of the Witwatersrand to be filled in by the medical officer attached to the mine, the latter being requested to medically examine the miners and to report upon the presence or otherwise of the disease in each individual case.

In pursuance of this resolution, over 200 mines were circularised, and your Commissioners consider it a grave matter for regret that out of the 71 which might reasonably have been expected to comply with the request, completed returns from only 45 were received. Moreover, in the case of those mines which sent in returns, owing to the reluctance of the miners to submit to medical examination, the number of miners in these returns is far below the number actually employed.

Your Commissioners therefore consider that although the information thus obtained is in many ways most valuable, in so far as it establishes a percentage of sufferers, the figures do not cover sufficient ground to be regarded as reliable or as accurately representing the facts.

6. In addition to the work already referred to, your Commissioners caused numerous experiments to be carried out with a view to determining the quantity, quality, and character of the dust suspended in the atmosphere in the mines and the best methods of allaying the same. They further arranged for samples of air and of gases given off during blasting operations from different parts of mine workings, taken under varying conditions, to be analysed for the purpose of enabling them to determine their composition.

The carrying out of these experiments and analyses has unfortunately had the effect of delaying this report, but the results obtained have proved to be of the greatest importance and have considerably influenced your Commissioners in arriving at their present conclusions.

7. On the 6th March a notice was published in the *Government Gazette* informing the public that, the evidence tendered having been exhausted, the Commission was about to conclude its sittings, and that all persons desirous of giving evidence were to send in their names to the Secretary on or before Wednesday, March 18th. A similar notice was inserted in the local papers.

The final sitting of the Commission at which evidence was taken in public was held on Friday, March 27th.

PART I.

EXTENT TO WHICH MINERS' PHTHISIS PREVAILS.

8. From the evidence laid before the Commissioners as to the extent to which Miners' Phthisis prevails in the Transvaal it would appear that the disease is largely confined to miners who have worked for some time in metalliferous mines and is chiefly noticeable among the rock drill miners of the Witwatersrand gold mines.

Although the incidence of the disease appears to be more marked in miners who have been working rock drills for some years, yet it is also found to prevail amongst miners who have never worked them; indeed, in districts in England where families have for many generations been engaged in metalliferous mining, the disease under various names, such as "Miners' Lung," "Miners' Complaint," and "Miners' Rot," is fully recognised, and has been known to exist long before rock drills were employed in mines.

9. The collection of reliable data as to the prevalence of the disease has been a matter that presented the greatest difficulty to us, and this has not been decreased by the fact that the disease as existing in the Transvaal has not been the subject of special attention, nor have the clinical and pathological conditions been clearly defined until quite recently. The information gathered, therefore, in this respect is naturally somewhat inexact, but, in our opinion, is sufficiently reliable to indicate that the disease prevails to a very great extent, and that a high mortality is due to it. It was decided that in addition to any evidence that witnesses might tender it would be advisable to cause an examination to be made of as many miners as possible who were working at that time in the mines within the Witwatersrand area, with a view to obtaining some indication as to the number suffering from the complaint.

10. The Statistical Report (see Appendix A) shows that out of 4,403 miners officially declared to be working underground in the gold mines of the Witwatersrand, 1,210 have been medically examined on behalf of the Commission. Of this number, 187 or 15·4 per cent. were certified by the examining doctors to be affected by the disease, while a further 88 were suspected cases. A factor which is to be taken into consideration is the difficulty in making a diagnosis in cases which present no distinctive features, so that the above percentage cannot be considered as absolutely reliable, in so far as those examined may not be representative of the whole body of miners. Viewed as a whole, however, the number of miners known to be, and believed to be, suffering from the illness under investigation is sufficiently large to confirm the impression already made that the

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extent to which Miners' Phthisis prevails at the present time is so great that preventive measures are an urgent necessity, and that such a large number of sufferers in our midst is a matter of keen regret, especially when it is found that their average age is only 35·5 years.

Concerning the 187 men who were certified as being affected, the following points are of sufficient importance to require separate comments :—

(*a*) Only 20 men give any family history which shows that they have a tendency to develop pulmonary disease.

(*b*) The figures in the Statistical Table somewhat confirm the statements that have been made—that amongst rock drill miners the disease is especially prevalent—as 172 or 91·98 per cent have been employed on rock drills. In addition, two other important points are brought forward prominently : 1st, the short average time, namely, 6·49 years, that the men have been employed on these machines ; and 2nd, a considerable section of the group have been exposed to risks of contracting silicosis in other countries where the work of rock drilling has been carried on under more or less similar conditions. Therefore, it is not only in the Transvaal that this disease prevails, for, out of the 187 men referred to, it has been ascertained that 169 have been employed in this country for an average of 4·89 years, whereas 61 men have worked for an average of 4·76 years on rock drills in countries outside the Transvaal.

Of the 172 men affected and who had been employed on rock drills :—

10	had been so employed for		1 year and under.			
16	do.	do.	over 1 year and up to		2	years.
18	do.	do.	2	do.	3	do.
17	do.	do.	3	do.	4	do.
21	do.	do.	4	do.	5	do.
13	do.	do.	5	do.	6	do.
17	do.	do.	6	do.	7	do.
14	do.	do.	7	do.	8	do.
11	do.	do.	8	do.	9	do.
11	do.	do.	9	do.	10	do.
24	do.	do.	over 10 years.			

As already observed, the Statistics do not deal with a large enough number of cases to warrant exact conclusions being arrived at, but they amply bear out the very valuable evidence

contained in the Report of the Transvaal Medical Society, and also that given by Drs. Irvine, Macauley, Frazer, and others, on this point. Report.

The statement made by Dr. Irvine that out of 93 males who died from chest diseases at the Johannesburg Hospital over 50 per cent. were miners is full of significance.

11. The report of the special committee of the Transvaal Medical Society was accepted by the Commission and has been incorporated in the Minutes, and the members of this Commission desire to express their thanks to the Society for having so kindly placed the results of their research at the disposal of the Commission. It may be noticed that practically no evidence has been brought forward which in any way traverses the views expressed in the said report.

12. The evidence brought forward by medical witnesses as to the difficulty, and, frequently, the impossibility of diagnosing the disease in its early stages is striking. The fact that so many sufferers only begin to notice any symptoms when the disease is quite in its late stage, and the patient almost incapacitated, prevents many of those already affected suspecting the presence of the disease during its commencement, when they might remove themselves from a dusty atmosphere and probably prolong existence considerably. Another point that should not be overlooked is that this disease, once extensively developed, gradually but surely destroys life, and no remedial measures apparently exercise any curative effect on the process. Early Stages of the Disease.

13. Medical evidence has not disclosed the existence of an appreciable amount of tuberculous disease amongst miners, and the emphatic statements that have been made dispose of any impressions that may have existed that miners frequently come to this country to restore health previously undermined by lung disease. Tuberculosis.

It is perfectly clear, however, that many miners working on the Rand have in past years been exposed to the possibility of contracting silicosis in other metalliferous mines in other countries, and probably a certain number were already affected on arrival in the Transvaal.

14. On September 6th, 1902, a letter was published in the medical journals asking doctors in England to forward to the Medical Officer of Health, Transvaal, notes of cases of Miners' Phthisis amongst those who had previously worked in this country. This letter was published for two reasons: first, because many statements had been made in the medical press that a large number of miners returning from Johannesburg were dying in England; and, secondly, because information on the subject would be useful when the Commission commenced enquiries. The response to this request was disappointing, only notes of three cases being received.

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Causes of the Disease.

15. As there is nothing in the physical work performed by miners which appears in any way to cause or predispose them to the disease, we must infer that it is caused or induced by something in the conditions under which they work.

We have, therefore, directed special attention to an investigation of:—

I.—Character and harmful properties of the inorganic particles held in suspension in the mine atmosphere.

II.—Mine ventilation.

(*a*) Composition and quantity of the air circulating throughout the working places in the mines.

(*b*) Composition of the gases given off during blasting operations under varying conditions.

III.—Mine sanitation.

General sanitary conditions of the mine workings.

IV.—Living conditions of the miners.

The facilities at the disposal of the miners with regard to the provision of suitable change houses in which they may change and dry their working clothes.

CHARACTER AND HARMFUL PROPERTIES OF THE INORGANIC PARTICLES HELD IN SUSPENSION IN THE MINE ATMOSPHERE.

Dust.

16. The fact that mining operations, such as blasting, drilling, shovelling, etc.—especially in dry mines such as the gold mines of the Witwatersrand—produce large quantities of dust, places the calling of the miner under the category of "dusty trades," and there is abundant evidence to show that the disease which we are investigating is in fact a silicosis produced by the inhalation of minute particles of inorganic matter with which the mine atmosphere is charged.

17. Miners' Phthisis must therefore be classed amongst those diseases produced by the inhalation of dust, and which are peculiar to certain trades, such as stone-quarriers, ganister miners, potters, etc.

"Raising."

18. The disease, although by no means confined to rock drill miners, is undoubtedly more prevalent amongst that class of underground workers than any other. The evidence gathered tends to show that, of the different classes of work carried on by the rock drill miners, "raising" is the most dangerous. That this should be the case is natural, since the holes bored by the rock drill machines when "raising" have an upward inclination, and on this account it has not been customary to inject water into them as is done when boring "wet holes," the latter being either horizontal or having a downward inclination.

19. The dust from these "dry holes" pours down whilst boring is proceeding, completely covering the miner, and the exhaust air forcibly expelled from the drill sets up currents of air in the confined working place, thus helping to keep the dust in suspension.

20. The same remarks apply to "drives," with this important exception, however, that whereas in a raise all the holes are "dry holes," in a drive only two out of the fifteen or sixteen that are required to complete the round are bored dry.

21. In stopes, as a rule, "wet holes" only are drilled; the working places, moreover, are usually of a more open nature and better ventilated. It is evident, therefore, that the total quantity of dust caused by drilling operations during a shift is very much greater in a raise on account of the greater number of dry holes drilled than in a stope or in a drive.

22. Analyses of two samples of mine air taken close to the rock drill machine whilst boring a dry hole show that there were 0·185 grain and 0·0839 grain respectively in a cubic foot of air, and the analysis of a sample of air taken in a raise under similar circumstances gave as a result 0·072 grain per cubic foot; whereas a sample of air taken at the same distance as the second sample just referred to from a rock drill machine boring a dry hole in a stope contained only one-sixth of this amount of dust per cubic foot of air.

23. It may therefore be fairly assumed that the quantity of dust discharged into the air during the time that dry holes are being drilled, under similar conditions, does not vary greatly, but the proportion of dust held in suspension in the atmosphere depends to a very considerable extent on the nature of the place —whether open or confined —where the drill is working.

24. It may be mentioned that the apparatus containing the filter in which the dust was collected was either inverted or placed in a horizontal position in order to avoid the inclusion of any of the coarser particles of dust that might be in the act of falling, and which on that account it may be assumed would not be so liable to be inhaled by the miner.

25. According to Halliburton (1896) the daily quantity of air respired per man varies from 400,000 to 680,000 cubic inches, and this amount is largely increased by exertion. Taking an average of 540,000 cubic inches, and multiplying by 4-3rds as a factor for exercise and by 6-5ths as a factor for the diminished pressure (25 inches instead of 30 inches), we get about 21 cubic feet per hour as a conservative estimate of the quantity of air breathed by a miner.

26. If the fine dust in the air breathed by a miner amounts to 0·1136 grain per cubic foot (the average of the three analyses just referred to), we find that he would be inhaling 2·38 grains per hour.

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Origin of Dust.

27. The origin of the dust is chiefly due to blasting and drilling operations and to breaking rock by hand, whilst the shovelling and handling tend to agitate the dust and keep it in suspension. It is therefore to be expected, and analyses have shown, that the mine atmosphere throughout the workings is pregnant with microscopic particles of exceedingly sharp silicious dust.

Respirators.

28. It is acknowledged that miners as a whole are averse to the use of respirators, chiefly perhaps on account of the discomfort attending their use, and also because a certain extra effort is necessary to inhale through the filtering material when working hard, and that the wearer, moreover, is unable to speak in a manner to be understood, or to smoke, when using them.

29. While we do not agree with the statement that legislation with regard to this matter is desirable, yet we are of opinion that, in the working places in the mines where water is not available for allaying the dust suspended in the atmosphere, the use of an efficient respirator is advisable, and should be strongly encouraged by those responsible for the management of the mines and for the safety and health of the miners.

30. Unfortunately, the Commission is not in a position to entirely recommend without reservation any of the respirators that have come under its notice as being an effective safeguard against the inhalation of dust.

The majority of respirators are not made so that they can be adapted to fit sufficiently closely to the face of the wearer, and an even more prevalent defect is noticed with regard to the outlet valve through which the respired air is supposed to escape, but which, in almost all cases, admits air and dust during inspiration.

31. The Commission is of opinion that the respirator forwarded to them and referred to as sample "A" in the covering letter is of use in minimising the quantity of dust inhaled.

This respirator was reported upon by Mr. Fisher, Inspector of Mines for Johannesburg district, and he has pointed out that it has this advantage—that the wearer can bend it into the necessary shape to fit the face. The edges are lined with india-rubber, which enables the respirator to fit sufficiently closely to the face to prevent the entrance of dust.

Unfortunately, in the act of bending the respirator in the manner just described, the valve seat often becomes distorted and does not act efficiently.

32. The respirator referred to in covering letter as sample "B" is also used by the miners and is alluded to in Mr. Fisher's evidence. The miners usually replace the mica outlet valve by a small piece of wet sponge, owing to the former permitting the dust to pass through. This is, in our opinion, a grave defect, since it does not allow the free escape of carbonic acid gas and moisture contained in the expired air.

MINE VENTILATION.

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(A) COMPOSITION AND QUANTITY OF THE AIR CIRCULATING THROUGHOUT THE WORKING PLACES IN THE MINES.

33. The fresh air required to ventilate the mine is obtained mainly by natural means. The supply, therefore, is not under control, but is liable to vary to a considerable extent according to the atmospheric conditions on the surface.

Mr. Wilkinson in his evidence pointed out that the ventilation of mines which are dependent upon natural causes for their supply of fresh air—*i.e.*, where the current of air circulating in the mine workings is produced solely by difference in the pressure of air due to atmospheric conditions—varies greatly and at times becomes exceedingly bad.

It is important, therefore, more especially in mines where the workings are situated at a considerable depth from the surface and where the miners will probably have to remain underground during the whole shift, that the ventilation of mines should be more under control than has hitherto been the case.

Aids to Ventilation.

34. We may here state that in some of the mines visited by us we noticed that the natural ventilation was aided by having the drill sharpeners' furnaces placed at the bottom of the up-cast shafts; also by having one or more of the compartments of the latter built up for some distance above the surface. These arrangements appear to have a beneficial effect upon the ventilation, and are evidence of the interest taken in the matter by the management of the mines in question.

Number of Shafts per Mine.

35. In view of the statement made by one of the witnesses to the effect that the majority of mines were only provided with one shaft, we caused enquiries to be made through the Inspectors of Mines as to the number of producing mines on the Witwatersrand that are not provided with more than one shaft on their property by which they are ventilated.

In reply we were informed that out of the 54 producing mines in the area in question there is only one that is fitted with a single shaft. Moreover, this mine has but a small claim area and its workings are connected with those of the adjacent mines.

36. The weight of evidence supports the fact that although the air circulating in many of the mines taken as a whole may be considered as reasonably pure, yet in the mines in the Witwatersrand area the atmosphere in the ends of the majority of drives, rises and winzes, is very harmful, owing to its contamination with an excess of noxious gases due to blasting and to the exhalations from the lungs and bodies of the miners.

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Exhaust Air from Rock Drills.

37. The air given off from the exhaust of the rock drills is certainly of benefit to the persons employed in their immediate vicinity, and since these are generally employed on development work at the ends of drives and rises, the fresh air derived from this source is especially useful. The improvement in the mine atmosphere caused by the exhaust air of the machine drills appears, however, to be very local, and does not appreciably improve the condition of the atmosphere in the drives at some distance back from where the drill is working. This is especially noticeable in cross-cuts and drives advanced in "dead ground" where the reef is not of sufficient value to pay for working, the ends of such cross-cuts or drives being often situated at a considerable distance from any place where a free current of air is maintained.

It would appear that too much reliance has been placed upon the ventilating properties of the machine drills, and that as a consequence insufficient attention has, in many mines, been given to the splitting up and directing of the fresh air coming into the mines through the shaft, thus producing an unhealthy condition of the atmosphere in the extremities of such mines.

Systematic Ventilation.

38. We are of opinion that systematic ventilation should be introduced, so that fresh air may be caused to enter each mine in sufficient quantity to sweep through the drives (to within a reasonable distance from their ends), and thus dilute and carry away up to the surface the injurious gases and particles of organic and inorganic matter that may be held in suspension in the air.

Lubricants used in Compressor Air Cylinders.

39. The composition of compressor air as shown by analyses has revealed the very great danger that attends the use of inferior oils (or oils of low flash point) for lubricating the air cylinders of the compressor engine. The analyses of compressor air (see paragraph 47) show that in some of the samples carbonic oxide gas was present in sufficient quantity to be extremely dangerous to health. We are of opinion that lubricants used for the purpose mentioned should be of such a nature that they are incapable of being decomposed or of giving off injurious products under the conditions that they are subjected to in the air cylinder of the compressor.

We may mention that in connection with this matter it is the practice on some of the mines to use a solution of soft soap in lieu of oil, and we are informed that the use of such a solution is more economical than if oil were used, and cylinders and valves are maintained in an equally efficient state.

No Previous Record of Mine Air Analysis.

40. It is well known, and Mr. Rathbone, Inspector of Mines to the late Government, has assured us, that under the late Administration no tests were carried out as to the quality of the air circulating through the mine workings. This apparent negligence has, we are informed, been remedied, inasmuch as the Government Inspectors under the present Administration take

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systematic measurements of the volumes of air passing into the mines. It appears to us unfortunate that up to the present no Government laboratory has been established where mine managers and also inspectors of mines could have quantitative analyses made of samples of air taken from working places in the mines, and we strongly urge the necessity of such a laboratory being established, especially in view of the fact that the use of delicate chemical apparatus is required in the estimation of the proportion of carbonic oxide in the atmosphere.

Carbonic Acid Gas.

41. In testing the purity of air in the factories and mines of Great Britain we understand that it is usual to take the proportion of carbonic acid gas present in the atmosphere as an index as to the proportional amount of other impurities that may be present. This method has probably been adopted owing to the fact that the carbonic acid gas is, in itself, the chief impurity found in these places.

In the mines in the Witwatersrand, however, we have very different conditions to those obtaining at home, inasmuch as it is well known that there is a much larger quantity of explosives consumed in these mines per man employed underground than is the case in England—*vide* evidence given by Mr. Wilkinson, who calculates that during the six months ending June, 1902, there was on an average over 0·75 lb. of nitro-glycerine explosives used per shift per each underground employee.

Further, the composition of the mine air, as shown by analyses and referred to later in our Report, varies so greatly in regard to the relative proportion of carbonic oxide and carbonic acid gas that we are of opinion that the latter gas alone cannot be accepted as a reliable indicator as to whether the amount of poisonous gases is sufficient in quantity to be injurious to the health of the workmen.

42. Though it is evident that it is very necessary that earnest attention should be given towards the attainment of good ventilation throughout the mines, and more especially in those portions where development work is being carried on, yet we are of opinion that the present provisions contained in the law regarding the ventilation of the mines are sufficient if carried out.

(B) COMPOSITION OF THE GASES GIVEN OFF DURING BLASTING OPERATIONS UNDER VARYING CONDITIONS.

43. In nearly all instances the witnesses have stated as their opinion that the cause of the disease is due to dust and gases inhaled by the miner when underground.

44. Though expert medical evidence has clearly pointed to the fact that the disease known as Miners' Phthisis and Silicosis are identical, and due to the action of minute particles

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of inorganic matter on the lung, yet we consider that, in view of the fact that the deleterious gases might act as a predisposing cause or tend to accelerate the disease, it would be advisable to collect evidence on this point and have analyses made of the mine atmosphere.

45. The effect on persons working in foul atmosphere found in the unventilated portions of the mines is to cause a pricking sensation of the eyeballs, headache, dizziness, and if the poisonous gases are present in sufficient proportions these sensations are more or less quickly followed by unconsciousness. This effect is commonly described by the miners as being "gassed."

46. It was also stated that being "gassed," either wholly or partially, is of comparatively frequent occurrence amongst the underground employees of the Witwatersrand mines.

47. It became necessary, therefore, to determine the origin and composition of these gases, and for this purpose a number of quantitative analyses of mine air were carried out.

Summary of Analyses See Appendix D).

	Mine Air.			
	Normal.	After Blasting.	Compressor Air.	
	Average of six samples.	Average of seven samples.	Average of three samples.	Pure Air.
O	20·38	19·90	20·76	20·96
CO_2	0·11	1·59	0·05	0·03
CO	0·13	0·39	0·08	
H	0·48	0·32		
N	78·88	77·57	79·12	79·0
NO	0·0004	0·0078		

48. Contrary to the opinion expressed by many of the witnesses, the proportion of nitrous oxides in the normal mine air is shown to be of small account. Possibly the undue prominence given to the presence and evil effects of nitrous oxides in the mines is due to the pungent odour and immediate irritating action on the mucous membrane, which would tend to mask the existence of the more poisonous but less noticeable carbonic oxide gas.

49. The high percentage of CO and CO_2 in the mine atmosphere clearly indicates the pressing necessity that exists for a more efficient supervision of the ventilation of the mines.

50. We are further of opinion that more careful attention should be bestowed with regard to the condition of the explosives

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used, and that miners should be instructed with respect to the more intelligent use of the same, thereby bringing about healthier atmospheric conditions through the diminution of the amount of the more poisonous gases created per unit of explosives used.

The composition of the gases resulting from the decomposition of nitro-glycerine explosives varies according to the manner in which they are used. It may be well, therefore, to briefly detail the principal conditions which we believe tend to create unnecessarily high proportions of the poisonous gases when blasting with these explosives :—

1. Bad quality explosives.
2. Insufficient tamping.
3. Bad quality, damp or weak detonators.
4. Bad quality fuse.
5. Overcharge of explosives in proportion to load.

51. It will not be necessary for us to deal with explosives other than those of which nitro-glycerine forms an active principle. When such explosives are detonated under proper conditions poisonous gases are not found in the resultant products; when, however, the detonation is not as perfect as it should be, gases of an extremely harmful nature are generated, and when, as is sometimes the case, the explosives merely burn, very large quantities of carbon monoxide and nitrous oxide are formed.

In ill-ventilated portions of the mine such products may make the working places unfit for human beings to live in for many hours after the explosion has taken place. This period is sometimes prolonged by the fact that the gases remain imprisoned under the fallen debris of rock that has been blasted, and thus diffusion is retarded. These gases, however, become liberated while the rock is being removed, and produce the "gassing" effects already described on the persons who may happen to be present.

52. The intimate acquaintance with the manufacture of nitro-glycerine explosives entitles the evidence given by Mr. Cullen, General Works Manager of the British South African Company for Explosives, Limited, to be received with the greatest consideration. His very practical remarks upon the use of explosives are most valuable, and he explained that what are termed by the miners "miss-fires," *i.e.*, an improper detonation of a charge, may be brought about by the existence of the five conditions enumerated above, and his statement that the use of a cheap fuse is a frequent cause of "gassing" is worthy of special attention.

53. It has been demonstrated when blasting with nitro-glycerine explosives that "miss-fires" will result if the initial detonation is too weak, and that detonators, although originally of good quality and sufficient strength, will rapidly deteriorate

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when exposed to a damp atmosphere such as exists in the mine workings. It would, in our opinion, therefore, be very beneficial if the practice were adopted of allowing a margin of safety in the strength of detonators used; for instance, where in the past a No. 6 detonator has been employed to explode the charges, we recommend that it should be replaced by a No. 8 detonator in the future—and further, the miners should be instructed to use every care that the detonators in their possession are enclosed in "damp-proof" boxes or wrappers and stored in as dry a place as possible. These precautions should moreover strongly appeal to the miner, since by their proper observance not only will the generation of harmful gases be decreased, but an economy in the use of explosives be effected on account of the more perfect explosions obtained.

54. It will, therefore, be seen that the practice of a reasonable economy in regard to the quantity of explosives used, together with the use of the best quality of dry fuse and detonators—the latter being preferably of greater strength than actually required—will cause a maximum disruptive effect on the rock by the explosion, with the minimum formation of injurious gases.

55. We are of opinion that the Government should direc their attention to the quality of the "safety fuse" imported into, and used in, this country, and that no such fuse should be permitted to be imported, sold, or used that is not of standard quality.

MINE SANITATION.

Contamination of Mine Water.

56. The general sanitary condition of the mines leaves much to be desired. While the main workings are usually kept in a good condition, the worked out or unused portions of mines are often permitted to get into a very foul state. We are concerned to find that the excreta of the underground workers is in certain mines systematically permitted to be mixed with the ore raised from the mine. This practice is most insanitary. It is obvious that if human evacuations are allowed to mingle with the water circulating through the mine (and this water is pumped to the surface and used on the sorting floors, mills, and other workings, and is constantly brought in contact with the employees), this pollution cannot but give rise to specific illnesses, and also tends to lower vitality and render individuals more prone to develop disease.

Bucket System.

57. It has been stated by Mr. Rosser that the bucket system had been introduced into the Wolhuter Deep Gold Mine, of which mine he is overseer, and that owing to the underground police supervision which he had established, he had experienced no difficulty in forcing the natives on the mine to adhere to the sanitary regulations laid down by him.

Underground Police System.

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58. We consider that in all mines where, owing to the depth of the workings or other causes, the employees have not easy access to the surface, suitable accommodation in the way of sanitary conveniences should be provided, regard being had to the number of persons employed in the mine, and we recommend that provisions enforcing the adoption of such a system should be incorporated in the mining regulations.

LIVING CONDITIONS OF THE MINERS.

59. Our attention has been directed to the fact that efficient change houses are not provided on many of the mines, in which the men may have facilities for washing and for changing and drying their clothes.

60. It is unquestionable that a miner returning to his habitation, exposed to cold air and wearing wet, soiled clothing, will not only suffer from ordinary pulmonary illnesses, but, if he is developing any special disease, such as Miners' Phthisis, the course of the disease will be hastened and increased in severity.

61. Where no special accommodation is provided, it is customary for the miners to change at their quarters. These quarters usually consist of a series of rooms, each shared by two men, and which are not provided with stove or heating apparatus or through ventilation. The wet clothes, therefore, taken off by the miner at the end of his shift, are in many instances still damp when put on at the time of his again proceeding to work.

Legislation Necessary.

62. We have noted with pleasure that very excellent change houses exist on some mines, and on those mines where such accommodation is not already provided, arrangements are for the most part being made to supply the same. We are, however, of opinion that the law should make it compulsory for the owner of every mining property to provide change houses within reasonable distance from the shafts in which the men are raised for white persons and suitable accommodation of a similar nature for natives.

Such change houses should be made more or less on the principle which practical experience has found advantageous in metalliferous mines in England and other countries; they should be artificially warmed and provided with arrangements for drying clothes.

We are further of opinion that the ventilation of the miners' quarters in many instances requires to be put on a proper basis.

PART II.

SILICOSIS.

63. The disease known as Miners' Phthisis, or more correctly as Silicosis, has been shown to be a chronic fibrosis of the lung, *i.e.*, the inhalation of fine angular dust suspended in the

Report.

mine atmosphere causes irritation which produces an enormous development of the delicate fibrous tissue in the lung; bands and patches of solid useless material gradually encroach on the normal breathing apparatus and interfere seriously with the respiratory functions—this alteration in the lung tissue is well depicted in the coloured prints attached to this report (see Appendix C).

64. The large amount of silicious particles inhaled, which remain in the lung, can be distinctly felt by cutting into the same; further, chemical analysis shows that the quantity of silica in some of the lungs examined amounted to 24·4 per cent., which amount almost entirely represents foreign matter that has been introduced.

Prevalence.

65. It is a matter of regret that we are unable to state with sufficient accuracy the percentage of miners in the Witwatersrand mines who are suffering from the disease. The fact that attention has but recently been directed to the presence of the disease, the outbreak of hostilities and the reluctance on the part of many of the miners to present themselves for examination, have all tended to defeat our efforts in this direction.

The report of the Transvaal Medical Society shows that the disease was present to a very great extent among the miners who were examined by members of the committee. This statement has since been amply borne out by the statistical returns obtained from the mining companies (see Appendix A), and is supported by the weight of evidence tendered by the individual witnesses.

Corroborative evidence on this point is also to be found in the Annual Report of the Government Mining Engineer for the year 1902. It is there stated that from data gathered by the inspectors of mines it is estimated that out of 1,377 rock drill miners employed in the Witwatersrand mines prior to the war, 225 or 16·34 per cent. had died during the two and a half years immediately preceding the outbreak of hostilities.

66. The average age of the diseased miners is low, and the remark of Dr. Frazer, one of the witnesses, that "he believed every miner who has worked for a year or two on rock drills is affected," is pregnant with meaning.

Causation.

67. Practically all the evidence given on this point tends to show that the inhalation of minute particles of inorganic matter is the primary and exciting cause of the disease. Whilst the various mining operations, such as drilling dry holes, blasting, shovelling, and breaking rock, are in progress, aciculiform dust is discharged into the atmosphere, and analyses have proved that the air breathed by the miners is impregnated with such dust to a more or less extent, according to the nature of their working places and the conditions for the time being under which they may be placed.

Report. Dust.

68. The drawings in Appendix B illustrating the character of this dust fully explain how it is that extremely fine, sharp, needle-like foreign material constantly brought in contact with delicate lung tissues produces such serious organic changes.

Vitiated Air

69. Dr. Pakes (whose opinions have weighed with us considerably in arriving at our conclusions) confirms the medical evidence, which is unanimous, that bad ventilation, air vitiated by gases produced by explosions, miss-fire or otherwise, lower the power of resistance in the miner and tend therefore to render him more liable to pulmonary diseases, Miners' Phthisis included. The ill effects produced by drinking water contaminated by excreta are too well known to need further special reference.

Change Houses.

70. Pulmonary complaints are contracted and accentuated by the miner being exposed whilst in his wet working clothes to the cold air on the surface after leaving the warm atmosphere of the mine.

Recommendations.

71. From the foregoing report it will therefore be seen that it is urgently necessary :—

1.—To prevent the discharge of the minute, hard, angular particles of dust already referred to into the mine atmosphere, and which are largely produced by blasting and rock drill operations.

2.—To supply the working places throughout the mine with air in sufficient quantities and in such a manner as to render harmless and sweep away all vitiated atmosphere.

3.—To maintain underground workings in every mine in a clean condition, and to provide for this purpose a suitable sanitary system.

4.—To provide change houses, suitably warmed and within reasonable distance from each shaft, where the miners can dry and change their clothes.

5.—To avoid the use of low flash point lubricants in the air cylinders of compressors, and to provide that the air intake be outside the engine house, so as to ensure a pure supply. (See Appendix D.)

Use of Water to Allay Dust

72. Analysis made of mine air has shown that the use of water, both in the form of sprays and jets, is most efficacious in allaying the dust produced by various mining operations.

While strongly advocating the use of water for this purpose, we consider that experience only will show which is the most suitable form to be adopted, and which will at the same time cause least discomfort to the miner.

Report.

Future Records.

73. The result of the investigations of this Commission will undoubtedly cause stringent measures to be taken to remove the causes of this serious malady, but it should be borne in mind that a large number of men are already suffering from it, and in consequence their health is probably permanently injured. It is evident, therefore, that even were it possible to remove all the causes of the disease from the conditions attaching to mining work, yet future records would still bear evidence of its existence, but we have every reason to suppose that when the causes of the disease are removed the life of those already suffering will be prolonged.

74. The samples referred to were collected by Mr. M. Fergusson, Assistant Inspector of Mines, and the examination and analysis of the same were carried out by Dr. Moir and Mr. A. Heyman, able assistants of Mr. J. R. Williams.

The best thanks of the Commission are due to both these gentlemen for the very careful and efficient manner in which they have carried out their very important researches, the results of which have weighed with us very considerably both during our sittings and our visits to the mines, and also to Mr. J. Stratford, Secretary to the Commission, for his valuable assistance.

The Commission also desires to express its recognition of the courtesy of the Chamber of Mines in kindly placing their Council Chamber at its disposal.

(Signed) H. WELDON.
„ C. L. SANSOM, M.D.
„ R. M. CATLIN.
„ W. T. F. DAVIES, M.D.
„ FRANCIS DRAKE.
„ S. HAWARDEN, M.R.C.S., L.R.C.P.
„ J. HARRY JOHNS.
„ E. PERROW.
„ J. R. WILLIAMS.
„ CHARLES PORTER, M.D.

29th May, 1903.

J. STRATFORD,
Secretary.

MINUTES OF PROCEEDINGS

OF THE

COMMISSION APPOINTED TO ENQUIRE INTO THE CAUSE AND EXTENT OF MINERS' PHTHISIS AND TO MAKE RECOMMENDATIONS AS TO THE PREVENTIVE AND CURATIVE MEASURES WHICH SHOULD BE ADOPTED EITHER BY LEGISLATION OR OTHERWISE.

FIRST SITTINGS.

Minutes of Proceedings.

CHAMBER OF MINES, JOHANNESBURG.

Wednesday, 4th December, 1902.

PRESENT :

MR. H. WELDON, *Chairman.*

DR. C. L. SANSOM,	MR. F. DRAKE,
MR. R. M. CATLIN,	DR. HAWARDEN,
DR. W. F. DAVIES,	MR. J. HARRY JOHNS
MR. J. R. WILLIAMS,	MR. E. PERROW.

MR. J. STRATFORD, *Secretary.*

The Commission assembled in the Board Room of the Exploration Buildings.

The Secretary read the Commission of H.E. the Lieutenant-Governor of the Transvaal. The Chairman intimated that he had received a Report on miners' phthisis from the Medical Society of the Transvaal.

Resolved that copies of this Report should be circulated among the members of the Commission, and that some of the Sub-Committee who drew up the Report should be asked to give evidence.

Resolved to circularize the various Mine Managers as to the extent of the disease, at the same time notifying the Chamber of Mines that the Commission had done so, and requesting their co-operation.

It was remitted to a Sub-Committee to approve of a draft Circular to be drawn up by the Secretary, containing the suggestions handed in by the members of the Commission.

Resolved that analyses should be made of the gases produced by explosives in the mines, and that the results should be submitted for expert opinion.

Resolved that evidence should be obtained on the ventilation of the mines.

A Sub-Committee was formed to act as a Working Committee.

Resolved that the Commission should sit on Wednesdays at 3 o'clock.

The Commission deliberated.

Adjourned until Wednesday, the 17th inst., at 3 o'clock ; due notice to be inserted in the Government "Gazette" and local papers.

Minutes of Proceedings

SECOND SITTING.

CHAMBER OF MINES, JOHANNESBURG.

Wednesday, 17th December, 1902.

PRESENT:

MR. H. WELDON, *Chairman.*

DR. C. L. SANSOM,
MR. R. M. CATLIN,
DR. W. F. DAVIES,
MR. J. R. WILLIAMS,
DR. C. PORTER,
MR. F. DRAKE,
DR. S. HAWARDEN,
MR. J. HARRY JOHNS,
MR. E. PERROW,

MR. J. STRATFORD, *Secretary.*

The Commission assembled in the Council Chamber of the Chamber of Mines.

The Secretary read a letter, dated 9th December, 1902, from the Assistant Colonial Secretary, stating that H.E. the Lieutenant-Governor had been pleased to appoint Dr. C. Porter, Medical Officer of Health for the Town Council of Johannesburg, to be a member of the Commission.

Dr. Francis Napier was called and examined.
Dr. Louis G. Irvine was called and examined.
Dr. Donald Macauley was called and examined.
Dr. W. G. Rogers was called and examined.
Dr. William Dyer Frazer was called and examined.
Adjourned until Wednesday, 7th January, at 3 o'clock.

THIRD SITTING.

CHAMBER OF MINES, JOHANNESBURG.

Wednesday, 7th January, 1903.

PRESENT:

MR. H. WELDON, *Chairman.*

DR. C. L. SANSOM,
MR. F. DRAKE,
DR. S. HAWARDEN,
MR. E. PERROW.

MR. J. STRATFORD, *Secretary.*

The Commission assembled in the Chamber of Mines, Johannesburg.
Dr. John Law Aymard was called and examined.
Mr. William Cullen was called and examined.
Mr. Eric Weiskopf was called and examined.
Dr. Robert Gow Ralston was called and examined.
Adjourned to 4th February, 1903.

FOURTH SITTING.

CHAMBER OF MINES, JOHANNESBURG.

Wednesday, 4th February, 1903.

PRESENT:

MR. H. WELDON, *Chairman.*

DR. C. L. SANSOM,	DR. S. HAWARDEN,
MR. R. M. CATLIN,	MR. J. HARRY JOHNS,
DR. W. F. DAVIES,	MR. E. PERROW,
MR. J. R. WILLIAMS,	DR. C. PORTER.
MR. F. DRAKE,	

MR. J. STRATFORD, *Secretary.*

The Commission assembled in the Chamber of Mines, Johannesburg.

Letter from Mr. T. Britten, Manager of the Wolhuter Gold Mining Company, inviting the members of the Commission to view his atomiser at work, was read.

Resolved that the members should visit the Wolhuter Mine on Wednesday, the 11th inst.

Letter from Messrs. R. T. Hanbury and Co., of London, addressed to Chief Mining Engineer, dealing with a certain spray, was read and discussed.

Letter from Messrs. Wallack Bros., of London, addressed to the Chief Mining Engineer, was read and discussed.

Written statement of Mr. David Wilkinson, Mine Surveyor, put in Mr. Wilkinson was requested to attend the next sitting for examination.

Dr. Edward Alfred Miller was called and examined.

Mr. Joseph Simpson Fisher was called and examined.

Mr. William Moses was called and examined.

The Commission deliberated.

Adjourned until Wednesday, 25th February.

FIFTH SITTING.

CHAMBER OF MINES, JOHANNESBURG.

Wednesday, 25th February, 1903.

PRESENT:

MR. H. WELDON, *Chairman.*

MR. R. M. CATLIN,	DR. S. HAWARDEN,
DR. W. F. DAVIES,	MR. J. HARRY JOHNS,
MR. J. R. WILLIAMS,	MR. E. PERROW.

MR. J. STRATFORD, *Secretary.*

The Commission assembled in the Chamber of Mines, Johannesburg.

Resolved that all written statements addressed to the Commission which were not supported by the evidence of the writer should be dealt with by the Sub-Committee.

Minutes of Proceedings.

Mr. Arthur Robert Sawyer was called and examined.

Mr. David Wilkinson was called and examined.

Mr. George David Stonestreet was called and examined.

Mr. John Richards was called and examined.

Mr. Thomas McIsaac was called and examined.

Mr. George Blight was called and examined.

Mr. Thomas Pearson was called and examined.

Mr. Thomas Pryce Rosser was called and examined.

Mr. James Beattie placed his patent spray before the Commission and explained its capabilities.

The Secretary was instructed to insert a notice in the Government "Gazette" and local papers to the effect that, owing to the evidence tendered by the public having been exhausted, the Commission was about to terminate its sittings, and calling upon persons desirous of giving evidence to send in their names to the Secretary on or before the 18th March.

The Commission adjourned to date to be fixed when evidence collected.

SIXTH SITTING.

CHAMBER OF MINES, JOHANNESBURG.

Tuesday, 17th March, 1903.

PRESENT:

MR. H. WELDON, *Chairman.*

DR. C. L. SANSOM,	MR. F. DRAKE,
MR. R. M. CATLIN,	DR. S. HAWARDEN,
MR. J. R. WILLIAMS,	MR. E. PERROW.

MR. J. STRATFORD, *Secretary.*

The Commission assembled in the Chamber of Mines, Johannesburg.

Mr. Joseph Montague Hodge was called and examined.

Mr. Evan Lewis was called and examined.

Mr. David Jones was called and examined.

Mr. Edgar Philip Rathbone was called and examined.

Mr. August Gorlick, representing Messrs. F. P. Beck and Co. Pretoria, exhibited and explained the working of various respirators to the Commission.

Mr. Joseph Bell exhibited a spraying apparatus.

Adjourned until Wednesday, 25th inst.

Minutes of Proceedings.

SEVENTH SITTING.

CHAMBER OF MINES, JOHANNESBURG.

Wednesday, 25th March, 1903.

PRESENT:

MR. H. WELDON, *Chairman.*

DR. C. L. SANSOM,	DR. S. HAWARDEN,
MR. R. M. CATLIN,	MR. J. HARRY JOHNS,
DR. W. F. DAVIES,	MR. E. PERROW,
MR. FRANCIS DRAKE,	MR. J. R. WILLIAMS.

MR. J. STRATFORD, *Secretary.*

The Commission assembled in the Chamber of Mines, Johannesburg.

Mr. Walter Charles Cross Pakes was called and examined.

Mr. Malcolm Fergusson was called and examined.

The Commission deliberated.

Adjourned to Friday, 27th March.

EIGHTH SITTING.

CHAMBER OF MINES, JOHANNESBURG.

Friday, 27th March, 1903.

PRESENT:

MR. H. WELDON, *Chairman.*

DR. C. L. SANSOM,	MR. E. PERROW,
MR. FRANCIS DRAKE,	MR. J. R. WILLIAMS.
MR. J. HARRY JOHNS,	

MR. J. STRATFORD, *Secretary.*

The Commission assembled in the Chamber of Mines, Johannesburg.

The Commission deliberated on the Report.

H. WELDON, *Chairman.*

INDEX TO WITNESSES.

MINUTES OF EVIDENCE.

SECOND DAY.

CHAMBER OF MINES, JOHANNESBURG.

Wednesday, 17th December 1902.

PRESENT:

MR. H. WELDON, (*Chairman.*)

DR. C. L. SANSOM,
MR. FRANCIS DRAKE,
MR. J. R. WILLIAMS,
MR. E. PERROW,
DR. S. HAWARDEN,
MR. R. M. CATLIN,
MR. HARRY JOHNS,
DR. W. F. DAVIES,
DR. PORTER,

MR. J. STRATFORD, *Secretary.*

DR. FRANCIS NAPIER was called and Examined.

Dr. *Francis Napier.*
17th Dec., 1902.

1. The Chairman: You are practising in the Witwatersrand and you are Secretary of the Transvaal Medical Society?—Yes.

2. Are you acquainted with this report made by the Special Committee on Miners' Phthisis?—Yes.

3. Please inform the Commission as to the origin of the report?—The Transvaal Medical Society received a communication in November of last year from the Association of Mine Managers asking them to appoint a Committee to meet a Committee of their Association in order to investigate the large amount of mortality going on amongst rock-drillers and to suggest means of preventing such mortality. A Committee of the Transvaal Medical Society was formed to meet the Committee of the Mine Managers' Association, and a meeting was subsequently held; I think in January. Then later on, in the early part of August, a deputation from the Transvaal Miners' Association waited on me and stated that they wished to interview the Transvaal Medical Society on this question, which they divided into two headings. The first one was to urge the Government to take such means for housing and medical attendance of those men, who had suffered from Miners' Phthisis to such an extent as to unfit them to follow their ordinary occupation and put them into a state of destitution; and, secondly, to consider preventive measures of the disease. I pointed out to them that the best method would be for the Medical Society to consider the matter by putting it into the hands of a sub-committee and that that sub committee should meet them. It was at a general meeting on August 7th of the Transvaal Medical Society that I brought this matter up, and they appointed the Committee which drew up this report. The instructions to the Committee were to collect statistics, to consider preventative measures, and to take any steps they thought necessary to obtain information on the subject of Miner's Phthisis. That sub-committee held several meetings, at which I was not present, as I was not a member of it, and this was the report

Dr. *Francis Napier.* 17th Dec. 1902.

sent in by that Committee to the Medical Society. The report was sent in in October, and was brought before the Medical Society at a general meeting in November, when it was adopted unanimously. I was instructed to write to the Commission appointed by the Government and offer this report, and at the same time I was instructed to write to the Transvaal Miners' Association, explaining the reason for taking these steps, instead of doing as we had intended before meeting them in Committee. This was the report which was handed in.

The report was as follows:—

TRANSVAAL MEDICAL SOCIETY.

REPORT OF SPECIAL COMMITTEE ON MINERS' PHTHISIS.

Your Committee has endeavoured to fulfil the instructions of the Society to collect information, and to report on the subject of pursuing the following lines of investigation:—

1. The collection of life histories of individual miners, who have succumbed to the disease, or are now suffering from it, by means of a collective investigation on several of the mines of the Rand. The object of this enquiry was to determine how far the disease is actually prevalent, and how far it has been a cause of mortality amongst the miners.

2. The clinical examination of miners suffering from chest symptoms believed to be the result of their occupation.

3. The collection of post mortem reports and the pathological examination af material.

4. The investigation of the actual conditions under which the miners work.

5. The consideration of suggested means of prevention of the disease; and

6. The question of treatment.

The information obtained by these means may thus be summarised.

I. STATISTICAL.

The life histories of a large number of miners at present living on the Rand, or of miners who have died of chest disease within the knowledge of our informants, were obtained by the efforts of several members of the Committee. The results elicited may be stated thus:—

1. Miners' phthisis is not peculiar to machine miners, for, although it is most typically and commonly seen in them, it frequently develops also in course of time amongst miners who have never used rock drills at all. Most cases of this sort, however, have been mining for long periods, *e.g.*, over 30 years, and it may be taken that the ordinary miner has a considerable advantage in length of life over the rock drill miner.

2. The disease undoubtedly falls most heavily on rock drill miners. Out of the living rock drill miners whose cases we have investigated, the majority of those who have been working rock drills for over five years were found to be suffering more or less from chest symptoms; the average time that those who were admittedly so affected had been employed on rock drill work from 7 to 9 years (ranging from 6 to 15) out of a mining life of 18 years.

3. Of the rock drill miners who have died from chest disease the average age at death was under 35 years, and the average number of years which they had worked machines was 7 to 9 years. Transvaal Medical Society's Report. — 17th Dec. 1902.

4. The conclusions strongly suggested by the above results are that the use of rock drills over a prolonged period greatly increases and accelerates the incidence of chest disease amongst miners, and that the working efficiency of any rock drill miner, working under the present conditions, will on the average be impaired or even exhausted after 7 to 9 years' work.

This shows the serious and urgent nature of the question, as many of those men die in the prime of life often leaving widows and children behind them, few of whom are provided for. Thus out of 30 men with regard to whom this matter was particularly investigated 19 left widows with 48 children.

It is true that men may be found who have worked for 10 years or more with rock drills and whose health is not perceptibly impaired; on the other hand others have become affected under the average time. Probably in this respect a great deal depends on the class and type of mining engaged in, and its locality. "Wet" mines have a much better reputation than "dry" mines. The quartzite of the goldbearing beds of the Witwatersrand is admittedly very hard, and the mines are practically all "dry." There is also no doubt that persons who inherit chest weakness are more liable to be attacked by disease of this nature, but, while this fact may explain some individual variations, it does not explain the enormous incidence of chest disease on miners as a class. The same observation may be made with regard to personal habits of intemperance and mode of living.

5. All the statistical evidence goes to show that developing, *i e.*, "raising" and "driving," is more dangerous to health than working in stopes. The most striking case in point which the statistics furnish is that of two brothers, who worked rock drills for four years only, doing nothing but "raising" all the time, and who died thereafter o chest disease at the age of 28 and 30 respectively.

II. CLINICAL.

Clinical investigation and examination show that the disease is an extremely insidious one, of very gradual development, having in its earlier stages little or no obvious effect on the general health, so that by the time the working efficiency of the miner becomes seriously impaired the disease is as a rule already well advanced.

1. The usual symptoms in a typical case are in the earlier stages recurrent and obstinate bronchial "colds," which may attract little attention, for the patient being for a long time quite able to work is apt to regard his earlier symptoms as of little moment.

Gradually as the disease progresses shortness of breath on exertion, cough and spit, a more frequent liability to contract colds and a greater difficulty in throwing them off, and sometimes flitting pleuritic pains, are the symptoms which usually first attract serious notice.

Gradual loss of weight and strength, and more urgent breathlessness, which may be of an asthmatic type, follow, as an increasing area of breathing space becomes disabled. Expectoration may or may not be a prominent symptom; haemoptysis is exceptional and when present is usually slight; night sweats are not as a rule noticeable, and pyrexia may be altogether absent throughout. Three of the characteristic signs of tubercular phthisis are thus frequently absent.

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Finally towards the end the patient rapidly loses ground in all directions.

The most striking feature brought out by *physical examination* in a typical case is the diminished expansion of the chest, which in many cases is very striking, and is accompanied by rigidity of the chest wall, so that the breathing becomes mainly abdominal. The lungs are not, however, emphysematous in the sense that their area of resonance is increased; often indeed it is noticeably diminished. Hollowing of the supra-clavicular, suprascapular, and intercostal spaces, together with general emaciation, is noticeable in the more advanced cases.

Percussion and auscultation often give very indefinite results, owing no doubt to the diffuse nature of the disease. The dyspnœa seems frequently quite out of proportion to the evident organic changes In the more advanced cases there is definite evidence of consolidation, and even in some cases of cavity formation, but in many, some impairment of percussion, here and there, perhaps more frequently at the bases than at the apices, with harsh, interrupted or bronchovesicular breathing, and sometimes crepitation and pleuritic friction are the most that can be made out. The disease is bilateral, but one lung is frequently affected to a greater degree than the other.

2. It is not common to find the typical physical signs of tubercular phthisis present, and this observation, together with the confirmatory fact, that, out of a series of over 30 sputa from cases of disease of the lung of miners examined by a member of your committee only two or three were found to contain tubercle bacilli, leads us to conclude that, while in some cases a true tubercular phthisis may co-exist or may be superadded, the conjunction is only seen in a minority of cases. Where tuberculosis does co-exist or become superadded the disease assumes more of the typical tubercular character with pyrexia, sweating, hectic symptoms, and the characteristic expectoration. The type becomes more of a "mois," one. The disease is primarily a local one, and is at first confined to the respiratory organs; secondary disorders of the heart, liver, stomach, and kidneys are late accompaniments. The heart is not as a rule dilated, but the pulse rate may be accelerated.

3. In the more chronic forms, seen perhaps more typically in the miners of many years standing, who as a rule are not rock drill workers, chronic bronchitic and asthmatic symptoms are perhaps more prominent, and in them dilatation of the heart and accelerated pulse rate are more common.

We may therefore perhaps usefully distinguish from a clinical standpoint three types of 'Miners Phthisis."

1. The pure fibroid non-tubercular type, the commonest and most characteristic form of the disease.

2. The mixed fibroid and tubercular type, where the two processes co-exist.

The very chronic type seen in miners of many years standing, where the fibroid change in the lungs, although more chronic is less extreme, and where secondary changes in the heart and kidneys are more prominent.

III. PATHOLOGICAL.

The result of several *post-mortem examinations* performed by various members of the committee has been to show that the essential nature of the disease is that of a chronic interstitial fibrosis of the

lung, of the type already well-known to be caused by the continuous inhalation of dust.

It is characterised by a chronic catarrh of the larger and smaller bronchi, and of the air cells, with a slow but progressive increase of the fibrous tissue around the bronchi and blood vessels, and throughout the substance of the lung, as the irritant penetrates into it along the lymphatic channels. The pleurae also are thickened, and in advanced cases almost invariablyextensively adherent to the chest wall. These changes result first in the formation of scattered fibrous nodules and fibrous bands, and later in actual consolidation by extension of the fibroid change, and by the multiplication, growth and coalescence of nodules, and they lead to a steady encroachment on, and diminution of the air spaces and blood vessels of the lung. The true lung tissue in the affected areas ultimately becomes replaced by fibrous tissue, and in advanced cases the consolidated areas are very extensive. The affected portions may come to have the consistency of indiarubber; the whole organ feels firm and is of a dark grey colour. In one case examined the tissue which could be described as even comparatively normal did not amount to more than a quarter of each lung. The breathlessness which is so marked a feature of advanced cases of the disease finds here its obvious pathological explanation. Cavaties may be found in the consolidated tissue; they are usually necrotic in origin. The disease is bilateral, the changes being similar in each lung, but varying in extent and degree, and while the process is a diffuse one it is usually found to be more advanced in the posterior and lower portions of the lung. None of the cases examined showed naked-eye signs of tuberculosis.

We have not as yet been able to examine a large number of *microscopic preparations* from specimens of Miners' Phthisis, but those which we have examined serve to confirm and extend the evidence of naked eye post-mortem examination.

Sections taken from portions of lung in which the process of fibrosis is least advanced enable one to trace practically from the beginning its character, distribution, and mode of development.

The first development of the fibrous nodule seems in most cases to take place around the small bronchi, arteries and veins. Lymphatic channels run in these situations and the particles absorbed from the air cells tend to collect there and beneath the pleura, giving rise by their presence to a chronic form of inflammation characterised by the development of new fibrous tissue.

The association of the deposit of the pigmented particles with the production of new fibrous tissue may be clearly seen localised around the small bronchi and blood vessels. This is the origin of the fibrous "nodule." The pigmented particles seem first to be contained within cells lying amongst the newly formed fibrous tissue. Around the developing "nodule" many of the air vesicles are seen to be in a condition of catarrhal inflammation.

The interlobular septa also show inflammatory thickening and deposit of pigment.

In sections taken from areas in which the process of fibrosis is rather more advanced the mode of its further development can be traced. It consists mainly in the multiplication growth, and ultimate congruence of isolated nodules, associated with a localised catarrhal inflammation of the air vesicles in their neighbourhood. In nodules large enough to be visible to the naked eye the small bronchus or

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vessel around which the origin deposit began has often quite disappeared, but the roughly concentric arrangement of the fibrous tissue and the pigment particles is retained. In the older denser central portions of the nodule the pigment is less conspicuous, because more diffused, and seems to lie free in the interstices of the fibrous tissue, the cells in which it was originally contained having degenerated and disappeared.

The larger bronchi are the seat of chronic catarrhal inflammation.

Preparations made from the areas where the fibroid change is complete and consolidation extensive show little or no normal lung tissue remaining; the nodules have increased and coalesced, although signs of their discrete origin are visible in the whorls and bands of fibrous tissue, and the distribution of the pigmented particles. These can be seen in abundance for the most part lying free in the fibrous tissue.

With regard to the nature of the pigmented particles whose presence is associated with the development of the fibrous change, many no doubt are carbonaceous. But by careful focussing it is quite easy to distinguish in the aggregations of pigment many minute angular transparent refractile particles. These are particularly numerous in the central parts of older nodules, and in the areas of advanced fibrosis.

In short the distribution of the fibroid change seems originally to follow that of the lymphatics of the lung, which taking up the mineral particles from the walls of the air vesicles carry them along the lymph channels surrounding the bronchi and blood vessels, and beneath the pleura. In these situations they accumulate and give rise to the irritative changes we have described. The fibroid nodules do not show any sign of being tubercular in origin.

Further and prolonged investigation, however, is necessary to determine in what exact proportion of cases a true tubercular change co-exists with the fibroid change, but whatever the result of such an investigation may be we may without hesitation assert that the process of fibrosis is usually the primary one, and is non-tubercular in origin, and that although tuberculosis no doubt does in some cases co-exist with or become secondarily grafted upon it, the essential pathology of the two processes is quite distinct.

The fibroid change in the lung characteristic of Miners' Phthisis being thus found to be of that type of disease known to be caused by the inhalation of dust, and the presence of mineral particles having been visibly demonstrated in the affected tissues under the microscope, it became a matter of interest to determine whether *chemical analysis* also could show the presence in the diseased organs of the constituents of rock dust.

With this object, at the suggestion of your Committee, Mr. J. R. Williams undertook the chemical analysis of two lungs from a case of Miners' Phthisis. The total ash of these after incineration was in the case of one lung 4.95 grammes, and in the other 2.28 grammes.

An analysis of the former gave the following results:—

Silica (1.214 grammes)	24.4 per cent.
Iron (as oxide)	19.2 per cent.
Alumina	8.1 per cent.
Calcium (as oxide)	10.3 per cent.
Manganese	2.2 per cent.

Sodium as phosphates, chlorides and sulphates.

Some of the iron present was in combination with sulphur.

Here the silica, alumina, manganese and iron (with the exception of a slight deduction necessary owing to the presence of a certain amount of iron derived from the blood), represent *inorganic matter of wholly foreign origin.*

It is interesting, in view of the high percentage of iron and the presence in the lung of a definite percentage of manganese, to note that the miner in whose case the investigation was made had worked for a number of years in iron mines in England. We have been unable up to the present to obtain a similar analysis of a normal lung for purposes of comparison, but the following analysis undertaken with a similar object in a case of "ganister miner's lung," and quoted in the Annual Report of the Chief Inspector of Factories and Workshops, England, for 1900, forms a particularly instructive parallel. Ganister is a close-grained, hard, silicious stone containing about 95 per cent of silica, and used for lining the bottom of Bessemer Converters. Owing to the high death-rate from "phthisis" among ganister miners an investigation was made of the matter. As a result of this it was determined that the disease is primarily due to the inhalation of silicious dust, the conclusion at which we have also arrived regarding "Miners' Phthisis" on the Rand.

The following is the analysis of the mineral constituents of the ash in the lung of a ganister miner:—

Silica	24.02 per cent.
Alumina	32.67 per cent.
Iron	4.83 per cent.
Calcium	14.58 per cent.
Magnesia	11.00 per cent.
Sodium chloride, etc.	

The parallelism in the two cases is so close as to amount almost to an indentity, and the drawing of a lung of a ganister miner, which accompanies the Chief Inspector's Report, is quite typical of the post-mortem appearances as we find them in "miner's lung" here.

We have taken a specimen of the insoluble ash of the lung in the case submitted for analysis by us, and under the microscope the fine angular gritty particles recovered by this means from the affected tissue are readily seen.

IV. CAUSATION.

Clinical history and physical examination during life, and examination of the lungs post-mortem thus all converge to the conclusion that the disease is a chronic interstitial inflammation of the lung with accompanying catarrhal changes in the bronchi and air cells, and that evidence of tuberculosis when existing usually points to its being a secondary development. This form of disease has long been known in Europe, and has been proved to be due to the constant irritation of dust inhaled more or less continuously over long periods. It has been abundantly shown that although the protecting mechanisms of the air passages are competent to deal with moderate quantities of dust, they fail to arrest the ingress of the particles, if dust exists in large amount, and is breathed almost without intermission. Under those circumstances the dust acts as a constant irritant, and produces changes of the kind we have described as being found in post-mortem examinations of cases of miners' lung. Thus anthracosis (coal miner's lung), siderosis (knife-grinder's lung), and silicosis (stone-mason's or

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potter's lung), are names for an essentially similar condition, differing only in degree and in minor features due to the nature of the irritant which is the causative agent in each case. In each type of the disease the foreign material which is the causative agent can be demonstrated microscopically in the affected tissues – coal dust in anthracosis, metallic particles in siderosis, and silicious particles in stone-mason's lung or silicosis.

The disease which is the subject of our investigation is in fact a silicosis; it is mainly the result of the inhalation of silicious particles generated in the processes of mining, which find their way into the air passages and air vesicles and are carried thence by the lymphatics through the substance of the lung. In all of these situations they set up irritative processes leading to the catarrhal and interstitial changes which we have described.

The condition is in no way peculiar to South Africa, for Cornish tin miners are shewn in Dr. Ogle's Comparative Mortality Statistics (dealing with a period before the mining industry on the Rand had drawn miners from Cornwall to this country), to have *the highest death-rate from diseases of the lungs of any occupied class in the United Kingdom.*

Potters, and this is significant from our point of view, come next, and very close behind.

This fact must be taken into consideration in appraising the statement that a miner's life on the Rand is much shorter than elsewhere, since a large number of miners who come to this country are already so far affected by the condition. Instances of this fact have come within our observation.

The inhalation of silicious dust is thus the main cause of the disease, and, as we have found, the fine angular gritty particles can be demonstrated under the microscope, and can be recovered in some quantity from the affected tissues.

This conclusion, which would be justified from clinical and pathological considerations alone, is fully and finally confirmed by the fact that the mining processes which are admittedly the most dangerous, viz., "raising" and "driving", are precisely those in which the presence of dust in the air is at a maximum.

The reasons for this may be briefly stated, namely: –

(1) That the "raise" and the "drive" are culs-de-sac in which adequate ventilation is a matter of great difficulty.

(2) That many of the holes bored are "dry", emitting a constant stream of fine dust, with which the atmosphere is impregnated; and

(3) That the practice is frequent of returning after blasting a certain number of holes to blast the remainder or to inspect the results, before sufficient time has been allowed for the fumes and dust to have cleared away.

Rock drill work in the stopes is not exposed to such great disadvantages, and few dry holes are there necessary unless "overhand" stoping is employed.

At the close of each shift the whole atmosphere of the mine after blasting quickly becomes charged with the dust and fumes so caused, and although this vitiation is not (so far as dust is concerned) as great as obtains under working conditions in a raise or drive, it still is a factor to be considered.

Further also, apart from the dust actually caused by drilling and blasting, the dust raised in the subsequent handling and removal

of the broken rock must be taken into account in considering both causation and prevention. We wish to emphasise this fact, as we believe it has hitherto been almost overlooked, and the quantity of dust raised in handling the ore in a dry stope is very great.

While we consider the dust generated in the process of mining to be the main cause of the disease, we may regard as subsidiary factors, irritation from dynamite fumes, which no doubt co-operates in producing and maintaining catarrhal changes, and possibly irritation caused by oil vapour contained in the exhaust air from the rock drills. To these must be added the effect of insanitary conditions in the workings, which are not uncommon.

V. PREVENTION.

The fibrosis of the lung brought about by the inhalation of silicious dust would probably not progress if cessation from work on the onset of early symptoms were the rule. But the pathological character of the disease is in itself sufficient evidence that *when well established* it cannot be wholly cured, although removal from its existing conditions will unquestionably greatly ameliorate its symptoms and prolong life. Consequently, it is essential that as much as possible should be done to *prevent its occurrence.*

Since the generation and inhalation of rock-dust are the primary factors in its production, the problem of prevention becomes the purely mechanical one of controlling the generation of the dust and preventing its inhalation.

(1) The former must be regarded as the most important end to aim at. *Dry mining should as far as practicable become wet mining.*

The means to achieve this are rather a question for the mining engineer, but the following suggestions seem to us of value:—

1. That the general ventilation and sanitation of the mines, and especially the ventilation of drives, be rendered as efficient as possible.

2. That "raising" should as far as is practicable be discontinued.

3. That some arrangement be provided which will under all circumstances ensure a jet of water being thrown into each hole as it is drilled.

4. That, wherever possible, and especially in a "raise" or "drive", water should be provided, by spray or otherwise, to lay the dust after blasting, and during handling. We are aware that the practical difficulties in carrying out the object are, under the conditions of scarcity of water existing in most of the mines of the Rand, very great, but it might be found feasible in many cases to give effect to this suggestion.

(2) The question of the possibility of finding means for the effective prevention of the inhalation of dust by the workers is one which demands careful and exhaustive trial under the actual conditions of work in the mines.

1. First we may say that stringent regulations of the practice of returning to blast a second set of holes, or to inspect the results of blasting before the air has become sufficiently clear from dust and dynamite fumes is very necessary. This is to some extent provided for by Article 93, paragraph K of Section X of the Mining Regulations.

2. There next remains the question of *Respirators.* Ideally the use of respirators seems a simple and effectual solution of the whole matter. But experience shows that in similar circumstances the greatest

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objection is shewn by many of the workers in dusty trades to the use of respirators. It is stated that under actual working conditions they are found to be an annoyance even by those whose lungs are healthy, and where the breathing is already impaired their use is still less practicable.

We have examined several different types of respirator at present on the market, and of these we selected as the only one likely to prove suitable a respirator supplied by Messrs. Wallach Bros, London, and specially recommended by Mr. A. L. Ronaldson, late Government Inspector of Mines, Drills and Machinery, as likely to prove satisfactory for miners working Machine Drills. This respirator is made of aluminium; it is simple; it is extremely light; it is non-corrosive, and easily refitted with the filtering medium, for which purpose flannel is probably the best material. Several of these were placed for trial on one of the mines here, in the hands of experienced rock drill miners, two of whom had already worked rock drills for over six years. Their report after continuous use of the respirator throughout several weeks is favourable. Not only are the respirators quite tolerable *under active working conditions* both in drives and stopes, but benefit is experienced from their use. Consequently we are encouraged to strongly urge that careful and extended trial should be made to thoroughly test the practicability of the use of respirators. We consider it likely that the employment of a respirator of the type we speak of, or a similar one, will be found practicable under active working conditions, and, *if so*, its use should certainly be made compulsory for workers in raises and drives and excessively dusty stopes

But even so we would not the less on that account strongly press first for the adoption of the suggestions outlined in the preceding paragraphs of this section, regarding the means of controlling the generation of dust. and the stringent regulation of the practice of blasting. *This should be the first object.*

Should these suggestions be carried into effect we might then regard the respirator as *a most useful second line of defence* in the special working processes we have named.

The respirator of the ordinary type is of course efficient only against the inhalation of dust; it does not protect against dynamite fumes.

The occasional practice of blasting a second time, which, apart from the risk from dust, has the added risk of "gassing" from dynamite fumes, could be rendered safe by the use of some such apparatus as firemen use, namely, a mask into which is lead a stream of compressed air from a portable reservoir. This, however, is a more complex matter.

It has also been suggested in various quarters that the use of a water spray, after blasting to lay the dust in drives and raises might be rendered even more efficacious by the addition to the water of chemical reagents, which would fix some at least of the noxious constituents of the dynamite fumes.

VI. PROVISION FOR THOSE AFFECTED BY MINERS' PHTHISIS.

This question merits a few words in conclusion. While from the nature of the disease it is impossible to hope that, when the pathological process we have described is well developed, even removal from the conditions in which he works will leave the worker without *some* permanent damage to his lungs, yet there is no question that,

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in cases where the process has not gone too far, great amelioration may be looked for by that means. Any other "treatment" is merely palliative.

We have again and again observed the fact that men who were suffering to some extent, and sometimes markedly, from chest symptoms before the war, have served during it, and have enjoyed good health. Yet many of these very men have, when they have resumed underground work, at once fallen off in health, and several have rapidly succumbed. Their lungs, capable of maintaining health in an open-air life, have proved unequal to the strain of a return to the conditions of mining work. Yet the fact that in an open-air life their health was good leads us to believe that, if such a provision were again made possible (*e.g.*, in prospecting), restored health would in many cases follow.

Those more advanced cases, whose working efficiency is exhausted, come into line with the wider class of cases of incurable disease from all causes, for which every settled civilised community makes provision.

4. The Chairman: Have you any personal knowledge of Miners' Phthisis?—My knowledge is purely academic and therefore for the purpose of this Commission it would be hardly of any value. I have no peculiar knowledge.

Dr. Louis G. Irvine, M.A., M.D., B.Sc. (Pub. H.), Edinburgh, was called; and examined.

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5. The Chairman: I think you are at present practising in the Witwatersrand?—I am.

6. In your experience as a mining doctor, have you personally attended many persons suffering from Miners' Lung?—A considerable number.

7. Have you had any experience outside of this country?—None except by hearsay.

8. Could you give the Commission your idea of the causes of this disease?—Do you wish simply to cross-examine me, or may I make a statement?

9. I would much prefer you to make a statement, and, if you have any figures, please embrace the extent as well as the causes?—I wish first of all, as a member of the Special Committee which drew up the report for the Transvaal Medical Society, to give my personal adhesion to the views expressed in it, and the evidence I wish to lead this afternoon is simply in amplification of that report or rather of certain portions of it. I wish in particular to give explanatory evidence on the following points:—

1. The method of collection of statistics upon which the results stated in Section I of the report are based.
2. The pathology of the disease dealt with in Section III, in amplification of which I wish to present certain drawings and specimens.
3. The causation of the disease; seeing that there is in the minds of the mining community a good deal of uncertainty as to what is the exact causation, I wish to summarise in a less technical manner than in the report the arguments, which led us to adopt the views outlined in Section IV; and
4. The question of prevention.

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With your permission I will make a statement on each of these.

1. The method of collection of statistics, etc. The conclusions outlined in Section I, that is to say, the statistical portion, rest on a basis which is admittedly incomplete. We have therefore made no pretence to attempt to express in figures the percentage death rate of Rand miners as a class or of rock-drill miners in particular. I do not believe that even the most exhaustive enquiry would enable one to arrive at more than a very rough approximation to such a result. It must be remembered that a great many miners, who had previously worked on the Rand, have since died in Cornwall and elsewhere, and it would be impossible to trace a very large number of those. What we did therefore was this. We selected on each of five mines an experienced miner, whose personal knowledge of the miners employed on the Rand was extensive. He was usually a "mine captain" or a "shift boss", and we requested him to collect the information for us under certain headings, which we gave to him. He was then cross-questioned as to the results, and we believe the information so obtained to be as near absolute accuracy as it is possible to reach. We had no difficulty in obtaining on these five mines the names of 174 rock-drill miners who had died of chest disease within the knowledge of our informants. They were not necessarily, however, working on the particular mines on which our informants were employed. For example, when I quote figures from certain mines, I do not mean that the miners whose names are in this list were necessarily employed on these mines. What I mean is that they were known personally to the informant on that mine. Thus we obtained the following figures. On the Geldenhuis Deep 21 men having worked rock-drills for an average period of 5.5 years, died from chest disease at the average age of 35.5 years; on the Geldenhuis Estate 33 men who had worked 6.9 years at rock-drills, died at an average age of 34.4; on the Jumpers Deep 39 men who had worked rock-drills for 6.8 years, died at the average age of 37; on the Crown Reef we got the names of 32 men who had worked rock-drills for 8.8 years and who died at the average age of 32 years. The bulk of these statistics were collected for us by Dr. Macaulay, who will bear me out. Of course the years these men had spent at rock-drilling did not represent their total mining life. They had all of them been employed in mining for years, but the figures represent the average number of years actually spent on rock-drill work. Later on we got from the Crown Deep a list of 49 men, who had worked rock drills on an average for 6 years and died at the average age of 36,6, making a total of 174 men. That therefore is the basis of the statistical portion of the report as far as concerns the incidence of the disease. The very fact, that we were so easily able to obtain such an extensive list of names, is in itself eloquent proof of the excessive incidence of chest disease amongst rock-drill miners on the Rand. With the establishment of this fact and a reliable approximation to the number of years which these men had on the average been employed on rock-drills, and their average age at death, we were content. I find that in Johannesburg Hospital out of 93 males, who have died from disease of the respiratory organs, and whose occupations were noted, from June, 1901, to November, 1902, 47, or more than half, were miners, as against 46 of all other occupations. The statistics in Section I, paragraph 2, of the report are based on the personal interrogation of miners now working on the

Rand. I have myself seen in this way over 60 miners within the last three months and the majority of these I have subjected to physical examination. That is all I have to say in amplification of Section I of the report. With regard of Section II, I have nothing of moment to add; but in amplification of Section III, the portion dealing with the pathology of the disease, I wish to show some drawings illustrative of the disease, and in particular I should like with your consent to demonstrate under the microscope to the members of the Commission the presence of silicious particles in the affected portion of a miner's lung. With regard to the sketches I wish to show you, I have here four drawings of the post-mortem appearances as seen by the naked eye of four lungs from cases of miners' phthisis. The first one which I show you (Appendix C, Plate I) shows the disease in as little advanced a stage as one is likely to find at death, although the disease was already considerably advanced. The drawing shews, as you can see, the scattered nodules of consolidation right through the lung, and in addition to that the fibrous bands, representing the thickening of the fibrous framework of the lung. These sketches I may say may be taken as illustrating the section of the report which deals with post-mortem appearances. You see in certain areas the consolidation has become more extensive, but it is nowhere very extensive. The dark green portions represent the fibrous portions fully consolidated, the scattered nodules representing the areas where the change is at present less extreme. The second sketch (Appendix C, Plate II) shews another lung in which as you can see the change is more advanced. The lower portion of the lung is fully consolidated, while the upper portion is still very much in the condition of the first lung, but you see the dense fibrous tissue in the lower portion, and you can make out what is plainly visible at post-mortem examinations, viz., that the fully consolidated portions are formed by the coalescence of nodules.

10. The Chairman: I understand that in the first case the patient need not necessarily die, when he reaches that stage, although it may be affected in this way?—Oh no. As a matter of fact, these two lungs are the right and left lungs of the same man, and illustrate another point that the change, although occurring in both lungs, is usually more advanced in one than in the other. Further, these two lungs are taken from an old miner aged 52, who had never worked rock-drills, and yet was a subject of miners' lung, but he was a subject of the most chronic form, and he died not so much from his lungs as from failure of his heart and kidneys. His case belongs to type three mentioned in the report. Now the third sketch (Appendix C, Plate III) which I shall show you, shews a condition originally very closely similar to number 2. It is again the right lung. Again the whole of the lower portion is consolidated and again the upper portion shews the least advanced change, but in this case the lung has begun to break down and two large cavities have formed. It therefore represents a lung originally like the second one, but the fibrous portions have begun to break down. This case was under the care of Dr. Macaulay, and he can give you full details of his clinical history. The fourth one I have here (Appendix C, Plate IV) was another case of Dr. Macaulay's. You see here an extreme degree of fibrous change, there is scarcely one-quarter of the lung even approximately normal, and even that portion is sown through with fibrous nodules. These sketches shew you very fairly, as I think Dr. Macaulay will corroborate, the course of the disease, as one can see it with the naked eye. I don't say the colouring is absolutely accurate, as I am not an artist.

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11. Mr. Johns: Are sketches 3 and 4 from rock-drill miners? —*Dr. Macaulay* will explain: Yes.

Dr. Macaulay: In regard to number 4 this man had a mining life altogether of 12 years, 6 of which he spent in this country. Part of it was as a young man in Cornwall and another part in Iron Mines in America. He had a rock-drill life of 5 years and one year as a "shift boss".

12. The Chairman: May I ask, in passing, what material was found in the lung? Was it all silica or did you find any iron?—Dr. Macaulay: The analysis is included in our report. In regard to number 3 this man died at the age of 34. He started mining as a boy in the North of England at the age of 11, but had been out here for 7 years—at rock drilling all the time.

Dr. Irvine: I do not know whether the Commission wish to follow me in the description of the microscopic appearances of these lungs.

Dr. Davies: I think we might do without this. It is very interesting, but if we have Dr. Irvine's statement it will be sufficient. It will take a lot of time. His statement will appeal more to the lay mind of the Commission than the microscopical specimens will.

13. The Chairman: Dr. Irvine, were you going to allude to these specimens and point out where this is included?—Yes.

14. I think if you make a statement to that effect it will be sufficient.

My object was of course to convince the lay mind of the Commission and not the medical one.

15. Dr. Davies: Yes, but if you give a statement that silicious particles are found in these specimens and describe how they are found, I think you give quite enough information.—Very good. This drawing may help you to understand the way in which the disease developes. Here is a portion of the fibrous covering of the lung and here are the fibrous bands which divide the lobules from one another. You will find in looking into this drawing that along the arteries, along the veins, and along the air tubes or bronchi and in the pleura there run the minute lymphatic channels which I have delineated. The particles from the air go into the air cells and from there are carried in the lymphatic channels along the sides of the air passages, arteries and veins and the lymphatic channels of the pleura. Collecting there, the mineral particles give use to irritative changes resulting in the formation of fibrous nodules. The first of the sketches from microscopic preparations which I show illustrates the earlier stage of that change (Appendix C, Plate V), the second shows the further development of the fibroid change by the growth and coalescence of originally separate nodules (Appendix C, Plate VI). I don't wish anything I have said in regard to the pathology of the disease to contradict the views expressed in the portion of the report dealing with that subject. The description I have given refers to the purely fibroid type where tuberculosis is not present. Of course in a certain proportion of cases tuberculosis is present. A man may come out here already affected by consumption and develop miners' lung in addition. On the other hand the disease may start with miners' lung, and consumption be grafted upon it later on.

16. The Chairman: Is that an opinion or as a matter of fact have you found the two?—We have not made a sufficient number of sections to say in what exact proportion of cases the conjunction

exists, but tuberculosis is found to be present in a certain number of cases.

17. Dr. Sansom: In your experience have you an impression that very many miners come here because they are already affected with lung trouble and think they will be able to live in this country?—I think that amongst the miners, this country has a bad reputation, but I do think a great many do come already affected by miners' lung.

18. Could you give me a sort of an idea of the number, whether a large number or a small number, or a very small number?—No I could not.

19. Would you say it was sufficieutly large to pay attention to the fact?—I think you may take it in this way; the miner has a dusty occupation and this disease we believe to be mainly due to dust. The miner is exposed to dust from the very first. and therefore this change begins, if rot from the very first, very soon afterwards. It is therefore simply a matter of time, of the extent of the man's mining life, as to how far he is affected. Of course if a man has been mining for a considerable number of years, he will naturally come here so far affected, not perhaps enough to affect his working efficiency, but still he is to a certain extent affected by the previous similar conditions.

20. With regard to the clinical paragraphs is there any further amplification you can give as to the recognition of the disease in its earlier stages that would guide the miners?—I think the statements made in that section convey all I can give, they are chiefly shortness of breath and especially the diminished expansion of the chest, and recurrent 'colds'.

21. With regard to breathing through the mouth and nose, have you introduced in your report anything particularly about that, that men who breathe through the nose are less susceptible, and have you introduced anything in connection with the free passage of air through the nasal?—No, I have not.

22. I take it you quite believe this disease is chronic interstitial fibrosis?—I have recapitulated our argument on this here.

23. I suppose you acknowledge the air passages are lined with epithelium?—Yes.

24. Why is it that this epithelium does not protect the lung from the irritation of dust?—Because the epithelium has been provided to deal with man in his normal condition, and it therefore deals with a normal amount of dust, but it cannot deal with an abnormal amount of dust.

25. After a certain time the constant presence of this dust sets up an irritation which disposes of this protection?—Yes and it therefore penetrates into the walls of the air cells.

26. If this dust was not crystalline, do you think it would affect them in the same way?—Of course the harder the dust and the more angular and the more gritty, the more irritating it would be.

27. For instance here are some pictures of micr scopical appearances of various forms of dust (Appendix B). Do you think the form of dust in the mines is very similar to these?—Yes.

28. These are taken from various mines?—I can quite confirm that.

29. Have you heard of any other form of lung disease in

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which so much silica has been found after death?—I have not seen the analysis of a lung of a stonemason or of a potter, but they must come very close to this.

30. Unless by inhalation is there any other way of accounting for the presence of so much silica in the lung?—No.

31. Do you think the want of proper ventilation has any effect on the process of the disease?—I think the want of proper ventilation is bound to depress the general vitality of the worker which would render him more prone to disease.

32. What about the presence of irritating gases and so forth?—I have covered that question in this report, which I can give you.

33. I see in the report it mentions insanitary conditions as one of the causes In what way do you think insanitary conditions will cause this disease?—By depressing the general vitality.

34. Have you noticed any group of diseases on the mines, independent of this disease, due to deficient or to bad sanitation?—I have seen a good deal of pneumonia amongst underground boys and also meningitis due to the same organism.

35. The Chairman: Would that last effect be due to bad air or bad conditions?—Of course you get pneumonia above ground, but the underground workers, the Kafir boys, are subject to meningitis due to pneumonia and also pneumonia itself. I don't say it is entirely due to insanitary conditions, but I think it accentuated by them.

36. You think they predispose the boys?—Yes.

37. Mr. Catlin: That is clearly by reducing their resistance through depressing their vitality and not by any specific germ?—Yes, partly, but the specific germ is certainly there and probably the moist, damp atmosphere underground gives it a favourable condition to grow in.

38. Have you noticed a large number of cases amongst the boys of recent origin or did it exist before the war?—Oh, before the war.

39. At the present time we are getting a great number of raw boys from the tropical regions and they come up into a more or less rigorous climate. Would not that largely account for pneumonia?—The conditions of which I speak were made a special study of by Dr. Rogers and Dr. Davies before the war, and they could give you absolutely full information about that.

40. The Chairman: There is one case I would like to ask you about. You mentioned that a man had died out here, who had been mining in iron mines abroad.

Dr. Macaulay explaining: In America.

41. The Chairman to Dr. Macaulay: And when he came here you found particles of iron dust in his lung?—No, we found on a chemical analysis by Mr. Williams that iron and manganese were in the lung.

42. Which tends to prove there was foreign matter there?—Unquestionably.

43. Proving that the disease started before he came to this country although it terminated fatally here?—Undoubtedly that is so.

44. Dr. Davies to Dr. Irvine: Do you consider the contributing causes, which you have mentioned, are more likely to predispose to Miners' Phthisis than to pneumonia or bronchitis?—Oh, no.

45. What I want to get at is, that it is no more likely to predispose to Miners' Phthisis than to anything else?—Oh, no, you will

find on looking at our report that our evidence tends to show this is mainly a dust disease.

46. It shows dust to be the chief cause?—Yes. With regard to the causation of the disease, I think I would emphasise the following points. Miners' Lung is not a new disease, for miners in Cornwall are already well known to have the highest death rate from chest disease of any class in the United Kingdom. They have a very high mortality figure, so that Miners' Lung is not a disease peculiar to this country. The only new thing about it is the knowledge of its excessive incidence on the Rand. That is the only new fact. Secondly, the disease is one of a group, and does not stand by itself. The diseases in this group are so much alike that they are classed by pathologists under a single heading, viz., "the dust diseases of the lung". Dusty occupations are all prone to give rise to this particular type of disease, and all the occupations in question, the dusty occupations, have a relatively high death rate from respiratory diseases. If we take for example Dr. Ogle's figures, we find that fishermen have a respiratory mortality of 198, which is very low, but as soon as you come to occupations where dust is prevalent, it begins to rise. Operatives in cotton mills have a respiratory mortality of 543, quarrymen 582, cutlers 760, file makers 783, earthenware workers 1,118, and Cornish miners at the top of the list with 1,148.

47. The Chairman: Per what?—These are comparative figures. The general average death-rate from all causes, of all males, is taken at 1,000. Now Cornish miners have a general death-rate of more than 1,800, which is very nearly twice the average, while of that death-rate the figure 1,148 shows the contribution of respiratory diseases.

48. Mr. Catlin: You speak of the potter. The potter's occupation is not necessarily a dusty occupation, as the clay is wet?—Some of his operations may be wet but the stone mason or potter are classed together in these statistics and there is very high mortality among them.

49. Dr. Davies: You are speaking of the potter working at the wheel, are you not?—Yes. You will observe, I think, that the common element in these occupations is not dynamite but dust! The potter has nothing to do with dynamite, nor has the file maker, nor the cutler and nevertheless they all have a high mortality from disease of this type. That is the point I wish to bring out, that the common element in these trades is not dynamite or fumes of any description but dust. Not only so, but the causative agent can be demonstrated in the tissues in every case, in the file maker's lung small particles of steel, in the earthenware worker's silicious particles, in the coal miner's abundant presence of particles of coal dust. The disease most closely related to the Miners' Lung we are now considering is the Ganister Miners' Lung which like "stone mason's lung" is a silicosis; indeed it is practically indentical with the Miners' Lung as we find it here, and I would ask the members of the Commission, if they have the report of Dr. Andrews contained in the Factory and Workshops Report of 1900, to compare the drawings he gives, with those I have given, and you will see they are identical. If you want further evidence between the connection of Miners' Lung, as we meet it here, and this group of dust diseases, I would point out that the clinical history during life, and the post-mortem appearances after death, as we find them here, are quite parallel to the descriptions given in the pathological text-books of the dust diseases; and, thirdly, I would point out that microscopic examination not only shows particles of dust in

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the lungs, but shows *their constant association with that formation of fibrous tissue which is characteristic of the disease.* So summarising this line of evidence we may say:—Workers in dusty trades are prone to chest disease of a difinite type, fibrosis of the lung. Mining on the Rand and especially rock-drill mining is unquestionably a dusty trade, and the type of chest disease found amongst the miners here is also of that definite type, namely a fibrosis of the lung; and, fourthly, the presence of the constants of rock-dust in the lung can be demonstrated. These are the lines of evidence, on which we rest our case that this is mainly a disease due to dust. With regard to the question of dynamite fumes as a factor, I would have you note that, while miners are practically continually exposed to dust, they are not so continuously exposed to dynamite fumes. It is only during certain portions of his working day that the miner runs any risk of being exposed to dynamite fumes. Dynamite fumes cannot cause a silicosis and therefore their effect must be limited to the possibility of their causing catarrhal changes which prepare the way for the entrance of silica, and also of their causing a depreciation of the general vitality. Now the fumes of normal blasting gelatine, when fully exploded, are known. They are CO_2, H_2O, N, and O, none of them being irritants. The incomplete combustion of dynamite, or the explosion of impure dynamite, undoubtedly does give rise to irritant gases, of which the important one is Nitric Oxide (N. O.), which is rapidly oxidised to NO_2 and it may be admitted that a certain percentage of NO_2 may be present in the dynamite fumes after blasting. Therefore we may allow a subsidiary position to dynamite fumes in producing and maintaining these catarrhal changes in the bronchi and air cells which we find in Miners' Lung, but we consider their importance in producing these changes is a subsidiary one. Dust itself is quite capable of causing catarrhal changes also, and does so. Further, we may allow that the irritation of mineral oils, found in the exhaust air from the rock-drills, may also be an irritating factor, and of course the deterioration of the air from the presence of gases such as CO_2 and CO will, if allowed to remain in the air of the mine through lack of ventilation, deteriorate the general health of the miner. I do not think, however, that the chief importance can be given to any other factor than that of the dust, but we have none the less laid especial stress on the necessity for adequate general ventilation of the mines.

50. The Chairman: Are you prepared to say what proportion of CO_2 is injurious in the air?—You can easily find that out. It begins to produce effects when it comes up to 3 per cent. and serious effects at from 8 to 10 per cent. but is not usually fatal until it rises to 20 per cent. or more.

51. 10 per cent. would be rather high for a man to work in for any length of time?—Certainly.

52. Mr. Johns: Do you find workers on the tailing dumps of the mines suffer from the same disease?—No, I do not think that I have noticed any respiratory disease amongst them.

53. What would be the reason for that?—I should say that the amount of dust inhaled is not so great, as they are working in the open air.

54. The Chairman: Do you think that dust is of the same degree of fineness as rock drill dust?—That I cannot say, as I have not compared them in that respect.

55. Mr. Johns: There would be some very fine dust and on

windy days the boys and men on tailing dumps are in greater clouds of dust than they would be in a mine unless exceptional circumstances such as drilling a dry hole or starting a new wet one.

56. Dr. Davies: When you say you have not found this disease amongst those working on tailing dumps, have you made any special investigations as to those particular persons?—No, except that they do not come to me complaining of chest diseases in any exceptional degree.

57. What is the class of man working on tailing dumps?—On the Crown Reef mostly Dutchmen.

58. How long have they been working?—A very short time.

59. From your experience would you be justified in saying that it had not some effect on their lungs?—I should certainly say that, if they worked long enough, is certainly would, but I have made no personal investigation.

60. As far as your experience goes, you do not know, that men working on tailing dumps do get it?—As far as my experience goes, I do not know that they suffer from respiratory diseases.

61. You do not deny the possibility that they may?—It is unlikely, unless they were at it a very long time.

62. I want to get at this specific fact. The point of the question that has been raised is to possibly minimize the value of dust as producer of phthisis, and, if it can be established that the workers on tailing dumps do not get Miners' Phthisis, then it lessens the evidence in favour of dust actually being the cause, and I want to know whether your experience is sufficient to show that these men do not suffer?—My experience is not sufficient to give a decided answer.

63. Dr. Hawarden: Don't you think there is an enormous amount of mortality amongst Kafirs which has never been investigated?—I quite agree with you, and I think you will find that mortality by investigating in the kraals. The Kafir boys do die of phthisis in the compounds but nevertheless not in such high numbers, but what I think happens is that as soon as the boy begins to be affected, he goes home and does not come back, and, if you went round the kraals, you would find a fairly large number dying of this disease, for undoubtedly one does see amongst the natives cases of the type of fibroid phthisis as among the white miners.

64. Don't you think that this only came into prominence lately and the boys discharged from the mines must have been affected and that there must have been a tremendous mortality in their own kraals?—Yes.

65. Very few of the old stock of boys have returned?—Yes.

66. We are now starting on a new set of boys?—Yes, largely.

67. Mr. Johns: It is not likely that the number of boys who have died from that disease would be comparatively very few?—We find that as a rule the boys on the mines do not usually remain nearly as long as the men who die from Miner's Phthisis?—That of course is an important point, viz., that the boys do not stay very long as a rule. Nevertheless you find that they suffer. One boy under my observation has been on a mine for nine years, but there are the two factors, that the boys do not as a rule remain here for a long time and consequently do not run the same risk of contracting the disease, and when they do contract it, they set out for their homes and die there.

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68 Dr. Sansom: The point is, supposing a boy stayed only two years or less, if he contracted the disease the probabilities are, in fact it is almost certain, the disease would go on and he would die?—I do not think he would contract under two years.

69. How long would you give a boy working at rock-drilling on a mine here in order to contract the disease?—I should say a shorter time than the white man because he is usually stationed closer to the drill and does not go away, as the white man has an opportunity of doing.

70. Do you think he would contract it in two years?—I do not think so. He would not be a clinical case of Miner's Lung in two years.

71. The Chairman: Is coal miners' lung and metalliferous miners' lung the same thing?—They are all of the same type of disease.

72. Is not coal dust amorphous?—The death rate from respiratory disease amongst coal miners is not high, and although coal dust can cause this disease, the coal dust itself is not nearly so irritating as the rock-drill dust we have to deal with here.

73. Dr. Porter: I want to ask Dr. Irvine, if he is aware that in the process of hat manufacturing, where the hats are subjected to sand papering, the finishers, as they are called, die in very large numbers of fibroid phthisis?—I noticed an article on that in the British Medical Journal some time ago, but beyond that I have no knowledge.

Dr. Porter: That is so.

74. Dr. Hawarden: Regarding this question of nasal obstruction I really think miners whose nasal airway is obstructed are more liable to contract the disease?—One would naturally expect so because the nose is the strainer of the dust and not the mouth. I should certainly expect a person, who breathes through his mouth, to contract the disease more quickly.

75. The Chairman: You have not noticed it in any particular case?—No.

76. Mr. Johns: What would be the difference in the lung disease millers would die of and Miners' Lung?—Flour is a much less irritating factor and statistics I could give you show a comparatively low mortality.

77. Would the lung be affected in the same way?—Only to a much less extent. The more irritating the dust, the more extreme the change and therefore the coal miner who works in a dust not so very irritating, suffers much less than the miner who works a rock-drill here, where the dust is more irritating. The only other thing I wish to show the Commission is a respirator which has been in use for some weeks. I have also specimens of the flannel after the men have worked a shift with one of these respirators on. A double layer of flannel is always used and you can see that the dust is pretty obvious. The men have found them very satisfactory and they like them.

78. Dr. Porter: I would like to ask Dr. Irvine, whether his experience with miners has been the same as with the workers in hat factories, that, although you recommend these respirators, there is a great deal of objection to wearing them, so intense almost as to neutralize their possible usefulness?—I have found miners so scared that they are very willing to wear these and they have taken them up

very willingly indeed. Men who have worn them longest speak of the benefit they derived after a five or six weeks use, and state they feel better for their use and have lost the feeling of dryness in the throat before complained of. Dr. *L. G. Irvine.* 17th Dec. 1902.

Mr. Drake: I think that is well recognised. Before the war miners were against the use of anything of this sort, but since the war they are only too glad to use them.

79. Dr. Hawarden: Speaking about the possibility of irritating gases, do you think it possible that NO. gas can be inhaled without causing any symptoms?—I think any irritant will produce a certain amount of effect.

80. I find that in the early stages miners will not admit tubercular symptoms?—How can you call them early stages?

81. I take it that in the early years of his work the miner is affected, but he will not perhaps admit to any bronchial irritation?—My experience is that very few miners under five years do show much obvious sign, but they are getting it all the time.

82. Do you think nitric oxide gas is a contracting cause?—Yes, I think it is subsidiary.

Dr. Donald Macaulay was called; and examined.

83. The Chairman: You are Dr. Donald Macaulay, M.A., M.B., C.M, Edinburgh?—Yes. Dr. *D. Macaulay.* 17th Dec. 1902.

84. You are practising on the Witwatersrand as a mine doctor?—Yes.

85. For how long have you been practising on the mines?—Since the beginning of 1897.

86. I understand you have been associated with Dr. Irvine in investigating the causes and extent of Miners' Phthisis?—Yes, I was a member of the Committee of the Transvaal Medical Society that drew up this report and I have been collaborating with Dr. Irvine in the preparation of these drawings (Appendix C).

87. Can you bring before the Commission any evidence of cases you have personally attended, other than the mere information you have gained in your research into Miners' Lung?—Two of the drawings shown you by Dr. Irvine were from post-mortem specimens I supplied.

88. Was there any evidence to lead you to believe that the disease had already started before these persons came to this country?—In the case of the lung of John Tregonning, illustrated in one of the drawings and of which Mr. Williams made a chemical analysis, there is present both manganese and an amount of iron in the lung tissue.

89. I see the analysis is given in the report of your Committee?—Yes.

90. What leads you to believe he contracted the disease before he came?—The presence of iron and manganese in his lung and also the history of his having worked in iron mines in America.

91. Previous to coming to this country?—Yes.

92. Is that the only case you are acquainted with of a man having contrac'ed the disease before arriving in this country?—As far as I have been capable of ascertaining, but the matter is very difficult to ascertain.

93. As to the question whether men come here for the sake of their health, in your experience have you ever found that to be the case?—A man, whose health is already bad, would certainly not come

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to this country to engage in mining occupation again. He might come to engage in other occupations but not to work in the mines. That many of them are previously affected is of course possible without their being actually aware of it.

94. In your experience do you find a miner is unaware that he has contracted the disease until it is very far advanced?—Yes.

95. It is usual for a miner to consider himself in perfect health and it is only suddenly that the disease appears?—Sometimes it appears suddenly and is occasionally discovered by the man's medical attendant before he himself has any knowledge of it.

96. Have you any reason to believe that going to a moist climate brings it on, when otherwise it might lie latent?—I have no reason to believe that.

97. There is a view prevalent that during the war this disease has shown itself, owing to the fact that miners have gone to moist climates which has made the disease more noticeable?—It is very possible that in a lung already disabled, the causes which produce tuberculosis at home and at coast ports would be more liable to act.

98. You are of the same opinion as Dr. Irvine that dust is the chief cause?—Yes, dust is the exciting cause.

99. Were you connected with mining before you came to this country?—No.

100. What is your opinion about irritating gases and the presence of vitiated air in assisting to cause the disease?—I think they are a large help in predisposing to the disease. I think the catarrh produced by irritating gases and insanitary conditions generally favour the entrance of the particles into the lymphatic channels which open in the Bronchi and likewise in the air cells.

101. Dr. Sansom: You believe the disease, we are called upon to consider, to be a chronic interstitial fibrosis of the lung and to be caused by dust?—Yes. With regard to phthisis in natives, we have not had time to make an exhaustive investigation, but I find on the Treasury Mine, for instance, out of 43 deaths since the new regime, 13 were cases of phthisis and of these thirteen twelve were underground boys and one was the assayer's boy.

102. Have you reason to believe it was Miners' Lung they were suffering from?—Not the same Miners' Lung as you get in the white man, but I stated this to show that tuberculosis is common among the boys.

103. Mr. Johns: Was it known whether those boys, you have mentioned in connection with the Treasury Mine, had been employed in the mines before the war?—Very few of them. They were new boys.

104. Dr. Porter: I should like to ask you about the question of phthisis amongst the natives. I have noticed in my returns that there is a considerable proportion of deaths amongst natives from this. It is returned as phthisis, and I should like to know whether that in your opinion is tuberculosis or Miners' phthisis?—I think it is mere tuberculosis.

105. And do you think the conditions under which they live account for that?—In hurrying up the process, yes.

106. Dr. Sansom: Do you think it is really tuberculosis or broken down pneumonia?—There are both.

107. Which do you think the commonest?—I think the larger proportion due to tuberculosis.

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108. Dr. Davies: Have you been able to make investigations as to the presence of bacilli?—No.

109. Then you are not giving it from actual fact?—Not from pathological experience, only what I believe.

110. Dr. Porter: Can you say whether the natives are naturally in their kraals exceedingly liable to phthisis?—I can only say that some boys come to the mines already suffering from phthisis.

111. The Chairman: You mean raw boys who have not been here before?—Yes.

112. Mr. Catlin: I should like to ask whether any case of fibrosis of the lungs has ever been discovered amongst natives not working on the mines. I refer to winter time here, when there is a great deal of silica in the air, and would like to know whether any cases have been observed in common practice?—I am not able to give evidence on that point.

Mr. Catlin: The amount of silica in the air here at times is very considerable, nearly as much as in dusty drives, and I was curious to know if it had produced any such cases.

113. Mr. Drake: In these cases in which you have examined the lungs, you mentioned a little while ago that the gases would predispose the boys to this condition. Did you examine the air passages to see if they were as they ought to be?—We found, in all cases which we have examined of the disease, that some of the bronchi are obstructed and all showed the features described in our report.

114. Can you tell whether that is due to the gases or to the dust?—No.

115. What I want to bring out is, you told Dr. Sansom in answer to a question that the gases predisposed the boys to this condition, but you have no proof?—No, except that the irritating gases will of themselves cause catarrh, if persons are subjected to these gases long enough, and catarrh is probably the first stage in this process, or, if not the first stage, then very nearly.

116. Dr. Davies: I want to ask you one or two questions. Any irritating gas will cause catarrh of the bronchial tubes if breathed for any length of time?—Yes.

117. It will go on also to cause broncho-pneumonia?—It will.

118. And dust in small quantities will cause catarrh?—Yes.

119. And going on further will cause chronic broncho-pneumonia?—Yes.

120. Either of these two causes may lead to the same thing he ultimate stage being the fibrosis?—Yes.

121. Dr. Macaulay states that catarrh and broncho-pneumonia may both be caused either by dust or gas?—Yes.

122. But that gas would not cause silicosis, which is caused by the inhalation of dust?—That is so.

123. And this disease is silicosis?—Yes, the disease which we are investigating.

Dr. W. G. Rogers was called; and examined.

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124. The Chairman: You are an M.D., M.S, London, and M.R.C.S. and L.R.C.P. of England?—Yes.

125. You are practising on the Witwatersrand?—Yes.

126. Have you had much experience on mines?—A fair amount but not a very great deal.

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127. For how long have you been in contact with the mines?—About two years altogether, actually with the mines as a mine medical officer.

128. Is that two years dating from the present time?—No, during the nine years I have been here, I spent two years altogether actually on the mines themselves.

129. At what time were you most intimately in contact with the mines?—Well, I am now. I see the miners now at my consulting rooms.

130. Have you noticed this disease?—Yes, I began to notice it first about two years before the war commenced.

131. Was it very prevalent?—I should think it was fairly prevalent then, but, when death took place, it probably would not be attributed to that cause, but ordinary chronic pneumonia.

132. Are you of opinion that the persons, who die from this disease, have as a rule been ill on the mines? They left the mines in consequence and went to the hospital and were thereafter lost touch of?—Yes, that must have happened in many cases.

133. Therefore the death rate was not noticed previous to the war; whereas during the war, when the miners were all waiting at the coast towns or went home to their friends, their illness was at once apparent and any deaths that occurred were noticed?—Yes.

134. Is that possibly the cause why so much attention is now being paid to Miners' Lung?—Yes.

135. But it is no new disease?—No.

136. I think you heard the evidence given by Dr. Irvine and Dr. Macauley. Does that evidence agree with your opinions?—Yes, I was also a member of that Committee.

137. Dr. Sansom: There is nothing in this report that you object to?—No, I am in agreement with the whole of it.

138. Is it your experience that miners come to this country because of previous ill-health, hoping to prolong life here?—Not at all.

139. You found that the disease is a chronic interstitial fibrosis of the lung caused by dust?—Yes.

140. What part do you think, irritating gases may play in that disease?—At present it is very hard to say. The evidence we have is microscopic and pathological, which entirely points to its being a dust disease.

141. In your opinion, if gases were absent, the disease would remain?—Yes, if the dust remained.

142. Do you think it would prevail to as great an extent?—No, I think that, if the places in which the miner works were perfectly ventilated, although the dust would still remain, it would take very much longer to affect the miner.

143. You think the gas irritates the respiratory passages first and allows the dust to do more harm than it otherwise would do?—Precisely.

144. Unless this dust was inhaled, you could not account for so much silica being present in the lungs after death?—No, to no other method.

145. Dr. Davies: You have come across a certain number of cases of death from this disease?—A good many.

146. In your own personal experience, what is the shortest

period of working in a mine that has caused death through this disease?—Three years.

147. Did the patients, who died, have any previous mining experience?—There were several people who died after very little under or shortly over three years of mining.

148. Would you mind giving a short statement with reference to any particular case?—Yes, the men I noticed particularly were in the South African Light Horse. They had been rock-drill miners for short periods before the war up to four years. They were not in the mines from the time they joined that regiment until they came back here, and then they did not go back to the mine. They died here in from five to six years, the last two of which they had not spent in the mines at all, and yet they died of Miners' Phthisis.

149. Do you consider their deaths were caused by Miners' Phthisis?—Undoubtedly.

150. Can you say whether in the interval of two or three years, while they were not mining at all, they were perfectly free from symptoms of the disease?—They appeared to be.

151. While living on the veld?– Yes, they appeared to be absolutely free from any symptoms and in good health.

152. Do you consider that the very fact of their coming back was sufficient to cause a fresh outbreak of the disease or what reason caused their deaths?—Personally I have not been able to decide, why it should break out when they return, but I suppose such causes as exposure or drink might be sufficient, certainly in one of the instances, drink might have brought on an attack of pneumonia.

153. An acute attack of pneumonia that followed on a damaged lung?—Yes.

154. Mr. Drake: You stated miners do not come out here who are already in ill-health or predisposed towards consumption?—Not if they know they are.

155. You would not say that in the case of the man we have here, whose lung was analysed and contained iron, you would not say that he did not have Miners' Phthisis when he came?—No, he had it, one of the other varieties.

156. I presume when you said that men in an unhealthy state do not come here to work on the mines, you mean as other people come here for the sake of their health?—I mean miners do not look upon South Africa as a kind of health resort.

157. Mr. Johns: Is it your opinion that many of the cases of Miners' Phthisis that occurred during the war, were due to the change of climate, men going from here to another country?—I don't think so. I thought it was simply the termination of the natural course of the disorder.

158. But have you compared the numbers of the rock-drill men of the Rand, who died during the war, with the numbers who died before the war for the same period, as I think you will find they were very much greater?—Would not that be on account of the fact that a great many more commenced to do rock-drill work, say two or three years before the war, than had commenced say eight or nine years ago, and the cases were only noticed because of a large number being away at one time.

159. Yes, but then many of the rock-drill men who died during the war had worked rock drills for probably 12 years, and were apparently in perfect health before the war; some of the cases I know

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myself?—Yes, of course it is possible that the change to a cold climate might be sufficient, but on the other hand, I have often sent men suffering from rock-drill Miners' Phthisis to the sea and they have frequently improved.

160. Has it not been proved that exposure has brought the disease on more rapidly to the finishing stage?—Yes, exposure would do so nearly always.

161. Dr. Davies: Do you think the fact, of our not having so many cases reported before the war, is due to the disease not being recognised as silicosis?—Yes, I said that in reply to a question that was first asked me. I think a good many cases of Miners' Phthisis were returned as pneumonia or ordinary phthisis before it was recognised to be silicosis.

162. It would have been impossible in the early stages to have recognised it at all, as the disease takes a certain number of years to develope? Precisely.

163. Even after that, I take it, it was not recognised for some time?—Yes; within my recollection it was not until 1897 that we first began to notice it. I think we had specimens about that time.

164. Mr. Johns: I think you will find that most of the rock-drill men, who had worked the drills up to 1895, were men who had worked for many years before that.

165. Dr. Hawarden: The process once started goes on to its ultimate end?—I believe it does, if the exposure is sufficiently long. I believe the man who works from three to four years and has acquired the disease at the end of that time—my own impression is, though not borne out by actual observation—is that it is fatal.

166. Sufficient damage can be done to the lung and he may die of it?—Yes.

Dr. William Dyer Frazer, M.R.C.S., England, and L.R.C.P. London, was called; and examined.

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167. The Chairman: You have been in practice in the Witwatersrand for some time?—Yes.

168. How many years?—Only about 18 months before the war.

169. Have you been all that time in close contact with the mines?—Yes, during the whole time.

170. Can you give the Commission any evidence as to cases of Miners' Phthisis that came within your own personal knowledge?—I have had a considerable number passing through my hands. During the last 2½ years I have examined about 150 miners, who had distinct evidence of Miners' Phthisis.

171. Can you give any evidence in regard to the extent to which it prevails at present?—I don't think I can give you evidence of any value, but my own opinion is that the vast majority of men, who have had anything to do with rock-drills for a year or two, are affected.

172. Although they don't know it themselves, by actual observation you know it and have examined these men?—Yes, and generally they have got the doubtful symptoms and have not good chest expansion.

173. The men at that time are ignorant of it?—Yes, as a rule they are quite ignorant, but they are all getting anxious now.

174. You have seen this report drawn up by the Transvaal Medical Society?—Yes.

175. Do you agree with the symptoms there described?—I quite agree with that report.

176. You have noticed symptoms after two years?—As I say, it is the very initial symptom, the difference of expansion, and a certain amount of immobility.

177. But sufficient for a Doctor to see?—Yes, sufficient to be suspicious.

178. With regard to the extent to which it prevails amongst the miners, can you convey any impression to the Commission?—I should think it is general under the present conditions of mining as far as rock-drill men are concerned and the old men, who have not touched rock-drilling, do not seem to be affected to the same extent. They have symptoms but these differ considerably.

179. Have you had any experience with regard to miners, engaged in what is called stoping, suffering from this disease?—Yes, I have had experience of timber men and men in shafts who have been affected, but they have been at mining all their lives and are older as a rule.

180. But not at rock-drilling?—No.

181. With regard to irritating gases, have you had any experience of gases underground?—Very little.

182. You have not come much in contact with the gases in blasting?—No.

183. Have you gone through the whole of this report?—Yes.

184. Do you agree with all that is stated there?—Yes, entirely.

185. And you believe the disease, we are investigating, to be a chronic interstitial fibrosis of the lung and caused by dust?—Yes.

186. You have heard some of the questions we have been asking Dr. Macaulay and Dr. Irvine; is there anything where you differ from them in their answers?—Well, there is one point where I differ considerably. Dr. Macaulay referred to the prevalence of tuberculosis amongst the Kafirs and sometime back for 18 months I had one lot of 8,000 boys under my medical care, when I was specially struck with the abscence of phthisis as far as ordinary clinical symptoms go.

187. The absence of Miners' Lung?—No, of ordinary tuberculosis, and the reason, why I was struck with it, was because I knew the number of deaths put down to phthisis amongst the natives,

188. Dr. Davies: In speaking of this large number of natives, whom you had under your care and looking over the returns of the deaths, did you notice whether a large number were returned as pneumonia, as I understand you to say that very few cases were returned as phthisis?—No, I cannot. I was particularly looking after the boys in the hospital and I generally had 150 or 200 boys in the hospital compound at one time.

189. They were under your medical care?—Yes.

190. I beg your pardon, I did not understand. Did many of these cases under your care die of pneumonia?—A good many, but the majority of them died of some obscure wasting disease.

191. Without any lung affection? Practically no lung affection at all.

192. Mr. Drake: In speaking of noticing timber men and shaft men, who had this phthisis, would you say they had contracted the disease before they took on these occupations and probably while mining in other countries?—The majority of them had been mining here since the early days, and I am afraid I could not give any

Dr. W. *Dyer Frazer.* 17th Dec. 1902.

evidence, as to whether in their previous mining life they contracted phthisis, or whether they did so here.

193. But as a matter of fact is it not true, that there is no dust to speak of where timbermen are working and also in sinking shafts?—In sinking shafts I should say there is a tremendous amount of dust.

194. Most of the shafts are damp, not to say wet?—Of course I am only giving you the facts as I get them from the men.

195. (*Mr. Johns*): I think that as a general rule that a timberman is one who is trained from boyhood to mining?—Oh, they are all old miners?

196. Mr. Drake: The reason why I wished to ask that question, was to try and bring out, if possible, that these men have got the disease somewhere else rather than here, as, being engaged in these operations here, they must have got the disease elsewhere?—But there is a considerable amount of this dust floating about whatever part of the mine you may take. In the unventilated portions you get it at the maximum, but the dust and silicious particles are all over the mine.

197. That is rather an important statement, because very often rock-drill miners throw up their work for some time and become stopers in order to get fresh air and get away from the dust, but in your opinion they don't?—Not entirely by any means.

198. Mr. Catlin: I would like to ask whether the 8,000 natives had been employed in mining?—Yes, all of them, They had been here during the war and were taken on by the railway. They were old boys.

THIRD DAY.

CHAMBER OF MINES, JOHANNESBURG.

Wednesday, 7th. January, 1903.

PRESENT:

Mr. H. Weldon, (*Chairman*)

Dr. C. L. Sansom. | Dr. S. Hawarden.
Mr. Francis Drake. | Mr. E. Perrow.
Mr. J. Stratford, *Secretary.*

Dr. John Law Aymard, M.R.C.S., L. R.C.P., was called; and examined. Dr. *J. L. Aymard.* 7th Jan. 1903.

199. The Chairman: You are at present practising at Krugersdorp?—Yes.

200. And I believe you hold an appointment as doctor to some mines in that district?—The French Rand Gold Mining Co., Ltd.

201. You wish to make a statement?—I was asked to make a statement.

202. Would you rather make your statement or be examined?—Just as you please.

203. Then will you read your statement?

The witness then submitted the following statement:—

I have made a personal study of this subject for the past nine months and have made numerous visits underground for this purpose.

I consider that the inhalation of rock drill dust to be the primary cause of the disease, but also think that the breathing of gases must also play an important part in the disease.

The question whether chronic carbonic oxide poisoning is prevalent amongst miners should receive attention, revealing itself by the presence of anæmia and altered conditions of the blood, easily recognised by the spectroscope.

The worst working places in mines are raises, owing to the somewhat primitive means available to the miner for transporting his heavy machinery up and down the raise, and, the at present considerable time employed in rigging it up, the miner is not disposed to adopt any measures likely to give him much further trouble.

I have examined from time to time the various respirators which have been sold or issued to miners.

I am of opinion that the same will never be constantly or effectively used, nor do I consider that their present mode of construction warrants that they should be.

My chief objections are: 1. That they are not made adaptable to all faces; 2. That the valves seldom act properly and no provision is made for cleaning; 3. Further, the extra effort necessary to inhale through an effec-

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tive filtration medium causes discomfort to the wearer, and for this reason will eventually be discarded.

I believe that no miner would ever suffer from phthisis if he were to breathe only air which had been compressed.

The impurities to be found in compressed air are entirely avoidable. Good oil used in the compressor and effective drainage cocks, etc., would tend towards the production of pure air.

The smell of sulphuretted hydrogen occasionally complained of as coming from the air compressor, in my opinion is fallacious. This smell is frequently produced when drilling pyritic rock, and is avoidable.

The practice of oiling the drill by pouring oil in the hose pipe should be discouraged, as this will decompose the rubber.

The presence in small quantities of petroleum oil in the compressed air, I think, would be more beneficial than otherwise.

I have examined old hose pipes and always find that the rubber is in a perfectly natural state, this shows that no large amount of oil reaches to this distance. The destruction of hose pipe proceeds from externally.

The large extent of sulphur used with the rubber causes the same to crack and become destroyed thus enabling moisture to come in contact with its canvas lining, which rots, and the pipe bursts.

I can see no reason why the air from a compressor should not be used to constantly supply the miners. I have found that such a system answers admirably and is extremely simple. The miner at present working in a raise breathes nothing but the exhaust air from his drill impregnated with dust. I most strongly recommend that he be induced to breathe the air before it reaches his drill.

I have experimented with a filter, but am inclined to consider it unnecessary.

I now use a simple inhaler connected by six feet of small flexible metallic tubing with a T piece placed between the hose pipe and the air cock on the drill. The same having a small plug tap.

The consumption of air is only one per cent. of that used by the drill, and the safeguard to waste is to be found in the fact that any excess is unpleasant to the miner, who regulates his plug tap accordingly.

Further, the inhaler need not necessarily fit so accurately, as the constant pressure of air prevents the ingress of dust.

The miner much appreciates the refreshing cool air and ease of breathing.

This simple apparatus is inexpensive and fitted in a few seconds, whereas the miner can instantly release himself if necessary.

GASES.

With regard to the gases produced by complete and partial explosion of dynamite, I think every effort should be made to control the same.

I consider that the introduction of water, especially when rendered alkaline, should play an important part in neutralising these gases.

(The witness produced a respirator, the working of which he explained to the Commission.)

204. The Chairman: Are any miners working with this respirator? —Yes in raises.

Mr. Drake (to the Chairman): I think we should have miners to give evidence as to its value later on.

205. The Witness: You will notice that I have used metallic hose in preference to ordinary rubber tubing, because ordinary rubber keeps stiff when it is new but very soon crinkles, while the metallic does not kink or get in the way of the men when they are working. I am of opinion that all inhalers should be made so that you can clean them. I have used a rubber disc for the valve on the inhaler in preference to anything else, as it can be easily renewed and it is very light. I only use one valve because if there are two one is apt to close imperfectly. I think if these are made they should be manufactured in brass and nickel plated.

206. Mr. Drake: Could you make them of aluminium?—Aluminium would be very good, only there is a difficulty as to making a joint. I find that if you give miners elastic to put over their ears they generally put it under, and therefore I have gone further, and I am making something in the form of a cap with hooks attached to the side of it to which the inhaler is fastened.

207. The Chairman: What must a miner do if he wishes to leave his drill?—He can unhook the inhaler and leave it on the handle. The miner appreciates the inhaler because as soon as he puts it on he finds the air so cool.

208. What filter do you use to filter the air from the Compressor?—None at all.

209. Then you do not filter the air from the compressor?—I did at first, but I have constantly used this inhaler myself and I find the air from the compressor quite good.

210. How many different compressors have you tried it on?—Only on the French Rand.

211. Sometimes you get a good deal of water in the compressors?—Yes, on the French Rand second level they complain of a good deal of water, but it does not pass to the inhaler.

212. The only thing you would suggest in the use of your inhaler is that precautions should be taken to prevent water getting into the air pipes and to ensure that good oil is used?—That is so.

213. Dr. Sansom: How many hours do the miners use this inhaler? During the hours of the shift.

214. How many hours would they use it then?—They don't require to use it the whole eight hours of their shift, because they are part of the time rigging up.

215. The Chairman: Do you consider it necessary only to use the inhaler when dry holes are being put in, or during the whole time?—During the whole time.

216. In your opinion then, gas is a potent cause of miner's lung?—I would hardly go so far as that, but I think that the evidence of Mr. Weiskopf and others is extremely important. We have frequently had cases of poisoning by gases, and the notion of nitrous fumes must be of importance.

217. Do you think that the inhaling of this gas is connected with miner's phthisis?—I think it reasonable to say it is. I don't see how we can very well prove it because no man works only in gas or only in dust.

218. What gas is it?—Nitrous and carbonic oxides principally.

219. What are the formulæ of the particular gases you refer to?—I have not tested these gases, and I do not think that I am qualified

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to state what they are because I have not had an opportunity of chemically testing them.

220. You would not say any particular fumes in a mine caused miner's phthisis?—I have found the same smell produced by nitrous acid in the laboratory present in the mines, and I am inclined to think that carbon dioxide gas is the most constant.

221. You would put that down as a cause of phthisis?—I would say that it is one of the assisting causes.

222. Could you enumerate the gases which you consider injurious, as that is rather an important point?—I do not like to make statements that I have not had an opportunity of practically proving.

223. This all leads to the question I asked as to whether the inhaler should only be worn at the time dry holes are being put in or all the time, and your answer was that gases are always present?—No, I say in some places gases are always present.

224. Yes, but as long as the gases are present you think these inhalers should be worn, and in your opinion the gases do have an effect on phthisis?—In my opinion, as soon as the miner starts working the drill, the gases must be disturbed.

225. Then gases do cause, or assist to cause, miner's phthisis?—In my opinion gases are one of the predisposing causes.

226. You have not investigated the exact nature of such gases?—No, I have not.

227. Mr. E. Perrow: Has not a miner got a good deal to do before he starts the rock drill, such as rigging up his machine?—When he goes on his shift he may find that the man in the shift before him has already rigged up.

Mr. Drake: But there must be an interval.

228. Mr. E. Perrow: After blasting the holes the miner has to clear out the loose ground, and I want to know whether he wears the inhaler at that time?—No, I don't think he would. A man cannot wear this inhaler when he is moving about, but only when at work on the drill.

229. I think the miner usually has two or three hours' work before he starts the drill?—Quite so.

230. The Chairman: What Mr. Perrow wants to bring out is that gases are present when the man goes on his shift?—I do not think I advocated this inhaler as a protection against gases.

231. Quite so, only against dust?—Yes. It is far better that a man should breathe through an inhaler such as this, which will keep out the dust, but this will not get over the gas difficulty.

232. In your opinion all the same, this gas is one of the causes?—Yes, and I think steps must be taken to counteract it as far as possible.

233. Dr. Sansom: I do not follow the line Dr. Aymard took up in his statement, but I would like to ask him whether he agrees with some of our former witnesses with regard to causation. Do you believe the principle factor in the causation of miners' lung is dust?—Yes, I do.

234. Have you made any post mortems on any of the men who have died from this disease?—I have seen only one post mortem.

235. What was your impression from that?—Undoubtedly the dust had accumulated in the glands, and there was evidence of some in the pleura.

236. Was that sufficient to cause death?—I think a

man's lung may be in a very bad condition for some time, and it is an acute attack on his chronic condition that eventually finishes him.

237. A certain amount of dust in a man's glands would not cause his death?—No. I did not see the lungs microscopically, but I could see it was very hard and gritty to cut. The bronchial glands were infiltrated pretty extensively, and round the bronchial vessels it was very hard.

238. Can you give me an idea of the condition of the lung?—Well, I made no microscopic examination.

239. But we have been having naked eye appearances described to us?—The air vessels were considerably congested.

240. That might be bronchitis?—Yes, it might.

241. You see we are dealing with this special disease?—Well, making the section through two or three portions of the lung, I could see it was very hard and gritty, and in places there were apparently nodules of accumulated grit.

242. That is the only case you have seen?—Yes.

243. What is your general impression as to the condition of the lung in those cases you have examined clinically?—Have you come across many?—Yes, a considerable number, and I was certainly surprised to find that you don't get more dulness.

244. Why do you expect that?—I should have thought that in advanced cases you would get dulness from chronic inflammation which probably takes place.

245. Do you think there is chronic inflammation in the advanced cases?—Yes, I think so.

246. What form does this take. As you know, there are various forms?—I think there is a considerable amount of fibroid tissue.

247. Then you think this disease is caused entirely by dust?—I would like to add that on examination I have found very little evidence of any temperature as in ordinary phthisis.

248. Do you think miner's phthisis is caused entirely by dust?—I think it reasonable to suppose it is caused entirely by dust. The foundation of the disease is dust, but the gases must weaken the tissues to a considerable extent.

249. It has been shown by a large number of post mortems here that this disease corresponds very much to stonemason's phthisis?—Yes.

250. Stonemasons are not exposed to gases —No.

251. How, therefore, would you account for the same conditions amongst stonemasons as amongst miners?—Has it not been proved that the death rate is much higher amongst the miners here?

252. Of course, you have miners here in a confined space, and therefore more constantly exposed to the dust?—That is very difficult to say.

253. You only saw that one post mortem, and you did not make it yourself?—Yes, I only saw the results of the post mortem; I have not offered any evidence on that because my experience is so limited.

254. What can you say has been your experience of miners' phthisis, because it makes an enormous difference whether you have had one or two cases or a great number?—My evidence has gone almost entirely on preventive measures.

255. If you have considered preventive measures, it must

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have been because you thought there was a good deal of this disease in existence?—Quite so.

256. If your experience has not been very great what makes you say so?—Well, there is a very large amount of evidence showing it to be so.

257. That is the very evidence we want?—It has come out even in Mr. Weldon's report, the question as to the prevalence of this disease.

258. But in giving evidence before a Commission we must have the evidence of individuals able to speak from their own personal experience. As you can see it makes all the difference?—I have not tendered evidence so much on the medical point as on the preventive measures.

259. I may take it that, in your opinion, gases and dust are the causes of this disease?—Quite so.

260. Would you explain to me exactly how you think gases cause this trouble?—I think the nitrous fumes must have a considerable weakening effect on the tissues, because when a man has been "gassed" he coughs considerably and gets irritation in the air vessels.

261. You say "when a man has been 'gassed' "?—Yes.

262. The Chairman: Have you found many men coughing after being "gassed"?—It sometimes happens.

so.

263. But as a rule a man who is "gassed" does not cough?—That is

264. Dr. Sansom: When down a mine, do you find men coughing very often?—No, very seldom.

265. Therefore if this gas causes them to cough they would inhale more dust, and therefore you think gases are likely to add to the risk of the disease?—I think they are assisting.

266. The Chairman: May we take it that you have not investigated the causes?—Quite so. I did not at all make a point of that. I have only experimented in a rough manner.

267. Dr. Sansom: I have been asking some of the other witnesses their general impression as to this disease. Have you had to deal with mines for any length of time?—Only during the last twelve months.

268. What is your general opinion as to miners breathing through their noses and their mouths?—I cannot say I have noticed that at all. Do you mean whether they keep their mouths open or not?

269. Yes, especially when they are suffering?—No, I have not observed any particulars as to that. I have seen one or two cases in which a miner has been pretty bad and has not gone back to drilling, but has gone back to work on the level, and he will come up some days and tell you that he has got a touch of gas, and accordingly feels worse that day. That is without going into the dust at all.

270. In what way does he feel worse?—He is very much shorter of breath.

271. Mr. E. Perrow: I think it is a common occurrence for miners and natives to get "gassed" in these raises and drives?—Yes, very common; but frequently it does not come to the notice of the doctor, as they go straight to the rooms without coming near him.

272. Have you happened to meet many of them?—I have constantly seen cases of it.

273. They don't get "gassed" very often in these stopes

as there is more air current there?—They get "gassed" in long drives without ventilation. Dr. *J. L. Aymard.* 7th Jan. 1903.

274. Mr. Drake: You mentioned something about the prevailing sort of respirator not being adaptable to the face. Have you seen the respirator shown us by Dr. Irvine, which is quite pliable and could be made to suit any face, and had an inlet and outlet valve?—Of course there must be respirators on the Rand which I have not seen. I am speaking of those which have been sold. There is an alumin um one and celuloid one and an india rubber one.

275. Mr. Drake to the Chairman): This was an aluminium one. Might I suggest that we should have specimens before us of these various respirators?—You understand that what I have shown you is an inhaler, which is entirely different from a respirator. It is not so important that an inhaler shall fit so closely as a respirator.

276. We have good results reported to us from the use of this other respirator, and the only difference between the one I have referred to and this one you have shown us is that the miner could put the other on when he goes to his work, while with this one he must wait until the drill is set up. I think it rather important that we should get your opinion as to this respirator, because you seem to have investigated the subject rather fully?—I have made respirators of my own for the miners, but I find if you are not there all the time they very frequently tear these respirators off. I have been shown a respirator a miner had been wearing. When I examined it I found that he had been breathing the dust quite freely and that his nose was covered with dust.

William Cullen was called; and examined. Mr. *W. Cullen.* 7th Jan. 1903.

277. The Chairman: You are General Works Manager of the British South African Explosives Co., Limited?—Yes.

278. You have made a statement of your evidence?—Yes.

The witness then submitted the following statement:—

In the few remarks which I am about to read to you, I shall endeavour as far as possible to confine myself to the practical aspect of the question of the gases produced during the explosion of nitro glycerine compounds.

Mr. Weiskopf, chief laboratory chemist at the Dynamite Factory, whom you have also asked to give evidence, will on the other hand confine himself more to the theoretical aspect of the question, and really without theory it is quite impossible for us to arrive at any definite conclusion. Fortunately, in this country, the question is simplified by the fact that the explosives used are exclusively of the nitro glycerine variety, and it is still further simplified by the fact that 70 to 75 per cent. is blasting gelatine, which, as you know, consists of nitro glycerine with 7 to 8 per cent. of a body called collodion cotton, and no other thing.

It will be shown to you that when nitro-glycerine explodes under proper confinement the gases produced are carbonic acid, nitrogen, water, and a small surplus of oxygen. The latter is a most important thing to bear in mind, i.e., that nitro-glycerine has within itself more than sufficient oxygen to burn up all the combustible elements contained in it. It is somewhat different from collodion cotton, as when it is burned in a confined space, a certain proportion of carbon monoxide is formed, proving at once that oxygen is not present in sufficient quantity.

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Taking the composition of blasting gelatine as that given by me, there is, however, sufficient oxygen from the nitro-glycerine to effect a complete combustion of the elements of the guncotton, therefore, theoretically speaking, the gases produced in the explosion of blasting gelatine do not differ materially, except in percentage, from those produced by the detonation of nitro-glycerine itself.

There can be no possible doubt whatever, that, given proper confinement, and given proper conditions, blasting gelatine does behave itself in practical use exactly as it does in theory. However, it is the practical use where unusual conditions are introduced that we have to consider, and it will be my endeavour to make clear to you how it is that frequently in practice blasting gelatine and other nitro-glycerine compounds behave quite differently from what we are led to expect. This is practically an admission that, in mining, blasting gelatine does not do all that is claimed for it.

Various conditions influence the results. There is first of all, and perhaps most important of all, the question of the physical condition of the explosive itself; secondly, there is the question of tamping; thirdly, there is the question of the detonator, and its proper insertion; fourthly, there is the question of the fuse; and fifthly, there is the question of the resistance, which means the surrounding rock.

A variation of any one of these in the wrong direction is apt to cause an abnormal explosion, which miners call a "missfire," and it is when a missfire does occur that gases are produced which are undoubtedly very injurious. Now the word "missfire" is a very wide term, and embraces all sorts of explosions, but in practice it means that instead of a complete detonation, a partial explosion takes place, which in reality is a slower form of combustion, and, as already said, when it does take place, deleterious gases may be produced. Of course, when I use the term "missfire" I do not include such cases as the detonator becoming separated from the charge and the charge, in consequence, failing to go off. That is really a missfire, but the term as used here on the Rand has a wider application.

As far as I understand the terms of the reference, you are not concerned with the causes which go to produce gases which might be injurious to human beings, but I think all the same that a detailed examination of these causes will assist us in forming conclusions. It will be conceded that, given a theoretically perfect detonation of blasting gelatine, little fear need be entertained that the gases produced will exercise any bad effect. True, a certain amount of carbonic acid is produced, but the quantity is small and could not possibly do any harm. I mention this point specifically, because I have both seen and heard it referred to here as the primary cause of all the trouble. Of course, the atmosphere of the working would certainly be better without it, but medical men could soon learn from a few simple experiments whether the quantity present after a blast and after sufficient time was allowed to elapse was hurtful or not. This then is what we might call case No. 1.

Now I do not forget that we are to deal with the matter from the practical point of view, and I at once admit that under certain circumstances the theoretical view referred to above is not borne out by practice. What these circumstances are will be dealt with in detail presently, but in the meantime it will suffice to state that the detonation is sometimes not as perfect as it ought to be, and, as a consequence, certain quantities of other gases are produced, which cannot be described as harmless. This we shall call case No. 2.

From causes which generally could be avoided, it also happens that occasionally the explosive merely burns. This we can call case No. 3.

In No. 2, undoubtedly oxides of nitrogen are produced together with carbon monoxide and carbon dioxide. The other gases need not concern us. The quantities produced will depend entirely on the circumstances and no calculation is possible, although it is possible to imitate the conditions. Let it suffice to say that in the case of a soft shot, or a very bad detonation produced either by insufficient tamping, defective or weak detonator, or one of the several other causes, or all combined, it is possible to have very large quantities of both gases produced, and undoubtedly this happens very frequently; more often, probably, than we know of.

In case No. 3, that is where the explosive merely burns, very considerable quantities of the oxides of nitrogen are produced, together with carbon monoxide.

For all practical purposes, therefore, we may consider classes 2 and 3 as producing much the same results, so it will not be necessary to refer to them separately.

I have thus briefly outlined what takes place in all three cases, and it is for the medical man to say what influence these gases may have on phthisis. Fortunately the influence of carbon monoxide and carbon dioxide have been thoroughly investigated, but it is not so with the oxides of nitrogen. Perhaps, therefore, you will pardon me if I put before you some facts which have come under my own personal experience. I have had to deal with many cases, and one only within the past fortnight. I put in a statement on this case by Dr. Wotherspoon, who has had some experience in these matters. You will see he also details the symptoms. I know of many other cases quite on a par, but I shall not refer to them in detail.

In dealing with nitric acid or mixture of nitric acid and sulphuric acid, it happens very frequently that large quantities of nitrogen oxides are produced, and a man sometimes inhales more than he bargains for. We say he gets "gassed," precisely what you say on the mines. In several of the cases the man has died within 24 hours in great agony, but the curious part is that for several hours after being gassed the men suffer no particular inconvenience, and all of a sudden they simply collapse. The symptoms at the end are those of acute pneumonia, accompanied by a blue appearance of the lips and skin.

Having thus disposed of this part of the subject, we shall next see what are the other possibilities.

No doubt a large amount of gases is produced as the fuse burns, but beyond being unpleasant and smoky, it is hardly possible to say they are injurious to the system, as the quantity of black powder contained in a coil of fuse is really after all extremely small, and if we take into consideration the gases produced from this amount of powder, they could not possibly of themselves exercise any baneful effect.

Then again, it is quite within the bounds of possibility that the mercury of the detonator produces effects which have been so far undiscovered. A No. 6 detonator, the size mostly used on these fields, contains one gramme of fulminate of mercury, equivalent to about 10 to 12 grains of metallic mercury. When detonation takes place, no doubt the mercury exists in the atmosphere in its metallic form, but finally it must be resolved into oxide. It is difficult to imagine what influence such a small quantity would have, but the point is worth noting.

One other point, and one which could only happen in the case of a

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partial explosion, is the presence of nitro-glycerine vapour in the atmosphere of the working. So far this has never been proved, indeed I hardly think it has ever been thought of, but when we consider that in the case of cordite, fired from a Maxim or from a large gun, nitro-glycerine in the form of vapour is projected into the atmosphere, we can hardly wonder if under certain circumstances it is also projected from the bore holes. Nitro glycerine vapour, as far as I am aware, is not hurtful, but at the same time the effects, which must be tolerably well known to all of you, are decidedly unpleasant for the time being. It is possible that this may account for the headache and heart-thumping often experienced by miners after a missfire.

It only remains for me to say a few words on the causes which bring about these undesirable results, as it may be that legislation on some of the points will help to minimise their occurrence.

In an earlier part of this statement I have referred to these causes which I shall deal with under the five headings already given.

Firstly comes the explosive itself. Now it is very difficult to explain to people who have no technical experience of the manufacture and storage of nitro-glycerine explosives, how blasting gelatine, for instance, should vary so much in effectiveness An impression seems to prevail that blasting gelatine is the same all the world over, but this is really very far from being the case. There is a certain physical state of blasting gelatine which produces the very best results. This physical state in practice means that the explosive must be fresh for one thing, and must contain a minimum amount of collodion cotton commensurate with non-exudation, for another. The more collodion cotton a blasting gelatine contains the more apt it will be to cause missfires, soft shots and trouble generally. On the other hand, the less it contains the more freely will the blasting gelatine, even when not properly treated, give results which approximate to those we are led to expect from theory. All gelatinous nitro-glycerine explosives, when freshly made, are much more sensitive to detonation than when stored for some time, and this is one advantage which local manufacture must of necessity always have. No one has ever discovered the reason for this change, but it is recognised by manufacturers, and is one of their greatest sources of anxiety. It is quite impossible to tell from the appearance of blasting gelatine, for instance, when it will cause trouble and when it will not, and the only real test is the practical one.

This is a point on which it would be desirable to collect statistics. The margin between good blasting gelatine and bad blasting gelatine, as far as collodion cotton is concerned is an extremely small one, and only careful analysis would bring out the difference.

Next in importance comes the question of tamping, and I can only say at this stage that it is one which receives too little attention. I am not a practical miner, and therefore cannot advise on the point, but there is nothing more certain than this, that if the tamping is carelessly done, the resistance is not sufficient, and the explosive loses in effectiveness. Not only so, but the very gases which undoubtedly cause trouble are formed at the same time. What these gases are I have already informed you.

We come now to the third point, that of detonator and its proper insertion.

We shall take the detonator itself first of all. On the whole I must confess that the detonators supplied here, or, for that matter, anywhere else, have reached a very high standard of perfection. Seldom indeed can one say that a batch of detonators, as they leave the manufacturer at any rate, are

bad. Naturally one does here and there come across detonators which have not received their full charge of fulminate. In cases of this kind a partial explosion is the result, with the attendant inconvenience. However, I am convinced that the greater portion of the mishaps are due to quite other causes. A frequent one lies at the miners' own door, viz., his omitting to remove all sawdust from the tube, when only two things can happen. One is that no explosion takes place at all, the other that it is a partial explosion. If much sawdust is left, the former result is the more common, but that introduces an aspect of the use of explosives with which we have nothing to do.

Detonators are extremely sensitive to damp, and a broken box is often allowed to remain in places which are damp for too long a time. The detonators themselves become damp—so damp that sometimes they go off like a squib, and naturally the effect on the explosive could hardly be worse. I have had detonators returned to me which could not be ignited by the fuse, and therefore did not explode the charge, but which after drying were quite satisfactory. The storage of detonators is, therefore, a most important point to remember.

Generally speaking no fault can be found with the practice on these fields of using No. 6 detonators, although I do know of people using No. 3, under the impression that it is more economical. No greater mistake could be made. If the smaller detonators are good, or even the best possible, a common result is that only a part of the charge goes off, but it may leave the other part burning and vomitting out noxious gases. Therefore as a means of avoiding anything in the way of a partial explosion it is always best and most economical to use the strongest and best detonators.

The most important point of all in connection with the detonator, however, is its proper insertion, and on this point I cannot lay too much emphasis. I firmly believe that failure to insert the detonator properly is responsible for quite as much that is harmful as all the other causes combined. Of course, I am only repeating what must already be familiar to all of you, and will not therefore enlarge on the subject beyond stating that if the ignition of the explosive is from the fuse at the side instead of from the detonator an explosion instead of a detonation will as often result as not, and this leads me on to consider the next point, viz., the fuse.

Now it is all very well for people who are not practical miners to say and even to insist on the necessity for only imbedding one half of the detonator into the cartridge, and by this means avoid spurting; but it is not so easy to do so always—as the light is never of the best. No doubt legislation would help matters, for instance, in the matter of always using string, but there is fortunately another means at hand, viz., the use of a good quality of fuse. Personally I cannot understand how cheap fuse is ever used at all—as the risk run thereby is simply terrible. If a good quality of fuse were always used, i.e., a fuse that will not burst and spurt out sparks, thereby igniting the charge prematurely—the number of accidents would be very sensibly reduced, and the number of cases of gassing would be much less frequent. This is a point on which I am convinced that legislation, and that of a most stringent kind, is necessary, and in other mining centres this view is gradually being given effect to. As a rule little attention is paid to the storage of fuse, and if it is of good quality there is not much occasion to bother about it. However, it does get damp occasionally, and in that condition it smoulders instead of burns, with the result that the detonator does not

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get a chance, and if the detonator does not do its work, the explosive can hardly be expected to do so.

The last point of all is one which I can dismiss with a word, viz., the resistance of the surrounding rock. I have already pointed out that the perfect detonation of blasting gelatine is, among other things, a function of resistance, and here I would say that the harder the rock the more prefect will be the resolution of the explosive into gases which theory leads us to expect. When a nitro-glycerine explosive is detonated in the open, oxides of nitrogen are always formed and can easily be detected by the smell, but as the resistance is increased this diminishes.

I have perhaps dealt at too great length with what I assume to be the principal causes for the production of gases which are undoubtedly harmful to human beings, but it is no use coming before you and admitting their presence and formation without indicating the causes and pointing out the remedies. I have purposely left the medical aspect of the question on one side altogether, as medical men will, I assume, come to their own conclusions when the facts are placed before them. I have confined myself in these remarks to the case of blasting gelatine alone, but what I have said applies at least to the other kinds of nitro-glycerine explosives used on these fields. Dynamite No. 1, or Guhr dynamite, being practically nitro-glycerine by itself, contains an excess of oxygen, and on account of its porous nature seldom fails to detonate perfectly under normal conditions. Gelignite and dynamite II. have just sufficient oxygen for their complete combustion, but in spite of that they will behave just like blasting gelatine if they are not properly treated. Perhaps it occurs to you that I have laid too much blame on fuses and detonators and left the explosive too much alone. Such was really my intention, as I am convinced that in most cases of "gassing" one or other of the circumstances which I have outlined has been responsible for the result. No doubt explosive is often bad, and I have pointed out minutely one point where it often fails. I could point out others, but as they have no bearing on the subject under consideration they were naturally left alone.

Before closing I would say that if you are desirous of having experiments conducted, or if you think it necessary to have facts instead of the generalities in which I have indulged for the most part, I shall be very pleased to assist you in carrying out the experiments or putting in the facts of nitro-glycerine.

(The following paper was also put in by this witness.)

NOTES ON A CASE OF BRONCHO-PNEUMONIA, FOLLOWING THE INHALATION OF NITROUS ACID FUMES; BY DR. C. G. WOTHERSPOON.

F.H., aged 34, a man of steady habits, good physique, and previous good health, was admitted to the Modderfontein Hospital on Wednesday morning, 23rd December, complaining of cough and pain in the chest. His occupation is that of foreman in the nitro-glycerine nitrating house, which position he has held for six years.

HISTORY.

On Monday evening, 21st December, at 7 o'clock, he was cleaning out one of the nitro-glycerine tanks with water, and noticed some acid fumes coming off; to this fact he paid little attention, having frequently experienced in the past the same thing without suffering any injury. He

then emptied in a bucket of water, which caused a greater formation of fumes.

At the time he felt nothing.

He went home to bed in his usual state of health, but at 2 a.m. on Tuesday, 22nd December, seven hours after the inhalation of the fumes, he was seized with a violent fit of coughing, accompanied with great pain down the front of the chest and in the left side, with profuse expectoration, streaked with blood.

In the forenoon of this day (22nd December) he went to the chief laboratory chemist, who gave him a draught of liq. ammoniae and chloroform water. The draught was repeated in a few minutes. He again visited the laboratory at five o'clock the same day, and was given a mixture containing the same ingredients, with instructions to take eight drops in a glass of water frequently. This he did eight times, and experienced great relief.

On Wednesday morning (23rd December) I was called to see him at his rooms. His breathing was rapid, the face suffused, expectoration copious and streaked with blood. Temperature 102.5. He was at once removed to hospital.

On admission, a physical examination revealed very harsh breathing over the left lung, in front and behind, accompanied by numerous whistling rales, and sonorous rhonchi. Laterally, however, there were scattered areas where the breath sounds were distinctly tubular with ringing rales, vocal resonance was increased and the dullness was marked. In the right lung also the breathing was harsh, with noisy accompaniments, but neither dullness nor tubular breathing could be made out. In the afternoon (December 23rd) the state of the patient grew worse, the breathing was faster (40 per minute), more oppressed, cyanosis of the face and finger tips was very marked, the pulse was small but regular (100 per minute), oxygen was administered for 15 minutes, but did not appear to improve the patient's condition. Brandy was ordered (half ounce) every two hours, and a diaphoretic mixture of liq. am. acet. spirit aether nit. pot. citrate every four hours. Calomel, 7 grains, was also administered. That evening the temperature dropped to 101 deg. F., respirations 36, pulse 100, but now much slower. The brandy was stopped, and a mixture was given containing spirit terebinth (3 drams), ovi vitellum unum, misce

Spirit aether nit	3 drs.
Spirit chlorof.	2 drs.
Aq ad	8 ozs.

1 *oz.* every six hours.

The patient complained of a severe headache, which was relieved by a draught of phenacetin 20 grs., tinct. of gelsemium 20 min., in two divided doses. He slept well this night (Tuesday, December 23rd), and on Wednesday (December 24th) I saw him in the morning. Temperature 100, pulse 72, respirations 28. The cough much easier and the expectoration still profuse, but no longer blood stained. From now on patient made a speedy recovery. On the following day (Thursday, 25th December) the temperature was 97.8 in the morning, 97.2 in the evening; pulse 56, respirations 20.

For the next five days, temperature was generally subnormal.

Friday, 26th December	M.	97.8
	E.	97.2
Saturday, 27th December	M.	97
	E.	98.2

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Sunday, 28th December..	M.	98.2
	E.	98
Monday, 29th December..	M.	96.2
	E.	97.4
Tuesday, 30th December..	M.	96
	E.	97.2

Patient was discharged from hospital, 2nd January.

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Patient has still a slight cough, with a small amount of expectoration. Examination reveals a few bronchitic rales over the left base. In the right lung breathing is normal.

He is going back to work in two or three days.

279. Dr. Sansom: Do you bring this case forward as a common case after exposure to fumes?—Yes.

280. This history is merely a typical history of a great many similar cases ?—Yes.

281. Because looking at it apart from that there is nothing in this history that does not presuppose the man might have had an ordinary acute pneumonia and the symptoms seem much more acute on the one side than on the other?—As a matter of fact, the man did not have pneumonia in any type or form before.

282. But pneumonia is a very rapid thing?—Quite so.

283. If this has followed in a great many cases of exposure to fumes, it, of course, puts a different complexion on the matter, but looking at it as a solitary case of a man exposed to these fumes, one would naturally expect symptoms to be the same on both sides, so that it is not a particularly good case to bring forward. I am not throwing any doubt on it, but only wish to get at the value of the evidence?—The reason I brought that case forward was because the case was under my own observation.

284. Can you give me an idea as to how many of these cases you have had during the last twelve months, of bronchial pneumonia following on the inhalation of nitrous acid fumes?—I know of four instances.

285. Then you do not have many exposures to the fumes?—It is a pure accident if it does happen, and it ought not to happen if care is taken.

286. Would you say that 70 or 80 per cent. of the cases of exposure to nitrous acid fumes in this way would probably get pneumonia?—From what I have seen I should think that would be so.

287. The point I am driving at is, that if a man down in a mine is exposed to nitrous acid fumes, not in any great quantity, but simply in small quantities which would add to the irritation, whether the gas would cause this disease. It has been proved over and over again that men do suffer from silicosis independent of fumes, but it has been stated that these fumes add to the frequency and rapidity of the trouble?—Yes.

288. If your report says that nitrous acid fumes increase the irritation cause and trouble in the lungs, it gives dust a greater chance to operate?—Yes, I should think so.

289. I should rather have asked you to take twelve months when you were in full working order?—As I stated before, when a

case of that kind does happen it is a pure accident, and it ought never to happen.

290. Have you had to deal with dynamite factories before?—Oh yes.

291. In these factories have you had the same experience with regard to these acid fumes?—Yes, very frequently.

292. When these accidents happen, have the people exposed to the fumes suffered very much in this way?—Yes, very much the same as in this case I have put before you, only as a rule it is very much worse, the main symptoms being very much more aggravated and generally ending fatally too.

293. If they inhaled the fumes you would expect them to suffer?—Yes, but of course a good deal depends upon the quantity of fumes inhaled. At the same time as this man inhaled the fumes, two natives also got a little, but they suffered very slightly and soon recovered.

294. The Chairman: You would not expect three persons to suffer from the same symptoms if it was merely an ordinary case of pneumonia?—No.

295. Dr. Hawarden: Have you known a man to have had more than one attack?—No, I cannot say I have.

296. When men recover, do they get perfectly well or do they have recurring attacks?—Not as far as I know.

297. The Chairman: I think we might go back to your main paper. The greater portion of it tends to prove that the composition of the gases resulting from explosions vary according to the treatment of the explosives?—Quite so.

298. Theoretically nitro-glycerine explosives give off perfectly innocuous gases, taking CO_2 as being innocuous?—Yes, I mean in that sense.

299. You lay down in your statement five principal conditions, any one of which existing at the time of blasting causes nitrous oxides to be given off. Do you know what nitrous oxides these are? Can you give me their chemical formulae?—Oh yes; although it is impossible to say that any particular gas is produced, and it alone. The general idea is that NO. is produced, but immediately that comes into contact with the air it oxidises into NO_2, NO is perfectly colourless, but NO_2 is a reddish gas.

300. In your opinion NO_2 is the gas that causes damage to the persons inhaling it?—Undoubtedly.

301. You are of opinion that these gases do cause mischief to the lung and are a secondary cause of miners' phthisis?—I do, but I am merely speaking as a mere outsider and give you my opinion.

302. For how many years have you been connected with explosive factories?—For fourteen years.

303. And during your fourteen years' experience you have come to the conclusion that these gases do injure the lungs?—Yes, that is so, quite apart from miners' phthisis.

304. You are of opinion it would assist miners' phthisis?—Yes, would aggravate the disease.

305. Your opinion also is that, although theoretically the gases produced by an explosion of nitro-glycerine are innocuous gases, yet frequently noxious gases are given off, and that in a great part is due to the carelessness on the part of the miner, such as using damp detonators, and to other causes?—Yes.

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306. And also to bad explosives?—Yes.

307. You said you could not tell the difference between good and bad explosives?—No, because the explosive may be very old and it would give off these noxious gases.

308. Are you talking of insensitive explosives?—Yes.

309. How does an explosive become insensitive?—It becomes insensitive very frequently through prolonged storage. That is perhaps the primary cause. Another cause is defective manufacture. I think I explained that by stating that if the amount of collodian cotton which gives the substance gelatinuous exceeds a certain amount the explosive is bound to become insensitive.

310. When the explosive is insensitive, is it more liable to burn and not to detonate?—It is less liable to detonate and to have the same effect you must use a stronger detonator.

311. And in your opinion in a six-foot hole charged with such explosives, the bottom portion of the explosive would not explode but would more probably decompose?—Quite so, and at any rate it would not detonate.

312. In one place you talk of a safety measure that should be enforced by having a string attached to the detonator. Do you think that should be enforced by law?—Yes, decidedly.

313. You think that if a detonator is properly inserted and tied securely it would avoid spurting and make the explosion take place properly?—Yes.

314. Do you think that ought to be enforced by law?—It ought to be enforced in some way, because it is an undoubted fact, as I point out in this statement, that some shots do go off by spurting from the fuse and not from ignition by the detonator, and that can have only one result. If the explosive burns instead of detonating, noxious gases are bound to be produced.

315. You wish to state that the less noxious fumes given off by an explosion the better the work is done?—Decidedly.

316. And work is done more economically?—I think so.

317. And with less injury to the miner?—Yes, that is my view.

318. You therefore think that the less fumes caused by an explosion the better work will be done and the least injury will result to the miner from the gases?—Yes.

319. Mr. Drake: I would like to know if Mr Cullen thinks the workmen who are in contact with nitrous fumes are more subject to lung disease or disease of the respiratory organs than other workmen?—I cannot speak as a medical man, but inferentially I should say so.

320. Dr. Sansom: I take it this exposure to nitrous fumes, when it does occur, is purely accidental?—Yes.

321. Mr. Drake: I meant to ask whether your workmen, who are subject to nitrous fumes, are not so healthy as other workmen?—I must say that as a rule those workmen who are amongst acid fumes are extremely healthy.

Mr. Drake: That also is my experience of workmen amongst sulphuric acid fumes.

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Mr. Eric Weiskopf was called and examined.

322. The Chairman: You are chief laboratory chemist of the Dynamite Factory?—Yes.

323. You have a statement to submit?—Yes. Mr. *E. Weiskopf*

The witness then submitted the following statement:— 7th Jan. 1903.

I have been asked to give evidence before you on the kind and amount of gases formed by the explosion of nitro-glycerine explosives, and their effect on the human system.

Laboratory experiments prove and scientific considerations bear out the fact that nitro-glycerine produces no noxious gases when completely exploded, not only so, but explosives scientifically built up from nitro-glycerine with other ingredients behave in the same manner. It cannot be denied, however, that in the practice of mining, carbon monoxide and nitrous oxides may be formed under certain circumstances.

The latter gases, through their irritating and cauterising effects on the bronchial tubes, larynx, tissues, and especially the blood vessels of the lungs, are apt to cause local inflammation, from which bronchitis, laryngitis, pneumonia and other more or less complicated pulmonary diseases arise.

The effects of "gassing" are mainly produced from these two gases, therefore I shall discuss their influence at considerable length later on. To serve our purpose it will be necessary to divide nitro-glycerine explosives into two classes, viz.,

(a) Nitro-glycerine explosives with nitro-cellulose base: (Blasting gelatine).

(b) Nitro glycerine explosives with active absorbents as a base:— (Dynamite 2 and gelignite).

The first kind of explosive is not only simple in its composition but also in its behaviour in exploding. Berthelot, Böckmann, Abel and others have carefully studied the properties of pure nitro-glycerine and nitro cottons, and all their experiments go to prove that neither of the above explosives produce nitrous oxides if exploded in a confined space. For all practical purposes a well rammed bore hole may be considered as such, and under these circumstances nobody will deny that theoretical considerations based on the above experiments will give us valuable information as to the kind and even quantity of gases formed.

In the practice of mining we have further to consider the occurrences of missfires, i.e., incomplete or partial decomposition of the explosive charge. With regard to these, there are some experiments on record, which in imitating the condition of a missfire, give us the actual figures of the gases formed.

It would be certainly going too far to assume that all missfires take place under the same conditions and with the same results, but the above experiments are nevertheless very valuable as giving us an idea of the processes taking place under conditions which are at least similar to missfires. In imitating a missfire under its most favourable conditions, these experiments give us further the maximum amount of noxious gases formed.

The foregoing serves, therefore, to show that practical experiments on the spot alone could give us an absolutely correct idea as to the kind and amount of gases formed. It will, however, be of some assistance to the medical man in showing him approximately what he has to deal with.

I am fully aware of the fact, that what I am going to say in these pages is by no means complete, but, if I may be allowed to offer an excuse, I should like to say that a subject such as the one I am dealing with requires a great deal of special study and many elaborate experiments, all of which take more time than I can spare

In treating now of the amount and kind of gases formed, I shall try to confine myself as much as possible to the actual facts, but I shall also

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illustrate in some instances the methods by which I arrived at the final conclusion.

In accordance with the introductory remarks, I shall deal first with the kind and amount of gases formed by the explosion of blasting gelatine under normal conditions and under such as result in a missfire. Next I shall deal with dynamites, and lastly give some of the effects of the noxious gases on the human system.

AMOUNT AND KIND OF GASES FORMED BY THE EXPLOSION OF BLASTING GELATINE.

(a) Complete explosion in a confined space.

Blasting gelatine as made at Modderfontein at present consists of 92—93 per cent. of nitro-glycerine and 7—8 per cent. of collodion cotton.

Nitro-glycerine itself decomposes when exploded completely, according to the following equation:—

$$2\ C_3H_5\ (O\ NO_2)_3 = 6\ CO_2 + 5\ H_2O + 3N_2 + O$$

(Nitro-Glycerine) (carbonic acid) (water) (nitrogen) (oxygen).

It will be noticed that a surplus of oxygen is set free in the reaction.

Sarrau and Vieille have by many experiments verified the correctness of this equation.

Collodion cotton of the usual percentage of 11.9—12 per cent. of nitrogen, corresponds to the formulae $C_{24}\ H_{22}\ (NO_3H)_9\ O_{11}$, and can thus be regarded as a mixture of octo nitric and ennea nitric cellulose.

In exploding completely it will decompose as follows:—

$2\ C_{24}\ H_{22}\ (NO_2OH)_{9}O_{11} = 24\ CO_2 + 24\ CO + 4\ H_2O + 27\ H_2 + 9\ N_2$, i.e., two molecules of collodion cotton require 51 more atoms of oxygen to make the complete explosion, also a total combustion. This equation further shows that considerable quantities of carbon monoxide are produced.

In the case of blasting gelatine, however, the surplus oxygen resulting from the decomposition of the nitro-glycerine combines with the carbon monoxide and hydrogen, set free in the explosion of collodion cotton, and thus no noxious gases are formed, provided there is enough nitro-glycerine to insure the complete combustion.

Calculation shows that a blasting gelatine which contains 8.34 per cent. of collodion cotton and 91.66 per cent. of nitro-glycerine will give the above results.

The reactions taking place are illustrated by the following equation:

$$51\ C_3H_5\ (O\ NO_2)_3 + C_{24}\ H_{22}\ (NO_2OH)_9\ O_{11} = 177\ CO_2 + 143\ H_2O + 87\ N_2$$

(Nitro Glycerine) (Collodion Cotton) (Carbonic Acid) (Water) (Nitrogen)

A blasting gelatine with a maximum percentage of 7.2 collodion cotton will, therefore, if exploded under normal conditions, produce only saturated gaseous compounds and some free oxygen.

Any blasting gelatine which contains more than 8.34 per cent. of collodion cotton will consequently produce carbon monoxide, the noxious properties of which will be dealt with later. In order to avoid complications, and seeing that Modderfontein blasting gelatine corresponds very nearly to the above, I shall use the equation just given for the purpose of calculating the actual amount of gases produced.

One such blasting gelatine cartridge of the average weight of 250 grammes will give the following amounts of gaseous products:—

CO_2 (carbonic acid) 154.2 grammes = about 61.7 per cent. by weight; H_2O (water) 50.9 grammes = about 20.3 per cent. by weight;

N (nitrogen) 44.9 grammes = about 18.0 per cent. by weight.

These quantities correspond in a moist state at a temperature of 25 degrees C. (77 degrees F.) at a depth of 200 m. (about 219 yards) below surface to 48 litres, or 1.69 cubic feet nitrogen, equals 27.48 vol. per cent. and 105.5 litres, or 3.73 cubic feet carbonic acid, equals 72.52 vol. per cent.

KIND AND AMOUNT OF GASES FORMED BY AN INCOMPLETE OR PARTIAL EXPLOSION OF BLASTING GELATINE.

I have already said that experiments prove that when nitro-glycerine or collodion cotton are exploded under proper confinement no noxious gases are produced, but if these explosives were simply to burn with a free escape of gases (missfires), nitric oxide, carbon monoxide, and nitrous vapours are produced.

These experiments have further shewn that the freer the products of explosion can escape, the more incomplete is the combustion and the nearer will their composition be to the one given below. Sarrau and Veille have ignited guncotton by means of a hot wire and allowed the gases to escape freely under a pressure very nearly the same as the atmosphere (conditions similar to missfires) and obtained the following results:—

100 volumes of the gaseous products contained:

Nitrogen monoxide	24.7	volumes.
Carbon monoxide	41.9	„
Carbonic acid..	18.4	„
Hydrogen	7.9	„
Nitrogen..	5.8	„
Methan	1.3	„

The same authors submitted nitro glycerine to similar experiments and obtained:

Nitrogen monoxide	48.2	volumes.
Carbon monoxide	35.9	„
Carbonic acid	12.7	„
Hydrogen..	1.6	„
Nitrogen	1.3	„
Methan	0.3	„

It will thus be seen that under unfavourable conditions the explosion of these bodies may produce considerable amounts of noxious gases.

In practice, a missfire will seldom take place under such favourable conditions as those under which the above experiments were carried out, and we can therefore safely take the above figures as maximum quantities of noxious gases which can possibly be formed.

Taking the above experiments as base, the amount of gases produced by incomplete decomposition of one cartridge of blasting gelatine calculates itself as follows:—

	Litres.	C. feet.	Vol. per cent.
Nitrogen monoxide..	84.81	2.99	41.65
Carbon monoxide	66.90	2.36	32.87
Carbonic acid..	44.24	1.56	21.73
Hydrogen	3.94	0.14	1.94
Nitrogen	3.10	0.11	1.53
Methan.	0.7	0.02	0.28

As reasoned before, these quantities will represent the maximum amount of the products of an incomplete explosion.

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NITRO GLYCERINE EXPLOSIVES WITH ACTIVE ABSORBENTS.

With regard to this class of explosive, there are no experimental results whatever obtainable, and in giving the kind and amount of gases produced we have to depend on theoretical considerations only.

Although the figures so obtained will not absolutely agree with the practical results, they will still be near enough to be of some value to us.

As mentioned already, there are two explosives of the above class which are used on the Rand at present, viz., dynamite No. 2 and gelignite.

The consumption of dynamite No. 2 is comparatively small, and I therefore do not think it necessary to consider it specially here. In the main, everything which will be said about gelignite later on applies also to this explosive.

GELIGNITE.

From the composition of this explosive a chemical equation for its decomposition can be calculated which will very nearly correspond to actual results. In giving you this equation I might mention that I have rounded some of the figures in a way as to simplify the calculations as much as possible, without, however, interfering too much with the accuracy of the final results.

As there are no experimental figures to guide me, I had considerable difficulties in properly distributing the available oxygen, but considering the law of chemical affinity, I have even allowed for greater quantities of carbon monoxides than are probably being formed.

The chemical formulae of our gelignite, calculated from its composition, is represented by the following bodies:—

480 $C_3\ H_5\ (O\ NO_2)_3$—Nitro-glycerine.
21 $C_{24}\ H_{22}\ (NO_2\ OH)_9\ O_{11}$—Collodion cotton.
286 $Na\ NO_3$—Sodium nitrate.
102 $C_6\ H_{10}\ O_5$—Cellulose.

The products of decomposition will be:

143 $Na_2\ CO_3$—Sodium carbonate.
1644 $H_2\ O$—Water.
82? H—Hydrogen.
51? CO—Carbon monoxide.
1900 CO_2—Carbonic acid.
1915 N—Nitrogen.

The gaseous products produced by one cartridge of 1¼ gelignite (average weight 250 grammes) will amount to:—

Hydrogen	17.3 litres	equals	0.61 cubic feet.
Carbon monoxide	18.0 „		0.64 „
Carbonic acid	87.1 „		3.07 „
Nitrogen	41.1 „		1.45 „

i.e., the gases produced are:

Hydrogen	10.6 vol. per cent.
Carbon monoxide	11.0 „
Carbonic acid	53.2 „
Nitrogen	25.2 „

It might be interesting to give here by way of comparison the percentage of gases formed by the explosion of ordinary blasting powder (black powder). It will show us clearly the great advantage nitro-glycerine explo-

sives have also in this respect over the old blasting powder. Sarrau and Veille found the gases to be of the following composition:—

Carbonic acid	49.4 vol. per cent.
Carbon monoxide	20.5 „
Hydrogen..	2.0—1.4 „
Methan	0.3—1.4 „
Sulphuretted hydrogen	7.0—5.5 „
Nitrogen oxydul	21.3 „

PARTIAL OR INCOMPLETE EXPLOSION OF GELIGNITE.

From the nature of this explosive it is evident that missfires will produce much more noxious gases than, for instance, blasting gelatine under the same circumstances.

As I do not know of any experiments which might guide me in giving you figures which correspond to practical results, I shall have to give you the theoretical maximum of noxious gases which possibly could be formed. For this purpose I shall assume that all the available nitrogen is given off as nitrogen monoxide, while the whole of the carbon is assumed to produce carbon monoxide. This is neither theoretically nor practically quite correct, but under the circumstances it is the only method to arrive at a result. One cartridge of gelignite would thus produce:

83.6 litres, equal to 2.95 cubic feet nitrogen monoxide.
111.7 „ 3.94 „ carbon monoxide.

We have seen up to now that a complete explosion in the case of properly constructed blasting gelatine forms no deleterious gases whatever, but that in cases of missfires considerable amounts of nitrous oxide and carbon monoxide are formed.

The figures given are no doubt, of practical value, as they are based on experiments carried out under actual conditions.

This applies to gelignite in a somewhat modified way only.

Although I myself feel confident that the process of decomposition as given above will very nearly agree with the actual reactions taking place, I should not like to give a definite opinion without having proofs from practical experiments.

So much, however, is certain: Firstly, there is a small amount of carbon monoxide formed even at a complete explosion ; and secondly, the amount of deleterious gases formed by incomplete decomposition exceeds by far the quantity produced by blasting gelatine under similar conditions.

In dealing now with the effects of these gases on the human system, I shall, as much as possible, confine myself to the theoretical aspect of the question, and leave it to the medical man to draw his own conclusions.

Some of the gases formed by incomplete decomposition in special, have a poisonous effect on the human system through being absorbed into the blood through the pulmenary membranes. Others, however, operate as negative agents, i.e., simply by excluding oxygen. To the latter belong the products of a complete explosion of blasting gelatine in general, and carbon dioxide, hydrogen and nitrogen in special.

A person exposed to either of the above gases will die from the deprivation of oxygen under the symptoms of ordinary suffocation. As the opinions with regard to carbonic acid may be divided, I give here a few remarks which might be of some interest.

It is true that carbonic acid penetrates into the lungs, and is absorbed and circulated by the blood. It combines with the oxyhaemoglobine of the

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blood, but this compound is not at all stable, but gives off the carbonic acid if in circulating through the lungs it comes into contact with inhaled oxygen (air). The gas is further not irritant by any means, as might be taken from the statement that Berzelius recommends a mixture of air and 5 per cent. of it in the treatment of consumption (Man. of M.J., A. S. Taylor, p. 465.)

Demargnay says that one part of carbonic acid (25 per cent.) and three parts of air produced in a man but slight discomfort after being breathed for some time. (Chem. News, Aug. 4, 1865.)

It is further generally believed that carbonic acid, being a gas much heavier than air, collects on the lower part of the respective locality. This is, however, not true. Carbonic acid and air mix readily on contact in all proportions, and in our own specific case, where quantities of heated CO_2 are, so to say, thrown into the air, it will quickly diffuse itself throughout the whole room.

Returning now to the subject of poisonous gases, there are two which we shall have to consider, viz., carbon monoxide and nitrous oxide.

Owing to the fact that these bodies are in a finely divided state of vapour, and that in the air cells of the lungs they meet at once with a large absorbing surface, and thus instantly enter the blood, their effects are very rapid and strongly marked.

Both gases combine with the oxyhaemoglobine of the blood. The haemoglobine thus loses its valuable property of transmitting the oxygen of the inhaled air to the system, and death resulting from suffocation due to the arrest of the internal respiration will be the consequence if a sufficient quantity of haemoglobine is fixed.

In the case of nitrous oxides, we, however, must not neglect their cauterising properties, and, as I shall show later on, a great number of deaths have resulted from this specific cause.

Carbon monoxide, although a noxious gas, cannot at the same time be called an irritant. It is indeed due to this latter fact that carbon monoxide is so well feared, as there is nothing to indicate its presence in the air.

All cases of poisoning by coal vapours, water gas, etc., are due to the presence of sometimes very small quantities of carbon monoxide and its specific action is so well known that I need not comment on it here. Its compound with haemoglobine is a stable body, and only dissociates very slowly when circulating through the lungs. The combination of carbon monoxide takes place progressively with each respiration made in an atmosphere contaminated with the gas. The action is strictly cumulative, so that the duration of the exposure as well as the amount of the gas present has to be taken into account when considering the effects likely to be produced by a given admixture. (Encyclopaedia Medica, p. 323.)

The circumstances connected with the death of M. Zola are very interesting in this respect.

As can be taken from the evidence. (British Medical Journal, Oct. 4, 1902.) Madame Zola escaped although she had breathed the poisonous air longer than her husband, who had got up during the night and was found lying dead in the middle of the room.

It is supposed that the air contained only a very small percentage of carbon monoxide, and that this and the time of exposure were not sufficient to fix all the haemoglobine of their blood. The slight exertion in getting up was probably the cause of M. Zola's death.

From this and many other cases, and taking the chemical action of the gas into consideration, I should say that a patient after he has been

rescued from the inhalation of such poisonous air, and after feeling comparatively well, his complete recovery will be a question of time only, and no relapse need be feared.

Not so in case of poisoning with nitrous oxides. Their cauterising effects on the larynx, the air passages, and, after inhalation, on the tissues and blood vessels of the lungs, prove much more dangerous than its combining with the haemoglobine. They have, furthermore, a distinct accumulative action, i.e., their effects continue even after the person has ceased to breathe them. In fact, these effects are in most of the cases only noticeable after considerable time has elapsed. In the chemical industry, poisoning by nitrous oxides is a not unfrequent occurrence. Although these gases originate from another source (chiefly fuming nitric acid, or mixtures of strong nitric and sulphuric acid) they are chemically identical and their action on the human system must be the same.

It will have been noticed that partial decomposition of explosives produces nitrogen monoxide. This gas oxodises immediately if in contact with oxygen (air) and forms the well known red fumes (nitrogen peroxide), which in turn are readily absorbed by water, giving nitrous acid.

To this formation of nitrous acid the action of the nitrous gases are due, and to illustrate their effects I cannot do better than quote a very marked case from Taylor's Manual of Jurisprudence, p. 75.

"In 1854, Mr. Haywood, an analytical chemist, of Sheffield, lost his life under the following circumstances:—He was pouring a mixture of nitric and sulphuric acids from a carboy, containing about sixty pounds, when by some accident the vessel was broken. For a few minutes he inhaled the fumes of the mixed acids (nitrogen peroxide) but it does not appear that any of the liquid fell over him. He was seen by a medical man, and complained merely of some cuts about his hands. He coughed violently. In three hours more there was a difficulty in breathing, with increase of the cough. There was a sense of tightness at the lower part of the throat, and the pulse was hard. At times, he said he could scarcely breathe. He died eleven hours after the accident. On inspection. there was congestion of the windpipe and bronchial tubes, with effusion of blood in the latter. The heart was flaccid and contained but little blood, and the lining membrane of the heart and aorta was inflamed. The blood gave a slightly acid reaction to test paper."

This and many other similar cases leave no doubt that the action of the above gases are most deadly in their effects.

In a mixture of poisonous gases, which contain nitrous oxides in anything like a quantity, the most dangerous effects will in all probability be due to the latter. A post-mortem examination might even prove clearly the presence of carbon monoxide in the blood of the victim, but still death might have been caused by the action of nitrous oxides.

With this, I bring these few remarks which I took the liberty to bring before you to a close, and I sincerely trust they will help you in clearing up the problems before you.

Head Laboratory,
Dynamite Factory,
5th January, 1903. (*Sgd.*) C. WEISKOPF.

324. The Chairman: In your paper you lay particular stress on the two gases met with underground due to explosions, viz., carbon monoxides and nitrous oxides?—Yes.

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325. These gases are injurious to the miner?—Yes.

326. Do you agree with Mr. Cullen that the chemical formula of this nitrous oxide is NO?—Yes.

327. And that on contact with the air it oxodises into NO_2?—Yes.

328. You deal here with the gases given off by burning explosives?—Yes.

329. Have you any experience of persons who have been in contact with that gas and its results?—Only in cases such as those mentioned by Mr. Cullen. The gases produced on those occasions are identical with the nitrous fumes given off at incomplete explosions.

330. You have not come in contact with any such gases as mentioned here, NO and NO_2. These would be the same gases as those given off in your own factory?—Yes. I have not come in contact with any cases of people who have suffered from breathing such gases when underground.

331. On page 9 you make a statement that carbonic acid gas usually mixes with the atmosphere and is not found in large quantities separated from the rest of the atmosphere?—No, except in cases where carbon dioxide penetrates from crevices in the ground.

332. I would point out that in a mine it is usual to find it accumulated in the sides of levels and drives?—That would be the case where more carbon dioxide penetrates from the ground than is mixed with the air by diffusion.

333. You mean that CO_2 given off from these explosives mixes with the air and does not settle?—It must mix with the air

334. Dr. Sansom: At the bottom of page 9 of your statement you say "it is further generally believed that carbonic acid being a gas much heavier than air collects on the lower part of the respective localities. This is, however, not true". How can you explain CO_2 at the bottom of a well?—The CO_2 there is formed at the bottom of the well and the air is quite undisturbed.

335. The question of disturbance does not matter if it diffuses?—But there is always new carbonic acid gas being formed. There is a very well known case, the celebrated grotto in Naples, where CO_2 is formed in a cave and, although CO_2 diffuses at the top of the cave, there is always sufficient near the floor.

336. Mr. Weldon will confirm what I say, that if you take an ordinary drive in a mine there is a good deal of CO_2 in a hole in that drive, and yet the air in it is disturbed a good deal?—Then CO_2 must come from the ground itself.

337. We do not find that in mines out here?—Then I cannot explain it otherwise.

338. The Chairman: Your experience with regard to this gas is confined to the Dynamite Factory and does not apply to the mines?—That is so.

339. Do you corroborate all Mr. Cullen has said?—Yes.

340. Are the views he expressed your views?—Yes. As to the action of nitrous oxide I would like to say this action is really due to the formation of HNO_2. The course would be the following. Nitrous oxide is given off by the incomplete explosion of the explosives. Then nitrous oxide on contact with the air oxidizes to NO_2 and NO_2 again, if in contact with any water or moisture, becomes HNO_2.

341. Any moisture in the lung?—Yes, any moisture will form HNO_2, and to its cauterising effects I consider all the effects of the gas on the air tubes or bronchial tubes are due.

342. Dr. Sansom: As to this cauterisation, is this from reports you have read or something which you have actually seen?—I do not know which cauterisation you mean. Do you refer to cauterisation contracted underground or such as mentioned by Mr. Cullen?

343. You refer to the cauterising effects on the bronchial tubes on the first page?—I have studied the thing very specially, and I have read a good deal of standard literature, and on page 12 I give a case from Taylor's Manual of Jurisprudence, and I could give many such cases.

344. It merely mentions congestion of the windpipe and bronchial tubes, with effusion of blood in the latter. You could hardly call that cauterisation. In nine cases out of ten you will find that men who die from any interference with the respiratory organs will have a certain amount of inflammation and congestion. There is no proof of cauterisation?—Chemically, an acid is formed, and any acid in contact with organic matter will cauterise it.

345. Not necessarily. What about citric acid?—That is a weak acid.

346. But dilute hydrochloric acid has no cauterising effect?—That is a much weaker acid than nitric acid.

347. I have not seen any particulars of a post-mortem showing any cauterising action on these parts. I would like to get at your reasons for saying so?—One of my reasons is, in cases of poisoning with nitrous oxides, the effects always come out a long time after the fumes have been inhaled.

348. That does not prove its cauterisation?—These effects are strongly marked after some time has elapsed, and it appears that there is something in the system which irritates, and the only body that can be in the system is nitrous acid.

349. Here you also say that 100 volumes of the gaseous products contain nitrogen monoxide, 24.7; and carbon monoxide, 41.9. Is that carbon monoxide very dangerous?—No, I don't consider that the inhalation of carbon monoxide has a very serious result on people if they inhale it for a short time, except through its combining with the themoglobine.

350. The effect is not necessarily immediate?—I think the effects are accumulative.

351. Have you had much experience of people exposed to fumes?—You will find that a great many people will die some hours after exposure to fumes of carbon monoxide. Here you have nitrogen monoxide 24.7, and you have a very much greater proportion of carbon monoxide.

351A. I would like to get a clear idea of the two things: I would like to know on what ground you state that you eliminate the one and hold to the other?—I do not eliminate the one, as both are present, but I consider the nitrous oxides more dangerous.

352. The Chairman: Is this evidence from your own experience?—No, this is quoted from experiments which have been made and are given in standard works.

353. Dr. Sansom: I think it is generally accepted that there is a very large proportion of carbon monoxide given off in missfires?—Yes, but there are really the two things we have to consider.

354. The Chairman: These quotations are very interesting to have, but I think your own evidence is confined to that which has taken place at

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the dynamite works and not on the mines?—That is so, and I agree that the whole of my evidence is from a theoretical point of view.

Dr. Sansom: I only wanted to get your data.

Dr. *R. G. Ralston.* 7th Jan. 1903.

Dr. Robert Gow Ralston was called and examined.

355. The Chairman: You are Dr. Ralston, F.R.C.S., England, M.B., C.M., and L.R.C.P.?—Yes.

356. Have you had any knowledge lately of this disease?—I am not a mining doctor, but I have had a certain amount of experience in the hospital of the cases brought there, more particularly the pathological aspect of the disease.

357. Since what time?—Since nine months ago.

358. Have you studied this disease in its earlier stages?—No, I have only studied the cases that came into the hospital, and these are generally bad cases.

359. Do you mean advanced cases?—Yes.

360. Dr. Sansom: How long have you been here?—I have been nine months in practice in Johannesburg.

361. Is that the full length of time you have been able to devote to any observations on this subject?—Yes, on miners' phthisis; but not on silicosis. I have studied silicosis in England.

362. Since, therefore, you have made post-mortems you must be able to make a comparison?—Yes.

363. What is the result?—I think that silicosis and the miners' phthisis here are identical.

364. Would you call this disease a chronic interstitial fibrosis?—Yes. I think there is very considerable doubt in a number of cases and that there must be an element of tubercle, and probably some of the miners coming to the Rand have already got it.

365. Supposing these people, who have a certain amount of tubercle, had not been exposed to this, do you think they would have developed silicosis?—I think they would develop fibrosis, but if you mean by silicosis a lung which shows particles of dust, then I do not think so.

366. That is the point; I specially state silicosis?—Then certainly not.

367. Therefore these people would probably, in the ordinary course of events, have lived longer if not exposed to the dust?—Decidedly.

368. Do you think many come here to this country because their lungs are somewhat affected, and hoping to live longer by coming here, or because they are miners already and have already contracted the disease before they came here?—I think the latter reason is the true one. They have probably been mining in England and contracted the disease there.

369. In making post-mortems do you find the glands particularly choked with dust?—If you mean the bronchial glands, yes. The glands round the bronchial tubes are distinctly enlarged and you can actually map them out quite easily from the substance of the lung. They are quite fibroid and dense.

370. I have asked this question because I wish to have the matter cleared up. Have you ever heard of any other form of lung disease where such a post-mortem condition, as you have described, is found?—No, I do not think so. I have never heard of one.

371. Have you read the report of the Transvaal Medical Society?—Yes.

372. You saw that they found a good deal of silica?—Yes.

373. Do you believe that it is likely to be accurate?—Oh yes, undoubtedly. You can feel it in cutting the lung.

374. Unless inhaled, is there any means of accounting for the presence of silica in the lung?—No, as there is no such deposit occurring in the body.

375. You have heard what these gentlemen have said about gases. In the course of your experience have you seen anybody suffering from being poisoned by irritating gases?—The only case I ever had anything to do with was when I was a student in Edinburgh and Sir Henry Littlejohn had one case there of two children poisoned by nitrous fumes from nitric acid, and in that case the post-mortem showed, I should not say cauterisation of the lung, but the parts showed acute congestion the whole way through, and, undoubtedly, if they had lived acute bronchial pneumonia would have developed.

376. Supposing you took an ordinary person exposed to irritating gases, what would you expect to be the result?—If you did not get acute pneumonia right off, I think you would probably get acute bronchitis.

377. Do you think a gas sufficiently irritating to cause acute bronchitis would get through the larynx?—I think it would.

378. Would you expect to find more effects further down, because you would have the much finer structure lower down and less fumes would effect the epithelium?—Yes, it is more delicate.

379. You are inclined to believe that, if miners are exposed continually to an acid irritating gas plus the dust, the protecting lining of epithelium is likely to be destroyed, and that would increase the chances of the disease?—Yes, but I cannot believe that gases have anything to do with the production of the actual fibrosis.

380. Then supposing there was no dust, do you think gas alone would do it?—No.

381. Have you ever heard or read of gases producing such conditions?—No.

382. What part do you think carbon dioxide and general want of sanitation in the mines would play in this matter?—There is a certain amount of truth in the fact that if you had carbon dioxide circulating in the mines there would be a tendency to fibrosis. I do not say it would produce it, but the venous condition of the blood would probably predispose to it.

383. Will you give me an example of that?—I could give you an example in the Swedish method of treating joints. If you take a tubercular joint and tie an elastic band over the limb, and keep up that pressure you will produce a distinct fibrosis. That is proved microscopally and otherwise. I do not say that CO_2 does produce this fibrosis, because I do not think it could be proved.

384. If a miner is breathing say O_7CO_2 just beyond the limit of respiratory impurity then the probability is that his pulmonary venous sympton has a tendancy to be engorged?—Yes.

385. And that is more likely to be the case than if breathing O_4 or O_5—Yes, I think so.

386. You have not seen many cases until considerably

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advanced?—No, I think I have only seen one that came on within six months.

387. You do not happen to know the occupation in the mines of all the miners you have made post-mortems on?—No, it is very difficult to get that, as they are hospital cases.

388. Dr. Hawarden: Do you find evidences of tubercle in many of the post-mortems?— I do not think any more than 25 per cent., but that is from a very limited number, and I do not think it wise to draw conclusions

389. The Chairman: Out of how many?—I could not exactly say, as I made post-mortems some considerable time before there was any talk of a Government Commission to inquire into the matter or anything of the sort.

390. Dr. Sansom: A large number of these people have been dwellers in cities?—Yes.

391. And you, as well as I, know that in such cases you find people with evidences of tubercle. Do you think that goes for very much on the whole?—I think it does to this extent, that I do not think it would be very prevalent otherwise. I think tubercle must have something to do with the extreme prevalence of the disease.

392. Was the tubercle active?—It is very easily distinguished from an ordinary fibrosis.

393. You say you had something to do with silicosis in England ?—Yes.

394. What was your impression about the presence of tubercle there ?—I have very mixed ideas as to whether tubercle is primary or secondary, and I think that the conclusion to which the Royal Commission in England came to on that point was that it was secondary.

395. Even if these people had tubercle, they would live very much longer if they did not work in a dangerous trade?—Yes, and in a dangerous trade there would be all the more danger, of course, if they already have tubercle.

396. That is a risk they must take when they come here, and is not exactly our business, which is to enquire into the cause and to suggest means of prevention?—I have here this book on Rontgen rays. The best test as to this disease is an examination by means of the X rays, but you cannot photograph them satisfactorily because the lung is continually moving, and while you can examine the parts on a screen and see the areas affected quite clearly, yet in taking a photograph with an exposure of 20 or 30 minutes you only get a blurred image. I had one negative which did show the areas affected, but unfortunately it got broken. It is Williams' book.

397. Supposing a man suffering from silicosis is exposed to X rays, do you mean you could declare whether he was suffering from the disease or not?—You could.

398. Could you say when it is absent and when it is present?—Yes, you can.

399. At what stage ?—More than one man I examined was stated not to have the disease at all. One man was examined by two doctors, so it was at an earlier stage than a medical man could tell.

400. How long had this man been working?—Five years.

401. In this country?—Yes.

402. On rock drills?—Yes.

403. The Chairman: It has been stated here that rock drillers who have been working for some two years have already got the initial stage of

the disease. May I ask whether you could, by means of the Rontgen rays, detect it at that time?—I think if there was any sign whatever in the lung you could tell any fibrosis. You see, in X raying the lung you can always get an outline of the ribs, and the spaces between are very clear. In the ordinary chest you can see it very well, and immediately you get any of this condition in the lung you can distinctly see the area in the lung substance that is affected. This I have seen repeatedly. I had one case where a man had worked for three months on rock drills altogether, and at the time he came to me he had a patch in the pleura cavity. I decided to operate on him, and got down to a bit of miners' phthisis which he had developed in these three months. I had previously X rayed the man and seen that patch, and at that time I believed it was a tumour, but I did not think he had had enough exposure to the dust to develop the disease.

404. May I ask as a layman whether you can tell the difference between interstitial fibrosis of the lung, which may be caused by silicosis, and a case where you may get a fibroid breaking down of the lung without any dust at all?—Yes, you can.

405. It is a form of consumption?—Yes.

406. Can you tell in that case that it may have been present previous to his working underground?—You can only tell that there is chronic inflammatory area in the lung.

407. Which might have been there before the man went underground?—Yes, it might have been.

408. Dr. Sansom: In tuberculosis you would see the shadow round the cavity?—No, it is the actual consolidated areas.

Dr. Sansom: He would have definite clinical symptoms of tuberculosis, while in this unfortunate disease the clinical symptoms are so vague that there is nothing to guide one at all, so the fact of getting an X ray shadow showing fibrosis would presuppose it to be a case of silicosis.

The Chairman: I was talking of the particular case where you mentioned the man had been working for three months.

Dr. Sansom: That is my point. Supposing it was a tubercular case, he would have clinical symptoms, while in this disease we are investigating we do not get early clinical symptoms.

409. The Chairman: You are convinced that the man you referred to had contracted miners' lung?—So far as you can tell from an examination, the appearance of the lung was exactly that of miners' phthisis, but this man had the most typical of all symptoms, dry pleurisy, probably one of the most usual and most common signs found.

410. Then with this X ray apparatus you would discover that, in cases of consumption and miner's phthisis, exactly the same parts are affected, but in the case of consumption you would have other evidence to prove that it was consumption. Am I right?—Yes.

411. It seems to be the clinical history that if a man leaves his work he goes down very quickly?—Yes, and I have had no evidence to show so far that the disease once started is ever arrested.

FOURTH DAY.

CHAMBER OF MINES, JOHANNESBURG.

Wednesday, 4th February, 1903.

PRESENT:—

MR. H. WELDON, (*Chairman*).

DR. C. L. SANSOM,	DR. S. HAWARDEN.
MR. FRANCIS DRAKE,	MR. R. M. CATLIN,
MR. J. R. WILLIAMS,	MR. E. PERROW,
DR. CHARLES PORTER,	DR. W. F. DAVIES,
MR. J. HARRY JOHNS,	

MR. J. STRATFORD, *Secretary.*

Dr. *E. A. Miller.*
4th Feb. 1903.

Dr. Edward Alfred Miller, District Surgeon, Boksburg, was called and examined.

412. The Chairman: Have you a written statement to present to the Commission?—I have not.

413. I believe that your evidence will be, chiefly, in regard to the gases met within the Mines?—Well, partly; but I should like also to give evidence with regard to the prevalence of Miners' Phthisis.

414. Will you make a short statement?—Yes. I was Medical Officer to two lead Mines for nearly ten years at home, the great Laxey and Snaefeld Mines where rock drilling was carried out in practically the same manner as in the Mines here and, during the whole ten years, I never saw a case of Miners' Phthisis such as I have heard described in this country. I have also seen many Rand miners, who went there from the Isle of Man and have worked here for years. They returned to the Isle of Man and many of them returned to die; but in my opinion they simply died of ordinary tubercular disease of the lungs and I have never seen one case of Miners' Phthisis such as I have heard described here. Tubercular disease of the lungs was a most prevalent complaint in the Isle of Man, not only amongst the miners but amongst their daughters, brothers and sisters.

415. The Chairman: I believe, the inhabitants of the Isle of Man are closely related and intermarried?—They are.

416. With regard to the conditions that prevail in the Great Laxey and Snaefeld Lead Mines, I think the miners there use very few rock drills?—There are a great number in the Great Laxey Mine. I have known men work them for ten years, who have been working a long time before that at rock drills.

417. I do not know the District itself very well, but I do not think that the miners do any rising by means of rock drills?—Oh yes, they do.

418. Have they been accustomed to doing that?—Yes, as a rule.

419. Have you any idea of what proportion of drills were used in rising?—I could not tell you that.

420. That is rather important is it not?—Yes, it is.

421. Because, if the driving is confined to wet holes, then you have not the dust?—Well, the mines I have seen have as much dust as any of the mines here.

422. Dr. Sansom: Did you make many post mortems?—I never made any but the cases I referred to had all the ordinary symptoms and death was simply due to tuberculosis.

423. You do not believe it might have been Miners' Phthisis?—I think not. The disease described to me here as Miners' Phthisis, I do not think any competent medical man could mistake.

424. Have you seen any case?—I have made a post mortem on one case.

425. It is rather difficult therefore for you to make a comparison?—I do not know about that. This Miners' Phthisis is totally different, and any competent doctor should know what is tuberculosis and what not.

426. How do you get over the fact that the death rate amongst miners dealing with hard rock and so forth is very much greater than amongst other miners?—I believe it has a good deal to do with dust.

427. The account given by the Inspector of Mines clearly proves that there is a fibroid thickening of the lung and a great deal of silica?—But I want to see these cases.

428. So you really cannot speak with authority?—No, because I have not seen one of these cases. If you show me a case, I am open to conviction.

429. Dr. Davies: Did you make any post mortem examinations on the cases of tubercular disease of the lungs which you saw at home?—No, but there was no doubt about it.

430. Supposing that there was a case of a miner who had a tubercular lung, would you be able to say from clinical examination that it was not Miners' Phthisis?—Certainly not.

431. Are you willing to admit that these people may have had fibrosis of the lung as well?—I admit that.

432. Are you able to say that there was no fibrosis of the lung, in the cases you saw?—No, only they ran the same clinical course as a girl who had never been down a mine in her life.

433. Would not an ordinary case of fibroid phthisis on which tubercular was superimposed run the same course?—I do not know, but I think not. I am not in a position to say.

434. You know perfectly well yourself from your medical knowledge what we mean here by a "Miner's lung"?—I do.

435. That is fibrosis of the lungs?—Yes.

436. If a man has chronic fibrosis of the lung and tuberculosis engrafted on it do you consider he would run a different course to a man who had ordinary phthisis?—Perhaps not.

437. Therefore you are not able to say that the cases of tuberculosis with which you were connected at home did not have fibrosis of the lung as well?—There were clinical symptoms such as you would have got in ordinary tuberculosis.

438. You are aware that a great many miners died of fibroid phthisis without any marked physical signs of consolidation?—That is not what I am aware of, but I am willing to be convinced.

Dr. *E. A. Miller.*
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439. Then you are prepared to say that your knowledge in this country is not sufficient to offer an opinion?—Not in this country.

440. Dr Porter. Would you mind telling us, if you happen to know it, what is the geological formation in which the miners work at Laxey?—I really dont know.

(The Chairman to Dr. Porter): I can tell you that. It is granite and slate.

441. The witness: I may also say that I have made a post mortem examination here on one white man supposed to have had Miners' Phthisis. He certainly had an empyema at the base of the right lung, but I could not find anything the matter with his lung

442. Dr Davies: Still you would look upon that as one of the ordinary mistakes doctors are in the habit of making?—Certainly.

443. Dr Porter: May I ask whether it was in the Snaefeld Mine that Dr Haldene made certain investigations as to carbon monoxide?—Yes.

444. Did he at the time investigate the questions as to its effect upon miners' lung?—No.

445. Did he confine himself solely to the effects of carbon monoxide on ventilation?—Yes.

446. He did not concern himself with the gases produced by blasting or anything of that kind?—That came in later.

447. Can you tell the Commission whether he arrived at any conclusion as to the effect, I do not mean the mere poisonous effect but any more distinct effect, which this gas has on the lungs because, of course, if we could get Dr. Haldene's opinion on that point it would be of value because he is such an authority?—In what way do you mean?

448. Whether he arrived at any conclusion as to whether these gases exerted a permanent weakening effect upon the lungs of the miners and whether it predisposed them to any disease?—I do not think that was his conclusion at all.

449. He did not investigate the point?—No, I don't think so as far as the effects on lungs are concerned.

450. The investigation was primarily undertaken in consequence of a big explosion?—No, an underground fire.

451. Do you remember whether he made any recommendations about ventilations?—I do not think he did.

452. You are aware that at present he is investigating the ventilation of Cornwall Mines?—Yes.

453. Dr. Sansom: You do not have to treat many of the miners here?—Not many.

454. Practically none at all?—None at all.

455. Therefore you really cannot speak very much about Miners' Phithisis?—I know nothing about it with regard to the Transvaal.

456. The Chairman: Your evidence is in respect to the Isle of Man, and you do not think that Miners' Phthisis is prevalent there?— I certainly do not think so.

457. Dr. Davies: I should like to ask Dr. Miller another question. Can you tell us whether those miners who went home from this country and died in England died of Phthisis diagnosed from clinical observation or by bacteriological examination?—They certainly had all the ordinary symptoms of tuberculosis and their families were reeking with it.

458. Mr. Harry Johns: Can you tell us whether water was used in connection with the bore holes in Great Laxey?—No, I think only sometimes. There was no systematic watering. Dr. *E. A. Miller.* 4th Feb. 1903.

Mr. Arthur Robert Sawyer, Mining Engineer, Johannesburg, was called and examined.

459. The Chairman: I understand you have got a statement to place before us, Mr. Sawyer?—Yes.

The Chairman: I think we had better have the statement read out.

Mr. Davis: If it is a long statement it might be a good thing to have it circulated as then we should have an opportunity of going over it in order to save the time of the Commission. If Mr. Sawyer could give us time to do this, it would be convenient.

460. The Chairman: Can you arrange to do this Mr. Sawyer and I will undertake to get copies made and circulated?—That will suit me very well. Then you will postpone my evidence?

The Chairman: Yes, and we will communicate with you and arrange as to having it at our next meeting.

Mr. David Wilkinson, A. R. S. M. Mine Surveyor, was called and examined. Mr. *D. Wilkinson.* 4th Feb. 1903.

461. The Chairman: You have made a statement Mr. Wilkinson?—Yes.

Witness submitted the following statement:—

The causes of the vitiation of the air of a mine and the supply of fresh air which is necessary to neutralize this vitiation and thus to provide continuously a healthy atmosphere for the miner, are of such importance that any contribution which will add only a little to our stock of ideas on this subject requires no apology for its introduction.

It is probable that the adequate ventilation of the Mines on this field has not in the past received the attention it deserves. We have been much concerned with the increase in the output and the difference between working costs and value per ton obtained and have perhaps neglected the important question of the health of the workman—both white and black.

There have been as yet, no serious attempts to supply a constant quantity of fresh air per man per minute to the Mines of the Rand, natural ventilation being deemed sufficient, and thus on certain days of the year extremely bad conditions have prevailed in many, even of the outcrop mines.

If we however except the ends of drives, winzes or raises the ventilation has on the whole been good, despite the want of system in the directing of the air currents, but as mining operations are undertaken at deeper levels a regular supply of air by artificial ventilation becomes more and more essential, and it is of importance to fix our ideas as to the suitable minimum supply per man,

This minimum supply for healthy conditions in a mine cannot be fixed with mathematical precision; all that one can hope to accomplish is the indication of the degree of impurity corresponding to certain supplies, and from the latter to decide upon the most suitable minimum.

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The usual gaseous impurities of the air in mines are:—

Carbon Acid (CO_2)
Carbon Monoxide (CO)
Sulphurous Acid (SO_2)
Methane or Marsh Gas (CH_4)

and the oxides of nitrogen derived from the explosion of nitrogen compounds such as nitro-glycerine.

In addition to these gaseous compounds there are certain suspended impurities in the air.

These consist principally of (a) suspended organic particles derived from the respiration of men. The structure and composition of these particles is variable, and not perfectly understood, but it is certain that they produce deleterious effects upon human beings and especially when present in an atmosphere which contains a smaller amount of oxygen than that usually present in the atmosphere.

(b) Microbes.
(c) Mineral particles.

It is usual in all estimations of this kind to use carbonic acid as an indicator of the degree of impurity of the air, and to stipulate that the CO_2 shall not be present in amount greater than a stated percentage.

If all or any of the above impurities are present in the air that is breathed, it is evident, that the percentage of carbonic acid present is not a sufficiently precise indication of the impurity of the air and it is only in those cases in which we are able to trace the proportional amount of other impurities and their effect upon the human being by the percentage of CO_2 present that the latter can be used as a sufficiently accurate indicator of impurity.

Thus for example if we know that the CO_2 has been emitted as a result of perfect combustion of Hydro—Carbons, we know that organic impurities are not emitted at the same time, and we can with safety conclude that the percentage of CO_2 in the resulting air will not be so deleterious as the same percentage when derived from the respiration of men.

It is, therefore, evident, that we cannot fix upon a maximum percentage of CO_2 allowable in the atmosphere for all cases, but each case must be investigated and calculated separately.

Sources of Vitiation of the Atmosphere.

If we limit this investigation to the air in the Gold Mines of the Witwatersrand the following are the principal sources of atmospheric impurities:—

1. Respiration of Workmen.
2. Burning of Candles.
3. Gases from Explosives.

In addition to these, we have as minor sources:— the impurities from the decomposition of Kaffir excrement, the decay of timber, and in some instances gases from underground stoves for reheating air, also the gases produced by the ignition of oil in the Air Compressor and the mineral particles produced by drilling and explosives.

In the following estimations it is assumed that the incoming fresh air is thoroughly diffused throughout the mine before it passes up the Upcast Shaft.

This is evidently an assumption that is never realised in practice; the other extreme case would be to assume that the whole of the air in the mine is driven forward by the incoming air.

In the case of a mine that has been exploited for many years the latter assumption is evidently impossible and it is probable that in almost all instances the former assumption is nearer the truth.

Respiration.

This is the most important cause of vitiation of the air in a mine chiefly because it is almost continuous.

To estimate the necessary supply of air per workman per minute to neutralize this vitiation, it is essential to fix upon some definite data as to the quantity of air respired per minute and the composition of the respired air and the degree of vitiation that may be allowed without injury to men who are constantly employed in the mine,

It is usual to assume that the average composition of the gaseous portion of the atmosphere is by volume:

79.00 Per cent N
21.00 » O
0.04 » CO_2

with small percentages of other constituents.

Authorities:

Kirke's Physiology.
Parkes & Kenwood's Hygiene.
Whitelegge's Hygiene and Public Health.

Number of respirations per minute varies from 16 to 18.

It is usual to assume the number 16 as an average per minute and 30 cubic inches as the average volume per respiration, or 480 cubic inches per minute at the sea-level when the subject is at rest. Assuming that the supply of oxygen by weight at this altitude should be the same as at sea-level, we obtain approximately 586 cubic inches as the volume of air respired per minute at this altitude.

Disregarding the aqueous vapour and the organic particles emitted, the composition of the respired air, when the subject is at rest, is usually stated as:

Nitrogen	79.00
Oxygen	16.96
Carbonic Acid	4·04

During hard work the percentage of CO_2 is said to be approximately doubled with a consequent decrease in the percentage of oxygen.

Maximum Percentage Of CO_2 Allowed In The Air In Rooms etc.

It is usual in works on Hygiene to assume that 0.06 Percent of CO_2 should be the maximum percentage present in air that has to be breathed continuously, a larger percentage causing a decrease in the vitality of the person breathing it.

If the allowable maximum percentage of CO_2 is fixed upon, it is easy to compute the number of cubic feet of air that is necessary to render this respired air innocuous when thoroughly mixed with it.

Attached is a table showing the variable volumes of air required per man per minute, according to the degree of vitiation assumed, when the person is at rest and when working hard.

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TABLE TO SHOW THE CUBIC FEET OF FRESH AIR PER MINUTE PER MAN REQUIRED TO PRODUCE RESPECTIVE PERCENTAGES OF CO_2 IN THE ATMOSPHERE.

Cubic inches required at 5700′ elevation is taken at 586.

Formula to find the amount (n) in cubic inches required per minute per man, so that the atmosphere shall not contain a greater percentage of CO_2 than v.

$$\frac{586 \times 4.04}{100} + \frac{n \times .04}{100} = \frac{(n + 586) \times v.}{100}$$

Example:— To find the number of cubic inches of fresh air necessary in order that the percentage of CO_2 shall not exceed 0.08.

$$586 \times 4.04 + n \times .04 = (n + 586) \times .08$$
$$2320 = n \times .04$$
$$n = 58000 \text{ cubic inches}$$
$$= 33.6.$$

Resulting percentage of CO_2 atmosphere. (V)	Cubic feet of fresh air required per minute per man at rest.	Cubic feet of fresh air required per minute per man when working.	Rest and Working Conditions One-third working conditions.
.06	67	134	89
.07	45	90	60
.08	33	66	44
.09	27	54	36
.10	22	44	29
.15	12	24	16

The most striking result of this calculation is the rapid increase in the fresh air required to cause a decrease in the CO_2 of only .01 per cent.

It must be remembered that the increase in percentage of CO_2 is an indication of the increase in the number of organic particles and of a slight decrease in oxygen.

It is necessary to fix upon what we may describe as the degree of vitiation, and in doing so we must be guided principally by precedent.

A Committee appointed in 1897 to inquire into the ventilation of Factories recommended that "as a measure of respiratory impurity the carbonic acid gas contained in 10,000 volumes of air in humidified sheds should not exceed 9 volumes" that is 0.09 per cent.

This is evidently an attempt to obtain a percentage of CO_2 which could be supplied without practical inconvenience, such as draughts and lowering of temperature.

It must be remembered that in the factories we have conditions which do not occur in a mine.

In Cotton Factories, for example, it is necessary for the proper spinning or weaving of yarn that the air should be moist and above a certain temperature and that draughts should be inappreciable, whereas in a mine there are no delicate operations undertaken; the temperature may vary considerably and currents up to 150 feet per minute cause no inconvenience.

It is stated by Dr. Oliver, in Dangerous Trades, that 0.09 per cent of carbonic acid is too high an indication of respiratory im-

purity if we fix upon 0.07 per cent of CO_2 as the maximum for good conditions we obtain 45 cubic feet per man per minute as the minimum supply for man at rest and 90 cubic feet per minute when working hard.

If we assume that the man is working hard for one-third the time, we obtain 60 cubic feet as the necessary average supply.

If we fix upon .08 per cent as the maximum we obtain respectively 33, 66, and 44 as the necessary supply of fresh air.

To contrast this result with well known instances.—

Whitelegge's Hygiene, page 21.

> " 3000 cubic feet of fresh air per hour per person » should be supplied to a room of 50 cubic feet per minute » per man for rest conditions."

Parkes & Kenwood's Hygiene, page 265,

> " It was assumed by De Chaumont, and experience has » confirmed his assumption, that air vitiated to the extent » of 0.2 per 1000 can be breathed with impunity but that » no greater vitiation ought to be allowed. That is to say » an adult requires 3000 cubic feet of fresh air per hour » in order that the respiratory impurity may not exceed » 0.2 per 1000 or the total impurity of 0.6 per 1000".

The subject in these two examples is assumed to be at rest.

It is therefore evident that a supply of 60 cubic feet per man per minute is less than the usual requirement for persons who are working.

BURNING OF CANDLES.

Parkes and Kedwood state that a Sperm candle (six to the pound) produces 0.4 cubic feet of CO_2 per hour. As the emission of this CO_2 is not accompanied by organic particles we may assume that the maximum vitiation from this source should not be greater than is indicated by 0.12 per cent of CO_2.

In Parkes & Kenwood's Hygiene from 0.08 to 0.1 per cent is the maximum of CO_2 allowed from this source.

Assuming a vitiation of 0 12 per cent and that each man has one candle burning we obtain 8 as the cubic feet of fresh air per minute which must be supplied to render the CO_2 from this source innocuous.

VITIATION OF THE AIR DUE TO THE EXPLOSION OF BLASTING GELATINE.

Explosives used in the Producing Mines of the Witwatersrand from January to June, 1902:—

Blasting Gelatine	1,412,600 lbs.
Gelignite	383,200 „
Dynamite No. 1	3,250 „
	1,799,050

Assuming for our purpose that the gases emitted by the explosion of Blasting Gelatine are practically the same in volume and composition as those obtained from the explosion of a similar weight of Nitro-Glycerine, and also that the gases formed during the explosion of Gelignite and Dynamite No. 1 are the same in volume and composition as those formed by the explosion of an amount of nitro-glycerine equal to the amount present in these respective explosives, the equivalent weight of nitro-glycerine used in the

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Producing Mines of the Witwatersrand from January to June, 1902, inclusive is:—

	lbs.	Percentage of Nitro-Glycerine present.	Equivalent weight of Nitro-Glycerine.
Blasting Gelatine...	1,412,600	100	1,412,600
Gelignite...	383,200	60	229,920
Dynamite No. 1 ...	3,250	75	2,437
Total equivalent weight of Nitro-Glycerine			1,644,957

Assuming 156 working days in this period and 312 shifts we have $\frac{1,644,957}{312}$ as the amount used per shift 5272 lbs.

The average number of workmen employed underground during this period was, Whites 1420 per diem, Coloured 12,566 per diem or a total of 13,986 per diem = 6993 per shift.

Therefore the weight of Nitro-Glycerine used per man per shift was $\frac{5272}{9693}$ = .7539 lbs.

Guttmann in the "Manufacture of Explosives", page 146, gives the following data:—

1 kilo of Nitro-Glycerine, perfectly exploded, yields 1,135 litres of gaseous products consisting of:—

58.20 Per cent CO_2
19.80 » H_2O
18.50 » N
3.50 » O

Assuming the condensation of the aqueous vapour we have produced a gas containing:—

72.57 Per cent CO_2
23.07 » N
4.36 » O

Sandford in Nitro-Explosives, page 20, gives the following data:

1 kilo of Nitro-Glycerine perfectly exploded, yields 714 litres of gas at 0°C and 760 mm. pressure, or, 940 litres at 70 F and 24.5 inches pressure of which 80 2 Per cent are permanent gases.

1 kilo = 2 2 lbs.

1 litre = 61 inches.

1 kilo produces 940 litres of gas at 70° F and 24.5 ins. pressure.

2.2 lbs. produce 940 × 61 cubic inches of gas.

1 lb. produces $\frac{940 \times 61}{2.2}$ 26,064 cubic inches of gas containing 58.20 Per cent of CO_2 or 20,903 cubic inches of gas containing 72.57 Per cent CO_2. 0.7539 lbs. produce 15.759 cubic inches of gas.

9.12 cubic feet of gas containing 72.57 Per cent CO_2.

What volume of air is required to render this innocuous?

We may assume that two hours elapse between the time when the workmen return to the surface and the full complement of men begin the new shift, i. e., the mean time per man that the mine is vacant.

If we also assume that on the resumption of work the CO_2 present in the atmosphere should not be more than 0.12 Per cent CO_2 (this being derived from chemical reactions) the necessary supply of air per man is obtained thus:—

Vitiated Air	Ordinary Air.	Innocuous Air.
$\frac{9.12 \times 72\,57}{100}$	$\frac{n \times 0.04}{100}$	$\frac{(n + 9.12) \times .12}{100}$

from which n = 8259 cubic feet
= 68.8 » » per minute per man for two hours.

Thus a supply of 69 cubic feet per man per minute during a period of two hours will at the expiration of that time have rendered innocuous the CO_2 derived from blasting always assuming a perfect explosion and complete diffusion of the fresh air throughout the mine.

The percentage of oxygen present in the gases produced by explosion of Nitro-Glycerine being only 4.30, it is necessary to determine the percentage of oxygen present in the air at the end of two hours with an assumed total supply of 8259 cubic feet of fresh air. Using the usual equation we have:—

$$\frac{\text{Fresh air}}{\frac{8259 \times 21}{100}} + \frac{\text{Fumes}}{\frac{9.12 \times 4.36}{100}} = \frac{\text{Innocuous air}}{\frac{(8259 + 9.12) \times k}{100}}$$

where k = percentage of oxygen at the end of two hours.

From which we find, k = 20.91.

The percentage of N estimated in a similar manner is 78.898.

Thus giving composition of the atmosphere at the end of two hours as:—

N	78.898
O	20.98
CO_2	0.12

SUMMARY.

Cubic feet of air required per man per minute to render the atmosphere suitable for working conditions:—

For Respiration	60 cubic feet
For Candles	8
	68

DYNAMITE FUMES:—69 cubic feet per man per minute for two hours assuming a perfect explosion and complete diffusion.

As explosions are never perfect and other and more obnoxious constituents are often produced such as CO_2, oxides of Nitrogen, and various hydro-carbon gases, the above supply must be regarded as a minimum.

Attached is a table B to show the probable condition of the atmosphere in mines when variable quantities of air are supplied.

TABLE TO INDICATE THE CONDITION OF THE ATMOSPHERE IN MINES WITH VARIABLE SUPPLIES OF FRESH AIR.

Cubic feet of air supplied per man per min.	Percentage of carbonic acid present in atmosphere due to Respiration and Candles.	Percentage of CO_2 due to respiration only.	Percentage of CO_2 present after two hours interval between shifts due to blasting.
30	0.123	0.100	0.223
40	0.102	0.086	0.178
50	0.089	0.076	0.151
60	0.081	0 070	0.132
70	0.076	0.066	0.119
80	0.071	0.063	0.109
90	0.068	0.060	0.101
100	0.065	0.058	0.095

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It is evident from this table that the regulation which insists upon a minimum supply of 70 cubic feet per man per minute is based upon sound reasoning.

It should be remembered that as the current passing through the mine varies enormously, as much as 100 per cent, this should be the supply on the worst day of the year.

In all the above estimations it has been assumed that the incoming fresh air is thoroughly diffused before its passage up the upcast shaft. Such conditions never occur in mines, much of the air passing through the levels and to the upcast shaft without complete diffusion throughout the mine.

Thus the air at the end of levels, i.e. beyond the last connection, will, invariably be found to be much less pure than that in the main connected levels, and personal observation points to the non-ventilation of these portions as being the worst feature of the ventilation of the Mines of the Witwatersrand, especially if boys are working at the Face.

It may be of interest to ascertain the velocity of the air-current which is necessary to supply the stopes with 70 cubic feet per man per minute.

As an ideal case, we may assume that there are five stopes on the level and 20 boys (Hammer and Shovel) in each stope, or 100 boys and men on this level in one shift.

The necessary supply of air is 7000 cubic feet and as the whole of this may pass at one place through a cross section of 33 square feet in area, we have at this place a velocity of 212 feet per minute.

This may be described as a fairly strong draught, but one in which a candle can be kept alight.

This is the highest velocity on the level and rapidly decreases as portions of the current pass up the stopes.

VELOCITY IN SHAFTS.

Assuming that boys only are employed for breaking ground also a Four Compartment Shaft with a clear sectional area of 110 square feet, we obtain the following velocities for variable numbers of workmen underground

No. of workmen.	Supply per man per minute.	Total supply of air per minute.	Average velocity in shaft.
300	70	21,000	191
400		28,000	255
500		35,000	318
600		42,000	382
700		49,000	445
800		56,000	509
900		63,300	573
1000		70,000	636

In the above estimations we have omitted the supply of air necessary to render innocuous the exudations from the skin of workmen, because this is difficult to estimate and also the obnoxious effluvia from Kaffir excrement. This latter is much more serious than many who are not intimately acquainted with mine workings could possiby imagine. From personal experience of many mines

one can only describe the condition of some of them as perfectly disgraceful and calling for the immediate adoption of an underground sanitary system.

462. The Chairman: For the benefit of the Commission could you make us a brief statement of what you have written there?— Yes. The statement I have laid before you is an investigation into minimum supply of air per man per minute required in the mines of the Witwatersrand, and, in making this investigation, I have started almost ab initio taking the statements of various writers on hygiene and calculated out by a simple and correct method what I consider the probable minimum that is required. In doing this I have taken into account principally three causes of vitiation:— respiration; burning of candles; and the gases emitted by explosives. The carbonic acid from these three sources is accompanied by different impurities in each case.

I have calculated the amount required for each case independently. In the case of respiration, and almost all other cases, I have taken, as a rule, the lowest data in order to calculate the minimum amount required. For instance in the case of respiration. I have taken the ordinary conditions of sixteen respirations per minute, and what is usually stated as the lowest volume exhaled, viz, thirty cubic inches, and from that I have calculated the amount of carbonic acid, exhaled per minute; and assuming certain figures of maximum vitiation, I have calculated, as on table "A", the number of cubic feet per minute required to render this exhaled air innocuous. As you will notice from the table, I have given you a list of six figures of vitiation, ·06, ·07, ·08, ·09, ·10, ·15. I have calculated the number of cubic feet required per man per minute, supposing a man to be at rest; the number supposing a man to be working hard and continuously; and then, in the fourth column, I have estimated that the man is working hard 1/3 of the time, which I assume is probably the proportion of the time which the Kafir does work hard. In the case of Kafirs, for example, I do not think they work half the time really hard, and I have deduced in that way column 4 from columns 2 and 3. As I pointed out in the paper, this is not intended, by myself at any rate, to fix upon the number of cubic feet that is required, so much as to point out the vitiation that results from certain causes. In this case for example a vitiation of .08 Per cent will be the result of supplying 44 cubic feet per minute per man. In all these calculations I have assumed that the mine resembles an elastic globe that expands when a certain quantity of air is forced into it and then contracts when a similar quantity passes out of it again. In other words I assume that the air supplied is completely diffused throughout the mine.

That is an assumption, which you all know, is not in accordance with facts but one must estimate something and that is perhaps nearer the truth than anything else I could think of.

463. The Chairman. That assumption would tend rather to lower your figures if anything?— Well, if I assume that all the air supplied passes straight through the mine, without diffusing in the mine, the amount required per man would of course be less We know such is not the case and that diffusion must take place. I have dealt with respiration in that way, and before passing on to the burning of candles it seems to me in looking at this question, that ·07 is a fair number to estimate as the maximum vitiation

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Most authorities are agreed that ·06 is the figure for vitiation of air which has been respired.

464. Dr. Davies. You mean allowable vitiation?— Yes. Well, I assumed here, and I show in this paper, that in cotton factories the Commission decided upon ·09, but there seems to be a concensus of opinion that ·09 is too high, so I have given you two figures ·07 and ·08 resulting in 60 cubic feet, and 44 cubic feet respectively, as the necessary supply. It seems to me that ·07 is a very fair assumption We cannot get conditions in a mine corresponding to those in a room. Passing to the burning of candles; I have taken my data entirely from Parkes and Kenwood's hygiene, in which it is stated that ·04 cubic feet of carbonic acid is given off per hour by the burning of a sperm candle of the weight of 6 to the lb., and I have assumed that the air may be vitiated to a large extent in this case. It may be vitiated to the extent of ·12. If this is assumed then 8 cubic feet per man per minute is required to render the CO_2,given off by the candles, innocuous. Then I have dealt with the question of the air required to neutralize, or render innocuous, the gases emitted by the explosion of Nitro-Glycerine. We all know that none of the explosives consist of pure nitro-glycerine; but, in order to arrive at some result I have assumed that the result of the explosion is the same as if nitro glycerine were exploded. In the case of blasting gelatine I have assumed that the gases emitted are practically the same, in volume and composition, as those obtained from the explosion of a similar weight of nitro glycerine, and I have estimated from the statistics furnished in the Government Mining Engineer's report the weight of nitro glycerine exploded per man per shift, and I worked this out at .7539 lbs. Then I have taken certain data. I have also estimated this over a certain number of mines and it varies from .9 to .7 in the few mines I took. This figure is probably, therefore, approximate to the truth. Then I have taken the volume of gases emitted by the explosion of a certain weight of nitro glycerine, and reduced this to the temperature and pressure which obtains down in the mine, or rather at the altitude, and I obtained 940 litres as the amount of gases emitted by the explosion of one kilo of nitro-glycerine. I then assume that the aqueous vapour is condensed; and calculated the volume of gas emitted by one kilo of nitro-glycerine to contain 72.57 of CO_2. In this way I have arrived at 9.12 cubic feet of gases containing 72.57 per cent of CO_2 as the amount of CO_2 emitted per man per shift. Then, afterwards, I have discussed the question of rendering this gas innocuous. I have assumed that .12 per cent of CO_2 should be the maximum amount of vitiation. You must remember, that in this case, there is a small proportion of carbon monoxide and oxides to nitrogen; but it seems to me that .12 is sufficiently high. Then I have assumed that this gas should be rendered innocuous in the two hours that elapse between the close of one shift and the beginning of the next. We know that is not the usual time, but I assume it is the mean time. A large number may come up at 3 o'clock, a large number at 4, and a large number at 5, but if we take the mean time, it is probably about two hours. I have supposed, then, that the gases from the dynamite explosion should be neutralized in these two hours, and I have worked this out in the usual manner. In this way, I have obtained a figure of 68.8 cubic feet as the volume of air required per man per minute for

two hours. Then I have calculated the oxygen in the atmosphere which, in the case of perfect diffusion, should be the result at the end of two hours. I have summarised this, and find the cubic feet of air required per man per minute, to render the atmosphere suitable for working conditions, is for respiration, 60 cubic feet, and for candles, 8 cubic feet, giving a total for these two of 68 cubic feet, and for dynamite fumes 69 cubic feet per man per minute for two hours subsequent to the mean period of blasting. I have also made a calculation on the last page but one, to show the vitiation of the atmosphere resulting from the supply of 30, 40, and 50 cubic feet per man per minute. It is very difficult to separate, in this case, CO_2 produced by burning candles, from CO_2 produced by respiration. I have given a total in the second column, and then, of this total, I have given a proportion in the third column. You will see, that by the supply of 70 cubic feet per man per minute the vitiation amounts to .076 of which respiration amounts to .066 and this is the amount supplied during the two hours after blasting. The vitiation at the close of that period corresponds practically to .12 of carbon dioxide. I have calculated from this that the regulation which insists on 70 cubic feet is a fair regulation, and takes into account the practical difficulties and also the requirements of the individual. I have also calculated, and it is a matter of interest, the draught that would be the result of supplying 70 cubic feet per man per minute to a certain number of boys above a certain level. This is obviously an ideal case and can be varied ad infinitum. I have assumed that there are five stopes on the level, and twenty boys in each stope, or one hundred boys and men on this level in one shift and I find the draught resulting to have a velocity of 212 feet per minute. This is the strongest draught that would result in this manner. I have also calculated out, as a matter of some interest, and as being especially valuable to mine managers, the shift velocity of the air when 70 feet is supplied per man per minute for given numbers of workmen. I have also referred in the last paragraph to what most men, who have any knowledge of the mines of the Rand, are perfectly cognizant of, and that is, the disgraceful condition of the mines as regards sanitation.

Dr. Sansom: I think Mr. Chairman we cannot ask any questions on this paper until we have had time to consider it.

The Chairman: I think it will be neeessary to go into the question of ventilation and the necessary amount of air required. I believe the point has been raised that Miners' Phthisis is produced not by dust, but by vitiated air, and, I think, that is one of the alleged cases which this Commission must investigate. I fully agree that this is rather a big paper full of figures and that it ought to be circulated amongst the members of the Commission, and we could then question Mr. Wilkinson at our next meeting.

465. Mr. Catlin: I would like to ask Mr. Wilkinson a question in regard to his last statement, that the sanitary conditon of the mines is disgraceful. Have you any suggestion to make in regard to the improvement of the sanitation?—Well, I have not any detailed suggestions to make to you, but I simply say that there should be some sanitary system and that there is none at present.

466. Mr. Catlin: I presume some of the mines have tried, and tried in vain, to improve the sanitary conditions, because this is the most striking thing one meets underground, and I did not

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know but that you had given the matter some thought?—I dont know any particular sanitary system which might be applied apart from the pail system, but in a large number of mines there is no sanitary system whatever. I have had to investigate so many blind ends,' and of course I have been again and again turned out of those ends, and it seems te me something should be done. In the cases I am speaking of, no system at all is adopted.

467. Dr. Porter: You are speaking of underground sanitation?—Yes.

468. The Chairman: If you can make it convenient to attend at our next meeting for examination I shall be obliged?—Certainly.

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Mr. Joseph Simpson Fisher, Deputy Inspector of Mines, Johannesburg, was called and examined.

469. The Chairman: I think, you have a written statement with regard to the wearing of the respirators?—Yes, I have it here.

The Chairman: I think we can take this paper as read.

Witness submitted the following statement:—

WEARING OF RESPIRATORS.

In connection with the wearing of respirators the following men have been interviewed and their statements are as follows:—

CROWN REEF.—RESPIRATORS MADE OF ALUMINIUM.

William Martin stated:—"I have been using my Respirator for about two months. When I wear it in dusty places I do not find my nostrils stopped up with dust as I used to before wearing one. The Respirator has given me no trouble due to breakage during the last two months; the valve is the only weak point. I do not smoke when I am drilling dry holes in the presence of dust. I am sorry that I have not used Respirators always in dusty places."

T. Shadwill stated:—"I have been using my Respirator for about 6 weeks. I consider it very good and as long as I remain underground where there is dust present I will always wear one. I have no trouble about breathing, and when I wear it in dust I have not noticed any coming through."

—Hudson stated:—"I have been wearing my Respirator for about 3 months. I wish I had worn one 10 years ago. I have no doubt that it is a good thing. I have no trouble about breathing, and do not feel any inconvenience now while wearing it; when I first used it, it was a little awkward. I do not smoke when dust is present. I am an old Miner and would recommend that everyone should use them when working in dust. I have not noticed any coming through my Respirator after wearing it in the presence of dust."

A. L. Shadwill stated:—"I have been using a Respirator for 3 weeks and I intend to continue using one when in dust. I have no trouble about breathing, and I find that I do not cough up dust and black stuff after being in the smoke and dust as I used to do."

WOLHUTER. — RESPIRATORS MADE OF INDIA-RUBBER, HURD'S. — Mr. *J. S. Fisher* 4th Feb. 1903.

Two men were interviewed at this Mine.

Richard Jones stated:— "I have been using my Respirator for 6 months. I use it always in my working face. When working my machine I find no difficulty in breathing unless I do very hard work. Instead of the valve I use a small piece of sponge on account of the valve getting out of order. After using the Respirator in dust I find that no dust comes through, at least I find no dust in my nostrils as I used to before using one. I find it of special use after blasting. I am working in a rise."

John Ulmar stated:— "I have been using my Respirator for about two months. I have no trouble in breathing through it when working on my machine, and I find no dust in my nostrils after using the Respirator in dust. I intend always using one when in dusty places."

NEW HERIOT. — RESPIRATORS HURD'S INDIA-RUBBER.

Pearce—Shift Boss—stated:— "I always wear my Respirator (an aluminium one) underground, but find it rather difficult to breathe with when climbing ladders. 5 months ago I went to Dr Rogers and he told me I was in the incipient stage of Miners' Phthisis and advised me to leave off work for two months. I then weighed 165 lbs. I knocked off work and went down to Natal for 2 months; on coming back I weighed 185 lbs. I started again as Shift Boss and always used a Respirator, and Dr. Rogers now says my lungs are improved vastly. I attribute my not having lost weight or gone back in health during the last 3 months to wearing a Respirator. I have never run a machine in my life and was most surprised when I heard I had Miners' Phthisis. I have been Shift Boss for 10 years."

Matthias Lavel stated:— "I am a machine man and have been running machines for the last two years; so far I have found nothing wrong with my lungs. I have been using one of Hurd's (India-Rubber) Respirators for a fortnight. The rubber is not stiff enough, and it therefore loses its fit to the face. I do not think much of it, although it saves a certain amount of dust, but a lot comes through the side. I always wear it when drilling dry holes. I find it most useful when there is any smoke about."

R. Little stated:—"I am a machine man. I don't think much of the India-Rubber Respirator as the valve is useless, and it does not fit the face. I don't wear mine now."

T. Mcboy stated:— "I am a machine man. The India-Rubber Respirator is useless. I have thrown mine away. The valves don't work and they don't fit the face.

D.I.M. I visited the Crown Reef Gold Mining Company and used the Aluminium Respirator. I gave it a severe test, keeping my face within 12 inches of the mouth of a dry hole that was being drilled. When the hole had been drilled 5 feet I examined my nostrils with a looking glass and found them coated with fine dust; there was no dust on my moustache. On examining the Respirator I am of the opinion that all the dust came through the valve, there was no appearance on my face of the dust having come under the edges of the respirator. The respirator is a good one if it was not for the valve, which is not effective.

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At the New Heriot an Aluminium Respirator was also tested while a dry hole was being drilled 6 feet deep in a drive. The results were much the same as at the Crown Reef. The test was taken standing by the bar, and on examination after the hole was drilled, dust was present on the moustache and in the nostrils. There was no appearance of dust entering excepting through the valve.

There are at present in the Johannesburg District a total of 24 Mines Milling, Developing and Shaft sinking:—

Mines Milling	21
» Developing	1
» Sinking	2
Total	24

In the two Mines sinking there is no dust owing to the water met with during sinking operations.

Having made enquires from the 22 Mines Milling and Developing, concerning the use of Respirators, I have come to the conclusion that, with a few exceptions, the men employed have taken little interest in the wearing of them as a preventative against the inhalation of dust.

Out of the 22 Mines I find that Respirators are used at 8 only, as follows:

Name of Mine.	Number of Men using Respirators.
Crown Reef	32
New Heriot	24
Village Main Reef	16
Robinson Deep	12
Wolhuter...	25
Henry Nourse	8
Bonanza	2
Crown Deep	2
Total	121

On the 8 Mines named where Respirators are used, 15.6 Per cent of the total number of men working underground wear them. The managers inform me the 15.6 per cent represents the number of men developing or working in stopes where a large amount of dust is present. The men working machines where wet holes are being drilled consider they are unnecessary; also the men on other mining work who do not come into contact with a large amount of dust.

At the remaining 16 Mines Respirators are not being used for various reasons, some of which are as follows:—

1. Men object to wear them.
2. Men take no interest in them.
3. In some cases very little developing is being carried on, and the men do not consider it is necessary to wear them while doing other work where there is but little dust present.

From my enquiries I am of opinion that the wearing of Respirators is not a perfect preventative against dust entering the lungs. It has many disadvantages, some of which are as follows:—

The men will not wear them during the whole shift; they are only used when the dust is plainly visible in the air, or when going into a working place after blasting; this is owing to the discomfort experienced in wearing them.

2. Most Miners smoke and they cannot do so when wearing them.

3. Some men complain that there is a difficulty in breathing when they are working hard.

4. The valves at present used are far from satisfactory, and are often discarded and the hole filled with filtering material.

ADVANTAGES.

There is no doubt that there are advantages also to be claimed for the wearing of respirators, especially those in use at the Crown Reef Gold Mine; they are made of Aluminium with a cotton wool or flannel filter. When going through this Mine I wore one, and though I walked up steep stopes, I cannot say that I felt any difficulty in breathing. Where men are working in dust and smoke, a good respirator is beneficial in that it prevents a large percentage of the dust being inhaled. I saw men working machines drilling dry holes, and on asking them to take their respirators off I examined their nostrils, and there was only a trace of dust to be seen caused very probably by altering the shape of the respirators in order to fit the shape of the face, which causes the valve to get out of order.

The men also stated that when wearing them in the presence of dust and smoke, they found very little deposit of dust or black matter coming from the nostrils, which is usual when they are working in dust and smoke and do not wear respirators.

Granting that Respirators are beneficial at the present time when water is not being used to any great extent, I am of the opinion that in the future Respirators will have to take a secondary place to the use of water, and they will only be used where it is found impossible to lay the dust by that means.

From the statements of old machine men using Respirators I find that they are taking a serious view of the effects of dust, and realise that unless something is done, their health will be permanently injured, and they assure me that when dust and smoke are present they will always wear them. On the other hand in the case of young men who have not been working long on the machines and do not feel any bad effect from dust, something else will have to be done as it will probably be too late when the seriousness of their condition leads them to believe that the wearing of a Respirator would tend to prolong their lives.

I am of the opinion that a good class of Respirator in the hands of a careful man will greatly assist in preventing a very large percentage of dust being inhaled, but from what I have seen I consider something else is necessary.

Having dealt with the bad and good points of the Respirator, before concluding I might state I consider that water is the agent which has to be depended upon in the future, and in my opinion water pipes ought to be laid in the drives to the different working places, the pressure being taken from the shaft or in any other suitable way. Up to the present time I have seen no jet with which it is possible to wash out the dust from a dry hole 6 feet deep, though it has been experimented with at a few mines; if this were possible it would satisfactorily deal with the dust due to boring.

There are two other methods of using water at present being tried, as follows,—atomizing the water, and also using it in the form of a spray.

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ATOMIZER.

The Atomizer patented by Mr. Britten is effective in depositing all dust within its sphere of action. I saw it working in a rise at the Wolhuter which was up about 170 feet and though all the holes were dry no dust could be seen present in the air, and dust could not be noticed on the faces of the men working the machines which under ordinary conditions would have been white. When the Atomizer is working in a drive during blasting operations, it will prevent any dust passing through the point where it is placed, which point may be in proximity to the face

Looking at the Atomizer from a dust-destroying point of view, it is effective, and in hot places it will cool the air, and by so doing, will naturally give a better circulation. Whether the finely divided particles of water floating in the air will be detrimental to the health of the persons employed, is a point that will have to be decided by Doctors.

SPRAYS.

Mr. Beatty has patented a spray which I consider will be effective in depositing the dust in the Mines Like the Atomizer it can be used for damping all places where dust is present, and also used to advantage after blasting. If the Doctors decide that the atomizing of water is injurious to the health of the workmen, then I am of the opinion that the use of a spray will do what is necessary without highly charging the air with moisture.

Where Atomizers or Sprays are used I consider that it is essential that water pipes should be laid down to the different workings, as at the Jumpers Deep If this is not done, and the water has to be brought from a considerable distance, it is probable that Atomizers or Sprays will not be used. The labour and discomfort arising from having to carry water up steep rises is well known to all accustomed to underground workings, and to my mind if the dust is to be effectively laid in rises, it will be necessary to have the water carried up in pipes.

470. The Chairman: Your paper chiefly deals, I think Mr. Fisher, with respirators?—Yes, the use of respirators.

471. Would you kindly give the Commission your experience, in regard to the efficiency of the respirators as used by the miners, and also of the different kinds in use?—There are only two kinds principally in use; Hurd's Respirator and the Aluminium one. This Aluminium one is the best one. It was brought out from home by the Crown Reef.

472. I think that is a respirator patended and sold by Messrs. Wallach Bros., London?—Yes. I used that respirator at the Crown Reef, standing about a foot from a dry hole, and I found no dust came through, but through the valve itself a certain amount of dust does penetrate. When I looked at my nostrils I found them coated with fine dust, but there was no dust on my moustache, and I noticed none on my mouth. Taking this, therefore, as the best class of respirator, I think it fails owing to the valve.

473. Then that particular respirator is a good one with the exception of the valve?—Yes, that is the best I have seen. In walking up stopes I found no difficulty in breathing, but the great trouble with regard to respirators is, that they are rather uncomfortable and men will not wear them unless they see dust present in the air or during blasting operations, and a man, who is not blasting or drilling

dry holes, will not as a rule wear them. I found many men who objected altogether to wearing them. Others, who say that their lungs are weak, experience difficulty in breathing through them. In the Wolhuter, where they use Hurd's Patent Respirator, the men complain that the mica valve does not fit, and the result is that the dust comes through. They often take the valve out and put in some filtering material, such as cotton wadding or sponge.

474. Does sponge act efficiently as a filter?—There is a certain amount of difficulty in breathing when working hard, but not when doing mild work.

475. Does that apply to all respirators or only to Hurd's?—In ordinary work, I have heard very few complaints except from one man who is a shift boss travelling about the mine, and he stated that he had some difficulty in breathing. That is the man, who was told by Dr. Rogers, that he had incipient Miners' Phthisis.

476. The Chairman: I think it would be rather interesting if you would just read out what he says?—His statement is as follows: "I always wear my respirator (an aluminium one) underground, but find it rather difficult to breathe through when climbing ladders. 5 months ago I went to Dr. Rogers and he told me I was in the incipient stage of Miners' Phthisis and advised me to leave off work for two months. I then weighed 165 lbs. I knocked off work and went down to Natal for two months; on coming back I weighed 185 lbs. I started again, as Shift Boss and always used a Respirator, and Dr. Rogers now says, my lungs have improved vastly. I attribute my not having lost weight or gone back in health during the last three months to wearing a Respirator. I have never run a machine in my life and was most surprised when I heard I had Miners' Pthisis. I have been Shift Boss here for 10 years."

477. Mr. Drake: Does he refer to this Respirator?—Yes.

478. Mr. Drake: I see you have here Hurd's Respirator on the New Heriot?—Well, the men on the Mine are wearing Hurd's but Pearce, the Shift Boss, wears an Aluminium Respirator.

479. Dr. Sansom: How many mines have you visited to enquire about these respirators?—I have enquired at all the mines, and have gone personally to those mines where the majority of respirators are in use.

480. And have you watched the men use them?—Yes, I watched the men using them.

481. On how many mines, do they use them?—There are 22 mines in the Johannesburg District, and I only found respirators being used on 8 mines, the Crown Reef using 32 and the New Heriot, 24.

482. I take it, your conclusion is, that although to a certain extent dust is excluded by these respirators, they are not a complete protection?—Not with their present valves.

483. Supposing these things were ordered to be used, is there great probability of men invariably using them or, do you think, that it is likely that the regulation would be disregarded and the respirators allowed to fall into disuse?—As far as I can gather from the old miners, they are taking a serious view of the case and they wear them, whenever they see dust present in the air.

484. You know that they will probably take a serious view of the matter for a little time, as long as attention is directed to the serious nature of the disease, but, when there is no longer this

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attention paid to it, the men are apt to get careless?—I think that a very great deal depends upon the managers of the different mines. I noticed, that where the managers take an interest in the matter, their men, to a very large extent, wear the respirators.

485. But Managers cannot be down at the end of every drive to see that the men are wearing respirators?—No, they cannot do that but, I think a certain percentage will always wear them.

486. A man will take off his respirator in order to smoke?—Yes, there is no doubt about that.

487. Mr. Drake: You have brought out the fact that only 8 mines, out of 22, are using respirators in the Johannesburg District?--Yes.

488. A little further on in your statement you state that—"At the remaining 16 Mines, respirators are not being used for various reasons, some of which are as follows:—

1. Men object to wear them.
2. Men take no interest in them.
3. In some cases very little developing is being carried on, and the men do not consider it is necessary to wear them while doing other work where there is little dust present."

I bring this statement out in view of the previous one because it might appear to the public that some mines were using more precautions than others and these three objections state the whole case. I think that in those mines, where developing is going on at present all the managers would probably take more interest in seeing that respirators were used. You would agree with me in that?—Certainly, I have no doubt they would.

489. The Chairman: You might just read out your opinion at the end of your paper with regard to respirators generally. I think it is the last page where you summarise?—"I am of the opinion that a good class of Respirator, in the hands of a careful man, will greatly assist in preventing a very large percentage of dust being inhaled, but, from wha I have seen, I consider something else is necessary.

Having dealt with the bad and good points of the Respirator, before concluding I might state I consider that water is the agent which has to be depended upon in the future, and in my opinion water pipes ought to be laid in the drives to the different working places, the pressure being taken from the shaft or in any other suitable way. Up to the present time I have seen no jet with which it is possible to wash out the dust from a dry hole 6 feet deep, though it has been experimented with at a few mines; if this were possible it would satisfactorily deal with the dust due to boring.

There are two other methods of using water at present being tried, as follow: atomizing the water, and using it in the form of a spray.

The Atomizer patented by Mr. Britten is effective in depositing all dust within its sphere of action. I saw it working in a rise at the Wolhuter which was up about 170 feet, and, though all the holes were dry, no dust could be seen present in the air, and dust could not be noticed on the faces of the men working the machines, which, under ordinary conditions would have been white. When the Atomizer is working in a drive during blasting operations, it will prevent any dust passing the point where it is placed, which point may be in proximity to the face.

Looking at the Atomizer from a dust-destroying point of view it is effective, and in hot places it will cool the air, and by so doing will naturally give a better circulation. Whether the finely-divided particles of water floating in the air will be detrimental to the health of the person employed, is a point that will have to be decided by doctors.

Mr. Beatty has patented a spray which I consider will be effective in depositing the dust in the mines. Like the Atomizer, it can be used for damping all places where dust is present, and also used to advantage after blasting. If the doctors decide that the atomizing of water is injurious to the health of the workmen, then I am of the opinion that the use of a spray will do what is necessary without highly charging the air with moisture.

Where dust or sprays are used, I consider that it is essential that water pipes should be laid down to the different workings, as at the Jumpers Deep. If this is not done, and the water has to be brought from a considerable distance, it is probable that atomizers or sprays will not be used. The labour and discomfort arising from having to carry water up steep rises is well known to all accustomed to underground workings, and to my mind, if the dust is to be effectively laid in rises, it will be necessary to have the water carried up in pipes."

490. The Chairman: That conclusion of your statement leads one to believe that you don't consider the present respirators really effective?—No.

491. Have you ever known any respirators really effective?—No.

492. When you examined the men at the mine did you notice, whether dust got through their respirators?—I have looked at their nostrils after working, and examined their moustaches.

493. And did you find the insides of the nostrils coated with dust?—Yes.

494 In all cases?—Yes, to a certain amount.

495. To what extent?—Not nearly as bad as you would expect to find, in the case of a man working a half-shift without a respirator.

496. Some respirators were worse than others?—Yes.

497. Depending upon the valve?—Yes. These respirators you can, of course, make to fit any ace, but the trouble is that in fitting it to the face you very often disturb the seating of the valve, so that it won't work.

498. Do these rubber ones fit better?—They are worse, I think

499. Mr. Drake: You say that you find the respirators not effective. Would you qualify that, and say not entirely effective?—Yes, but it is only a matter of time before that valve becomes ineffective.

500. But still a respirator has some beneficial action?—Yes, as a whole it is good.

501. Mr. Harry Johns: One other point I should like to make. Mr. Fisher has mentioned, in his statement about dust-destroying apparatus, atomizers and sprays. Have you seen anything, so far, which would lay the dust after a blast?—Yes.

502 When the holes are blasted we have dust, and no atomizers or sprays are present. You would have to saturate the whole heap?—

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Yes, but then the spray would come in, because you could have different sized nozzles with your spray. You would, however, have to thoroughly saturate the stuff you were blasting.

503. That would be a difficult thing to do?—Well, it would be difficult.

504. Without you had the spray or the atomizer playing on the heap of dry rock you would not be able to get rid of the dust? That is so, and you would naturally have to keep the spray playing continuously.

505. I mean in the case of men drilling fresh holes and boys shovelling rock already broken, you could not saturate that rock in order to prevent this dust rising unless you had the spray playing on it.

506. Mr. Drake: One would require to have a spray playing on the point where the shovelling was taking place?—Yes.

507. Mr. Catlin: In places where the atmosphere is already charged with moisture, is that not sufficient to settle the dust? I understand it takes two hours after blasting to settle the dust?—Well, in working the atomizer, water is divided into very fine particles but with the spray it would be thrown more as a large body against the face of the surface.

508. I understood that it would take two hours after the atomizer was at work to settle the dust?—Oh no; I think you mean that it took two hours to take noxious gases out according to Mr. Wilkinson

509. Have you seen the effect of these atomizers on gases after blasting?—No, I have not.

510. You cannot state whether it has any effect in laying the gases?—No.

511. Dr. Davies: How many miners do you think, Mr. Fisher, would use these respirators supposing they were perfect and miners knew it would be to their advantage to wear them?—That is a very difficult question.

512. From your practical experience of miners, you must know perfectly well their various idiosyncrasies and how many, do you suppose, would use them?—I believe 70 Per cent of the miners would use the respirator, in dusty places, where they could see the dust.

513. But if they could not see the dust, they would not wear them?—No.

514. The Chairman: Do you mean at the present time or always?—No, in dusty places even in the old days men used to tie a rag, of some description round their faces.

515. That is only when the dust is visible?—Yes.

516. They would not take any notice of finer dust which was not visible?— No.

517. From your knowledge, do you think the use of respirators could ever be made compulsory?—No.

518. Do you think that the opinion of the men is, that the respirators are good to a certain extent?—Yes.

519. And, so long as the respirators are not uncomfortable, they think them good?— Yes, when they are in dust the majority of the men would wear them.

520. Dr. Sansom: Have you talked to the miners who work this atomizer?—Yes.

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521. Have they any complaints?—No, no complaints. One man, who was working 170 feet up, told me that if the atomizer was taken away he would have to leave the place.

522. That was not a complaint?—No, it was rather in favour of it.

523. Then, with regard to the atomizer, you have heard no difficulties whatever?—No.

524. Now, as to the spray, are there no complaints about that?—That spray has been tried by the Robinson Mine and, I know, they have ordered four.

525. Mr. Drake: That is Beatty's?—Yes.

Dr. Sansom: A certain number of samples of air have been taken from difierent mines in order to see how much dust per litre is in that air. Have samples of air been taken for testing purposes when the atomizer was at work?

The Chairman: Not yet

Dr. Sansom: I think I should like to have that done, because we would then know whether it was an effectual means of laying the dust.

The Chairman: Yes that is so.

Mr. Drake: It would also prove whether it had any effect on the gases, and that would be a very strong piece of evidence If there was no dust in places where rock drilling was going when the atomizer was being used, then we should know where we were

The Chairman: Thank you, Mr. Fisher.

Mr. *W. Moses.*
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Mr. William Moses, Inspector of Mines was called and examined.

526. The Chairman: Mr. Moses, have you come across many cases of Miners' Phthisis?—No, very few.

527. Is that because the cases don't exist or because you do not come in contact with them?—I suppose the latter. I have had 32 years experience in mines, principally in coal mines but I have not come across any cases, with the exception of four cases here quite recently.

528. Where was your experience of Coal Mines?—In England, British Columbia, China and also here in the Transvaal.

529. And you never came across Miners' Phthisis?—No, not in Coal Mines.

530. Did you come across other pulmonary complaints?—Yes, these are very prevalent.

531. In your opinion Mr. Moses, Miners' Phthisis does not exist out here, in the Transvaal, or is it only because you have not come across any?—I would not say that, I should say, that it does exist. I come in contact frequently with Miners, Mine Managers and the Medical Officers, and all I am telling you, is what I have gathered from them, and that is that there is not so much Miners' Phthisis as we are led to believe.

532. But it does exist?—Oh there is no doubt.

533. Have you any idea as to the cause?—Well the principal cause is the dust created by the working of the rock drill, the fine particles of dust developed there.

534. Is this the chief cause?—I should say so.

535. In every case?—I should say it was aggravated very much by the gases, and so forth, given off in the explosions.

Mr. W. *Moses.*
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536. Have you any evidence to lead, as regards the injury caused by gases?—No, I have no evidence beyond this that during my experience I have seen men gassed and I have also come across deaths from the inhaling of fumes, but as to the injurious effects of gases that is more a point for a medical man.

537. Have you any suggestions to make as regards the prevention of the disease?—As far as I can gather, the best prevention would be the application of water and an improved respirator. There is no doubt that the present respirators are not the very best that might be made, but improvements could be brought into them. The application of water would stop the dust rising and getting into the atmosphere. Mention has been made as to the sanitation of mines, and, as far as I have seen, this is not so bad underground in any new mine, but is worst in the older mines where there are disused workings, which have not been shut up.

538. Do you mean disused portions of a mine?—Yes.

539. In these portions where working is proceeding the sanitation is not so bad? It is not so bad.

540. That is in the newer mines?—Yes.

541. What do you mean?—Deep levels.

542. You mean to say there is not the same number of worked out stopes in a new mine as in a deep level mine?—Yes.

543. Do you think that all deep level mines would eventually get into the same condition?—No, because precautions are being taken.

544 What precautions?—The bucket system,

545. Has that been introduced into all deep level mines in your district?—I won't say all, but I should say the majority of the deep level mines. Then, as to the health of the miner, if the system of having change houses was applied to the different mines, the miners would be very greatly benefitted. His clothes should be left in the change house and they should he dry and clean for him before he returns to his work. He should not be allowed to go to his room and hang up his wet clothes, inhaling all the time the damp atmosphere caused by these wet clothes. This leaves the miner open to all kinds of other diseases and would probably induce a more rapid course of this phthisis.

546 Do you mean that for a man to change in his bedroom is very unhealthy?—Yes.

547. Examined by Dr. Davies.

548. Do you make a statement that Miners' Phthisis is not so common as one would be led to believe?—Yes, that is so, as far as I can gather.

549. That is rather an important statement, is it not?—Well, I don't know. I can only give my opinion, and the opinion of the people in my district, that is also what they think.

550. Do you know what Miners' Phthisis is?—Not in the least, excepting what I have been told.

551 Do you know what it is caused by?—By the inhaling of the atmosphere which is laden with dust.

552. If you don't know what Miners' Phthisis is how do you know what is the cause?—From the instructions of medical men.

553. Then do you not know of your own knowledge?—Oh dear no, I have never made a post-mortem.

554. Do you know what you stated regarding prevention from your own personal knowledge?—Not from my own personal knowledge.

555. You say, you don't know anything except what the Doctors have said. You make a statement that dust is the cause?—Yes, and I say apply water and stop the dust.

556. Very good. Then, you are assuming, that certain statements, that have been made as to dust being the cause of Miners' Phthisis are true?—Certainly.

557. Very good, then we also have to take your evidence, as being purely an assumption on an assumption?—It is an assumption as far as that is concerned.

Then, Mr. Chairman, I object to evidence being taken of this kind. I don't think it right that we should get evidence as to opinions, unless the gentlemen giving these opinions are willing to prove them.

The Chairman: I think, Mr. Moses, as Inspector of Mines, has visited a large number of mines in his district, the eastern portion of the Rand, and, I think, he is reflecting, possibly, the opinions of those with whom he has come in contact.

Dr. Davies: But, Mr. Moses is on oath giving evidence as an expert and if he does so, we must get categorical evidence and not what he has got from other people as it seems to me we may be led astray by evidence given entirely made up of statements by other people.

The Chairman: Cannot we take Mr. Moses' evidence as being that of the general opinions obtaining in his district?

Dr. Davies: I am quite willing to accept his evidence from that point of view.

558. The Chairman: I think Mr. Moses stated his opinion has been based, practically, on the opinion of people with whom he has come into contact. Is that not so?—Yes, that is, Mine Managers, medical officers, and miners generally.

559. And you have reflected their views with regard to the cause of Miners' Phthisis?—Yes entirely.

560. You are not stating it, as a fact?– I cannot state it.

561. Is it merely the opinion prevalent amongst the employees of mines in your district?—That is so.

562. Dr Davies: As long as that is perfectly clear I am satisfied, but I want it to be made perfectly clear that your evidence is merely the opinion of other people.

563. Dr. Porter: I should like to ask the witness whether I was correct, in believing him to state, that the majority of deep level mines were supplied with buckets underground?—I stated some of the deep level mines were.

The Chairman: We are only talking of Mr. Moses' district.

564. Dr. Porter: I can only say that in the district within the extended boundaries, I made a careful survey some time ago and, as far as my memory goes, there were, I think, only two that had any arrangements underground at all, and there are some 22 mines shortly coming under the jurisdiction of the Town Council of which I say only two have any underground sanitary arrangements.

565. Dr. Sansom: You had a long experience of coal mining in England?—Yes.

566. You have been at work underground?—Yes.

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567. Were you there as Inspector?—No, as Assistant Manager and Manager.

568. But you were constantly underground?—Yes.

569. How does the ventilation of the Coal Mines in England and the ventilation of a mine here compare?—You cannot compare them. I was connected with the most fiery mines in the north of England and the ventilation there is all artificial, while here you have natural ventilation so that the two cannot be compared.

570. Conplaints have been made that the ventilation in the mines is very bad. Have you found it very bad?—I have in one or two cases on coming to a dead end, but taking it on the whole I express the opinion that the ventilation of mines in the Transvaal is much better than the ventilation of the metalliferous mines at home.

571. Now as to the conditions of the individual compared with those existing at home?—These I should say are on a par. I mean the living conditions.

572. The whole conditions of the individual?—Yes.

573. You made certain remarks just now about going to their rooms and hanging up their wet clothes?—Yes, and it is the same at home. There are only a few places where there are change houses.

574. The Chairman: Do you mean that there are no change houses on metallifferous mines?—They have on metalliferous mines, but I am speaking of Coal Mines which generally have no change houses.

575. Dr. Sansom: I was questioning you on Coal Mines because I understood from you that your experience has been amongst Coal Mines and not so much amongst Metalliferous Mines. Now you speak about gases here. You have been in mines in England and other places where they use explosives?—Yes, all of them.

576. Have you had much difficulty with gases?—Not in Coal Mines.

577. Then you never had any trouble with gases in Coal Mines?—No.

578. Why not?—Because ventilation cleared it all away.

579. Did you not say that the ventilation is better here?—Oh! that is in the case of Metalliferous Mines but the ventilation here is not to be compared with the Coal Mines. Here you are content with 20,000 feet while at home they get 2, 3, or 4 hundred thousand feet per minute.

580. The Chairman: Your experience at home was confined to Coal Mines?—Yes, to Coal Mines

581. You did not come much into contact with Metalliferous Mines?—No.

582. You have no wide experience of them?—None whatever.

583. In stating a comparison between the ventilation of Metallifferous Mines at home and the mines here; do you know that from your own knowledge?—I cannot say so as a manager of any of these mines, but I visited them.

584. As regards the ventilation of the mines here, you say it is very good with the exception of dead ends? Yes.

585. Are not all working places as a rule dead ends, the drives for instance?—Yes, but where you have rock drills working then you get ventilation.

586. In that case the ventilation depends on the rock drills? Yes, I have not come across any artificial means being adopted for ventilating dead ends or rises.

587. Mr. Drake: Speaking generally Mr. Moses, the underground conditions which you experienced in the old country and here are much alike, that is as to the comfort of the men. I do not mean you to go into any scientific method of determining the quantity of the deleterious matter in the air but it is the fact that you feel more comfortable here than at home when underground? -- Yes, I should say so generally.

588. Mr. Harry Johns: Is it not a fact that in all these dead ends you speak of there is ventilation when the miners are working there?—Yes, when the rock drills are working.

589. Reverting to the sanitation of the outcrop mines, do you know of any reasonable method by which the manager of a mine or his shift boss can get the miners to use the pails supposing they were put there?—The only way is to close up all the openings of the old workings.

590. That would be almost impossible in an outcrop mine where you have a couple of reefs and a lot of stopes worked out?—Yes that would be almost impossible.

591. Dr. Davies: Is there not a Kafir in charge of the boys who could overlook that kind of thing?

592. Mr. Harry Johns: Take a mine with ten to fifteen miles of levels open, what kafir can supervise all these boys?—I know of a mine exactly like the mines here in which at every level there was a closet and the miners were compelled to use it.

593. Dr. Davies: Have kafirs any objections to these things? —No, I think they would prefer using them.

594. Mr. Harry Johns. Would you not find considerable difficulty in carrying out a regulation to that effect, supposing the boys were working three or five thousand feet away from the end of the level?—You would of course have to train the boys into it.

595. Do you think it possible to train raw kafirs within three or four months?—Not within three or four months.

596. The Chairman: Don't you think that underground supervision would be useful in the matter, placing a few native policemen on duty?—Yes, that would be a very good suggestion.

597. What number do you think would be sufficient ?—I really could not say.

Mr. Harry Jones: I have tried these various matters and I know the difficulty and, in my opinion, it would be next to impossible unless you employed a body such as the S. A. C. of the Transvaal. I have found the greatest difficulty in getting the Kafirs to use any system whatever as long as they can get into these dark disused workings.

598. Mr. Williams: With regard to these change houses you were speaking of, do you know whether the miners use them?—Yes, I was in charge of one mine where we had change houses and the men were not allowed to leave the mine without using them.

599. Was the use of the change house made compulsory?— Yes, they were compelled to use it.

600. I have a mine in my mind where they had really good change houses and the men did not care very much abont using them?—I think that depends very much upon the manager, and he should make rules that they do use them.

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601. That means legislating. I mean that hot water has been laid on for baths and very frequently the miners would go home rather than use the baths prepared for them?—Exactly, but I think you will agree it would be very much better for them if they did use these change houses. In one mine I knew of the rule was that they either had to use the change houses or leave the mine.

FIFTH DAY.

CHAMBER OF MINES, JOHANNESBURG.

Wednesday, 25th February, 1903.

PRESENT:

MR. H. WELDON (*Chairman*).

MR. J. R. WILLIAMS.	MR. J. HARRY JOHNS.
MR. E. PERROW.	MR. R. M. CATLIN.
DR. DAVIES.	DR. HAWARDEN.

MR. J. STRATFORD, *Secretary.*

The examination of Mr. Arthur Robert Sawyer was continued. His statement was as follows:—

Mr. *A. R. Sawyer.*

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As I have not the advantage of being personally known to the majority of the members of the Commission I think it well to read the following before tendering my evidence.

Secretary of State,
Home Department.

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METALLIFEROUS MINES REGULATION ACT, 1872.

I, the Right Honourable Richard Assheton Cross, one of Her Majesty's Principal Secretaries of State, in pursuance of the power vested in me by Section 15 of the "Metalliferous Mines Regulation Act, 1872," do hereby direct Arthur Robert Sawyer, Esq., being a person duly appointed an Inspector under the "Coal Mines Regulation Act, 1872," to act as an Inspector under the aforesaid "Metalliferous Mines Regulation Act, 1872."

Given under my hand at Whitehall this 16th day of April, 1879.

(Signed.) R. ASSHETON CROSS.

I may add that I left the service in 1890, and have been engaged professionally in Africa ever since.

The following is the substance of a letter I wrote to the Commission on the 15th December, 1902:—

"The only recommendations I can suggest to prevent or to minimise miners' phthisis are:—

"1. A greater regard to ventilation not only in quantity but in its distribution. The distribution of air should be studied in pretty well the same manner as if we had to deal with inflammable gases instead of with non-inflammable gases and fine, sharp dust.

"2. Dry drilling should be entirely discountenanced. The fine dust produced by drilling should be systematically wetted and rendered innocuous. Several methods of allaying dust, some mechanical, exist and have been in operation for many years. No doubt the most suitable method will suggest itself to managers of mines as soon as dry drilling is prohibited."

We have recently been informed by an eminent Johannesburg Doctor that phthisis is due, so far as I understand him, to the clogging or destruction of the membrane of the lung or, so to speak, of the diaphragm

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between the lung proper and the outer atmosphere, which prevents an exchange of gases through it by endosmose and exosmose, so that, however much oxygen there might be outside, it could not get into the lung to purify the blood.

This, he stated, was entirely due to dust and not to noxious gases, except indirectly in weakening the constitution of the individual and thus making him more susceptible to the disease. From this statement it has been deduced that good ventilation is not an important factor in this enquiry, and that the only thing to be done is to allay the dust.

I do not know what the scope of the Commission is, but if it were restricted strictly to Phthisis, which I cannot suppose, an allusion to ventilation might be considered out of place in this connection after the statement referred to above.

I consider that the accompanying table on the comparative mortality of males in England and Wales, from 25 to 65 years of age, in different occupations from all and several causes, accompanying Dr. Ogle's evidence before the Royal Commission on Labour in 1892, which shows the number of deaths that took place in the years 1880, 1881 and 1882, is of importance.

From this table it will be seen that Phthisis is not the only disease of the respiratory organs, and I venture to think that the inhalation of impure air and noxious fumes contributed considerably to some of these other diseases, such as miners' asthma and chronic bronchitis.

Dr. Ogle draws attention to the death rate in miners from diseases of the respiratory organs other than phthisis. In the case of colliers and ironstone miners it is considerably higher than that from phthisis.

He further states that, owing to the loose way of certifying death, many deaths registered under the name "miners' phthisis" should really be registered under one or other of the diseases of the respiratory organs.

Diseases of the respiratory organs, other than phthisis, are due to several causes, among which are breathing impure air and sudden change from one extreme of temperature to another. Ventilation tends to remove the first cause, and suitable wash and dressing houses at the shaft the latter cause.

It will be seen from Dr. Ogle's table that there is comparatively no high mortality from diseases of the respiratory organs among colliers and ironstone miners. The mortality amongst ironstone workers is only very slightly higher than that amongst colliers. The figures for Cornwall are, however, appalling. They are from three to four times as great for diseases of the respiratory organs, including phthisis.

The health conditions of coal and ironstone mining in England have improved considerably during the last quarter of the century owing to a great improvement in ventilation, just as the death rate from accidents has improved as under:—

Year.	Output in tons.	Death per 1,000 employed.
1855	64,000,000	3·9
1894	188,277,525	1·6

As a member of the Commission appointed to revise the mining regulations in the Transvaal in 1896, I am partly responsible for the insertion of the following clauses:—

52. Every mine must be constantly provided with an adequate supply of fresh air.

Not less than (2) two cubic metres or 70 cubic feet of such air per minute shall be provided in the intake for each and every person employed underground, and as much more as circumstances may require.

53. The ventilating current shall be suitably split where necessary and the air conducted to and along the face of each and every working place throughout the entire mine in sufficient quantities to render harmless and to sweep away the smoke produced by blasting, or any other noxious gases, so that all working places and travelling roads shall be in a fit state for persons to work and travel therein.

These regulations, I believe, are still in force.

As regards the outcrop mines on the Rand and the deep level mines generally, it may be said that but for blind ends, headings and rises (winzes) the amount of air circulating through them is not insufficient.

These blind ends are, so far as I know, invariably ventilated by diffusion and by the exhaust air from the drills, which is, of course, only available when the drills are working. This supply of air is thus cut off at the time of blasting, just when it is most needed to purify the air at the face, which the exhaust air does to some extent. The blind ends cannot strictly be said to be ventilated in the spirit of the above regulations.

Headings are frequently driven many hundreds of feet before being connected with an upper heading through a winze, and much time is then lost by the men in waiting until the face is clear enough for them to go in. There is also a great temptation to miners making high wages to return to their work before the fumes and gases have cleared away sufficiently, and for the fine dust shaken into the air from the floor and sides of the heading by the blast to subside.

The small outlay necessary to ensure the circulation of a regular air current in the blind ends would, I feel sure, be fully repaid by the quick removal of the noxious gases enabling the miners to start work quicker than is generally the case at present, and, through better health conditions, to accomplish better results.

Healthy underground conditions must also have some influence in attracting drill and other boys, for we must not forget that boys are also affected. This must be known to their friends at home, and must act as a deterrent to their coming to work in the mines.

It is a question whether the proper ventilation of blind ends might not also enable the blocks to be made larger, thus reducing the cost of development.

With regard to the deep level mines, and especially the very deep ones now contemplated, I cannot too strongly urge, as I have already done, the necessity of a plentiful supply of air and its proper distribution, and that the mine be so laid out that two or more splits, quite independent one from the other, be ensured. It is not a matter of outlay so much, which is comparatively insignificant, but a matter of application of the laws of underground ventilation. It is in connection with these deep level mines that the headings are sometimes driven inordinately far without proper ventilation, before connection can be made with a second opening.

I have no wish either to state or to insinuate by the foregoing remarks that the necessity for good ventilation has escaped any of the Engineers or Managers on the Rand, or that most of these are not fully qualified to deal with this matter and most desirous of looking to the health conditions of the miners. It is, however, my experience that metalliferous miners "per se," who have not had any experience in stratified deposits outside the Rand like the stratified ironstone deposits in England, are not always quite aware of the necessity of good ventilation as a factor, not only in healthy underground conditions, but in cheaper working, and are not always experienced in the application of the laws of ventilation underground.

Mr. *A. R. Sawyer.*

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The mortality from diseases of the respiratory organs amongst ironstone miners in England compared to the high mortality in the metalliferous mines of Cornwall, in which the character of the dust approximates to that in the mines of the Rand, is very instructive.

The illustrations which I produce are taken from a book on "Accidents in Mines," which I published in 1886. They show some of the workings in the stratified ironstone mines of North Staffordshire. Naked lights are used in these mines, but they are ventilated like collieries, in a systematic manner, and the miners have seldom to wait long after a blast before being able to return to their work.

I do not wish it to be understood that the conditions of mining in these ironstone mines are the same as in Cornwall or on the Rand, or that the fine dust produced is as angular, but I do think that the small mortality from diseases of the respiratory organs amongst ironstone miners in England is greatly due to proper ventilation, which removes one of the predisposing causes of these diseases.

A glance at the illustrations will show that the stratified ironstone beds, which have an inclination varying up to 45 degrees, are worked by modified systems, or "Longwall," thus saving in development, and ensuring better ventilation.

In a joint report made by Mr. J. Harry Johns and myself, some years ago, for the Geduld Proprietary Mines, Ltd., on the proper method of working their reef, which dips at an angle of eight degrees, we advised that it should be worked by the "Longwall" system, which they have decided to adopt.

A wider resort to this system, where practicable, would simplify ventilation, and reduce the cost of development considerably.

Electric blasting should be resorted to where practicable, as there would then be a total absence of smoke and fumes from the burning time fuses, which greatly add to the fumes produced by the explosives.

Before closing my remarks on ventilation, I should like to mention an arrangement, shown me by Mr. T. Britten at the Wolhuter Mine, to counteract the evil effects of the noxious gases produced by blasting at the end of a long heading. A small pipe from the main air pipe, with an end somewhat on the principle of Giffard's injector, is placed not far from the face. The miner, on his way out after lighting the fuses, turns on the air, which sucks up a solution containing salts of alkalies and spreads it as spray towards the face. This, to some extent, neutralizes the fumes, and enables the men to return to the face sooner.

We were recently informed that it is best to allay the dust at the bottom of the hole, on the principle that prevention is better than cure, because a damp atmosphere at the face, which, no doubt, combined with great heat sometimes caused by want of ventilation, is objectionable, would thus be avoided. But it seems to have been overlooked that drilling is not the only source of dust, and that blasting, breaking and falling of quartz also produces dust. Blasting is especially obnoxious in this respect, as it disturbs the finer particles from the floor and sides of the headings and winzes, which then float in the air for some time, and are inhaled by all those working in these blind ends. To state that they are carried away by the ventilating air current, except in rare instances, is bordering on the imagination, as already explained.

Dust, which might have injurious properties, is also, in some cases, produced by dynamite itself. In parts of Bohemia, dynamite is not used because it covers coal with a fine reddish dust after blasting, and this affects the selling price. It would be interesting to know whether any appreciable

quantity of dust, blown about from the sand and slimes heaps on certain very windy days, is carried down shafts in their immediate vicinity with the intake air.

As is well known, the fine coal dust in collieries is not so very injurious in itself, but is a most important factor in the production of explosions, causing, in some cases, explosions without the presence of fire-damp. In Europe, before a shot is fired in dusty collieries, the roof, floor and sides have to be thoroughly wetted or damped to allay the dust. The cost of this is infinitesimal, and is well repaid by the greater amount of work which the miners are able to perform in a purer atmosphere. Independently of legislation, the dust is also allayed along the roadways at several collieries.

Although not necessarily applicable or desirable to do this in the mines of the Rand, or even at all collieries, I think it well to enumerate a few methods which are adopted for this purpose:—

1. A water waggon, which waters the roof and sides by means of a pump fixed inside of it. It is worked by cranks on the axles of the wheels, and throws out the water in thin sprays from jets or roses.

2. Another kind of waggon has a brush at one end, and the motion of the wheels makes the brush whirl round, causing the water to fly out from its circumference and to water all parts of the road alike.

3. $1\frac{1}{2}$ inch or 2 inch pipes are laid from the pump column in the shaft along the main road, having a rose or jet fixed on upright standards attached to these pipes. These emit a constant discharge of a thin fine spray of water into the air. This method has been greatly developed at the Maybach Colliery in Germany, where a network of pipes starting with 4 inches and ending with $\frac{3}{4}$ inch in diameter is spread through the colliery. As it was found that the air current dropped the particles of water only a few feet beyond the sprayers and that the roadways could, therefore, not be kept damp, stationary sprayers were abandoned. The nozzles produced fine spray to the greatest advantage, but as they were expensive and often required to be repaired and cleansed, they were abandoned and narrow pipes with narrow openings substituted.

Fine, angular dust is certainly a most, and probably the most, important cause of diseases of the respiratory organs. This is corroborated by the high mortality among trades other than mining in which dust is formed, as shown in Dr. Ogle's table.

I believe it is, therefore, generally admitted that the fine, sharp dust formed in the mines on the Rand should be rendered innocuous. The only question is as to the best method of doing this.

To their credit be it said, many engineers and managers on the Rand have made strenuous efforts to cope with this question. The methods so far tried are:—

1. With air drills. Mr. Britten has introduced a spray, which he calls an atomiser, on the principle already described, but without the alkaline solution, at the drill itself. This spray is turned on to the face of the hole whilst the drill is at work. It allays the dust coming out of the hole, and also has the effect of damping the dust in the headings and winzes (rises) for some considerable distance. The results, as I saw them, were certainly very encouraging, water in conjunction with compressed air forming a most efficient spray.

Mr. Strangmann Hancock has introduced pipes somewhat on the principle described above, which are laid at the same time as the air pipes, and thus at little cost.

The Leyner drill has recently been introduced. In this drill the

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drill steel is perforated, and water is forced through it from the back right up to the end of the drill, thus converting the dust into mud before it issues out of the hole. This drill, I believe, is in use at the Simmer and Jack Mine.

Mr. J. C. Manion, of the Ingersoll-Sergeant Drill Co., has also improved their drill in this respect. This new drill, which is on its way out, also requires a perforated drill steel, but the water, instead of entering the the drill at the back, enters it at the front head, and, what is very important, issues not at the end of the drill but through four holes, one in each wing, several inches back. The advantage of this is, that the drill is not likely to clog, and the steel is easier to sharpen. The present Ingersoll-Sergeant drill can be used, the piston and front head alone requiring to be changed.

2. With a hydraulic drill, the invention of the late Mr. Thompson. This drill is worked by water, which is forced through pipes by a head of water similarly to the third method described above. Some of this water is forced right up to the end of the hole and converts the dust into liquid mud. The water pipes being there, it would be an easy matter to allay the dust by water sprays. Should this drill, which is now being tried at the Meyer and Charlton, prove a commercial success, compressed air would probably, in some cases, be abandoned and strict regard to ventilation would be still further necessary.

It is premature, and not my desire now, to express any preference for any of these methods.

Good work is certainly being done by some in devising inexpensive and efficient means of allaying the dust, and I should certainly not like to check the development of fresh ideas on the subject by recommending one of these methods specially.

Whenever the subject is ripe for legislation the particular method of allaying the dust should not be laid down, but it should merely be stated that the dust shall be allayed. As shown, it is practicable to do so, and will, in my opinion, decrease rather than increase the cost of mining.

I would not recommend any fresh legislation with regard to ventilation as, in my opinion, the clauses of the mining regulations, already referred to, meet any and every case. They only require to be carried out.

(Signed.) A. R. SAWYER.

602. The Chairman: You are under your former oath. At the last meeting, Mr. Sawyer, you stated before the Commission that the ventilation of the mines on the Rand here was good except in the ends of drives, winzes and raises?—Yes.

603. This was said by another witness in addition to yourself?—I think, generally speaking, that the ventilation is good, but not in all cases, especially where the headings are rather extended.

604. Then apart from these portions of the mines which are being developed, the remainder is well ventilated?—From my visits to the mines, the ventilation generally is good except in the case of those headings which are usually badly ventilated, but I have not seen the workings in all cases.

605. Have you been much amongst the mines, and are you well acquainted with them under their present conditions?—Yes.

606. Have you been down the mines?—I have been down several mines since the war, and, of course, I went down more often before the war.

607. Do you advocate that the drilling of dry holes should be prohibited by law?—I should prefer that the law should not be too specific, but should simply state "the dust shall be allayed," and leave it to the inspectors of mines or the Mining Office, in conjuction with the managers of mines, to determine what is best for each individual mine.

608. You mean that the law should be in general terms?—Yes.

609. And that it should prohibit working in dusty places?—Yes.

610. Do you think that would have the desired effect?—Well, that in conjunction with ventilation or, I should rather say, with a due regard to ventilation.

611. What, in your opinion, is the cause of miners' phthisis?—I am unable to say, because I do not know the definition of miners' phthsis. If under the term is included all diseases of the respiratory organs, then I should say, that ventilation has a good deal to do with it.

612. Dr. Hawarden will probably define what miners' phthisis is to you just now. From the remark you have just made, and from what you state in your paper, one would imagine you do not consider that miners' phthisis, *i.e.*, consolidation of the lung, is so prevalent as some witnesses have given the Commission to believe, and you think that there are other causes such as bronchitis, pneumonia and other respiratory diseases often classed as miners' phthisis, and, accordingly, an undue weight has been given of late to the term?—It seems to me, I may be wrong, but I think there are other diseases of the respiratory organs just as fatal and as bad.

613. You think they have been wrongly entered under the heading of Miners' Phthisis?—Yes. Of course I have only Dr. Ogle's statement for that, and he does say so distinctly,

614. You are unable to give an opinion as to the relative importance of dust and impure air with regard to the diseases of miners?—I should say that perhaps, on the whole, the dust is of more importance, but at the same time I consider the question of ventilation as almost equally important.

615. Then you do not think that dust is the primary cause?—I should say the primary cause of certain diseases of the lung—probably phthisis—and, no doubt, other diseases as well.

616. Are you acquainted with metalliferous mines in Cornwall?—Yes, I have been down them.

617. Do you think the dust there is as sharp and angular as it is here?—I would infer it is so, but it is a long time since I was there, and I did not study that particular question at the time. I should think that as the Rand banket contains quartz, the dust would probably be very similar, except, of course, that it may have a different chemical composition from the dust in Cornwall.

618. I was referring more to the physical qualities?—Physically I should think the dust there would be almost the same as here—viz., sharp and angular.

619. Have you prepared any scheme, or have you got any suggestions to offer with regard to the most efficient method of ventilating the mines here?—The mines here are not quite the same as those you meet at home. They are worked on a different system, and possibly the system of ventilation would have to be different.

619A. Have you gone into the details of the matter?—Of course in my own mind I have.

620. For instance, we were speaking of those portions of the mines which are being developed. Have you any particular suggestion to make with regard to the ventilation of these places?—Well, in those ironstone mines referred to in my written statement they are ventilated either by brattice cloth or by iron pipes from 8 to 10 inches in diameter.

621. You mean thin pipes?—Yes, very thin air pipes.

622. Do you find that the joints of these pipes are always

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efficient ?—Of course there is a slight leakage at the joints, but that does not matter as long as a certain quantity of air gets to the face.

623. How does it get to the pipes—by natural means, or is the air forced through ?—In the ironstone mines it is sucked through the pipes by means of a furnace or a fan.

624. I am talking of iron mines ?—The air is forced through the mine either by means of furnaces or fans, which suck the air out of the mines and it is led along the various turns and twists, being thus practically forced through the pipes.

625. Not by natural means ?—No.

626. With regard to brattice cloths, do you not find that in this country more explosives are used ? There are rock drills in all drives which take out big cuts six feet in depth, and the concussion is very great. Don't you think the concussion from a cut of that description would destroy all bratticing down a drive ?—Of course with such heavy blasts I would not have the ends of the brattice or the pipe as near as I would in an ironstone mine, but I do not think the blast would have that effect on a light brattice or on a light air pipe, because they would present to the blast a very thin surface—almost as thin as a sheet of thick paper.

627. I have seen trucks upset in drives after a blast ?—Yes, in a mine I was down the other day they told me that wooden doors at the shaft had been injured through concussion of a big blast.

628. Mr. J. Harry Johns : I think you stated just now that in most of the mines the working places, with the exception of headings, are fairly well ventilated ?—Yes.

629. Don't you think the drives, if driven by rock drills, are equally well ventilated while the men are working there ?—I should not say so in all cases, especially in the deeper mines, before connection has been made with a second shaft.

630. That would be in the case of deep level mines where they have not connected with the two shafts ?—Yes.

631. I am speaking of an ordinary drive in a mine being extensively worked. You have the exhaust air from a one-inch pipe practically all the time ?—That is so, but of course ventilation by compressed air is a rather extravagant method of ventilating a mine.

632. I am referring to the exhaust air from the drill ?—As far as I understand, in most cases the ventilation of the headings is produced by the exhaust air from the drill whilst at work, but as far as I know I should think that there are very few mines here that can afford to let the air continue to run out of the one-inch pipe whilst the drill is not at work. I mean to say that they require all the air they have.

633. Yes, but when the holes are being drilled. Is not the drill at work most of the time, and, when the drill is at work, is not the exhaust air sufficient to ventilate the end of the drive ?—I have calculated here the amount of air passing through a one-inch pipe, and I find, I do not know whether I am right, that the velocity through a one-inch pipe would be about 440 or 500 feet per second, so that the quantity would be about 345 cubic feet per minute through a one-inch pipe.

634. The Chairman : Through a pipe or drill ?—Through a full opening of the pipe.

635. Mr. Catlin : Under what pressure ?—80 pounds at the surface. With a 12-inch ventilation pipe, which is rather a large one, the velocity of air passing through would be about 7 feet per second to produce the same amount of ventilation, and, to arrange the ventilation so as to direct the air through those pipes to the face, would, I think, be cheaper than ventilating

by compressed air. (To Mr. Johns.) I do not know, Mr. Johns, whether that is the point you asked me about.

636. Mr. Johns: No, the point I wanted to get at was, is it not your opinion that a drive is sufficiently ventilated by the exhaust air from a drill when at work?—When at work at the face, yes.

637. And in a mine that is being extensively worked with the winzes within a reasonable distance of the headings, do you think the headings leading beyond the winzes would be sufficiently ventilated?—Well, I should say that depended on the dip of the reef and the extent to which the winzes and headings have been driven.

638. I mean when the winzes are connected of course?—Well, it would all depend on the length of the heading itself.

639. You will generally find that in most mines here we rarely drive beyond 300 feet. What, in metalliferous mines, is considered a reasonable distance?—Here I think they drive them as much as 500 feet in some cases.

640. Rarely over 300 I think?—In some cases I could mention I think they have gone as much as 500 feet, but I should say that 300 feet is a long way to ventilate, as I put it in my paper, by diffusion and exhaust air from the drill.

641. Dr. Hawarden: What do you think the diseases of the lungs in these miners are due to?—Personally, I have no knowledge of medical science, but of course I know a little about the lung. The lung itself may be affected, or the bronchial tubes, or of course the other parts of the mechanism, both by dust and gases.

642. Do you think this disease is caused by gases principally?—Oh no, I do not say that. I should say that I put it as about equally by dust and equally by gases, but dust is a very important factor.

643. Are you familiar with ganister mining in England?—I think I have been in a mine working ganister, but I cannot say that I am very familiar with it. It occurs in the coal formation in England.

644. I believe they obtain it to make a lining?—Yes.

645. Do you know that there is a very large mortality among the men who work in that?—I cannot say, but I have an idea that I was aware of it at one time.

646. Dr. Davies: I understood you to say that, in your opinion, the causation of the miners' phthisis is equally dust and equally gases?—Well, as I said at the beginning, when I entered the room, I first want to know the definition of miners' phthisis before I could reply to that question. If phthisis is what I have understood as stated in my written statement, then, of course, it is caused purely by dust.

647. Do you think that a definition is sufficient to base a diagnosis upon, however good that definition may be? Do you think that, if you had a definition given of blood-poisoning, you would be able to tell what caused it?—I dare say.

648. You think you would?—Yes.

649. Have you ever made any pathological examinations of a lung which has been affected by miners' phthisis?—No.

650. Have you ever made an anatomical examination of a lung?—Yes, I have.

651. Have you made a microscopical examination?—Yes. I studied with Professor Huxley years ago, and at that time I knew more about it than I do now.

652. Did you ever examine one that has been diseased or affected by miners' phthisis?—No, but I examined a lung once which was completely filled with coal dust; a lung from a miner who had been working in a coal mine for a long time.

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653. Do you think you would have been able to say from that examination and a definition of coal miner's lung what proportion of that lung was interfered with by dust and what by gases?—No.

654. Do you think you are competent in any way to give an opinion as to whether miners' phthisis, according to those definitions you have got, is caused by dust or by gas?—Not from a medical point of view, but certainly from the effects on the miners.

655. How are you able to exclude every other kind of cause except dust and gas which might cause phthisis, unless you look at it from a medical and pathological point of view? (To the Chairman.) What I want to show, Mr. Chairman, is that Mr. Sawyer is giving evidence with no knowledge of the pathology or anatomy of the disease, and I therefore think his evidence is of very little value, and we may say that the amount of personal knowledge he has of miners' phthisis, from a medical point of view, is very little. I think you will agree with me, Mr. Sawyer?—I do not profess to be a medical man.

656. The Chairman: You base a good deal of your figures on this table of Dr. Ogle's? (See Appendix E.)—I certainly go a great deal by that table.

657. Not any personal knowledge you have?—No medical knowledge.

658. Dr. Davies: That is all I want to get at. Now, as to ventilation, I notice on page 2 of the report an analysis of mine gases taken from ordinary mine air, in which the analysis is given: oxygen 20·46 per cent., carbonic acid less than 0·05 per cent., carbon monoxide 0·08 per cent., hydrogen 0·26 per cent., olefines in traces, nitrogen by difference 79·2 per cent. Would you consider that fairly good air?—I would like to compare it with one I have here. I do not think I could reply to that question either one way or the other without having carefully considered it.

659. You cannot tell whether that is a good sample of air for breathing?—Not at a moment's notice.

660. Mr. Johns: On page 4 of your evidence you state, "these blind ends are, so far as I know, invariably ventilated by diffusion, and by the exhaust air from the drills, which is, of course, only available when the drills are working. This supply of air is thus cut off at the time of blasting, just when it is most needed to purify the air at the face, which the exhaust does to some extent." Is it not the usual custom to open the pipes to some certain extent and allow a lot of air to escape directly after blasting?—It is done, but I do not think it is the usual custom.

661. May I ask whether you have ever known of any drive being driven without that being done?—I won't say I have.

662. Personally I never have?—No, I never have, but I go, to some extent, by hearsay, and, of course, the quantity of air could only be very small.

663. I take it from this that you considered only air from the exhaust air was used for ventilating the end of the drive?—Of course I may be wrong, and I may have omitted to state that a certain amount of compressed air passes through while the drill is not at work by the cock being slightly open, but my point is, that this is an expensive and unsatisfactory way of ventilating compared with ventilation pipes in extensive mines.

664. And directly after blasting?—Yes, as soon as the men get in.

665. So that the fumes and dust are blown from the faces before the men come in?—Yes, but of course I take exception to ventilation by compressed air. It is customary only to open the cock to a small extent, allowing a small proportion of the air through, but not the full extent necessary to work the drill.

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666. Is it not a fact that more air is allowed to escape out of the pipes when the men are not working, and directly after blasting, than when the drill is working?—Of course, they suit the opening of the cock to the state of the air, and if they require more air they open it further.

667. What I wanted to bring out was whether, in your opinion, the quantity of air that comes from the exhaust of the drill and what is let out after a drive is sufficient to ventilate the end of a drive while the work is being carried on?—To a certain extent it is, but not altogether.

668. Mr. Catlin to Mr. Johns: I understood the witness to distinctly say he considered the ventilation from the drill to be sufficient so long as the drill was running?

669. Mr. Johns: That is why I brought this matter up, because in his evidence he made no mention of the air allowed to escape out of the pipes after blasting?—The reason I did not refer to it, I remember now, was because the amount could only be necessarily small. It cannot be the full amount that passes through the pipe.

670. Mr. Catlin: Why not?—Because you may want your air for other drills in other parts of the mine.

671. The Chairman: I think, Mr. Sawyer, it is customary in all mines on the Rand that blasting takes place at a stated time, and after that time the cocks are all left wide open, and the engines kept running right through the shifts. I think, in the majority of mines, the cocks are fully open, and the full amount of air is passed into the drives during the interval between the shifts?—Yes. I do not think that an economical way of ventilating a mine.

672. Mr. Johns: I merely wanted to know from you whether the air let out was sufficient?—Yes, up to a certain point.

673. Mr. Catlin: In what does deficiency of ventilation consist, in quantity or quality?—In quantity of oxygen.

674. Not in any possible deleterious matter present in the compressed air itself?—Personally, I do not know of any deleterious matter in this compressed air, but I have heard it stated that this is sometimes the case.

675. Then your objection is merely on the grounds of economy?—*Quite right.*

Mr. D. WILKINSON was called and examined.

Mr. *D. Wilkinson.*

676. The Chairman: I notice that you mention that marsh gas is an impurity in the air of mines. Do you find a very large quantity of marsh gas in the mines of the Rand?—This statement was not made on actual knowledge of analysis. When I wrote that I wished to refer principally to the coal mines of the Transvaal.

677. You state that the drives, winzes and raises of the mines—I think you are talking of the Rand mines—are not well ventilated. Do you consider that in the working operations of the mines the stopes and drives of all the mines are well ventilated?—In all the mines, certainly not. The mines vary a great deal. There are many mines in which it is a difficult matter to retain the workmen, owing to bad ventilation, but a general statement of the kind you have put to me is rather misleading.

678. You state here that the mines, as a whole, are well ventilated with the exception of the ends of drives, winzs, air-raises?—Yes, taken on the whole, that is my experience.

679. Then you merely wish to draw attention to the fact that some of the mines are not well ventilated?—Yes.

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680. The calculations in your paper are based upon conditions which you do not find existing in the mines. You take it for granted that the gases in mines are completely diffused; as a matter of fact it is well known that at the end of drives the air is more impure than at any other place?—In the case of the ends of the drives, there are two conditions we have to consider. There is a portion of the drive near the drill, and in this place the air from the drill issues at a considerable velocity and forces the air from the end of the drive outwards towards the cross-cut. The end of the drive, near the drill, therefore, is well ventilated, but the portion between that and the cross-cut may not be well ventilated.

681. Do you think the amount of air coming from the exhaust of a drill is sufficient to keep the air pure when seven or eight men are working behind?—Yes, at the face, but not in the drive itself.

682. Then, of course you do not take into consideration the fact that a portion of the air from the down cast shaft is short-circuited, and that only a portion of the air finds its way through the workings?—No, I have not assumed that.

683. But that is a fact?—Certainly, that is the case.

684. Therefore, we can take it that 70 cubic feet required per man per minute is a minimum?—Well, what I think is, that it appears to be a suitable condition and if 70 cubic feet per man per minute is not supplied, then the consequences shown in the table will result. I am not sufficiently well versed in medical matters to say that, because there is 1·1 per cent. of carbonic gas in the atmosphere, the air is not fit to breathe. I simply had to rely upon certain statements in medical works for these assumptions, and I have assumed a maximum of ·07 per cent. because in medical works they take ·06 as the maximum amount of carbonic gas that ought to be present in the air.

685. May I refer you to page 7 of your statement, where you say that 60 cubic feet per man per minute is less than the usual requirement for persons who are working? Further on you state that 8 cubic feet of fresh air per man per minute is required for each candle burning, in order to render the CO_2 from this source innocuous. This does not take into account the presence of organic particles in the mine?—Yes, it takes into account the organic particles produced by the respiration of miners while working.

685A. But not in the organic particles from excrement?—No.

686. Therefore the air would be more impure down below than you have put it, and we may take it that 68 cubic feet of air per man per minute is not sufficient?—I take it that 68 cubic feet, according to the reasoning, should be the minimum. It may be sufficient, but it is a question of degree.

687. Do you think this quantity of air passing through a mine, even if well split up, would thoroughly cleanse out the gases from a mine. Are not the gases given off by an explosion occulted in the broken rock?—Some portion is usually retained in the interstices of the broken rock.

688. You have not gone into the question of dust, Mr. Wilkinson?—I do not understand the medical portion.

689. Mr. Johns to the Chairman: I merely wish to refer to his reply to one of your questions, in which he stated that he thought the air running through the drill was sufficient for the men at the face to ventilate the end of the drive within a certain distance.

To the Witness: Is it not a fact that all the men working in that drive would be working at the face?—Oh, no, not always.

690. But they would be close to the face?—Well, the boys who

take the stuff from behind the drill would not be working at the face, but along the length of the drive.

691. But they would be close to the face ?—Yes, but from the drive to the cross-cut the trammers would be working in the drive. I think with reference to that matter it seems to be the general experience that as you go along the drive you find the air rather bad, but nearer the face you find the ends better. That is my experience. There probably would be two or three boys tramming between the face and the cross-cut. I should like to go into that matter about the end of the drive if you like. I think, if you calculate it out, you will find the amount of air supplied is not sufficient for six persons in the drive.

692. Oh, no, probably not, but, according to Mr. Sawyer's statement, there would be 345 cubic feet of air per minute given off, and as a rule you would rarely have more than three men at the face at a time. Is it not the custom at most of the mines to have the drive cleaned while there is a good blast of air from the pipes between shifts, after the blast and before the drill men go down again ?—As far as I know the rule, the portion near the face is cleared out before the men return to the face. The remainder of the stuff is then taken to the cross-cut, so that the boys are working at the face a considerable time before the miner fixes up his drill.

693. Do you know of any mine in which the whole of the rock is cleared out of the drive between the taking out of the drill and rigging it up again ?—Not where two men work each shift at one face only, but where the man work alternately at two faces.

694. Dr. Davies : You consider the air in a large number of the mines as being perfectly good, taking the mines as a whole, with the exception of certain parts ?—Yes.

695. As to the other parts, where you say the means of ventilation is very bad, are they ventilated on a different system, or is the bad ventilation due to any peculiarity in the mine itself ?—My experience of mines is generally that there are two shafts, which are placed so that the driving is east and west towards the boundary and the shafts. Now, the portion between the two shafts, the central portion, is generally very well ventilated, because the currents of air are direct, but in the case of the other parts of the mine that are situated between the shafts and the boundaries, the mine may not be well ventilated, because a considerable distance may be driven before there are communications from one level to another.

696. I understand you to say that there are a certain number of mines well ventilated on the whole ?—Yes.

697. Now, are those which are not well ventilated on the whole different from the good ones in being ventilated in a different way ?—No. It is usually due to temporary conditions.

698. Do you consider the present method of ventilating mines on the Rand is, speaking generally, sufficiently good to supply good air to the mines below ?—Yes, I think so, generally.

699. You do not advocate that there should be any change in the method of ventilating ?—I certainly do think that the most important point is want of interest in the question of ventilation amongst the mines. In a great many mines no interest whatever, or very little indeed, is taken in the question of ventilation.

700. You consider there is not as much interest taken in the ventilation of these mines as in that of coal mines ?—Oh, no.

701. And you think more interest ought to be taken in the question ?—Yes, I think so.

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702. Mr. Catlin: Is it not true that we have different conditions here from those prevailing in the coal mines of the British Isles, and that the same amount of ventilation is not required on the Rand?—I take it, that the difference in conditions is the cause of the difference in ventilation.

703. You certainly think a different arrangement should be made for the ventilation of deep level mines. Is that because they are deep levels, and because the distance vertically to the point of work is greater than in others, or because of a larger area drained by these shafts? If you have a shaft 2,000 feet down to the reef, and you have a number of levels communicating with it, you consider the air is rendered impure before it gets below. Is that your idea, or is it because it is 2,000 feet more or less deeper?—Not precisely that. There are a number of causes. In the deep levels the men would have to remain down probably the whole day, and, therefore, the supply of air will have to be greater in the deep levels than in the present mines. As that is the case, all ventilation should be more under control, for at the present time the ventilation of the mines depends largely on the atmospheric conditions above. If you have artificial ventilation in addition to natural ventilation, you would get more constant ventilation. Anyone working in these mines knows that the difference in ventilation between one week and another is, at times, enormous.

704. In the case of a deep shaft having a greater volume of air, is it not a fact that the incoming air, replacing that going out, would come with greater velocity?—If the first assumption is right, the second is right. Assuming it is once set in motion, it appears to me the circulation of the air in deep mines is dependent on precisely the same conditions as in other mines. In the deep mines the velocities of air currents passing from one shaft to another may be very small under certain atmospheric conditions.

705. If you have two shafts on the same level, is there no circulation?—I do not say that, but I say that there are certain days on which circulation will be very bad.

706. Mr. Williams: In allowing a maximum of ·08 per cent. of CO_2 do the authorities quote the amount of CO?—Not as a rule. They refer in that case to air which has been respired.

707. Admitting ·08 per cent. of CO_2 is injurious to health, would not the same percentage of CO be very much more injurious?—Certainly, CO_2 is only an indicator and can only be used as an indicator of any value when you know the general composition of the air in question. You find that CO_2 up to a certain amount is harmful, but you may have other conditions where the same amount is not harmful—you would of course in this case require a larger percentage of CO_2 as an indication of viliated air.

708. We have cases before us where there is far more CO than CO_2 in the mines. In one case, at all events, we found ·05 per cent. of CO_2 present, and that would be considered very pure air, but the same sample of air has got ·08 per cent. of CO. Would you call that a very much worse case than if there was ·08 per cent. of CO_2 present?—In the first place if that is a sample of ordinary mine air, it is difficult to understand the analysis. In the case of air taken, say, from the compressor pipes or from the air under ordinary circumstances, it is difficult to account for the presence of ·08 per cent. of CO. I would rather question the analysis, or the taking of the sample you will excuse me saying so.

709. This was taken at the face of a drive where there were nine men working and nine candles burning?—For myself I could not frame a theory to account for the presence of ·08 per cent. of CO and only ·05 per cent. of CO_2 in the same sample of mine air.

710. You will also find that the compressed air taken direct from

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the compressor contains a greater amount of CO than CO_2?—That could only be accounted for by the ignition of the oil in the compressor, but I should doubt this very much, because ignition would take place in the presence of a large excess of oxygen, and the formation of CO under these conditions appears to be almost impossible. If you will excuse me saying so, I question the analysis.

711. Of course you know that the tests for CO_2 and CO are very distinct, and the results unmistakable?—Yes. I cannot account for it.

712. Mr. Perrow: I think you said just now that, in your opinion, most of the mines are well ventilated?—Yes, taken on the whole, I think they are.

713. What mines are you acquainted with?—Well, I suppose I have been down 20 to 30 mines on the Rand.

714. The majority of them deep level mines?—No; the majority are outcrop mines.

Mr. G. D. STONESTREET was called and examined.

Mr. *G. D. Stonestreet.*

715. The Chairman: I think you have a statement to make with regard to Dr. Aymard's patent inhaler?—Yes, and first of all I want to point out that it is quite different to a respirator. This inhaler is merely a mechanical appliance for compelling the breathing of air direct from the compressor. The air comes through the mains into a small pipe, and compels the man to breathe the air from the air mains while he is using it.

716. I think Dr. Aymard has described his inhaler, and we have had it on the table before us. I think it will be sufficient if you will give us your experience of it?—I put on this inhaler, and took it from the hands of the miner with the strength of air which was then running, when I found it unpleasant, being too strong a current, and too cold, but on reducing the pressure of air I felt more comfortable with it; I could detect no smell of oil—nothing at all unpleasant except the usual smell of the engine-room. The miner who had been using it assured me that when he first used it—and he had been using it for some five or six weeks - he found it equally unpleasant to start with, but gradually increased the force of the pressure of the air, and got to like it, and in raises he preferred the coolness of this air.

717. Dr. Davies: Do you think that the miner gets practically pure air through this inhaler?—He gets engine-room air.

718. Do you think the air that passes through the inhaler is very much lower in temperature than the ordinary air?—That I could not say, but I assume it is. I am sorry I did not take the temperature at the time as I might have done so, but I should say the temperature of the air in the inhaler would be about 50 degrees.

719. So you might have a difference of 30 degrees?—Yes.

720. Quite apart from the question as to whether that would be a good condition of things, do you look upon that mask as being practical from the miners' point of view, and do you think a large proportion of the miners would use it constantly?—I think they would. The inhaler would, of course, require to be removed if a man has to go round the column of the drill or to the face, and this is due to the shortness of the connecting pipe as I saw it. I noticed that the men put it on readily.

721. When at work?—Yes, and from investigations I made I found they were in the constant habit of putting it on the moment they had a dry hole to put in.

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722. Of course, the only time they would wear this would be when rock drilling?—When they are putting in a damp hole they do not use it, because water is pouring in usually.

723. Do you give it as your opinion, speaking generally, that, supposing this inhaler were said to be the best method of dealing with all conditions of air, the miners would generally use it?—I think so. Of course I am quite unprepared to speak as to the quality of the air.

724. But, apart from that, supposing that were said to be the best method, do you think the general run of miners would use a mask of that kind?—I do think so, particularly in raises, because the coolness would obviate the heat in the raises. As far as I could ascertain, they seemed to like it, and I have brought in a couple of miners with me who have been using it, should the Commission desire to hear them.

725. Mr. Williams: You know that with the use of an ordinary respirator through the working of the valve the nostrils of the miners are frequently covered with fine dust. Is that dust entirely excluded by this inhaler?—It is entirely excluded by this inhaler, for it passes tightly over the face of the miner, and the current issuing keeps the valve open and keeps the dust from entering. When you take it off the exposed part of your face it is white with dust, but there is nothing at all inside.

726. Mr. Perrow: Have you got many miners using it?—At this mine there were ten in use some few weeks ago, but owing to certain conditions on this particular mine they have reduced them, and when I saw them there were only four.

727. How many men were working there?—I did not take the exact number, but I think eight.

728. Then four miners were using them out of a small number?—Yes.

729. Dr. Hawarden: Have you ever heard any complaints as to the quality of the air from the compressor?—The men told me they had not noticed anything bad. They only had it in use about five or six weeks and they had not noticed any oil.

730. Mr. Williams: Working with a minimum number of miners the pressure would not be forced in any possible way?—Well, they worked at full limit when I was there, owing to the number of machines being used in the stopes.

731. Where they working at full pressure?—Yes, practically so, with a pressure of 80 lbs. on the surface.

732. Dr. Hawarden: Have you any experience of any other respirator or machinery for keeping down dust?—Of course, I have seen the ordinary respirator in use with the sponge, which has to be washed out very frequently, and which I do not consider a good appliance.

733. Have you seen the atomiser at work?—I have not.

Mr. JOHN RICHARDS, miner, was called and examined.

Mr. *John Richards.*

734. The Chairman: I believe you have been using one of Dr. Aymard's inhalers?—Yes, sir.

735. On what mine?—The French Rand.

736. How long have you been using it?—About two months, sir, but I could not exactly state the date.

737. Would you make a statement as to how you find it works?—Well, I have used it, and I did not feel anything coming through but the pure air. I have been working when lots of water has been coming from the compressor through the rock drill, but no water came through the air

of the inhaler. Again, if a miner drills a dry hole in reef it makes him cough a good deal, but with the inhaler on he does not cough at all. The air is very cold, but you breathe just as freely with the inhaler as you do without it, and you do not feel any discomfort in drilling a dry hole while you wear it. Absolutely no dust can get through it.

738. Do you feel any effects from the cold air?—No, sir, I do not.

739. Do you not find that there is great difference in the temperature of the air coming from the compressor and the air from a hot raise?—Yes, it is a little cooler, and I have heard some say that when they first used the inhaler it gave them a cold in the head, but I have never had one.

740. How many persons could use the inhaler at a rock drill?—Only one.

741. So that this inhaler is not a universal preventive, so to speak?—No, sir. It screws on to the machine practically the same as the hose on the top of the rock drill.

742. And you do not see how more inhalers could be attached?—Well, we have only one white man there at a time.

743. So it means that the rock driller turning the handle is the only person who can use it?—Yes.

744. The work would interfere with its use in the case of the assistants?—Yes.

745. You have to take it off when you leave the machine?—Yes, sir.

746. Your opinion of the inhaler is that you would always use it in future whenever you get the chance?—Decidedly.

747. Have you been working in the mines long?—Yes, sir, for seven years.

748. And at home?—I worked there for six years.

749. Have you been rock drilling all that time?—No, sir, I have been rock drilling five years here.

750. Did you do any rock drilling at home?—No, sir.

751. Have you experienced any ill-effects?—None whatever that I know of.

752. How many mines have you worked on?—I have worked on five mines.

753. How do you find the ventilation of these mines with regard to the working places?—On one of them there was a vertical shaft, and it was not ventilated at all because there was no occasion.

754. Was it a single shaft?—Yes, sir.

755. And you found the air pure?—Yes, sir.

756. Did candles burn well?—Oh, they burned all right.

757. Was it hot?—It was a little warm, but it was a wet shaft.

758. With regard to the other mines, how did you find the ventilation?—On one of them it was very good indeed.

759. What about ventilation in a drive?—When working in a drive, you have no ventilation whatever until that drive is connected to the level above.

760. You wish to say that the mine, as a whole, is well ventilated, but those portions where development work is being carried on are not well ventilated?—Yes, sir.

761. The exhaust air from the drill gives a certain amount of ventilation?—Yes, sir, that is what we look to.

762. Have you had any experience with regard to miners suffering from this phthisis?—Yes, sir, I have a friend suffering very badly from it.

763. How long has he been working?—Seven years on rock drills.

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764. In this country?—Yes.

765. Was he working at home?—Not on rock drills, sir.

766. What was his motive in coming out here? Was it as a miner to earn his living?—Yes.

767. It was not for his health, I suppose?—No.

768. He was perfectly well when he left home?—Decidedly.

769. And he has been working for seven years here?—Yes. I have known hundreds of cases in Cornwall where men have died after having been five or six years in this country.

770. Are you acquainted with men accustomed to working rock drills at home?—Not very much.

771. Do you mean that they don't make such frequent use of the rock drill at home?—They use them just as much, but it does not seem to have the same effect as here.

772. Do you think that men in the old country, working as they do in pairs, having to do their own tramming, and having no boys to work behind them, do the same proportion of rock drill work as in this country?—I have a friend who worked a rock drill in the old country for seven years. They worked eight hours a shift, and one pair took the matter out of the other pair's hands, and yet rock drilling there does not have the same effect as here.

773. You must remember that in one shift you take the blast and in another shift you take the stuff away. You have got no natives?—No, sir.

774. Here, in this country, you are drilling all the time and natives take away the broken rock?—Decidedly.

775. Whereas at home you yourself would have to take away the broken rock?—No, other men do that at home. The developer has nothing to do with rock after he breaks it.

776. Is that usual in Cornwall?—Yes.

777. From your point of view, as a practical miner who has been brought up to mining, to what cause do you attribute the prevalence of this disease?—I could not say unless it is the pyrites in the reef. That is only my opinion, and I do not know whether it is true or not.

778. Do you get more pyrites here than at home?—I do not think we get more here.

779. Mr. Johns: In connection with your statement as to the drilling at home, you say that the workmen do not suffer in the same way as they do out here from this disease?—No, sir, they do not.

780. In the working places you are alluding to, is water ever used in the holes?—No, sir.

781. What do you think of Dr. Aymard's inhaler, and what do you think would be the effect on the whole of the miners?—I think it would be very beneficial to the men if they would use it.

782. But supposing rock drilling is worked by white men only, and only one inhaler could be used, it would not have any good effect on the others?—No, it would not.

783. I understood you to say that only one inhaler could be used at a time?—I do not see how you could fit on another pipe. The tube of the rock drill is only about six inches long, and, as there are two tubes already connected, a third would be a matter of impossibility.

784. The Chairman: But you stated that, even if it were possible, you did not think the assistants could wear them on account of their work?—No.

785. Mr. Johns: Therefore it is not an appliance that could be used with universal good effect?—That is so; only the man using the handle can wear it.

786. Dr. Davies: In the first years of your work as a rock driller, did you feel the effects of the dust from the rock drill pressing on your chest?—No, sir, I have never felt that.

787. You do not feel any discomfort at all?—I breathe as freely now as ever I did.

788. I am not speaking of the inhaler, but when you worked without the inhaler?—I was the same then as now.

789. I mean at the time itself. The feeling one has who is not accustomed to rock drilling is a great feeling of depression on the chest. Is that a common feeling?—Yes, if they have nothing on to prevent it.

790. Does that wear off in time?—Yes, when you go out into the fresh air.

791. When they go down they get it again?—Yes.

792. Does this inhaler relieve that?—Yes.

793. Do you think it would do away with the danger of drilling?—It would not prevent the inhaling of dust altogether, because the rock drill is not at work all the time.

794. You can only use it at certain times?—Yes, only when rock drilling.

795. Then in future the most healthy occupation will be that of a rock driller?—Yes.

796. Do you ever get wet when working in a mine?—No, sir.

797. The miner does not get wet?—No, except a little with perspiration.

798. He does not get his clothes soaked?—No, sir, provided he is not sinking a vertical shaft, because then the water drops down on him.

799. Do the natives get wet?—No, sir.

800. It is very much hotter down below than above?—Yes.

801. And you get very warm?—Yes.

802. Do you get excessively hot?—Pretty hot sometimes.

803. In the mines you have been working at, what arrangements have been made for any change of clothing?—Well, we have change houses.

804. Are these generally found in every mine?—As a rule they are.

805. What does that consist of?—Hot pipes to dry your clothes, baths, etc.

806. Do you change there?—Yes.

807. Does that apply on any mines to the natives?—No, sir.

808. In no case?—In no case.

809. Is the change house looked upon by the miner as being of considerable comfort?—Yes, sir, it is.

810. Does he invariably use it?—Very few miners don't.

811. They don't look upon it as a nuisance?—No, sir, there are baths there.

812. Dr. Hawarden: I understand it is only possible for one man to use this inhaler at a time?—Yes.

813. So your two native assistants could not possibly use it?—No.

814. Your boys cough a good deal?—Yes, sir.

815. In your experience on the Rand, have you known many of your boys dropping off and going sick?—No, sir.

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816. You have not known of many natives who said that they had no more breath, as they express it?—No.

817. Do you think natives are exempt from miners' phthisis?—I could not say.

818. Don't you have the same boys working with you always?—Not as a rule. They leave and go home, and we get a fresh lot of boys. The boys working with me now have been working with me for twelve months.

819. Do they show any signs of difficulty in breathing, and do they cough more than they did?—No, they are just the same. We drill fourteen or fifteen holes, and we have only two dry holes out of the lot, and when you are raising you get every one a dry hole.

820. Have any miners spoken to you about boys suffering from miners' phthisis?—I heard there were some in the George Goch who went home during the war and have returned, and I hear these are suffering from miners' phthisis.

821. Don't you think it strange that in seven years you have never met a boy who has suffered from this disease?—I have never met one.

822. Mr. Catlin: I understood you to reply to Dr. Davies that miners only got wet in vertical shafts. Did you never see a drive from the roof of which water drops on to the miner?—I have never experienced one like that, sir. They exist, I know, but I never worked in one, and it does not usually last so very long.

823. Mr. Perrow: I think you stated that the places you have worked in have all been dry places?—Yes.

824. Since you have been wearing this inhaler, your cough stopped, and the Kaffirs still kept on coughing?—Yes.

825. And you are satisfied that this inhaler is a good thing for the miner?—Yes.

826. Do you think gases have anything to do with miners' phthisis?—I think they have, but I do not know, as I am not a medical man.

827. The Chairman: Have you seen any respirators?—Yes, sir.

828. What do you think of them?—I do not think much of them. I have used Hosken's.

829. That is the one with the sponge?—Yes.

830. And you find they are not much used?—No. They are much inferior to Dr. Aymard's patent.

831. In what way do they fail?—Well, if you drill one dry hole, you must take off the sponge and wash it, and then you will have to draw your breath through the sponge, which is rather difficult.

832. Is there not a valve on the top of it?—The valve is no good. The sponge is the only thing, and it is very difficult to breathe through. Then you have a strap across your head, which is very uncomfortable.

833. Do you find it effective in keeping out dust?—Oh, yes; it is better than nothing.

834. Does it keep the dust out?—Yes, but not altogether.

835. You find your nostrils and moustache are covered with dust after using a respirator?—A little.

Mr. THOMAS MCISAAC, miner, was called and examined.

Mr *Thomas McIsaac.*

836. The Chairman: Have you been working underground long?—About ten years.

837. How long in this country?—Fifteen months.

838. And the remainder at home?—No: in British Columbia and Canada.

839. You have not worked in England?—Not at all.

840. How long have you worked the rock drill ?—About four years.

841. Have you been working a rock drill here ?—Yes, all the time.

842. Have you ever experienced any discomfort ?—I have had a bad cough, but nothing to keep me from working.

843. Did you find miners' phthisis prevailing in British Columbia and Canada, and was there any notice taken of it ?—Yes, of course, most of the old miners were troubled with it as well as here.

844. It was a recognised disease ?—Exactly.

845. Were any precautions taken ?—Yes, water sprays in raises and headings.

846. Was it recognised that dust was the cause of the disease ?—Yes, sir.

847. What kind of sprays were they—roses ?—No, small water pipes.

848. A jet of water ?—Yes, in the dry holes.

849. Did they apply it on the collar of the hole and moisten the dust as it fell ?—I have seen a strong jet going to the bottom of a hole six feet deep.

850. How far would the jet penetrate ?—A strong jet would keep the hole clear all the time.

851. Did you not find the dust choke your drill and prevent you from drilling ?—Sometimes.

852. If you get the dust in a rock drill hole damp or only partially wet, you get it clogged altogether ?—Yes, and you have to take out your drill and start again.

853. How many mines have you worked on here ?—Five mines in all.

854. Did you find ventilation good in these mines ?—Yes, comparatively.

855. Quite as good as in British Columbia ?—Yes.

856. With regard to this inhaler, do you like using it ?—I use it all the time when putting in dry holes.

857. Would you always use it when drilling a dry hole ?—Yes.

858. Do you find the air cold through it ?—It is cold, but not uncomfortably so.

859. It does no harm ?—I do not think so.

860. Do you find any water comes through it ?—None whatever.

861. Nor oil ?—No.

862. In your opinion the cause of this complaint is dust ?—Yes, dust and gas.

863. What do you mean by gas ?—For instance, in headings there is always bound to be a bit of gas.

864. Do you mean gas from explosives or bad air ?—I mean from explosives.

865. And you think that has an effect on a miner's lung ?—I think it has.

866. Have you tried any other respirators besides that one ?—Well, I have never given any other a thorough trial.

867. In your opinion, should drilling dry holes be prohibited by law ?—I do not see how the mines could be worked otherwise, unless working with a water jet.

868. Supposing a method was found by means of a jet of water of some description to allay the dust, do you think it would be a good thing

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to bring in a law forbidding the drilling of dry holes?—I believe that working in dust is the cause of the disease amongst miners.

869. Dr. Davies: Were not inhalers used on those mines you were working at before you came to this country?—I never used any.

870. Did you ever see them used?—No.

871. Do you know whether they ever had been used?—I could not say.

872. I take it they used a jet of water because they thought that most efficacious?—That is all I ever saw used.

873. Was there no particular interest taken in the matter, or was there so much sickness amongst the miners as to cause any special interest to be taken?—I have never seen any special interest taken in the matter. It was recognised that the work of a miner was unhealthy, and I never saw any steps taken to make it more healthy.

874. Was the jet of water used fairly efficacious in stopping the dust?—Yes, to a certain extent.

875. There was still a good deal of dust?—Yes, and the trouble was it interfered sometimes with work.

876. But it did some good?—Yes.

877. Mr. Johns: In drilling the holes inclined downwards, have you ever got dust when using a jet of water?—No, because the jet of water plays right into the hole.

878. The Chairman: Did you find the miners objecting to use this jet?—Yes, a great many would not use it at all.

879. Was it because they found they could work quicker without it?—Yes.

880. They would sooner have the dust and get ill?—Exactly.

881. Which do you prefer, the jet of water or the inhaler?—Well, I have not worked in this country with white men about me. They happen to have been boys.

882. Do you prefer the inhaler to the jet of water?—Yes.

883. For what reason. Is it that you get purer air through it and, if there was no dust, would you not have the same air?—The jet is more trouble to use and takes more time, and you cannot work so fast. Of course, I have always worked by contract, when the more you do the more you make.

884. Dr. Hawarden: In the mines of British Columbia, did you say that the miners suffering from this disease were principally old men?—No, as a rule old men do not suffer. They do not get very old.

885. The Chairman: I think in answering my question you meant by "the oldest men," the men who worked longest?—Yes, I stated that these men suffered from the complaint in British Columbia.

886. I think you implied that they were the older men, the men who had been working longest?—Yes.

887. Dr. Hawarden: Then you find young men suffering from this illness there and dying from it?—Yes, just the same as here, sir.

888. Mr. Catlin: I understood you to say that the use of the jet was not considered very favourably because it impeded the work. How does it delay your work?—It takes more time to adjust it.

889. To rig it up?—Yes.

890. Is it fastened to the drill?—Yes, sometimes; at others you hold it in your hand, but frequently the hole gets clogged up.

891. That is the point. The water then does not go to the bottom of the hole?—It depends upon the force of the water. At times you get a stronger stream than at others.

892. It was because of this liability to clog, by virtue of the water not getting to the bottom of the hole, that this delay in your work was caused?—Yes.

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Mr. GEORGE BLIGHT, miner, was called and examined.

Mr. *George Blight.*

893. The Chairman: Have you been acquainted with underground work long?—Since 1866.

894. Have you had much acquaintance with rock drilling?—Well, I was running a drill in the old country in 1882, and I have been in this country something like 14 years.

895. What part of the old country were you in?—I was born in Cornwall and worked in the Cornish mines until I was 17 or 18, when I went to the north of England.

896. To what kind of mining?—Iron mining and coal mining.

897. In Lancashire?—Yes, Furness district.

898. What experience have you had of rock drilling? Have you been rock drilling constantly since 1882?—Not constantly, but off and on.

899. How long altogether have you been on rock drills?—I should say 10 or 12 years in all.

900. Have you found any inconvenience through having worked the rock-drill so long?—Yes, I am not so well as I was when I started rock drilling.

901. Do you think it due to the rock drill?—It is due, if you will allow me, to dust from the machines and from the channelling of ground in stopes, smoke after blasting, vitiated air from the machines, bad sanitation and insufficient ventilation, which I think is the main cause of the disease here.

902. You mention a rather curious thing. We have just had two witnesses who stated that the air from the machine, which they have been breathing, was very wholesome, and yet you mention vitiated air from the machines?—Yes; impure air or insufficient oxygen, not being compressed and sent down to the drives. In fact, in the exhaust air from the machine, when you have nothing else to do, you will see floating about minute particles of oil, dust, and filth of one kind or another, which almost choke you, especially when you first start the machine.

903. You have not tried the experiment of breathing compressed air?—I have had nothing else to breathe when working in the drives a long way from any ventilation. To this cause I attribute the abnormal death rate amongst the miners, as well as to the want of accommodation on most mines to enable a miner to change his clothing, with the result that he has to sleep in his room with these bad smelling clothes.

904. The witness before last stated that there were change houses on each of the six mines he had been working at?—Well, I only know of one mine having a change house, and it is only an apology for one.

905. How many mines have you worked at on the Rand?—About six.

906. And do you think dust is the chief cause of this disease?—I do, sir; one of the primary causes anyway.

907. And the other causes you consider are bad sanitation, etc.?—Well, we must be pretty healthy or we would all have been dead long ago.

908. What do you mean by bad sanitation?—Well, bad privy accommodation.

909. Is there no accommodation for either white men or natives?—None at all.

910. And the result is, excrement all over the mine in certain portions?—Yes, sir, in certain portions.

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911. Does the bad sanitation exist only in dead ends of old drives —It is bad enough in the drives I work in, and I go there every day.

912. Have there been any efforts made to make regulations in regard to this?—Not on any of the mines on which I have worked.

913. Was there no bucket system?—No.

914. What is your experience with regard to the ventilation of the mines?—Very bad.

915. Could you give descriptions?—Well, I go down to-night at 6.30. 300 yards before I get to my face it is as vile as it can be, and you can hardly see your hand in front of you.

916. Is the atmosphere thick?—Yes.

917. Is that with smoke?—Yes, and with gas.

918. How can you tell that gas is present?—Because you can feel its effects in your head. You get a fearful headache, dizziness in your head.

919. Do you feel the effect of this after your shift?—Yes, certainly but by the time you are in your drive and have got your machine rigged up, you are exhausted. Of course, when your machine starts it has a tendency to clear away those fumes.

920. Is it usual for all men to get gassed?—Not at all. I suppose they would not get gassed if a sufficient amount of pure air were sent down between the shifts.

921. Can you describe the peculiar conditions existing on this particular mine, or do you maintain that these conditions are to be found on all mines?—Well, the same conditions prevail in all the three mines I worked at in Roodepoort, but, of course, that was some years ago, and they may be different now.

922. With regard to change houses. You say that a man comes up from underground and goes to his room and changes there?—Yes, and he is practically breathing the fumes arising from his clothes, in which he has been working all day.

923. The clothes carry the gases with them?—You are never without the smells.

924. And I suppose they are often wet with perspiration?—Yes. And very often quite wet with water dripping from the roof.

925. In what condition are these clothes in the morning? Are they wet or dry?—In the morning they are damp and clammy.

926. Through not being dried properly?—Yes.

927. And, in your opinion, if change houses were erected on all mines it would improve the health of the miners?—Yes, that along with hot and cold water would have a tendency to minimise the effects. I do not say for a moment that it would stop the disease, because in the old country, in Cornwall, men have died from this disease before the rock drill was ever invented.

928. You think this complaint existed before rock drilling?—Yes, I am sure of it. My father died of it.

929. Was that heart disease from climbing ladders or respiratory disease?—Well, they call it sick miners' lung, and I should call it the same thing. They were not very particular in the old days.

930. I would like to know whether, in your opinion, you consider legislation should be passed prohibiting persons from working in dusty places, and whether you think it would have a beneficial effect?—Yes, it would, but how are you going to work these places if you prevent it by Act of Parliament?

931. Then you think it impossible to work a mine without dry holes?—Yes, but you can obviate the dust to a great extent by the use of water.

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932. Will that entirely remove the dust?—It will make mud of it. I have tried with a jet of water at one mine, and it was impossible to lay the dust effectively, because I could not get sufficient pressure.

933. But if some spray is discovered that would lay the dust, would not legislation then be a good thing?—Yes. I also think a system of water should be carried into every working place and the dust laid after blasting. Where you have several tons of rock thrown up by blasting, that ought to be saturated with water before being touched. In most cases, especially at the stopes, it is red hot.

934. Mr. Johns: How many shafts are there in this mine you are working on?—There is only one shaft.

935. With no connection except with the winzes?—Well, there is no direct communication at all.

936. Then you are really describing abnormal circumstances, and not cases where there are two shafts in a mine?—That is so. If we had an upcast and downcast shaft the case would be different altogether.

937. I simply want it to be understood that the conditions you have been describing in connection with the drives, and so on, are not conditions that would prevail in a mine laid out with two shafts?—No, the conditions of a mine with two shafts would be better after you have made your connections, but, of course, there are certain drives east and west that would always remain in a state of insufficient ventilation.

938. You say insufficient ventilation in certain drives, but the end of your drive is never more than 100 or 200 feet from the winzes or raises, and they would never be badly ventilated?—But they are.

939. Under the conditions you name?—Yes, in almost every mine on the Rand. Some of them are a distance of 500 or 600 feet.

940. Well, that is hardly what one would term a reasonable distance?—We know all about that, sir. I think, with a greater interval between the shifts and with a better system of ventilation, it would minimise the disease very much by which we are carried off sooner or later. In my opinion there is not sufficient time between the shifts to ventilate the mines.

941. You stated that your father died from miners' phthisis?—Yes.

942. Do you mind stating what year that was in?—I think it was 1870.

Mr. THOMAS PEARSON, miner, was called and examined.

Mr *Thomas Pearson.*

943. The Chairman: I think you gave some information to Mr. Fisher, the Inspector of Mines, with regard to respirators?—Yes, sir.

944. Would you read that to the Commission, or would you give your views with regard to the use of the respirator?—Yes, sir. The respirator that we tried was one of the aluminium respirators, and the Mine Inspector stayed with us while we drilled a dry hole. A little dust got in through the side of the respirator. I may say that I have worn a respirator for about five months, and that I was not very well previous to doing so. The doctor advised a change and I had it; and then Dr. Rogers advised me to use a respirator. I have worn this respirator, and have derived a great deal of benefit from it. There is no doubt that the respirator is far from being perfect. It is too complicated altogether. It has a small valve on the top, and the least touch it gets knocks it out of gear, and you may not get one in a hundred to fit your face. There is a rubber respirator which the men complained of as being worse than useless. Small pieces of grit get inside of the valve.

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945. That is Mr. Hosken's respirator, a valve with a sponge ?—Yes, sir. All the men condemn it as being worse than useless.

946. Your opinion of respirators as a whole is that they are not yet efficient ?—Yes.

947. May I ask how long you have been mining altogether ?—About ten or twelve years.

948. In this country ?—Yes.

949. Have you done any mining at home ?—About ten years.

950. Is that in addition to the twelve years here ?—Yes.

951. In what part of England were you mining ?—The county of Durham.

952. Coal mining ?—Yes.

953. Have you been rock drilling ?—I never ran a rock drill.

954. Have you seen any experiments carried out with water sprays ?—None whatever.

955. Dr. Davies: What part of the mine have you been chiefly working in ?—All parts. Of course, we have to visit the drills and stopes.

956. How many hours a day on an average do you spend in the mine ?—About nine or ten.

957. Where would your business carry you to ordinarily ?—All working parts.

958. Not so much in the old workings ?—Where the miners are working.

959. So as a matter of fact, although in a lesser degree, you breathe practically the same kind of dust as a man at the rock drill ?—Yes. Of course, we are further back in the drives than the rock driller generally is.

960. Is there not dust visible in the air in the parts of the mine where there are no rock drills ?—Not unless there is a dry hole or there has been some heavy blasting.

961. Then it is dusty ?—Yes, you can notice it.

962. Has any other method of laying dust been used ?—I have not seen any.

963. The inhaler is the only thing ?—Yes.

964. And that has only been comparatively recently introduced ?—Yes.

965. What is your experience, in the time you have been mining, as to men who have had lung trouble ? Have you known many men who have suffered from it ?—Not so many men on the mine, but we have heard of deaths after they have gone home. I have never heard of a single case while the men were working.

966. Do I understand you to say that you have heard of men, working as miners, who have gone away and died afterwards ?—Yes.

967. And have their deaths been put down to lung troubles ?—That I do not know.

968. Do you look upon the inhaler which you are using now as fairly efficient ?—Yes, with a little improvement it would be. Of course, there is a great deal wanted yet before it is quite efficient.

969. Supposing you could get one that would keep the dust out absolutely, do you think it would be generally worn ?—I would compel the men to wear them.

970. Do you think they would wear them of their own accord ?—I am rather inclined to think they often would not. It is, of course, tight breathing, and the men are apt to throw them aside.

971. That is to say, his breathing is not so free as without it ?—No, sir.

972. You think, I suppose, that if these things were made efficient it could be made compulsory for the men to wear them ?—I should think so.

973. Have you got a change house at the mine you are on ?—Yes, there has been one for some years.

974. Is any provision made for the Kaffirs ?—Not that I am aware of.

975. They come straight up from the mine and go to their compound ?—Yes.

976. Have they usually nothing on when they come up ?—Very little on.

977. They come from their huts with a cloth round their waists ?—Yes, some have a jacket.

978. But practically they go down to the mine and come up in the same things and go back to the compound ?—Yes, sir.

979. Have you ever suffered any inconvenience from bad ventilation in the mine apart from dust ?—No, sir.

980. Is the ventilation on your mine bad ?—It is very good generally.

981. Have you ever been gassed ?—Yes.

982. Did it have any bad effect on you afterwards ?—Well, it was some years ago, when we had those large headings and developments. I felt it for a few days, but nothing to speak of.

983. What is the thing that troubles you most working underground ? As regards the conditions of the mines, what would you have improved if you had your choice ?—I should certainly have a good current of air and something to allay the dust generally arising from the dry hole and rock drilling. During blasting operations dust is raised in all parts of the mine and held in suspense. You will find the dust on the walls, the roofs, and everywhere.

984. That is, dust produced by rock drills is not the only dust in the mine ?—Quite so.

985. Where would the dust you have inhaled come from generally —from the moving of rock already blasted or from the drilling of dry holes ?—Well, I should say dust generally held in suspension in the mine as a whole. I do not know of anything else. As a rule I do not stay opposite these dry holes.

986. Do they use any means of allaying dust from heaps of rock already blasted ?—Not generally.

987. Do you think if it were done it would prevent a large amount of dust ?—I think so.

988. Has a jet of water ever been used on these dry holes ?—I have never seen it used.

989. Practically you have used no preventative until the time you wore respirators ?—That is so.

990. Mr. Johns: Have you worked at any other mine ?—I have worked on one for a few months and on another for six months.

991. You have not seen any mine here that has been damp enough generally to prevent any dust rising from the rock in the stopes ?—No, sir.

992. Supposing the miners were forced when below to wear respirators, do you think they would wear them ?—They would have to, if there was a law.

993. But do you think they would even in the face of a law ?—Yes, I think so.

994. You think most of them would ?—I do.

Mr. *T. P. Rosser.*

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MR. THOMAS PRYCE ROSSER was called and examined.

995. The Chairman: How long have you been working in mines?—About 17 years.

996. Would you give a rough idea of where you have been working?—I spent nine years in collieries in South Wales and eight in South Africa in various deep level mines.

997. Then during the last eight years you have been working in the Rand mines?—Yes, with the exception of the war period.

998. That is about three years that must be subtracted?—Yes.

999. Have you been on many mines on the Rand?—I have been on four mines.

1000. On deep level mines?—Yes, all deep levels.

1001. Can you give the Commission your experience with regard to these inhalers and respirators for the prevention of dust?—I consider the wearing of respirators is very effective in preventing a man breathing dust as long as his employment is such that he is not engaged in hard work. A man cannot work hard while wearing a respirator. A rock drill man can easily wear one with advantage to himself, but a certain amount of difficulty is experienced in breathing. I have worn one for five months, and I have experienced no particular difficulty unless I exert myself a great deal.

1002. Do you find that miners willingly wear these respirators?—Miners who realise how dangerous it is to breathe dust wear respirators readily, but new men don't worry about wearing them. The young miners are not disposed to wear them and are not so cautious as the older men.

1003. In your opinion are miners careless as to their health in regard to breathing dust?—On the whole I do think that miners are careless, and contractors, who are paid by the piece, certainly are.

1004. We are talking of the same person?—Yes, but I am speaking of one class particularly, viz.: contractors who go back to the face before they should.

1005. You mean that those men who are paid according to the work they do are very liable to risk their health in order to carry on their work quicker?—That is the case in my experience.

1006. How long have you worn these inhalers?—For five months.

1007. Do you find, after using them, that your nostrils are covered with dust?—No, I do not think that is the case. I think the respirators are perfectly effective.

1008. What respirator are you talking of?—The dry emergency respirator.

1009. That is manufactured by Sherif Swingley & Co. Could you describe it?—It is an indiarubber arrangement with a space inside containing a sponge and a little valve on the left-hand side made of mica.

1010. Do you find that the valve works efficiently?—In the majority of cases the valve becomes disabled in about a week and a piece of sponge is put in.

1011. That must cause discomfort?—But if you inhale you can exhale through the same source.

1012. Except that you will have a certain amount of moisture condensed on the sponge?—I think that an advantage, because it keeps the sponge moist, and one wetting will last all day.

1013. How many men are there working on the mine you are working on now?—There are about 120 white men engaged.

1014. How many of them are rock drilling?—About 20.

1015. And how many wear respirators?—Fifteen—about three-fourths of them.

1016. Do they wear them out of compulsion or of their own accord?—Well, of their own accord, although I have used considerable persuasion with the majority. I have used no compulsion whatever, but have induced them to wear them.

1017. I suppose they only wear them on the stopes when putting in dry holes, when you have a large amount of dust given off. Do not a good many miners imagine there is no dust in the air?—The question of dust has been so thoroughly discussed lately that I don't think many miners are unaware of its presence.

1018. Then you advocate the use of inhalers?—By all means, compulsory if necessary.

1019. Do you think it a matter for legislation?—Certainly.

1020. As regards ventilation, do you find that the mines on the Rand are well ventilated?—I think that the mines on the Rand are very inefficiently ventilated, the deep level mines particularly.

1021. With regard to outcrop mines, are they fairly well ventilated?—Well, you may take them as being fairly well ventilated, but there are drives in certain instances five to six hundred feet beyond a connection.

1022. That is not a frequent occurrence?—Five hundred feet is a very common occurrence.

1023. In your opinion, therefore, ventilation requires great improvement in order to be healthy for the men to work in?—I think the natural means of ventilation should be supplemented by mechanical conditions.

1024. May I ask, in regard to your experience as to the natural means of ventilation that now exist, whether there are any precautions taken to split up the air so that it will circulate through the mine? Are brattice cloths used?—I have seen doors of brattice cloths used in the way you suggest, but such is not the general practice.

1025. How many mines have you been on?—Four.

1026. With regard to these four mines, have they used brattice cloths or any means for splitting up the air?—I have seen doors used on one mine evidently intended to split up the air.

1027. Then there is a certain amount of attention being paid to ventilation?—Yes, where there is a current to split up, but where there is no current it is not necessary, because you have got no current to split up.

1028. But a mine must have ventilation. It could not exist without it. We are speaking of mechanical ventilation?—A deep level shaft is ventilated by mechanical means through the air compressor.

1029. I did not know you were including that. I was talking of natural ventilation, and there is a certain amount of attention evidently being paid to splitting up the air currents?—I think so, but not sufficient.

1030. With regard to sanitation, do you find any provision made for the miners underground?—Provision is being made, Mr. Weldon, on several mines, at the suggestion of your department.

1031. Is it being efficiently carried out?—Yes, on some mines.

1032. And do you find an improvement?—The bucket system has been adopted and works very effectively.

1033. Do you find a difference in the mine?—The air is certainly purer. Natives are in the habit of stooling underground, but I have appointed policemen to prevent that, and I have no difficulty. I see that latrines are placed at every level.

1034. And you find it possible to keep the air pure in that respect?—Yes, quite possible with good supervision.

Mr. *T. P. Rosser.*

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1035. Have you had any experience with regard to the laying of dust by means of sprays?—Yes, during the last five months a spray has been adopted in all dusty places in the mine I am engaged on.

1036. With what result?—It has been very effective in allaying the dust immediately it leaves the hole—in fact it is damped during the time the hole is being drilled. That applies to the collars of all the holes.

1037. The water is not injected, but plays on the collar of the holes?—Yes.

1038. In your opinion no dust escapes?—Very little dust escapes, because I have seen men wearing respirators and yet the parts of the sponge showed no trace of dust after working through the whole day.

1039. With regard to dust from shovelling and blasting operations, does this spray also affect it?—When a wet hole has been started water can be thrown in, and the spray can then be turned backward on the stuff being shovelled, which thus answers a double purpose.

1040. With regard to dust caused by blasting operations?—Sprays can be used in that instance, but cannot be taken right up to the face. Thus you have a section of your drive where dust exists. It would not be safe to put a spray nearer than 60 or 70 feet from the face of the blasting. A strong spray is projected towards the face, and all the fumes, having to pass through it, are purified to this extent, that the dust is allayed.

1041. In your opinion it is quite possible to allay all dust in a mine?—I think so, simply by meeting it on the spot where it is created.

1042. Would it be useful, in your opinion, to introduce legislation to the effect that miners should not work in dusty places?—I think it highly essential, considering the view medical gentlemen take of the dust.

1043. And you think it would be effective?—I think so.

1044. Have you a change house in your mine?—There is a change house on the outcrop property, but not on the deep level. I think it highly necessary on every mine.

1045. Mr. Johns: Do you think respirators would be sufficient protection for the workmen?—I do not think so, because a respirator does not affect, in the slightest, the inhalation of gases.

1046. You think a spray would be more effective than a respirator?—I think, considering the extreme danger of dust and gases driven off, both means could be adopted with advantage.

1047. You mean that where you could not get a spray you would use a respirator?—A spray is valuable in all places.

1048. But only where you have compressed air?—Yes, I am referring to developing places.

1049. I was speaking of the mine generally?—Then I agree with you.

1050. What is your experience about the dust being raised in clearing rock out of stopes? Do you find much dust raised in shovelling?—Yes, there is a considerable amount.

1051. That is when rock is shovelled shortly after blasting?—Yes, there is a considerable amount of dust raised.

1052 But in mines where there is a lot of broken rock, and it is necessary to take the rock out directly it is broken, is it your experience that the same amount of dust would be raised, or is the general dampness of the mine sufficient to prevent that?—The general dampness of the mine considerably allays the dust in that instance, but not the whole of it.

1053. That would partially depend on the time it has been lying there?—Certainly.

1054. Dr. Davies: You take the view that the best plan to prevent the dust is at its inception?—Certainly, because once converted into mud I do not think the dampness of the mine would ever allow it to be converted into dust again.

1055. Although you are somewhat of an enthusiast in regard to respirators, would you prefer some means of spray or a jet of water?—I would simply take the respirator as a supplementary safeguard.

1056. If there were any dust left, you would say use a respirator?—By all means.

1057. I understand you have had five months' experience of spraying in the mine you are working on, and that it produced a good deal of dampness in the air. Can you tell me whether the men complain of that as having any ill effects?—This point was brought to my notice by a medical gentleman who visited the mine, and I have made enquiries. I do not know whether the period is too short to allow me to speak, but I can say that up to the present time there have been no bad effects on the men using these sprays.

1058. They have not complained of any discomfort?—Not the slightest. In fact, it is difficult to get a man to raise without a spray.

1059. You have no difficulty in getting the men to wear respirators?—A certain amount has been experienced with the younger men, who do not understand the danger of breathing dust.

1060. Supposing the time comes when a spray is used on the mines which will do away with a large amount of dust, and the danger of the disease becomes lessened, do you think it probable the miner will throw aside his respirator?—I think a respirator will always be necessary.

1061. But do you consider miners will always consider it necessary?—In development work it will always be necessary, because within 70 feet of the face you cannot introduce your spray, and, therefore, that section will still be dusty, and a respirator is essential, if only to commence the drill.

1062. I understand you to say that you have your spray 60 feet from the face, and that this 60 feet is full of dust and full of gas, and when the miner comes back this has not been cleared away?—It is not full of foul gas, because fresh air has been admitted, and one of the most prolific causes of dust is not altogether drilling, but blasting.

1063. But as soon as the miner has his drill up he can get rid of the dust, so that the dangerous time is until he gets his drill set up?—Yes.

1064. And during that time you think he should wear a respirator?—I think so.

1065. With reference to mine sanitation, have you found any difficulty in making the miners use the buckets?—During the first two weeks there was considerable difficulty, but after that policemen were put on.

1066. And it was carried out effectively?—Yes.

1067. You do not believe the statement of some witnesses that you will never get natives to use buckets?—I say it is a matter of supervision.

SIXTH DAY.

CHAMBER OF MINES, JOHANNESBURG.

Tuesday, 17th March, 1903.

PRESENT:

MR. H. WELDON, *Chairman.*

MR. J. R. WILLIAMS.	MR. R. M. CATLIN.
MR. E. PERROW.	MR. FRANCIS DRAKE.
DR. C. L. SANSOM.	DR. HAWARDEN.

MR. J. STRATFORD, *Secretary.*

MR. JOSEPH MONTAGUE HODGE, shift boss, was called and examined.

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1068. The Chairman: How long have you been connected with underground mining?—About 14 years.

1069. Did you commence mining in England?—I cannot speak much of my experience at home, as it has been chiefly in this country.

1070. You have been 14 years in this country?—Yes.

1071. The whole time on the Rand?—No, some portion of time I spent in Barberton district, but I have been about eight years on the Rand.

1072. The last eight years you spent in Johannesburg?—Yes.

1073. What has been your experience during that time?—I have been running rock drills a considerable portion of the time, and at present I am shift boss.

1074. Could you give the dates between which you have been running rock drills?—At no time longer than 12 months.

1075. At a stretch?—Yes.

1076. And for what period of the eight years were you running rock drills?—About four years.

1077. Have you suffered any inconvenience during that time?—My last experience of rock drills was at New Kleinfontein. I was raising for about eight months on end, and I was not feeling at all well when I left there, but I do not know that I feel any ill effects now.

1078. You don't feel any the worse now?—No.

1079. During the time you were raising for eight months you did suffer?—Yes, towards the end of the period.

1080. In what way were you affected?—I had shortness of breath and felt without any energy, and did not feel at all myself.

1081. As a practical miner, I would like to ask you whether you are in a position to make a statement with regard to the prevalence of the disease?—Of course I cannot quote any statistics, and can only give you simply my own observation.

1082. That is what I mean. What is your opinion about the prevalence of the disease?—I know it is very prevalent.

1083. Can you give any instances?—Yes, quite a number of men whom I have been employed with, and who have remained at the same work for five, six or seven years, I cannot find now, and I am informed by those I enquired of that they are dead.

1084. From what cause?—Presumably phthisis.

1085. Before this Commission sat, and before the commencement of the war, were you aware of the existence of this disease?—I know we always regarded rock drilling as a very unhealthy occupation. I am speaking now of perhaps two years before the war. I think it began to be generally noticed then, and that was when I first took any notice of it.

1086. Rock drilling was considered unhealthy?—Yes.

1087. From your own experience only, I would like your own observations as to the causes?—I consider that the primary cause is dust.

1088. Is that from your own observation?—Yes, absolutely. From my own observation I have found that men who have habitually been raising suffer considerably more from the disease than men driving or stoping. This is the conclusion I have come to from cases I have watched myself.

1089. And there are no other causes. There is not a greater quantity of gas in a rise than there would be in a drive?—There would be, I believe.

1090. But not to a great extent?—I regard the gas certainly as being a contributory cause to the disease, but I consider that dust is the principal cause.

1091. Have you any opinion as regards the prevention of the disease?—The only thing I should advocate would be the conversion of dust into mud at the drilling point, and a better system of ventilation. Some of these long drives are very close, and I regard that as a contributory cause; and, further, the sanitation of some of the principal large mines is very defective. I also think it might help if changing houses were improved.

1092. Do they exist on the mines you have worked on?—We have a change house on the mine I am working on at present, but it is not a very good one, and I think the men should be absolutely compelled to use the change houses when they are put into good order.

1093. That is to leave their clothes there to be dried, and not to take them to their rooms?—Yes.

1094. Have you worked on any of the deep level mines?—No, I am on an outcrop mine now.

1095. In the outcrop mines, surely the ventilation is fairly good?—No, sir.

1096. You mean on the deep levels?—No, sir; some of the upper levels of our mine are the worst ventilated. The ventilation of the 14th Level is better than in one section of the 6th level.

1097. Why is that; is it because the air currents are not led?—Yes, there is no system.

1098. How many mines have you been on altogether?—About half a dozen.

1099. Has there been sufficient attention given to splitting air currents in these mines?—I have never seen any system at all, with the exception of temporary bratticing. I have never seen any mine on the Rand where they have ever really tried to take advantage of the currents they have got in the main.

1100. In your opinion, if the proper attention was paid to the diverting of the currents, there is adequate ventilation going down?—Oh, yes.

1101. Do you think it requires more attention?—That is my opinion.

1102. There is no necessity for any further legislation on that point?—I think the law as it stands, if thoroughly carried out, may serve the purpose, and I think ventilation is a matter that would affect the

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question of gas. If the ventilation in long drives was properly looked after there should be very little gas, certainly not to the same extent as at present.

1103. Dr. Sansom: What made you say the ventilation was bad when you were working in these raises?—I said so from my own opinion. Going into the place in the morning I find it full of gas.

1104. I want to know how do you know?—You very soon find out when you get it on your eye-balls. You feel a sensation almost like pin-pricking.

1105. Did you find any other symptoms at all?—That was the first symptom I got. Latterly I could stand a good deal, but I used to try and arrange to get away when I felt that sensation coming over me, because it was the forerunner of becoming unconscious altogether.

1106. Now as to the ventilation; how did you know that the ventilation was bad?—Simply by finding the air bad when I got into the raise.

1107. You mean some little time after blasting?—When I was raising we were working double shift, following after blasting at 5 in the morning and going up at 6.30. The difficulty was getting sufficient air until your machine was rigged up. After that it was not so bad.

1108. You mean that it was on entering these raises after blasting and before your machine was rigged up?—Yes.

1109. How were the fumes of dynamite blasting allowed to get away?—There is no system whatever.

1110. None at all?—No, none at al

1111. Then how did it get away?—I presume, eventually, by the current set up in starting the machine.

1112. Not before that at all?—I do not think so. We used to go and turn the air on.

1113. Was the air pipe not left on before blasting?—Yes, 35 to 40 feet from the face, but the concussion of the blast denudes the face of fresh air altogether, and assuming the air is knocked back 20 or 30 feet, you have only got a one-inch lead to supply the whole of that distance with air.

1114. You mean to say that the discharge of air from the pipe did not reach within 30 feet of the face of the raise?—It would go further than that, of course, but that was reckoned to be a safe distance at which to leave your hose pipe.

1115. Therefore, all the space left over was left full of gas?—Yes.

1116. And the only way you could get rid of it was by taking a lead, as you call it, up to it, and allowing more air to get in?—Yes.

1117. And meantime you had to suffer —Yes.

1118. Was it only this pricking of the eye-balls, or did you suffer in any other way?—No; after some months, as I said before, I got to feel that I had not the strength and energy that I usually credit myself with having.

1119. How long is it since you worked underground?—On rock drills?

1120. Well, underground?—I am working underground now on an outcrop mine.

1121. Mr. Catlin: On rock drills?—No, I am shift boss there now.

The Chairman: Thank you very much.

MR. EVAN LEWIS was called and examined.

Mr. *Evan Lewis.*

1122. The Chairman: Have you been working underground long?—Yes, ever since I started work at 13 years of age.

1123. Where did you start work?—At home.

1124. In Cornwall?—No, in Wales.

1125. On what kind of mines?—Coal mines.

1126. How long were you there?—I was 16 years at home, but six years out of that I was on the official staff.

1127. What have you been doing in this country?—Contracting rock drills.

1128. In the mines of the Witwatersrand?—Yes.

1129. Could you give us any idea of the length of time you have been contracting rock drills?—About three years.

1130. On end —Yes.

1131. Have you felt any ill effects?—Very little.

1132. Have you done much raising?—I did one raise of about three months, but I had a drive as well.

1133. That is, you worked in two places?—Yes, I had a party of boys drilling one face at a time.

1134. From your experience, can you give us any information as to the prevalence of the disease?—Yes, I have personally seen many friends of my own suffer from this disease.

1135. How can you identify the disease?—Well, shortness of breath, and you find that men working in raises, drives and ends suffer more than men that stope or have other work about the mine.

1136. And you think men working especially in raises and rock drills are subject to a special disease which you can recognise?—Undoubtedly.

1137. What is your idea of the causes of this disease?—It is dust penetrating the lungs and remaining there, and different effects taking place afterwards.

1138. And you suggest water to lay the dust?—Well, all our experience at the Wolhuter shows hat water is the best thing.

1139. You are using a spray at the Wolhuter?—Yes.

1140. How do you find it acts?—Splendidly; in fact, the miners are all eager to have it. Of course it is optional whether they use it or not, but very few men object to it.

1141. Does it, in your opinion, entirely do away with the dust?—Well, not quite entirely, but there is very little dust left. It is only just the little that is caught by the ore, but that is nothing to speak of.

1142. In your opinion dust is the only cause of miners' phthisis?—Yes, dust is the chief cause.

1143. Did you notice anything of this sickness amongst the coal miners?—No, but asthma was very prevalent.

1144. You did not think it was miners' phthisis?—Well, it was not so bad as this. Of course there is such a thing as black lung known at home, but it is rare.

1145. You think in the metalliferous mines it is more prevalent than on the coal mines?—Yes.

1146. Dr. Sansom: Which mine are you working on?—The Wolhuter mine at present.

1147. And they are using the spray?—Yes.

1148. Does that spray produce a very damp atmosphere?—Not at all.

1149. Do you find your clothes getting damp?—No; the earlier spray we had broke the air into such minute particles that it flew everywhere about the place, but the improved one does not throw any damp into the atmosphere at all. It kills the dust and finishes there.

1150. You have had no unpleasant effects since using this improved y?—No, sir.

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1151. You are altogether pleased?—Yes.

1152. Does your spray overcome the dust thrown out by blasting?—That has not been tried in my case.

1153. So the blasting takes place, and that dust is allowed to settle in the air independent of a spray?—Exactly, sir.

1154. Do you think that is a good plan?—Well, you cannot avoid it; but if a man is given two working places you can easily avoid it.

1155. How?—By making it compulsory that a man should not go there until the effect of the blast has settled down.

1156. You would have 24 hours' rest after a blast, and the place watered before you rig up your machine and start drilling?—Yes. You would then have a perfectly clear and healthy atmosphere, but if men set to work after one, two and three blasts with perhaps one little hole to crawl in, the result is that every bit of dust is held in the air; and, again, when you go to blast one round or half a round it is impossible to force the air to the face.

1157. You heard what the last witness said about the gas in raises?—Yes.

1158. Do you find that to be so?—Yes, it is quite true.

1159. And the pipe that leads the air, the lead as you call it, does not drive away the gas from the face until you get it laid right up to it?—The present way is to go as soon as possible after blasting and lead the pipe over the broken ground, in order to prevent the air blowing the dust about.

1160. Have you had much trouble with ventilation and gases personally?—The ventilation on our mine is remarkably good for a deep level shaft, because one compartment is bratticed all the way down to the second level, and from there downwards it is conducted round the workings from level to level, and brought back through the raises and stopes.

1161. How long do you say you have been working on this mine—About three years.

1162. Has the ventilation been good all the time you have been on this mine?—Well, there was bratticing prior to the war down to the second level, but beyond that there was none.

1163. So you cannot make any comparison?—No.

1164. And you do not know whether the disease is more prevalent now than when you first started?—I could not say. We notice it more because there is inclined to be a scare, but on the machines I used to take a silk handkerchief doubled and tie it on my face when going into dry holes, in order to prevent the air getting into my lungs.

1165. Then you thought dust was the cause?—Yes, I did so years ago. I was in two explosions at home, and in one particularly we were closed in for seven hours. We had to come through a tremendous lot of fumes, and the men who took that precaution were able to come out much better than the people who did not.

1166. Mr. Catlin: I notice you speak of the coarse or improved spray. I suppose experience has taught you that the coarse spray effects the settling of the dust better than the fine spray?—Yes, much more so.

1167. Further, you stated that the fine spray makes the particles of water so attenuated that I suppose it was like a fog?—Precisely.

1168. That did not settle the dust?—Well, it did, but it made the men rather uncomfortable in the way of catching colds.

1169. Under these conditions you noticed that men caught colds from the moisture in the air when using the finer spray?—Yes, sir.

1170. You noticed that the men did catch colds in this fog?—Yes, sir.

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1171. If this finer spray were used before you fire your holes, so as to saturate the atmosphere with this fog, and the blast should take place in this saturated atmosphere, do you, or do you not, think that the particles of dust would be settled more quickly?—Undoubtedly.

1172. But that experiment you have not tried?—I have not seen it tried.

1173. Do you know whether it has been tried?—I am not aware of it, sir.

1174. Mr. Perrow: I think, Mr. Lewis, you stated just now that in the course of your three years' experience of rock drills you did three months' raising?—Yes.

1175. And you had a drive at the same time?—Quite so.

1176. How long would it be from the blasting until you went back to the raise again?—I used to blast every 24 hours, and then raise the next 24 hours, so that I was a complete 24 hours away from the raise.

1177. So when you went back to the raise you did not find any gas or any dust?—I used to take precautions by sending Kaffirs before me with a hose pipe and plenty of water before I would enter myself.

MR. DAVID JONES was called and examined.

Mr. *David Jones.*

1178. The Chairman: Will you inform this Commission how long you have been working underground?—About 12 years.

1179. And all in this country?—No, I have only been nine months in this country.

1180. Where have you chiefly been working?—In South Wales.

1181. In coal mines?—Yes.

1182. Were you acquainted with miners' phthisis, and was it recognised as a disease in the mines you were working in at home?—No.

1183. Was there any special disease amongst the miners there?—Asthma.

1184. But you did not connect that with miners' phthisis?—No.

1185. During the nine months you have been working in this country, have you been on rock drills all the time?—Yes.

1186. You have not had very much experience?—No, sir.

1187. On what points do you wish to give evidence?—I have come to give evidence on my experience of using the spray, and I am driving a raise which is now over 100 feet.

1188. You approve of a water spray in allaying dust?—Yes.

1189. This spray is used at the Wolhuter mine by Mr. Britten?—Yes.

1190. It was patented by Mr. Britten?—I think so.

1191. In your opinion does the use of that spray prevent dust?—Yes, I think so.

1192. Dr. Sansom: You say you find that it prevents dust. How do you know?—Because the first month I worked on rock drills I was drilling without the spray.

1193. And what difference do you find?—I found myself much healthier. When working without the spray I felt a tightness in the chest at night after I had finished work, but since using the spray I have not felt this.

1194. You find it better from a health point of view?—Yes.

1195. Have you noticed any difference in your nostrils that leads you to think this spray useful, and have you taken any pains to compare

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your condition since you used it with your condition before that?—Yes, usually when you come out of a raise after drilling a dry hole you are covered with dust like a miller.

1196. Now you don't find any?—No, none at all.

1197. Do you find the dust in your nostrils?—Yes, without the spray.

1198. But since using the spray?—No.

1199. You found none at all?—No.

1200. And you looked carefully?—Yes.

1201. How long was the raise you were doing?—About 100 feet. I am doing that now.

1202. Do you find any difficulty with regard to ventilation and gases?—No, of course this spray does not make much difference in the blasting. The only thing we do is to damp the sides and top before blasting and afterwards much of the dust sticks there.

1203. A great deal of the dust is caught on the wet sides and roof that would otherwise go free?—Yes.

1204. Have you had any trouble with gases yourself?—No, none at all.

1205. What is your idea as to the ventilation of the mines?—The ventilation is very good where I am.

1206. Have you had any trouble yourself, or have you heard of any?—No, sir.

1207. Before this subject was brought up, were you at work on the mines here?—Yes.

1208. Had you heard of many cases?—Yes.

1209. Do you know of many cases?—I know of a few cases.

1210. Have you heard of many others?—Yes, I have heard of many cases.

1211. What was it generally thought to be caused by before it was talked about and made public?—By dust. Of course I am not competent to answer as to that, but men working in raises suffer more than people working in drives or stopes.

1212. Working in raises is very much more dusty?—Yes.

1213. Dr. Hawarden: How long do you usually allow after blasting before you return to the face?—Half an hour or three-quarters.

1214. Could you go back earlier than that?—I think I could go in twenty minutes.

1215. Have you known of any men being gassed while using the spray by going back too soon?—No, I do not know of any, but I have heard of men getting gassed by going back too soon.

1216. Although using the spray?—No, without using the spray.

1217. Don't you leave the spray on when blasting?—Yes, back in the drive, but not at the face. It must be 30 or 40 feet away from where you blast.

1218. Mr. Catlin: You say you do not use the spray when blasting. Is that because the construction of the spray is such that the blast would damage it?—Yes.

1219. But the spray is left further back in the drive?—Yes.

1220. Some 40 feet back?—Yes.

1221. Would it not be possible to conduct the spray nearer the face and have the atmosphere surcharged with moisture?—It would be possible if it was properly protected.

1222. This spray apparatus consists of a tank or bucket?—Yes.

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1223. And if that were connected with a hose would it not be possible ?—There is a small hose.

1224. Could not that be made longer, so that the apparatus could be protected ?—You must have the spray with the injection, because it is attached to the bucket.

1225. Then it is merely a mechanical difficulty that prevents you putting it in there ?—Yes.

1226. In your experience have you noted any difference in the ventilation of your mine between the different levels ? Is the ventilation better at the surface than at the bottom ?—I have only worked in one level.

1227. One witness has just testified that the lower levels were better ventilated than the upper ones, and I think he works in the same mine as you ?—But I do not work in the same level.

1228. I wanted to know if it was a peculiarity of your mine or generally your experience. In other mines where you have worked have you noticed any difference in ventilation between the upper and lower levels ?—Coal mines are different, as they are all on the same level.

1229. You have only worked on one mine here ?—Yes.

Mr. EDGAR PHILIP RATHBONE, M.I.M. and M., A.M.I.C.E., late Government Inspector of Mines to the Transvaal, was called and examined.

The witness submitted the following statement :—

Mr *E. P. Rathbone.*

"I have been connected with practical mining operations for 23 years. I am acquainted with the coal, iron, and copper mines of Europe, also gold, silver, and other mines in South America, Central America, the United States, and Canada. I have an intimate knowledge of nearly all the mining districts in South Africa, most especially of the Witwatersrand Goldfields, having for several years occupied the position of Government Inspector of Mines.

"I consider that the atmosphere in the mines of the Witwatersrand is peculiarly dry, and so far as my recollection carries me I do not remember any other mining district where such a large quantity of fine dust results from the drilling operations. I, therefore, think that it is probable that the disease of 'miners' phthisis' will be far more prevalent on these goldfields than in any other mining district, and I am strongly of opinion that special measures must be taken to prevent the *creation* of dust. Having lately visited a number of mines on the Rand where drilling operations were being carried on in a very dusty atmosphere, and having examined the special apparatus for laying the dust, by the use of the fine sprays of water, and having interviewed the miners personally as to their opinion of the various forms of respirators used, I found that many of the miners had no objections to working in a moist atmosphere resulting from the use of the sprays, and claimed that they derived a certain amount of benefit. I found that the sprays most distinctly laid all dust when properly applied, more especially in the drilling operations. After blasting operations it is more difficult to lay the dust, but I found that the sprays had considerable effect in rapidly improving the condition of the atmosphere in the neighbourhood of the places where blasting operations had been carried on, so that it was possible to return to such working places very much quicker where the sprays were used. I did not find many miners who seemed much in favour of the respirators. My own opinion is that they might easily become almost an additional danger, if not constantly cleaned. I consider that special attention should be given to

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the condition of the atmosphere as supplied to the rock drills, that is to say, to see that the air pipes and air receivers are not contaminated with deleterious matter, such as would vitiate the atmosphere. I have strong reasons for believing that the air supplied to the drills is frequently vitiated, and that, consequently, the atmosphere which the miners breathe, as delivered from the rock drills, is frequently not of a healthy nature, and can certainly not be considered such good air as that derived by any good system of mechanical ventilation. I am strongly in favour of more attention being given to the better ventilation of the deeper mines, especially where the mines are working deposits which are slightly inclined. I consider that, by the introduction of some of the improved forms of mechanical fan ventilators in the deep level mines of the Witwatersrand, such a fresh current of air could be carried round through all the working places as would remove the very deleterious dynamite fumes, and enable the men to return to their working places in a far shorter time than is now possible.

"Although the fine dust would naturally not be removed from the atmosphere by a better ventilating current, as it would be held in a state of suspension, still it would be so improved as to materially strengthen the men who were working in stopes, rises and winzes, so that they would be in a far better condition to resist the action of the disease known as 'miners' phthisis.' I consider that no conditions could possibly be more favourable to the propagation of the disease known as 'miners' phthisis,' than for miners to work in an atmosphere in which an enormous quantity of fine dust is held in suspension, and, in addition, charged probably with a large quantity of carbonic acid gas, resulting from imperfect explosions after blasting. I therefore consider that, in the first place, in all drilling operations it should be sought to prevent the creation of dust in any form. This can be done either by using another form of drill supplied with water injections, or by fine sprays of water directed on to the drill hole, and, secondly, by far better ventilation of the mines than now exists.

"I am strongly of opinion that, except in the main air ways, where there is usually amply sufficient ventilation, the atmosphere in the stopes, rises and winzes is frequently, if not generally, of a very deleterious nature. I think there are few men in a position to give better evidence on this subject than myself, as, when Inspector of Mines, this was my very constant experience in visiting the working places of practically all the mines on the Rand. I note that many of those who are giving evidence insist that the ventilation is good. This is, I believe, because the doctors and many of the others have merely been taken down shafts and along main levels, in which, of course, the atmosphere is, and should be, perfect. I consider that, in order to obtain anything like a good mine ventilation, an air current equal to fully 100 feet per minute is required for every man employed in the mine. The Government, I consider, should introduce into the mining regulations certain clauses which would provide for the better ventilation of the mines than now exists. I firmly believe that, if these precautions were taken, the disease of miners' phthisis would be so considerably reduced as not to be any worse in character than it is in any other mining district of the world. I would point out that in the coal mines and iron mines of England, where ventilation is good and is insisted upon by the Government, and where there is no explosive gas, the death rate amongst the miners from ordinary causes is far less than it is in the Cornish and other metalliferous mines, thus distinctly showing that for the better sanitation of the mines a good system of ventilation is of the greatest possible importance for the health of the miners."

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1230. The Chairman: You state here that the atmosphere of the mines of the Witwatersrand is peculiarly dry. What opportunities have you had of comparing the atmosphere of the mines here with that of mines in other countries ?—Take, for instance, the mines in Bolivia, which are 13,000 feet above sea level—more than twice what we have here. I was there for some time, and drives were a long distance in the mountains. There was one 1,500 feet in length into the mountain of Potosi. The atmosphere there is peculiarly dry. It was practically in the tropics, and the miners did not suffer in any kind of way, as far as I remember, from any disease such as miners' phthisis, although strangers did suffer greatly from asthma and pneumonia.

1231. May I ask whether they use rock drills there ?—They did after I left, but not when I was there.

1232. In that case you really had not had an opportunity of comparing ?—They were working in a dry atmosphere with drills, and there was dust being formed, but they were not rock drills. I was merely giving that as an instance of a place much higher above sea level than this ; as some people are constantly putting forward the height above sea level of the Rand as having something to do with this disease.

1233. You mention the dryness of the atmosphere, and you say that there is a larger quantity of dust resulting from drilling operations ?—I do say that there is a much larger quantity of dust in the mines here.

1234. Larger than in the Cornish mines ?—Most certainly. The atmosphere, to my mind, is much drier here.

1235. You think this results in a greater quantity of dust being formed in drilling ?—Well, I should say so, yes. If you have a moist atmosphere it must have the effect of laying the dust more or less, and it seems to me that in a moist atmosphere there would not be the same liabilities of dust rising. If the atmosphere was very dry and rarefied the dust would have a better opportunity of rising.

1236. You give your experience here with regard to sprays, and you say you have found the sprays to allay the dust ?—Yes.

1237. And you say you found that they rapidly improve the conditions of the atmosphere in the neighbourhood of the places where blasting operations were being carried out ?—Yes.

1238. Would you inform the Commission when you saw them working ?—First of all at the Wolhuter mine.

1239. If you just mention the sprays you have seen it will be sufficient ?—I saw the sprays working in the Wolhuter mine. I have not seen them working anywhere else.

1240. Then you have only seen the one spray ?—Yes.

1241. And all you say here refers to one spray ?—Yes.

1242. In your opinion is that spray efficacious ?—Yes, but I think it could be improved upon. I think there are many improvements which could be made in connection with sprays, but the one I saw is better than nothing.

1243. It is a step in the right direction ?—Most distinctly.

1244. Now, Mr. Rathbone, you say here that you have reason to believe that the air supplied to the drills is frequently vitiated, and consequently the atmosphere which the miner breathes, as delivered from the rock drills, is frequently not of a healthy nature. I would like to hear what you have to say with regard to that ?—Well, I was Inspector of Mines, and on various occasions I have heard the men complain about the condition of the atmosphere. I have asked them whether they thought it was anything in the drill pipes or receivers which could possibly affect the

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air, and on many occasions I have heard them say that they thought it was so. I cannot, of course, speak from knowledge, but only hearsay, what these men told me.

1245. You have not found it to be so yourself?—No, I have never seen anything of it. It is merely what I have heard miners say.

1246. You have heard of Dr. Aymard, who has invented an inhaler for the men to breathe compressed air. Would it be a good thing to ask the men to breathe that air if it was deleterious?—You mean one of those things connected to the drill?

1247. There is a small pipe connecting the inhaler to the air mains, the same as a chloroform inhaler?—I do not know anything about it.

1248. He has invented one of these inhalers and some men on the French Rand are using it?—I do not know anything about it, and do not quite understand how it could work.

1249. The inhaler is over the man's mouth and he breathes the air directly from the receiver?—It would seem to me to be a rather complicated sort of business.

1249A. In any case the men have used it and they say the air is good. Dr. Aymard too says he has investigated the matter and finds the air good?—I only think that if you are breathing the air in that way it is a matter of serious importance that you should take care that the receivers and pipes are clean.

1250. But you state here that you have strong reasons for believing that the air supplied to the rock drills is frequently vitiated?—Yes, that is what I have heard from miners, and, therefore, it would be of importance to see, if such an apparatus as you are speaking of is used, that the receiver was clean.

1251. You cannot make that statement from your own experience?—No, all I say, from my own experience, is that when I was Inspector of Mines I have frequently found the atmosphere in the winzes and raises very vitiated, but I wish to say that this miners' phthisis was entirely new to me when I returned to the Transvaal. I do not remember ever having heard of miners' phthisis at all, and it has all come up since I was Inspector of Mines in 1895, and the whole question seems to have arisen during the last six years. It came as quite a revelation to me when I returned and heard that so many men were suffering from it.

1252. Have you not heard that there is a Commission sitting on the same disease in Cornwall?—Now?

1253. Yes?—No, I have not heard.

1254. Have you any experience of mining in Cornwall?—I have visited most of the principal mines.

1255. Have you never heard of phthisis amongst the miners there?—No. I was practically five years in coal mines and I never heard of it there either.

1256. I was talking of metalliferous mines?—I never heard of any disease to speak of.

1257. Have you heard of a disease in England called ganister?—No.

1258. You say that the air in the mines, except in the main airways, is generally of a very deleterious nature?—That is my impression, most strongly.

1259. What do you mean by deleterious?—That the atmosphere is bad from dynamite fumes and the fine dust arising from drilling operations, and in a general way I should say that the men working in those places must suffer from the bad state of the atmosphere, and one suffers more in

these mines here, not only because of the dry atmosphere, but because of the naturally bad state of ventilation through not having two shafts. I think that if there were two shafts there would be very little talk of bad ventilation.

1260. Have not the majority of mines two shafts?—No, certainly not. They have perhaps one shaft connected with another mine.

1261. Are not the majority of mines possessed of two shafts?—Yes, but not two shafts close together in the same way as I mean.

1262. Would you make the statement that the majority of mines on the Rand have not got two shafts on their own properties?—I would not say that the majority have, but I should say a certain number have. It is impossible to say which mines are working in conjunction with others, and so practically have two shafts.

1263. Do not the conditions you mentioned just now as to dynamite fumes and dust exist in other metalliferous mines in England?—I never heard of it. It may be there, but it could not be very serious, as I have never heard of anything approaching the serious nature of this disease here.

1264. You mention some iron mines?—I was working for some months in iron mines in England, and I never suffered from worse ventilation in my life. In order to work the face we had to keep our candles well back.

1265. And yet you mention that the iron mines of England are well ventilated. Where were you working?—In Lancashire. I was speaking of the Cleveland district, where are flat deposits.

1266. You did not mention that. You talked generally of iron mines of England?—I think that applies especially to the Cleveland mines. I also visited the Hematite mines.

1267. Therefore the excellent ventilation you talk of in your statement with regard to iron mines in England only applies to the Cleveland district?—No, to other iron mines as well. The only qualification I would make there would be in the case of the Cumberland iron-stone mines, where they work on what, I think, is known as the cock-in-lock system, in which the atmosphere is frequently very bad.

1268. Do you happen to know whether they suffer from phthisis in these badly ventilated places?—I never heard of it, and I do not think it exists.

1269. Is ventilation compulsory in iron mines in England?—Yes, everywhere, both in iron and coal mines, there is a certain minimum quantity of ventilation required by law.

1270. Do you know what that is?—One hundred cubic feet is the minimum.

1270A. Is that English law?—Yes.

1271. For all iron mines?—Yes. In coal mines it may be up to 200 cubic feet. The Commission that sat on that question considered 100 cubic feet the minimum required for every man and boy working in a mine, and they said that where there was any gas at all, 200 cubic feet was absolutely necessary. This is what is considered absolutely necessary by the highest authorities for the sanitation of the mines.

1272. That does not occur in metalliferous mines in England, leaving out iron-stone mines?—The mines in North Wales you mean?

1273. Well, the metalliferous mines throughout England?—I do not really know what they do with metalliferous mines.

1274. It does not apply?—I do not think it does.

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1275. You mention here that you consider the Government should introduce into the Mining Regulations certain clauses which would provide for better ventilation of the mines than now exists. Are you of opinion that the present clauses are not sufficient?—Are there any present clauses which provide for a minimum quantity of ventilation?

1276. They state that there shall not be less than 70 cubic feet per man?—That is too little.

1277. Is that the only point?—What are the others? (The Regulations were shown to the witness.) I see these have been introduced since my time, and I think if these were strictly carried out, and the inspectors insisted upon their being carried out, they are sufficient.

1278. You make the statement here that certain clauses should be introduced?—But I did not know that these clauses did exist. They have been introduced since my time.

1279. Are you in a position to give any evidence to the Commission as to the cause of miners' phthisis?—No.

1280. You do not happen to know of any definite cause?—No.

1281. Dr. Sansom: I see you state here that 100 cubic feet per miner is necessary. Why do you think so?—I only go on the experience of a Commission which sat in England to consider this question as to what was necessary for every man and boy working in a mine, and in that Commission, in the course of Mr. Blackwood's evidence, it was stated that 100 cubic feet was the smallest quantity necessary for the sanitation of any mine, not only to do away with dust, but to avoid any diseases which might arise through bad sanitation.

1282. And the Commission adopted that in England for all mines?—Yes.

1283. Metalliferous and coal mines?—I do not know as to Cornwall.

1284. Our attention is directed to metalliferous mines?—I want particularly to point out that the conditions of a metalliferous mine in England, taking equivalent mines, are absolutely the same as on the Witwatersrand, viz., buried deposits, and, therefore, one must not cheat oneself with the idea that because these are metalliferous mines here, they are different from the metalliferous mines working in England. The iron seam must be a metalliferous mine, and there they insist upon the ventilation being perfect.

1285. You say there is not sufficient ventilation in the mines here. Is that the case?—Yes, most distinctly.

1286. What reason have you for thinking that has done any harm?—I should say, where a man is working in an atmosphere which is not sufficiently charged with the necessary quantity of oxygen, it would make that atmosphere bad for a man to breathe. It must, in any case, weaken him, and, therefore, if there was any disease about he must be affected.

1287. That is your supposition, but I want to know whether you have any actual experience of bad ventilation causing illness?—Yes, you are quite right, it is supposition. All I could take as evidence is the fact of there being a disease such as miners' phthisis so prevalent here, and by going down the mines and feeling the bad effects of the air myself.

1288. But you say that miners' phthisis did not exist to your knowledge?—That is so.

1289. Was there any other illness existing due to bad ventilation?—Yes, miners were constantly being gassed by fumes from bad ventilation, and there were other diseases.

1290. What were the other diseases?—Fever from bad sanitation Men were constantly being laid up with fever entirely got from bad sanitation of the mines.

1291. Do you think improved ventilation would improve the sanitation of a mine and prevent fever?—Most distinctly.

1292. Do you think fever is caused by gas in the mines?—No, but if you have a number of men with no proper arrangements underground for their convenience, and thus have a bad sanitary condition in the mines, you can certainly get typhoid fever if you breathe that atmosphere just as much as you could in a house. That is what I have always understood from several eminent doctors. You have only got to be in the same room with a man suffering from fever, where things have not been cleared away, in order to be infected.

1293. Dr. Sansom: While you were Inspector of Mines, did you have any experience of carbon monoxide poison?—Yes.

1294. Was any investigation made of air in the mines in these cases?—No. You mean any special investigation to see what it was due to?

1295. Yes?—Not to my knowledge.

1296. Mr. Catlin: You say that you consider the atmosphere here is much drier than in any other mining locality in the world?—Yes.

1297. Have you ever visited mines on the high plateau in America, in Mexico, or Arizona, or Nevada?—In Mexico I have visited a great many mines.

1298. And you consider that the atmosphere there is not so dry as here?—Well, I am not quite sure about Mexico. I should say that in Mexico and Bolivia the atmosphere is as dry as here.

1299. Have you any knowledge of Arizona?—I have never been in any of the mines there.

1300. Is it not a fact that Arizona is one of the most arid of all regions?—Most distinctly.

1301. Well, then, in your experience here, have you never noticed the miners complain of the great amount of water coming down the air pipe? Have you never noticed the amount of water collected in the air receivers?—You mean coming along in the drilling operations?

1302. The air is compressed and passes into the receiver, and is it not a fact that all the air receivers on the Witwatersrand have to be provided with arrangements for removing that water?—I believe so. I am not quite certain and I would not like to say definitely.

1303. I think it is a fact that there is a great deal of water, certainly much more than any other place I have been in?—I could not state that.

1304. Now, you say in your paper that you are strongly in favour of more attention being given to the better ventilation of the deeper mines. Why deeper mines? Are they less amenable to natural ventilation than the upper levels, and does the difficulty of ventilation vary directly with the depth?—I should certainly say it made a good deal of difference in a mine in the early days when there were a number of shafts close to the surface and one could create a very strong ventilating current. You could then have a very much better condition of things than when working with one or two shafts and going down to great depths, and when you had no system of mechanical ventilation which would cause the air to be forced through the mines into the workings far away from the main inlet or outlet. I should say deeper mines would require better ventilation.

1305. As an engineer, do you not consider that the principle of ventilation depends upon the putting in motion of a quantity of air, whether by heat, due to the expansion or rarefaction of the air, or otherwise?—Quite so.

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1306. Now would it not be probable that the larger the mass of air put in motion, *i.e.*, the more cubic feet of air, the greater its inertia would be?—Certainly.

1307. In other words, when you have a long air pipe or chimney the inertia is greater than that in a short pipe or chimney?—Certainly.

1308. What I want to arrive at is why you say particularly that the deeper mines should be better ventilated. Is it not quite as easy or even easier to ventilate the deeper mines than shallower mines, because you would have in a deep shaft a greater volume of air in motion than in a shorter shaft, and would you not have available the most perfect conditions of ventilation, but under the present conditions you claim it is not so without mechanical ventilation?—They do not pay sufficient attention to the conducting of the air currents. The air goes down one shaft and up the other, and it is not conducted to the points where the men are working.

1309. What has the adjective "deeper" to do with this? If they don't divert and use the currents of air, but let them merely pass down one shaft and up the other, that has no relation to the depth?—I did not mean to convey that the bad ventilation was simply due to the mine being deeper. I mean to say that where the mines are deeper and you have no means of splitting that air current and taking it round the mine, with the result that the air simply goes down one shaft and up the other, then you do not have such good conditions, because it is a much bigger proposition to carry out. In the early days you had natural ventilation and no one troubled about it, but when you get down to a tremendous depth and the air is not taken and split up, then certainly you would have a much worse condition of affairs.

1310. Yes, if the air is not split up?—Yes.

1311. Is it not a fact that if you have a number of columns of air going down different shafts, and the one current eddies against the other—it is much more difficult to ventilate a mine properly with such a multitude of small shafts than when you have only two shafts?—Most distinctly.

1312. Therefore, this remark of yours as to the deeper mines conveys a distinctly erroneous impression. You mean, I gather, that it is no more difficult to ventilate the deeper mines naturally than the outcrop ones?—Most distinctly; I say it would be a much easier proposition to ventilate a deep level mine. As you say, with several shafts you would have diverting currents, and so long as the air was taken and used properly you would get better conditions on a deep level mine than you would on one of the early mines, where there would be a number of currents which would eddy against each other.

1313. How do you account for the fact, which I understand appeals to you, that when you were here six years ago fibrosis of the lungs amongst miners was unknown?—That is quite true.

1314. Was the ventilation much better then than it is now?—No, I do not think it was altogether due to that.

1315. Is the disease common now?—I think it is. I think the surface rocks seem to be more permeated with moisture, and when you get down a considerable depth you get very dry rocks. There is a distinct difference, and I think the disease due to the very much drier condition of the rock itself, and atmosphere.

1316. One more question with regard to this fever you speak of. What fever was prevalent at that time?—Typhoid and enteric.

1317. Do I understand that this fever in your opinion is conveyed in the air in the shape of germs?—Most decidedly. I have always under-

stood that it is quite possible for anyone inhaling an atmosphere permeated by bad sanitary conditions to get enteric or typhoid without taking it in the form of liquid.

1318. Would you expect typhoid to ensue from a bad smell in a mine? Supposing a mine smelt ever so badly, would it be an indication that the germs might exist there, or would you consider that they necessarily did exist?—Certainly not. I simply have been told by others that where, for instance, one man suffering from enteric was in the same room with another, and the utensils were not removed from that room, there was a possibility of the other man taking the fever. I have heard of men in the early days being crowded into rooms where such cases did exist, and I take it that is the reason why they are always so careful in hospitals to remove everything of that sort.

1319. That there is no danger from the smell, but merely from the matter itself?—Exactly; and that matter is deposited in the mines.

1320. (Mr. Williams): You say you had every reason to believe that the air supplied to the rock drills is vitiated. You had a lot of experience underground yourself. Did you notice any inconvenience from breathing that air?—I have most frequently. I have felt, when I was up near the drills, that the atmosphere I was breathing was of such a nature that I would not like to have stayed very long in it.

1321. Did you attribute that to anything at all in the air?—I only attributed it, as I say, to something wrong in the pipes, whether the gutta-percha or whatever they were made of. It had, to my mind, some effect upon the atmosphere, and it always struck me that the air I breathed from a rock drill was by no manner of means as good and strong as in a perfectly healthy atmosphere. I felt that if I had to be a long time in it I would have been affected by it.

1322. In reply to Mr. Catlin, you stated that it was usual to find a lot of water in the pipes from the air compressor?—No, I said I could not speak with any confidence on the point.

1323. Would you admit that in the receivers it is necessary to make arrangements for taking the water off?—Yes, I know there are taps to take the water off.

1324. That being the case, would it not indicate that the air, as supplied to the miner, is saturated with moisture?—In that case I should say it was not—that the water would be taken up by the receiver, and when it came to the miner it would be very dry.

1325. By the law of diffusion that water would not deposit, the air still retained a certain amount of moisture. It would mean that the air was super-saturated with moisture?—Not super-saturated. It would have some moisture, but super-saturated is a very different thing from being simply moist.

1326. There would be an excess of moisture?—No, there would not be an excess. There would be a certain amount of moisture, and if deposited in the receiver and pipes by the time it got to the drills, it would simply mean the heat of the mine itself, and perhaps being near hot pipes, and moisture in the atmosphere would naturally be deposited in the receiver, and therefore the air would still be drier.

1327. Is it not a fact that the air you get in the end of a drive, where you have to depend entirely for ventilation on the exhaust air from the drill, is fairly moist?—I should not think it was, but I have never gone into the question, and I should like to see experiments showing that it is so. My impression is that it is not so.

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1328. The Chairman: Before you go, Mr. Rathbone, I would like to draw your attention to a remark you make, which, were it left unnoticed, might be taken to attribute ignorance to the persons previously giving evidence. You say, "I note that many of those who are giving evidence insist that the ventilation is good. This is, I believe, because the doctors and many others have merely been taken down shafts and along main levels, in which, of course, the atmosphere is, and should be, perfect." I want to draw your attention to the fact that the people who have given evidence on ventilation before us have been practical mining men, of considerable experience underground, and I know you would not yourself like this remark to be misconstrued?—Certainly not.

1329. There is no intention on your part to cause it to be believed that the previous witnesses did not know what they were talking about?—No. The only reason I had was because I saw in a report of the proceedings that one doctor, either Dr. Davies or Dr. Napier, went down a mine and stated the ventilation was very good indeed, and when we came to enquire where he had been we found it was along the main drives.

1330. I do not think that either Dr. Napier or Dr. Davies gave evidence on that point?—Certain statements were made which gave rise to that remark.

1331. Then your remark only applies to one particular witness?—Yes.

1331A Not to the general evidence before the Commission?—No.

SEVENTH DAY.

COUNCIL CHAMBER, CHAMBER OF MINES, JOHANNESBURG.

Wednesday, 25th March, 1903.

PRESENT:

MR. H. WELDON, *Chairman.*

DR. C. L. SANSOM,	DR. S. HAWARDEN,
MR. R. M. CATLIN,	MR. J. HARRY JOHNS.
DR. W. F. DAVIES,	MR. E. PERROW.
MR. FRANCIS DRAKE,	

MR. J. STRATFORD, *Secretary.*

Mr. WALTER CHARLES CROSS PAKES, Analyst and Bacteriologist to the Transvaal Government, was called and duly sworn.

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1332. The Chairman: You are an L.R.C.P., London, M.R.C.S., England, D.P.H., Cambridge, F.C.S., F.S.I., late lecturer on hygiene to Bedford College, bacteriologist to Guy's Hospital, demonstrator of bacteriology and sanitary science in Guy's Hospital, late examiner to the Royal College of Surgeons in hygiene, late assistant examiner in hygiene under the South Kensington Science and Art Department, late Grocers' research scholar?—Yes. I have prepared a statement, but before I read it I should like to say that I do not wish to be as dogmatic as perhaps this statement appears to be. I have made it as short as I could and am prepared to be examined on it.

The witness then submitted the following statement:—

As I understand that the Commission does not wish me to confine myself to the influence of certain gases upon the human frame, and as there are certain points in connection with dust diseases with which I am familiar, particularly from the pathological point of view, I purpose speaking of these facts also.

I understand that the Commission is inquiring into the causation, prevention, and cure of miners' phthisis, and not of the diseases from which miners suffer. By miners' phthisis, I understand a disease which produces certain definite and recognisable pathological conditions. The term is somewhat unfortunate, because of the general meaning which the term phthisis has acquired; the term silicosis is preferable, because it does not even suggest phthisis.

Silicosis may be defined as a chronic fibrosis of the lung tissue due to the presence of foreign particles of a silicious nature in the tissue of the lung. There are, of course, various kinds of foreign particles which may set up irritation in the lung tissue and give rise to the various forms of pneumoconiosis. The acuteness of the irritation, and, therefore, the virulence of the disease, depend upon the nature of the particles and their shape Hard particles which are angular in shape have a much more pernicious effect than soft and round particles. Thus, tin miners, quartz miners, buhrstone dressers, and those who inhale hard, sharp dust suffer from fibrosis of the lung to a much greater extent than sweeps or millers.

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Among all the subjects of fibrosis of the lung the only possible common environment is the dust, and in this connection I should like to quote paragraph 13 of the final report of the departmental committee appointed to enquire into certain miscellaneous dangerous trades.

"In all occupations of a dusty nature the workers run the risk of their lungs becoming affected; especially is this so in the case of dust which is given off when stone and flint are chiselled, for it is of a hard, penetrating and irritating character; the particles are sharp, and when they are inhaled and reach the lungs their presence in these organs is followed by greater reaction than is the case with either coal or flour dust. The result is that by degrees the lung becomes so changed in structure that it ceases to be a spongy organ; it becomes converted into a mass of hard fibrous tissue, embedded in which are found particles of stone. Once the lung becomes affected the tendency is for the solidification to advance, for the worker to become short winded and to suffer from severe bleedings. The illness gradually or quickly proceeds to a fatal issue. It has been difficult to obtain accurate statistics as to the extent of the liability of buhrstone masons to phthisis. Although the records of the Victoria Park Hospital for Diseases of the Chest have been searched, out of 679 cases of phthisis only five occurred among stone masons. Buhrstone industry is but a small one, and it is more than likely that, owing to social circumstances, the men when they become affected would find their way into one of the workhouses, than into any of the special hospitals. A few years ago the coal miners of our country died in large numbers from a form of consumption, but since the compulsory introduction of improved methods of ventilating pits and watering the coal dust in the main ways, the calling of the miner is now a comparatively healthy occupation. The committee feel that what has been accomplished for the safety of the coal miner should, if possible, be attempted for the millstone builder."

When discussing the cause of a disease it is as well to define exactly what is meant, because so many people use the term "cause" in a very casual sense. For instance, one hears that a chill will cause pneumonia. In the strict sense of the term this cannot be so, because pneumonia is a specific disorder. In order to eliminate any doubt on this point it is convenient to use the term *causa causans*. The *causa causans* of pneumonia is generally a micro-organism called the pneumococcus; in the same way the *causa causans* of tuberculosis is the bacillus tuberculosis, and that of silicosis, the fine hard sharp silicious dust.

As regards predisposing causes: however susceptible a person may be to a given disease, such as those I have named, in the absence of the *causæ causantes* the disease cannot arise.

From this we conclude that, in the absence of quartz dust, silicosis will not exist; indeed, cannot exist.

In phthisis—*i.e.*, tuberculosis of the lung—every degree may be met with, from a few small tubercles in the apex of one lung to the cavitation of half the lung substance. In a similar manner every degree of silicosis may be met with. Within the last few days I have had the opportunity of examining the lung of a miner who died suddenly. From the appearance of the lung he probably had no symptom of the disease, because the actual fibrosis had hardly begun, but in the intra-alveolar tissue, and especially around the blood vessels, the particles of silica could be seen, together with an increased number of leucocytes.

On the other hand, the lung may be so fibrotic, and contain so much silica, that it is very difficult to cut with a knife, and practically impossible to cut with a razor.

One great difference has been pointed out between the symptoms of phthisis (*i.e.*, tuberculous phthisis) and silicosis; in the latter, the miner does not notice that he is ill until he is almost past work. A little shortness of breath upon exertion perhaps, and some wasting. In tuberculosis, however, the patient is ill long before the lungs are extensively affected. The reason for this difference is undoubtedly to be found in the toxine or poison secreted by the bacillus in the one case, and in the absence of any soluble poison in the other.

In health the lungs are capable of oxygenating the tissues without any exertion, because the absorbing surface of the alveoli is in excess of the absolute requirements. A certain fraction of the lung can therefore be rendered useless without much immediate detriment to the patient. In the case of silicosis this is what happens. In the case of tuberculosis, however, this is not all that happens; in addition to the cutting off of a certain portion of the lung, the toxines are absorbed into the blood stream, and are responsible for the rise of temperature seen so early in phthisis.

In silicosis, when the amount of absorbing surface is reduced to such an extent that the whole of the surface which is left is required to oxygenate the blood, the least exertion on the part of the sufferer is followed by dysenœa, and then, probably for the first time, he realises that he is ill.

Now it is easy to understand how quickly he gets worse. The patient has only sufficient lung surface to oxygenate his tissues during rest, and he is bound to cease work. But the worst is not over, because there will be in his lung areas which are fibrotic, but in which some portions of lung are still available; as the fibrous tissue contracts, these portions are occluded and rendered useless. In addition there are areas where the fibrosis is in the initial stage, and this will progress to complete fibrosis, thus cutting off more of the absorbing surface.

By the time that there is extensive fibrosis another condition has arisen. The fibrosis may not be complete, and cavitation may take place; these cavities are frequently the seat of putrefactive change, as in bronchiectasis, and absorption of the putrefactive products may take place and give rise to symptoms of toxæmia.

The fact that all dusty trades are associated with some form of pneumoconiosis shows that the predisposing causes play but a minor part in the production of the disease. In the Rand Mines the rock drillers, it is true, have to work in a very foul atmosphere, but many of the other trades, such as the buhrstone makers, work in the open air, or in an atmosphere which is fairly free from noxious gases.

In so far as irritating gases will cause an inflammation of the mucous lining of the air passages, the action of the cilia may be stopped or retarded, and thus the removal of at least some of the dust will be prevented: but beyond this, it is difficult to see how breathing noxious gases will really predispose to silicosis. That the noxious gases will impair the general "tone" is, I think, obvious, and this may result in a greater reaction and a greater proliferation of cells for a given amount of dust; in this way the life of the miner may be shortened, because the fibrosis may be more extensive and take place with greater rapidity, but I cannot see that it will, in any but a very minor way, act as a predisposing cause to silicosis. One thing is certain: a miner may die as the result of constantly breathing noxious gases, but he will not contract silicosis in the absence of dust.

I have had the opportunity of examining various samples of dust from the Rand Mines, and under the microscope, even the finest particles

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were sharply angular. I have searched through field after field without finding more than one or two particles which could be said to be rounded off. That they are very hard is too self-evident to need emphasis.

I have received the analyses of the mine gases which were made for the Commission, and before discussing the effects of these gases upon the human frame, I wish to say that it seems to me a pity that analyses could not have been made before and after an explosion in the same mine in every case. The one occasion upon which it was done (on January 20, at the Village Main Reef Mine) gives very instructive figures.

The four analyses of ordinary mine air are to me, in the absence of any knowledge of the conditions of working, somewhat extraordinary. Sample 751 shows only 0·5% per thousand of CO_2, whilst there is 0·8 per thousand of CO and 2·6 per thousand of H_2. During this time nine persons were working and nine candles burning. Counting the nine candles as equal to one person, the ten people would exhale 6·5 cubic feet of CO_2 per hour, but neither CO nor H_2. If the CO_2 were therefore reduced by ventilation, 65,000 cubic feet would have been entering the level per hour. As the compressed air (samples 968 and 1035) contain 1 per thousand of CO, the fresh air might account for the CO, but as the compressed air contains no hydrogen it seems impossible that the level could have been ventilated to this extent, or we should have to assume that 169 cubic feet of hydrogen were being admitted into the drive per hour.

CO_2 is a soluble gas and H_2 and CO are very insoluble gases, so that it is possible that some absorbent, such as alkaline water, was being used or sprayed into the level at the time of the experiment, but this should have been stated had it been the case.

The same difficulty meets us in samples 1,031 and 1,037. In point of fact, sample 1,037 shows less CO_2 than pure mountain air.

Oxygen. It will be seen that, even after explosion, the oxygen is only slightly diminished—so slightly that the effect of the diminution would probably not be felt by anyone.

Carbon dioxide (carbonic acid). This gas has in itself practically no poisonous properties; when it is in great excess in an atmosphere it produces symptoms to the extent that it replaces the oxygen. In none of the samples did the CO_2 exceed 2·47%, and this can be breathed for hours when mixed with air without producing any effect.

Carbon monoxide (carbonic oxide) is a dangerous gas on account of its great affinity for hæmoglobin. The classic experiments of Haldane on the subject of poisoning by CO are so well known that I need only remind you of some of Haldane's conclusions, and show you the results when applied to the gases under consideration. CO, when breathed, is absorbed by the blood into the capillaries, and enters into a chemical combination with the hæmoglobin of the red discs, forming carbox-hæmoglobin.

The affinity of CO for hæmoglobin is about 140 times that of oxygen, so that a very small tension of CO is capable of turning the oxygen out of combination with hæmoglobin.

The symptoms produced by CO do not become sensible (during rest) until sufficient has been absorbed for the corpuscles to become about a third saturated. When the blood is half saturated the symptoms become urgent.

The percentage of saturation produced by any mixture of air and CO depends upon the percentage composition of the air when the CO is in small quantity, and approximates to the formula $S = \frac{100 \times p}{\cdot 16 + p}$ where S is the percentage saturation produced, and p is the percentage of CO in the air.

In order to produce symptoms (provided that there is a sufficiency of CO in the air breathed) it is necessary for a man to have absorbed about 330 cubic centimetres of CO and have breathed about 660 c.c.

These facts allow us to deduce the effects of breathing the mine gases.

Sample 751 contains 0·08% of CO. Applying the above formula, the saturation produced by breathing this air will be 33%, so that urgent symptoms would not be produced in a normal man at rest. The time taken for slight symptoms to appear would be about two hours or more.

Sample 1,031 contains 0·26% of CO. The saturation produced would be 61%, and the time required to produce one third saturation about 40 minutes; in less than an hour the symptoms would be becoming urgent.

Sample 969 contains 0·90% of CO. The saturation produced—were it possible—would be 84%, and the time required to produce one third saturation about 10 minutes; urgent symptoms would come on in about 15 minutes.

The samples of compressed air contained 0·10% of CO_2, and the continuous breathing of this air would undoubtedly produce symptoms, because a saturation of 38% would be obtained.

The symptoms of CO poisoning are more rapid breathing, palpitation, fulness in the head, and some loss of power in the limbs. As the amount of CO increases these become very marked, and unconsciousness will supervene if a sufficiency of CO is inhaled.

Recovery from poisoning is fortunately frequent, but the elimination of CO from the blood is much slower than the absorption. It appears, however, that the CO has a distinctly harmful effect upon the central nervous system, and constantly inhaling CO even in small quantities cannot fail to produce ill effects upon the general system.

Moreover, cases are recorded which show that a man may be badly "gassed," and apparently recover, and yet die as the result of the gassing. It does not at all follow that because a man has regained consciousness, and even the use of his limbs, he will therefore recover. Nor does it follow, because he died many hours after, that he mnst have died of some other form of poisoning.

Hydrogen and nitrogen are quite inert gases, the Olefines which have been found are also probably without effect.

Nitrous fumes or nitrogen peroxide, or whatever may be the actual composition of the brown, pungent gas which is found in the mines, is undoubtedly noxious. In the samples examined it was found only in small quantity.

The gas is very irritating, when in any strength, to the mucous membrane of the air passages, and will set up irritation, and even inflammation, and when inhaled in large quantities, and in considerable strength, has caused death.

The gas does not, however, cause death by cauterising any part of the buccal cavity, or of the mucous membrane of the pharynx, larynx or bronchi. In the first place, it is difficult to see how it could cause cauterisation when breathed in the strength that it is usually met with, for the acid fumes melting the alkaline secretions all along the respiratory passages would be neutralised almost as quickly as it came in contact with the secretion to form neutral nitrite and nitrate. Secondly, direct experiment shows that no cauterisation does take place. I caused a rabbit to inhale nitrous fumes for about 45 minutes. It died a little over half-an-hour afterwards, and I immediately made a *post-mortem* examination. The

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mouth, nostrils, trachea, bronchi, and lungs were filled with froth which was distinctly alkaline. There was no sign of cauterisation, but the trachea, bronchi and lungs were already hyperæmic, and, in places, injected.

Death may occur some time after the inhalation of nitrous fumes, either from intense inflammation of the trachea, or from a form of pneumonia. I may remind the Commission that pneumonia in elderly people may be set up in a similar manner by the inhalation of ether given for anæsthetic purposes, and ether certainly has no cauterising power.

In the very dilute form in which this gas is actually found in the mines it may give rise to a slight irritation, but I think that the amount of irritation is less than that produced by the dust.

Sulphuretted hydrogen as found in the mines is practically innocuous.

Although I have said that I cannot see how the mine gases can really be predisposing causes to silicosis, I am certain that they must have a very bad effect upon the miners, and will predispose to some of the diseases to which miners are particularly prone.

There is no doubt that the air of the mines which has been analysed is bad—in fact, I should say very bad—and the constant breathing of such air would tend to make the miners anæmic, and less resistant to ordinary diseases, and especially to diseases of the lungs.

Further, an otherwise healthy miner would suffer from the bad air, but a miner who was the subject of silicosis would suffer from the bad air still more. When, as I have pointed out, a miner who has silicosis has only a portion of his lung available, he requires the best air to enable him to oxygenate his tissues. When, therefore, he is exposed to impure air, it is practically impossible for him to keep his tissues in proper repair, and he necessarily becomes more susceptible to disease. Further, having less hæmoglobin than a healthy man, he will be more susceptible to the action of CO, and, having less lung, he will assuredly be more susceptible to the action of the irritating gases, and, therefore, more likely to develop pneumonia after the inhalation thereof.

The prevention of silicosis consists in allaying the dust or preventing its formation. (The disease being a fibrosis, there is not, nor can be, a cure, if by cure we mean repairing the damaged lung.) How the dust is to be prevented is rather for the engineer to say than for me. This much I will venture to say: much more real good will be done by preventing dust than by trying to prevent its ingress into the lungs by means of respirators or other similar devices. In respect to respirators, I would venture to call the attention of the Commission to the first interim Report of the Departmental Committee on Certain Miscellaneous Dangerous Trades :—"If this were all, the Committee would say that, so far, the balance of advantages is on the side of the respirator. But there are other circumstances to consider. An employer or manager setting people to work in dusty or dangerous processes, having supplied them with respirators, considers his responsibility at an end ; and that, if any accident occurs, such as the worker being overcome by the noxious fumes and asphyxiated, or becoming poisoned by lead or bronze, the operative ought to take the consequences. In the opinion of the Committee the responsibility only *begins* (my italics) when the respirators are given out. The duty of seeing that they are worn is a much more responsible task, and, they may add, one infinitely more difficult to perform. There is another factor which enters into the case which the Committee wish to emphasise. The duty of supplying respirators is important, but not less important is the duty of maintaining

them in a cleanly condition. If, as is often the case, the respirator be allowed to get clogged with metallic or other injurious dust which, becoming moist, forms a sort of paste, the worker is naturally repelled by its unpleasant condition, and jeopardises his health, either by rejecting it or by breathing through a vitiated medium. It will therefore be seen that the temptation to disregard the warning of the foreman or manager must be considerable at any time, and in a hot day in a close room well nigh irresistible. When you add to this that, broadly speaking, the workers, in such processes as are under consideration, are careless and even reckless, from familiarity with the danger, ignorance, or want of forethought, one can imagine the difficulty of enforcing such a regulation. The Committee have seen, without surprise, respirators often used carelessly or perfunctorily. To employ respirators in this manner is almost as bad as not to employ them at all. *Therefore, a trade or occupation which, by reason of the noxious gases, or dust produced in its operation, is dangerous to the health of the workers, and in which the only available precaution or safeguard is the use of a respirator, remains an unhealthy or dangerous occupation still.*" (My italics.)

CONCLUSIONS.

1. Rand miner's phthisis is a silicosis whose *causa causans* is dust.

2. The noxious gases as found in the mines are deleterious to health, but are in no way a cause of silicosis.

3. The subjects of silicosis are more susceptible to the ill effects of vitiated air and noxious gases than normal people.

4. The most dangerous gas found in the mines is carbon monoxide.

5. Nitrous fumes are, as compared with carbon monoxide, almost negligible. They are not in any sense a cause of silicosis, nor are they so dangerous or fatal as has been suggested.

6. The prevention of silicosis will follow the prevention of the formation of dust, since in the absence of dust silicosis is not produced.

1333. The Chairman: If dust were destroyed in the mine on its inception by means of sprays, would there still be any ailment (we leave out the words miners' phthisis) due to the gases?—I certainly think there would.

1334. There is such a thing known as miners' asthma, and you know that one of the first symptoms of asthma and of phthisis is that the breathing becomes impaired?—Yes.

1335. Do you think that in the former case the patient really suffering from phthisis and calling it asthma, does so from the fact that his breathing is impaired?—Do you think the two are mixed up together by persons ignorant of the clinical symptoms?—I think that would depend upon the time the miner had been working in the mines. If a miner had been working a fortnight and got asthma I should think it could not be mistaken for phthisis. On the other hand, if he had been working for years, the two might easily be mistaken.

1336. I happened to know myself of two cases where men had been working for years in a mine and were sometimes troubled with shortness of breath?—That would probably be miners' phthisis, if, as you say, they were in a mine for some years.

1337. It appears to be a general opinion, and the facts brought before this Commission seem to show, that miners' phthisis is more prevalent on the Rand than in other mining places. We all know that in Cornwall miners' phthisis has occurred for years and it has also occurred in other mining districts, but on the Rand it appears to be much more prevalent. In my opinion there are more explosives used per underground

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employee in the Rand mines than elsewhere, and as a result more dust and gas produced. Do you think that the increased amount of dust would cause this prevalence?—The extent of the silicosis, that is to say the extent of the disease, as seen pathologically in the lung, and the rapidity with which the disease progresses, depend practically alone on the amount of dust allowed to get into the lung, and therefore the answer to your question would be that the greater prevalence of miners' phthisis and perhaps the shorter life of the miners on the Rand is due to the fact that the increase in the use of explosives causes an increase in the amount of dust.

1338. You have no opinion with regard to the character of the dust here as compared with that of Cornwall or any other district?—I think from the Rand mine dust I have examined that its angularity is as great as any other dust I have ever examined, and certainly quite as hard as anything you can conceive coming from anywhere.

1339. In view of the varying proportions of CO and CO_2, when sometimes CO is present in greater proportions than CO_2, do you think it would be correct to take the percentage of CO_2 as indicating the standard of the purity of a mine atmosphere?—No, I don't; and from the analyses before me it is no indication whatever. I have gone through them very carefully and there seems to be no parallel at all.

1340. One other question with regard to CO poisoning. From the analyses you have before you of the mine air and also of the gases after explosion, is it possible that such a thing could occur as chronic CO poisoning of a man working day after day in an atmosphere containing a certain proportion of CO, not enough to poison him, or have any marked effect, and could that remain in his blood continuously?—I think that, knowing what Haldane has shown, the affinity of CO for the hæmoglobin being 140 times that of oxygen, and the deduction from his experiments being that the elimination of CO is such a comparatively slow process when atmospheric oxygen is breathed, the probability is that if we were to examine the blood of any series of miners they would have no CO in their blood for a shorter period of the 24 hours' working day than they would be free from it. Is that clear?

1341. Yes, I think so; if a man remains in ·08 per cent. of CO for nine hours for instance?—Then it would probably take him a further nine hours to eliminate the last trace, so that he would only have the remainder of the 24 hours of freedom from CO.

1342. You say that the thing is possible?—Well, I think the effect of carbon monoxide on the central nervous system is well known, and the constant presence of CO in the blood, even in small quantities, must affect the general system, and if that can be called chronic carbon monoxide poisoning, I do think they would suffer from carbon monoxide poisoning.

1343. With regard to the analyses you have received from us, I think you call in question the accuracy?—No, sir. May I stop you? I do not question the accuracy, but there must have been some other than normal conditions to account for the CO_2 being so small.

1344. Possibly. I will leave that to Mr. Williams, but with regard to the analyses of 750, 751 and 1,037, if there is any objection at all to these analyses, I had rather that we had your opinion now. As to the other analyses, do they appear perfectly normal?—I should not venture to do anything else but accept these analyses, not in the least. The only remark I made was, that I ought to have been put in possession of the facts as to the conditions under which they were made, but do not think that I am calling the accuracy of the analyses in question.

1345. I think we might go into these matters now, and therefore,

if there is any doubt, I would much sooner you raised that doubt now, whilst the Commission is sitting?—My opinion about them is this, that I have not been put into possession of all the facts as to the circumstances under which these analyses were taken, if they are correct analyses.

1346. Before we go we might give you full information as regards the three samples, and if there is any question about the samples I would like the question to be brought up to-day.

1347. Dr. Sansom: I should like to ask a question about CO. Now, a man who breathes a certain amount of CO practically loses very many blood corpuscles. You might almost bleed him for the time being; therefore a man working too many hours in CO loses so much blood?—Yes, the oxygen-carrying value of so much blood.

1348. Then he would suffer from anæmia?—I have definitely said that will happen.

1349. It has been suggested that in the presence of nitric fumes?—I think the generic term is nitrous fumes.

1350. I think it is better to call them nitric?—Then you do what I will not do—take upon yourself a definition.

1351. Well, we will call them nitrous. Then the result is so long as the water is vapour the fumes are there, and when the water gets down to the floor they go with the water and you get a mixture of nitrous and nitric acid. It has been suggested that the particles of dust that have been analysed coming into contact with the fumes would have a certain amount of the fumes, but your evidence goes to say there is a large amount of alkaline mucius. Would that be sufficient to neutralise the amount of nitric fumes present?—If the amount were no stronger than found in this mine, it would. But to make myself clear. If you put two drops of absolute alcohol on the tongue it is extremely irritating, but if you put the two drops into a tumbler of water it has no irritating effect. The amount of irritation from the acids would be insignificant in comparison with other sources of irritation, *e.g.*, the dust.

1352. There has been a respirator brought here to us, connected with a pipe in the air compressor. Through this it is said a man would breathe pure air from the compressor and no mine air at all. What is your opinion of that?—I think the man would suffer from chronic carbon monoxide poisoning. If the compressor air contains 0·1 per cent. of carbon monoxide, the miner will undoubtedly inhale sufficient of the gas to produce symptoms upon exertion, and I should say that it is undesirable to allow a miner to breathe the compressor air if it be avoidable.

1353. You have stated above, the CO_2 being 2·47 per cent. Would you be satisfied if that was produced by respiration?—Oh, no, certainly not.

1354. What would be your figure?—I should say no air should be breathed by people working which contained more than 0·06 per cent. of CO_2.

1355. It has been suggested that a great amount of CO_2 has been given off by the fæcal matter. Is that your opinion? You may know that no buckets are provided as a rule down in the mines, and men are in the habit of going into odd corners and leaving excreta about the mine. Is it your opinion that a large amount of CO_2 comes from this?—The gas given out by the excreta is generally ammonia, and there is a certain amount of carbon dioxide, but in analyses of gases evolved from excreta the chief gas is found to be ammonia, and the amount of carbon dioxide is very small in comparison with the amount of excreta. The amount per unit as

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compared with the amount of excreta is very small, and I do not think it is possible that it can make a difference of more than a figure in the third place of decimals.

1356. Then, of course, you eliminate perspiration ?—Oh, yes, the carbon dioxide excreted by the man is included in the 0·6 cubic foot per hour.

1357. Dr. Hawarden: I understand you to say there is such a thing as chronic carbon monoxide poisoning ?—I say that if you call the condition produced by the constant inhalation of carbon monoxide by this name, then there is. If I may make a statement to amplify—whoever is breathing air containing carbon monoxide to the extent shown by the analyses must during a considerable portion of the day have a portion of the oxygen-carrying power of the blood taken away from him, and he must suffer from that loss, and must suffer from some chronic form of disease as a consequence. Probably it would show itself chiefly as anæmia.

1358. If you made an examination of the blood of miners, would you expect to find signs of carbon monoxide poisoning ?—I have made examinations of hæmoglobin in blood, and I have estimated the carbon monoxide. It would be often possible to detect the presence of carbox-hæmoglobin in the blood of a miner who had no symptoms of CO poisoning, but not always. If his blood was, say, an eighth saturated, it would probably be possible, but if the blood was only one-hundredth saturated, it would probably be impossible. Many of the miners must frequently have their blood from one-eighth to a quarter saturated with CO.

1359. Miners' phthisis is much more rapid in its course on the Rand than elsewhere; is there any reason why that should be so ?—I have no reason to give. I have an idea, but I fear it is but an idea, and I may be wrong from arguing from a false premise. But, supposing my premises are not false, I take it that silicosis kills more quickly here for two reasons. The first is the greater amount of actual dust produced on the mines. The second is that the miners breathe more deeply than those living at sea level, on account of the rarefaction of the atmosphere (the mercury standing four inches less than at sea level), and on account of the replacement of some of the oxygen by other gases.

1360. In the sputa you have examined at the laboratory have you found any particular coccus ?—I have a large number of samples going through my hands, and I cannot remember.

1361. What I wanted to ask you was, if you had found streptococcus in the earlier stages ? I should not venture to make any statement about that, because I have not examined any specimens which I have known to be from those in the early stages of silicosis.

1362. Dr. Davies: Speaking of the amount of carbon monoxide in the samples, you have stated that the fact of the replacing of oxygen will produce disease. Are you speaking from a theoretical, chemical, or clinical point of view ? Would the amount be worse than in a person who smoked, who would be suffering, of course, from chronic nicotine poisoning ?—My own opinion is from a general knowledge of physiology and pathology. If the amount of oxygen reaching the tissues is reduced (and carbon monoxide does reduce the oxygen-carrying power of the blood), the resisting power of the man must suffer. Supposing, instead of breathing the ordinary atmosphere, a considerable fraction of the oxygen present in the atmosphere were replaced by hydrogen, persons breathing that atmosphere constantly would suffer from anæmia, because, although the oxygen-carrying power of the blood is unimpaired, the amount of oxygen inhaled with each breath

is so much less, and consequently the exertion entailed in more rapid and deeper breathing causes a consumption of energy which necessitates more oxygen ; he, therefore, would certainly suffer from anæmia.

1363. There is a very large margin of health between an anæmic and full-blooded person. Does the amount of carbon monoxide which the miner is breathing have any effect clinically upon him ?—I should say yes, most undoubtedly, because it acts as a direct poison on the central nervous system.

1364. Then the matter of ventilation must be a most important one ?—Most distinctly.

1365. With regard to compressed air, it has been stated that the air breathed through a mask is cooler than the surrounding atmosphere. Would that have any deleterious effect ?—I should like to know the actual temperature of the air in the mine and the air that reaches the miner.

1366. Well, we will take the normal temperature of a mine. Would the breathing of air of any lower temperature have any deleterious effect ?—I should say no, but it would affect him if he were alternately breathing cold and hot air. That would be very deleterious. People coming from the steaming hot air of a cotton mill and going into the cold air are affected.

1367. Can you give an opinion as to the necessity of a change house at the surface for black and white; do you consider it a necessity ?—May I ask for the difference between the temperature up above and down below ?

The Chairman, to the witness: I think it is about 70 or 71 down below.

1368. Dr. Davies : I only want an opinion generally. A miner is generally wet when he comes up, and I want your opinion as to the necessity, or otherwise, of a changing house at the surface ?—I think, the conditions being as you state, it would act deleteriously to the miners to simply proceed to their residence and do nothing further. If the miners would wash and clean in the house, there would seem to be no reason for anything in the ay of wlavatory accommodation. But if the difference in the temperature is considerable, it would be advisable to have some arrangement whereby the miners could walk into a room warmer than the outer air and cooler than the mine air, as in the cotton mills in the North of England.

1369. Take the winter here; the temperature down below is about 75 degrees and on the top perhaps below 40. Do you not think a man suffering from a chest disease would get worse ?—I do, most distinctly.

1370. In these cases can you give me a percentage in which you found tubercle ?—The fallacy of taking percentages in small numbers of cases, say of less than 1,000, is so great that I do not care to.

1371. Can you perhaps tell me the numbers ?—I cannot now, but they are so small that I would rather not put them in at all.

1372. Mr. Johns: In the event of sprays being used in the mine, making a moist atmosphere, do you think that would have a deleterious effect ?—I think it is not desirable if it is possible to work in an atmosphere which is more than three-quarters saturated. Therefore, if the spray produces saturation it would have a somewhat deleterious effect upon the miner.

1373. In what way ?—It would affect him generally because, being several hours in a saturated atmosphere, especially in this country, it would render him more liable to infectious or specific chest disease than persons not so working would be liable to.

Mr. *W. C. C. Pakes.* 25th Mar., 1903.

1374. Mr. Catlin: I understood you to say that pneumonia was always caused by a definite bacillus?—I do not think I said caused. I said occasioned, perhaps.

1375. Well, later on you said it might arise from other causes, such as etherisation. Will you explain that? I am seeking information?—I am sorry I put the matter so obscurely. What I mean is this. Pneumonia is a specific disorder which is caused by a distinct micro-organism, which is known as the pneumococcus. A person getting a chill or having his bronchioles irritated by ether will have his resisting power reduced and will therefore be more susceptible to the influence of the bacterial diseases. In the case of a person getting pneumonia from etherisation, it is not a true pneumonia, but is generally a broncho-pneumonia, the *causa causans* of which is generally streptococcus or staphylococcus, which are generally present in elderly persons' lungs, but which they are able to resist until their resisting power falls below a certain minimum.

1376. Mr. Williams: I think, as regards the chemical analysis of the carbon dioxide and monoxide, they are very distinct?—That is so.

1377. And it is generally admitted that the detection of the presence of the dioxide is very much easier?—That is so.

1378. Now, the question is, when air goes through the compressing plant, using low flash oil, heated in contact with the metal, is it possible to get carbon monoxide and free oxygen?—I should say yes, distinctly.

1379. The Chairman: I take it that oxygen going through a furnace is first formed into CO_2, and comes into contact with incandescent carbon and forms CO. In the compressor, however, there is no incandescent carbon present, but the oil is heated to a high temperature. Under those conditions CO can be formed?—It is formed. You can produce it under similar conditions at any time.

Mr. MALCOLM FERGUSSON, Assistant Inspector of Mines, was called and examined.

Mr. *M. Fergusson.*

1380. The Chairman: With regard to these samples and the analyses before us of mine atmosphere and gases underground, have you taken these samples?—Yes.

1381. With regard to samples of dust underground?—There was one taken by Mr. Williams. I was not present. That was at the Wolhuter; it is No. 951.

1382. Have you any observations to make as regards the samples?—Mr. Pakes was talking about the conditions under which the samples were taken; all the conditions are given here.

1383. With regard to the three that were mentioned, Nos. 750, 751 and 1,037, can you find us the conditions?—No. 750 was taken 17 feet from the face five minutes after explosion of 11 lbs. of gelatine. Three cut holes exploded at once. The last level was the sixth level. This sample was taken 300 feet lower, at the ninth level under ordinary conditions. It was a sort of reservoir of air below the working part of the mine.

1384. Mr. Williams: Was it very moist there?—No, there was very little water coming in. The floor of the level was damp.

Mr. Williams: My reason for asking the question is, that carbon dioxide is soluble in water, which would account for the lowness of the carbon dioxide to the level of mountain air.

1385. The Chairman: Was there an excess of water present?—There was a stream going from the back a few feet; the air would have to pass through that water.

1386. Mr. Williams: Was there a through current of air?—No, it was close to the face.

1387. Then the air would be practically stationary?—Yes.

1388. Mr. Catlin: Have any samples been taken of air? We have one taken from the compressor pipe. What was it like before it went into the compressor? Did it contain any CO_2?—No; no analysis was taken before the air went into the compressor-pipe.

APPENDICES.

INDEX TO APPENDICES.

Appendix B.

SAMPLES OF DUST.

G.L. 118, 119/023.

Public Health Department,
Government Laboratory,
Pretoria, 22nd September, 1902.

Report upon two samples of dust, marked respectively (118), specimen of quartzite dust 606 feet below surface, and (119), specimen of reef dust 606 feet below surface.

Sample 118 is white in colour and gritty to the feel; under the microscope the particles are seen to be often sharply angular, many of them appearing to be fragments of actual crystals. Even the smallest particles show this phenomenon. Only the smaller particles have been illustrated; there are present many particles from five to ten times as large as the largest ones illustrated.

Sample 119 is grey in colour and very gritty to the feel; under the microscope the particles are seen to be angular; even the most minute have a tendency to be angular rather than spherical or oviform. In the diagrams, only the smaller particles have been drawn; there are present particles from five to ten times the size of the largest illustrated.

WALTER C. C. PAKES,
Government Analyst etc.

118/023
Quartzite Dust, 606 ft. below Surface.

× About 250.

119/023
Reef Dust, 606 feet below Surface.

× About 250.

Appendix B.
Samples of Dust.

G.L. 194, 195/023.

Public Health Department,
Government Laboratory,
Pretoria, 2nd October, 1902.

Report upon two samples of reef dust from the District Medical Officer of Health for the Transvaal, marked as follows:—A. Reef Dust; and B. Dust after Blasting.

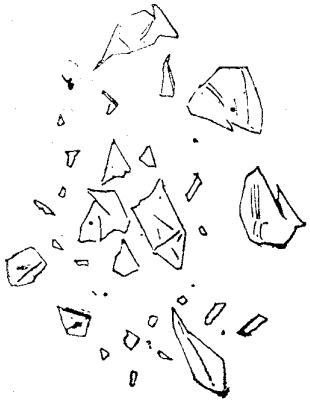
The reef dust was grey in colour and contained a large proportion of macroscopic particles. Even the fine dust felt gritty. Under the microscope the general character was distinctly angular. Only the smallest particles have been illustrated.

The dust after blasting was also grey in colour, and consisted of a very coarse powder with larger lumps of very friable stones. The finer powder was very gritty to the feel. Under the microscope the particles are seen to be angular and jagged and much larger than the reef dust. Only the smaller particles have been illustrated.

It would be superfluous to remark that the consistence and shape of these particles are those which are associated with damage to the lungs and the final fibrosis characteristic of the so-called "miners' phthisis."

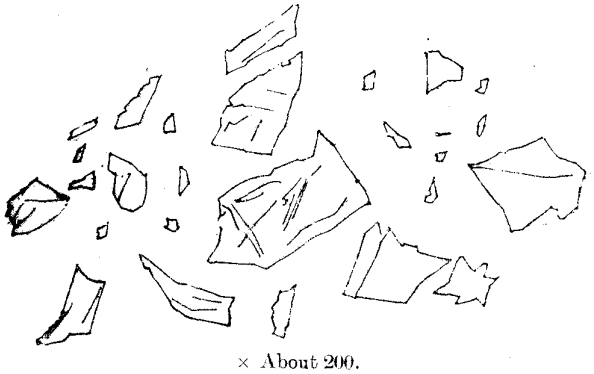
WALTER C. C. PAKES,
Government Analyst, etc.

194/023
A. Reef Dust.



× About 200.

195/023
B. Dust After Blasting.



× About 200.

G.L. 383, 4, 5/023

Public Health Department,
Government Laboratory,
Pretoria, 10th December, 1902.

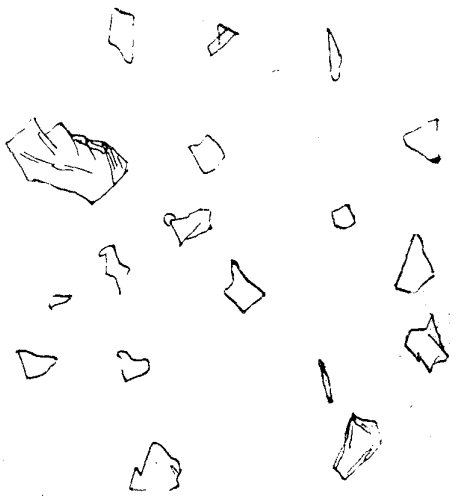
DR. C. LANE SANSOM,
Johannesburg.

Report upon three samples of dust after blasting received here on 20th November, 1902, from Dr. C. Lane Sansom.

The illustrations of the samples of dust which are appended herewith show that the particles are distinctly angular in character. Only the smaller particles were examined under the microscope. The macroscopic particles would probably fall very quickly to the ground, and would, therefore, not be inhaled by the miners. There can be no doubt that the dust is very injurious to the miners; the character of the particles is that associated with the development of fibrosis of the lung due to the inhalation of dust.

WALTER C. C. PAKES,
Government Analyst, etc.

383/023



× About 200.

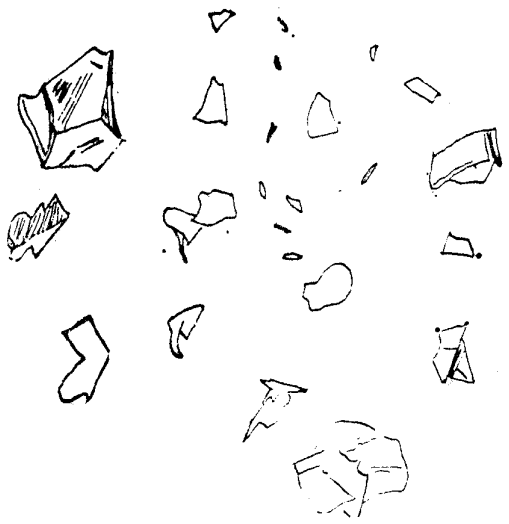
385/023

× About 200.

Appendix B.

ples of Dust.

384/023



× About 200.

Fine Dust from Drill, caught in Inverted Tube.

× About 680.

× About 240.

Left lung of S. W., miner, aged 52. Showing diffuse nature of the fibroid change. Patches of consolidation (nowhere very extensive) and numerous discrete nodules are shown.

Right lung of S. W., miner, aged 52. The middle and lower lobes are fully consolidated.

Right lung of W. P., rockdrill miner, aged 34. Two large cavities are apparent, one in the lower and one in the middle lobe.

Left lung of J. T., rockdrill miner, aged 37. Very advanced, fibrosis with cavity formation.

Appendix C.

Microscopic appearances of commencing fibroid change in case of miners' phthisis (×50).

The Section shows here and there pigmented particles in the walls of the air cells, and shows also the special tendency of these particles to accumulate round the blood vessels and bronchi, there giving rise to irritative changes and the development of new fibrous tissue.

Some of the air cells are seen to be the seat of catarrh, but many are normal.

The aggregation of pigmented particles in one of the interlobular septa is also clearly shown.

Specimen prepared by Dr. E. Hamilton.

Appendix C.

Section from same lung as No. 5, in an area of more advanced fibrosis (× 50). The nodules here shown are just visible to the naked eye.

The development of the fibroid change by the growth and coalescence of nodules is well seen.

Six nodules are shown in the field; in the two largest the blood vessel or bronchus around which the fibroid change originally developed has disappeared. The others still show the blood vessel or bronchus in the centre of the discrete nodule.

The surrounding air cells are in a condition of catarrhal inflammation, and numerous pigmented particles can be seen in their walls.

Specimen prepared by Dr. E. T. Hamilton.

Appendix C.

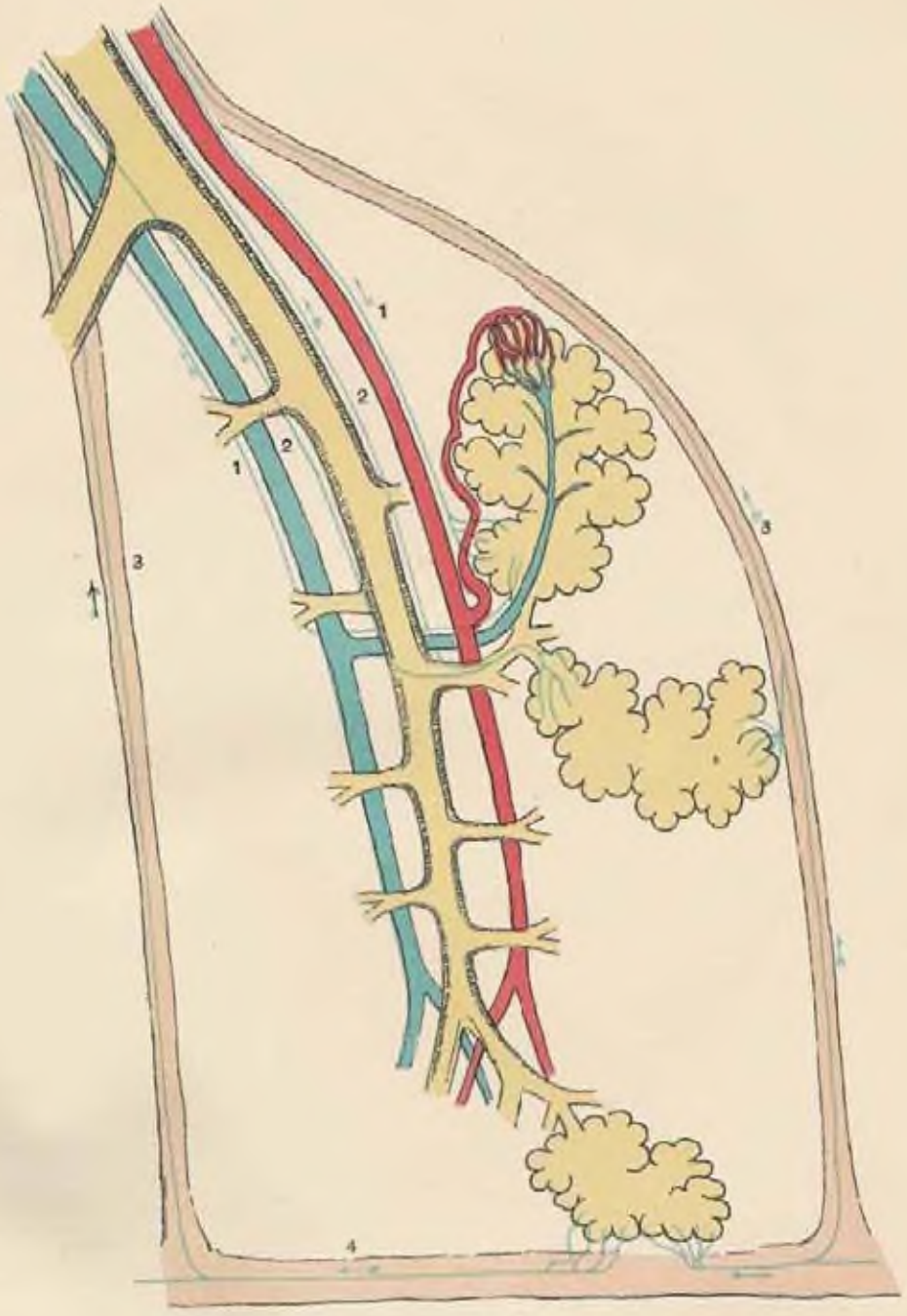


Diagram of a lobule of the lung, showing the main channels of lymphatic drainage.

1. Peri vascular.
2. Peri bronchial.
3. In the interlobular septa.
4. In the deep layer of the pleura.

Appendix D.

ANALYSES.

1.—Inorganic Dust held in Suspension in the Air at Working Places.

No. 752. VILLAGE MAIN REEF G.M. CO., LTD.

20th January, 1903.

Dust.—0·185 grain of dust per cubic foot of air.

Locality.—Drive. Sample taken 14 feet from machine and 17 feet from face. Area of drive 7′ x 5′.

Conditions.—Dry hole being drilled by machine. No water in drive.

No. 762. VILLAGE MAIN REEF G.M. CO., LTD.

30th January, 1903.

Dust.—0·0839 grain of dust per cubic foot of air.

Locality.—Drive. Sample taken 25 feet from face. Area of drive 7′ x 5′.

Conditions.—Dry hole being drilled by machine. No water in drive.

No. 951. WOLHUTER G.M. CO., LTD.

11th February, 1903.

Dust.—0·023 grain of dust per cubic foot of air.

Locality.—Drive. Sample taken 13 feet from the face.

Conditions.—Dry hole being drilled by machine. Britten's Atomiser working.

No. 970. WOLHUTER G.M. CO., LTD.

14th February, 1903.

Dust.—0·036 grains of dust per cubic foot of air.

Locality.—Drive. Sample taken 100 feet from face of drive.

Conditions.—10 minutes after blasting.

No. 972. WOLHUTER G.M. CO., LTD.

14th February, 1903.

Dust.—0·039 grain of dust per cubic foot of air.

Locality.—Drive. Sample taken 100 feet from face of drive.

Conditions.—10 minutes after the blast. Britten's Atomiser working 25 feet in front of the filter.

Appendix D. Analyses.

No. 1033. VILLAGE MAIN REEF G.M. CO., LTD.
25th February, 1903.
Dust.—0·0187 grain of dust per cubic foot of air.
Locality.—Drive. Sample taken 12 feet from face.
Conditions.—Before commencement of work. 5½ hours after blasting.

No. 1035. VILLAGE MAIN REEF G.M. CO., LTD.
25th February, 1903.
Dust.—0·006 grain of dust per cubic foot of air.
Locality.—Stope. Stope 60′ x 60′. Damp hanging wall.
Conditions.—Two machine drills working. Boys shovelling.

No. 1127. FERREIRA G.M. CO., LTD.
10th March, 1903.
Dust.—0·014 grain of dust per cubic foot of air.
Locality.—Stope. Sample taken 25 feet from machine drilling dry hole. Sample taken 40 feet from machine drilling wet hole.
Conditions.—Boys shovelling.

No. 1130. WOLHUTER G.M. CO., LTD.
10th March, 1903.
Dust.—0·072 grain of dust per cubic foot of air.
Locality.—Raise. Sample taken 7 feet from face.
Conditions.—Machine drilling dry hole.

No. 1371. ROBINSON DEEP G.M. CO., LTD.
30th March, 1903.
Dust.—0·018 grain of dust per cubic foot of air.
Locality.—Drive. Sample taken 9 feet from the face. 2,300′ level, South Reef West.
Conditions.—Two machines working; one dry hole and one wet hole. Teale's Injector working in dry hole.

No. 1459. LANGLAAGTE DEEP G.M. CO., LTD.
7th April, 1903.
Dust.—0·011 grain of dust per cubic foot of air.
Locality.—Raise. 930′ level, Main Reef West. 160′ up.
Conditions.—Machine drilling dry hole. Britten's Atomiser working.

2.—Mine Air after Explosion of Dynamite.

No. 680. FERREIRA DEEP G.M. CO., LTD.
12th January, 1903.
Analysis.—Oxygen, 19·45%; carbonic acid gas, 1·85%; carbon monoxide, 0·01% (about); olefines, 1·90%; residue (nitrogen, etc.), 76·79%.
N.B.—A source of experimental error was found in the olefines, which are, therefore, probably too high and the nitrogen correspondingly low.
Locality.—Drive. Sample taken 2½ feet from face of drive.
Conditions.—Sample taken 20 minutes after explosion. 23 lbs. Nahnsen's gelatine had been used. No compressed air was turned on.

No. 750. VILLAGE MAIN REEF G.M. CO., LTD.

20th January, 1903.

Analysis.—Oxygen, 19·27%; carbonic acid gas, 2·47%; carbon monoxide, 0·63%; olefines, traces; hydrogen, 0·44%; methane, 0·20%; sulphuretted hydrogen, trace; nitrogen, 76·99%.

Locality.—Drive. Sample taken 17 feet from face of drive.

Conditions.—Sample taken 5 minutes after blasting. 11 lbs. Transvaal blasting gelatine had been used. No. 6 detonators had been used. No compressed air was turned on.

No. 761. VILLAGE MAIN REEF G.M. CO., LTD.

30th January, 1903.

Analysis.—Oxygen, 20·13%; carbonic acid gas, 0·87%; carbon monoxide, 0·68%; olefines, 0·56%; hydrogen, 0·20%; nitric oxide, 0·0202%; sulphuretted hydrogen, 0·01%; nitrogen, 77·53%.

Locality.—Drive. Sample taken 25 feet from face.

Conditions.—Sample taken 10 minutes after the explosion. 20 lbs. Transvaal blasting gelatine had been used. Two No. 3 and four No. 6 detonators had been used. No compressed air was turned on.

No. 949. WOLHUTER G.M. CO., LTD.

11th February, 1903.

Analysis.—Oxygen, 30·52%; carbonic acid gas, 0·70%; carbon monoxide, 0·23%; olefines, 0·05%; nitric oxide, 0·0064%; nitrogen, 78·49%.

Locality.—Drive. Sample taken at the face, 380 feet from the crosscut.

Conditions.—Sample taken 9 minutes after the explosion. 24 lbs. Nahnsen's blasting gelatine were used. Compressed air was one-third on.

No. 950. WOLHUTER G.M. CO., LTD.

11th February, 1903.

Analysis.—Oxygen, 19·47%; carbonic acid gas, 1·70%; carbon monoxide, 0·54%; nitric oxide, 0·0083%; nitrogen, 78·28%.

Locality.—Drive. Sample taken 150 feet from the face and 450 feet from the crosscut.

Conditions.—Sample taken 13 minutes after the explosion. 30½ lbs. Nahnsen's blasting gelatine were used. Britten's Atomiser was working 70 feet in front of where the sample was taken.

No. 971. WOLHUTER G.M. CO., LTD.

14th February, 1903.

Analysis.—Oxygen, 19·37%; carbonic acid gas, 2·00%; carbon monoxide, 0·55%; olefines, 0·20%; nitric oxide, 0·0086%; nitrogen, 77·87%.

Locality.—Drive. Sample taken 100 feet from the face.

Conditions.—32 lbs. Nahnsen's blasting gelatine were used. Ten No. 8 detonators were used. Britten's Atomiser was working 25 feet in front of where the sample was taken.

Appendix D

Analyses.

No. 969. WOLHUTER G.M. CO., LTD.

14th February, 1903.

Analysis.—Oxygen, 19·50%; carbonic acid gas, 2·29%; carbon monoxide, 0·90%; olefines, 0·33%; nitric oxide, 0·002%; nitrogen, 76·98%.

Locality.—Drive. Sample taken 100 feet from the face.

Conditions.—Sample taken 10 minutes after the explosion Transvaal gelatine had been used. No. 8 detonators had been used. No compressed air was turned on.

No. 1187. FERREIRA DEEP G.M. CO., LTD.

17th March, 1903.

Analysis.—Oxygen, 20·32%; carbonic acid gas, 1·20%; carbon monoxide, 0·13%; nitric oxide, 0·0027%; residue, 78·35%.

Locality.—Drive.

Conditions.—Sample taken 15 minutes after the explosion. The receiver exhausted with bellows. Compressed air blowing 30 feet from the place where the sample was taken.

No. 1188. FERREIRA DEEP G.M. CO., LTD.

17th March, 1903.

Analysis.—Oxygen, 20·13%; carbonic acid gas, 1·80%; carbon monoxide, 0·19%; residue, 77·38%.

Locality.—Same as preceding sample.

Conditions.—Sample taken 10 minutes after the explosion. The receiver had been filled with mercury at the surface, and was emptied at the place where the preceding sample was taken.

N.B.—The difference in analysis between these two samples is doubtless due to dilution with compressed air during the time which elapsed before the second sample was taken. If we suppose 100 volumes of the last mixed with 50 volumes of compressed air, we get:—

$$150 \text{ vols.} \begin{cases} O = 20{\cdot}13 + \frac{1}{2} \text{ of } 20{\cdot}80 = 30{\cdot}53 \\ CO_2 = 1{\cdot}80 + \frac{1}{2} \text{ of } 0{\cdot}08 = 1{\cdot}84 \\ CO = 0{\cdot}19 + \frac{1}{2} \text{ of } 0{\cdot}04 = 0{\cdot}21 \end{cases} = \begin{cases} 20{\cdot}35\% \\ 1{\cdot}23\% \\ 0{\cdot}14\% \end{cases}$$

which is practically identical with the preceding sample.

3.—Normal Mine Air under Ordinary Working Conditions.

No. 751. VILLAGE MAIN REEF G.M. CO., LTD.

20th January, 1903.

Analysis.—Oxygen, 20·46%; carbonic acid gas, 0·05%; carbon monoxide, 0·08%; hydrogen, 0·26%; olefines, traces; nitrogen, 79·2% methane, sulphuretted hydrogen, nitric oxide—absent.

Locality.—Drive. Sample taken 15 feet from the face.

Conditions.—Nine persons were present and nine candles burning. Machine drill working.

No. 1031. VILLAGE MAIN REEF G.M. CO., LTD.
25th February, 1903.

Analysis.—Oxygen, 20·26%; carbonic acid gas, 0·08%; carbon monoxide, 0·26%; hydrogen, 0·86%; nitric oxide, 0·0003%; nitrogen, 78·54%.

Locality.—Drive. Sample taken at face, 806 feet from crosscut.

Conditions.—Sample taken before commencing work. Last blast had taken place five hours previously.

No. 1032. VILLAGE MAIN REEF G.M. CO., LTD.
25th February, 1903.

Analysis.—Oxygen, 20·07%; carbonic acid gas, 0·21%; carbon monoxide, 0·18%; hydrogen, 1·08%; nitric oxide, 0·0005%; nitrogen, 78·5%.

Locality.—Stope. Size of stope 60′ x 60′, 400 feet in from the crosscut.

Conditions.—Sample taken before commencing work. No connection between the stope and the level above.

No. 1037. VILLAGE MAIN REEF G.M. CO., LTD.
25th February, 1903.

Analysis.—Oxygen, 20·32%; carbonic acid gas, 0·02%; carbon monoxide, 0·18%; olefines and methane, 0·10%; hydrogen, 0·71%; nitrogen, 78·67%.

Locality.—Drive. Sample taken at face, 1,000 feet from the shaft.

Conditions.—A wet drive with water falling from the back. Disused portion of the mine—no work is being done below the 6th level, which is 300 feet above the level where the sample was taken.

No. 1231. FERREIRA DEEP G.M. CO., LTD.
21st March, 1903.

Analysis.—Oxygen, 20·78%; carbonic acid gas, 0·05%; carbon monoxide, 0·03%; hydrocarbons, 0·02%; nitric oxide, 0·001%; residue, 79·11%.

Locality.—Winze. Sample taken at bottom of winze, 65 feet deep.

Conditions.—Boys cleaning up at beginning of shift. Nine persons present and nine candles burning.

No. 1232. FERREIRA DEEP G.M. CO., LTD.
21st March, 1903.

Analysis.—Oxygen, 20·37%; carbonic acid gas, 0·25%; carbon monoxide, 0·07%; residue, 79·3%.

Locality.—Winze.

Conditions.—Sample taken in a winze, which had not been worked for two weeks, 100 feet depth.

4.—Air Supplied by the Compressor.

No. 968. WOLHUTER G.M. CO., LTD.
14th February, 1903.

Analysis.—Oxygen, 20·70%; carbonic acid gas, 0·09%; carbon monoxide, 0·10%; nitric oxide, 0·0002%; nitrogen, 79·1%.

Locality.—Underground.

Appendix D.
Analyses.

No. 1036. VILLAGE MAIN REEF G.M. CO., LTD.

25th February, 1903.

Analysis.—Oxygen, 20·78%; carbonic acid gas, less than 0·05%; carbon monoxide, 0·13%; olefines, traces; nitrogen and hydrogen (difference), 79·09%.

Locality.—Underground.

No. 1128. FERREIRA G.M. CO., LTD.

10th March, 1903.

Tested for carbon monoxide with $PdCl_2$ paper—small trace found.

No. 1156. WOLHUTER G.M. CO., LTD.

10th March, 1903.

Simultaneous analyses were made, using in one case Cu_2Cl_2 in ammonia, and in the other Cu_2Cl_2 in HCl, for carbon monoxide.

Analyses.—(a) Oxygen, 20·78%; carbonic acid gas, practically absent; carbon monoxide, absent; N_2 (residue), 79·2%. (b) O, 20·32%; CO_2, perhaps 0·02%; CO, absent; residue, 79·16%.

No. 1185. CITY & SUBURBAN G.M. CO., LTD.

14th March, 1903.

Tested for carbon monoxide with $PdCl_2$ paper—small trace found.

No. 1186. CITY & SUBURBAN G.M. CO., LTD.

10th March, 1903.

The compressed air was passed through a 2% solution of blood for one hour—CO was undetectable with the spectroscope.

No. 1380. ROBINSON G.M. CO., LTD.

31st March, 1903.

Tested for carbon monoxide by a new method, using I_2O_5 (see Jour. Chem. Soc., London, March, 1903).

Found.—CO = 0·0034%.

Locality.—Air cylinder in engine house.

No. 1381. ROBINSON G.M. CO., LTD.

31st March, 1903.

Carbon monoxide determined by same method as preceding sample.

Found.—CO = 0·002%.

Locality.—11th Level, Main Reef Leader West.

No. 1410. JUBILEE GOLD CO., LTD.

2nd April, 1903.

Carbon monoxide determined by same method as preceding samples.

Found.—CO = 0·0018%.

Locality.—6th Level, Main Reef East.

Conditions.—Compressing in one stage.

No. 1411. JUBILEE GOLD CO., LTD.

2nd April, 1903.

Tested for carbon monoxide with $PdCl_2$ papers—no CO was detectable.

Locality.—Receiver.

No. 1479. VILLAGE DEEP G.M. CO., LTD.

8th April, 1903.

Tested for carbon monoxide by I_2O_5 method.

Found.—CO = 0·0017%.

Locality.—No. 2 Shaft, 1,800 feet from the compressor.

Conditions.—Compressing in one stage.

5.—Miscellaneous.

No. 763. VILLAGE MAIN REEF G.M. CO., LTD.

30th January, 1903.

OLEFINES.

Analysis.—Ethylene dibromide. Solid bromo compound.

Locality.—Drive. Sample taken 100 feet from the face.

Conditions.—Sample taken 10 minutes after the explosion. Air was aspirated through a solution of bromine to determine the composition of the olefines.

No. 764. FUSE.

Analysis.—Oxygen, 18·64%; carbonic acid gas, 2·4%; carbon monoxide, 1·2%; olefines, absent; residue (nitrogen, etc.), 77·75%; sulphuretted hydrogen, present.

Conditions.—The sample was obtained by burning 4·2 inches of fuse in 4,300 cubic centimetres of ordinary air.

No. 765. DYNAMITE WRAPPER.

Analysis.—240 grains of wrapper contained 139 grains of carbon, 21·1 grains of hydrogen, and 80 grains of oxygen.

N.B.—If exploded without extra oxygen, it gave 150 litres of carbon monoxide and 98½ litres of ethylene, together with small quantities of water and hydrogen.

LUBRICATING OILS.

WOLHUTER G.M. CO., LTD.

10th March, 1903.

Valvoline oil gave no carbon monoxide on heating in air to 200° C., but on heating to 260° C. (500° F.), carbon monoxide was detected.

VILLAGE MAIN REEF G.M. CO., LTD.

10th March, 1903.

Valvoline oil gave distinct signs of carbon monoxide at 200° C. (392° F.).

Appendix D.

Analyses.

TEMPERATURE OF COMPRESSOR.

CITY & SUBURBAN G.M. CO., LTD.

23rd March, 1903.

Temperature 156° C. = 313° F.

A weight thermometer was left in the box at the head of the (vertical) high pressure cylinder for 24 hours.

N.B.—The pressure was 70 lbs. above atmospheric.

Comparative Tables Summarizing the Analyses shewn in the foregoing Lists.

1.—Inorganic Dust held in Suspension in the Air at Working Places.

No. of Sample.	Quantity of Dust in grains (per cubic foot).	
752	0·185	Face of drive.
762	0·0839	„ „
951	0·023	„ „ behind spray.
970	0·036	100′ from face of drive after blast.
*972	0·039	„ „ „ behind spray.
†1033	0·0187	End of drive 5½ hours after blasting.
1035	0·006	Stope ; boys shovelling.
‡1127	0·014	„ „ „
1130	0·072	Rise.
1371	0·018	Drive ; injector working in dry hole.
1459	0·011	Raise ; dry hole, atomiser working.

*25′ behind spray, and 100′ from face.

†No work being carried on.

‡Two machines at work, distant (1) 25′ ; and (2) 40′.

2.—Mine Air after Explosion of Dynamite.

	Sample 680.	Sample 750.	Sample 761.	Sample 949.	Sample 950.	Sample 969.	Sample 971.	Sample 1187.	Sample 1188.
Oxygen ...	19·45	19·27	20·13	20·52	19·47	19·50	19·37	20·32	20·13
Carbonic Acid Gas ...	1·85	2·47	0·87	0·70	1·70	2·29	2·00	1·20	1·80
Carbon Monoxide...	0·01	0·63	0·68	0·23	0·54	0·90	0·55	0·13	0·19
Hydrogen ...	—	0·44	0·20	—	—	—	—	—	—
Olefines ...	1·90	—	0·56	0·05	—	0·33	0·20	—	—
Nitric Oxide..	—	—	0·02	0·006	0·008	0·002	0·009	0·003	—
Sulphuretted Hydrogen...	—	—	0·01	—	—	—	—	—	—
Residue—Nitrogen, etc.	76·79	76·99	77·53	78·49	78·28	76·98	77·87	78·35	77·88

3.—Normal Mine Air under ordinary Working Conditions.

	Sample 751.	Sample 1031.	Sample 1032.	Sample 1037.	Sample 1231.	Sample 1232.
Oxygen	20·46	20·26	20·07	20·32	20·78	20·37
Carbonic Acid Gas	0·05	0·08	0·21	0·02	0·05	0·25
Carbon Monoxide	0·08	0·26	0·18	0·18	0·03	0·07
Hydrogen ...	0·26	0·86	1·08	0·71	—	—
Nitric Oxide ...	—	0·0008	0·0005	—	0·001	—
Nitrogen ...	79·2	78·54	78·5	78·67	79·11	79·3

4.—Air Supplied by the Compressor.

	Sample 968.	Sample 1036.	Sample 1156.	
			(A).	(B).
Oxygen	20·70	20·78	20·78	20·82
Carbonic Acid Gas	0·09	0·05	—	0·02
Carbon Monoxide	0·10	0·13	—	—
Nitric Oxide ...	0·0002	—	—	—
Nitrogen	79·10	79·09	79·2	79·16

Appendix E.

Table showing Comparative Mortality of Males in England and Wales, from 25 to 65 years of age, in different occupations, from all and several causes, 1880—81—82.—(From Dr. Ogle's evidence before the Royal Commission on Labour, 1892.)

Occupation.	Comparative Mortality from all causes.	Diseases of the Nervous System.	Phthisis.	Diseases of the Respiratory Organs.	Liver Diseases.	Other Diseases of the Digestive System.	Alcoholism.	Accident.	All other causes.
Clergyman	1,000	180	116	116	28	49	4	11	496
Physician	2,018	334	222	250	183	74	25	84	846
Farmer	1,135	146	185	178	74	54	11	54	433
Agricultural Labourer	1,261	144	219	281	36	77	2	59	433
Gardener	1,077	113	218	200	32	40	4	43	427
Fisherman	1,433	146	194	162	58	62	7	273	531
Commercial Traveller	1,705	250	432	264	110	47	41	65	496
Innkeeper	2,736	360	531	390	432	67	99	81	776
Grocer	1,387	192	300	209	94	56	18	25	493
Draper	1,588	196	541	232	63	68	14	41	433
Butcher	2,104	250	470	375	173	59	41	63	673
Baker	1,723	245	381	334	83	47	27	38	568
Tailor	1,890	259	513	335	86	76	20	32	569
Shoemaker	1,658	219	457	282	58	54	7	31	550
Printer	1,926	162	829	299	50	58	5	43	480
Earthenware Manufacturer	3,133	252	851	1,160	88	61	14	43	664
Wool Manufacturer	1,856	228	462	369	65	72	7	49	604
Mason	1,743	158	453	362	54	61	9	81	565
Plumber	2,162	300	442	333	86	68	22	131	780
Carpenter	1,475	160	367	239	65	54	7	68	515
File-maker	2,998	471	779	629	74	58	5	11	971
Blacksmith	1,750	171	388	367	56	63	14	88	603
Miner, Durham and Northumberland ...	1,570	158	243	219	59	61	7	353	470
All Males „ „ „ ...	1,723	205	320	279	65	74	23	176	581
Miner, Lancashire	1,671	149	225	412	32	58	5	356	434
All Males „	2,246	255	450	552	76	81	31	147	654
Miner, West Riding	1,388	108	200	309	38	56	2	290	385
All Males „	1,854	212	423	383	67	70	13	113	573
Miner, Derby and Nottinghamshire ...	1,320	115	212	248	31	61	7	293	353
All Males „ „ ...	1,522	178	299	266	74	59	16	118	512
Miner, Staffordshire	1,671	146	183	468	36	50	2	309	477
All Males „	1,811	210	313	406	77	70	16	135	584
Miner, South Wales and Monmouthshire	1,944	108	299	527	43	63	9	412	483
All Males „ „ „	1,809	174	363	376	67	70	13	221	525
Mean for Coal Miners	1,603	135	227	353	42	58	5	338	445
Miner, Ironstone Districts	1,500	92	254	371	25	25	14	371	348
Miner, Cornwall	3,308	210	1 241	824	72	101	4	210	646
All Males „	1,595	178	365	297	49	65	7	106	528
Quarrier	2,018	149	554	493	45	68	9	266	434
Hawker	3,379	372	854	755	85	119	34	95	1,065
All Males, England and Wales... ...	1,799	214	396	327	70	68	18	121	585

Appendix F.

Medical Report on Five Cases of "Silicosis" amongst Natives.

Band, Mchopie, who died on the 28th August, 1902, at the Compound of the Lancaster West Gold Mining Company, Limited, came, shortly after his arrival to the mine, to me complaining about a persistent cough. I treated him for some time with the usual remedies, but as I saw no improvement, had him transferred to the Compound Hospital, to have him under closer observation.

The physical signs of the lungs were almost normal, the breathing always vesicular, with very few Ronchi, and no dulness by sounding. There was constant dryness of skin, and accompanying the persistent cough, an ever increasing shortness of breath. The patient expectorated freely; sometimes the expectorated fluid was tinged with blood. Shortly before his death he coughed up a great deal of blood. Very often he was complaining of severe pain over the chest. After four months' treatment in hospital the patient expired.

Suspecting that this case was one of Silicosis, I made a *post-mortem* examination, which showed a very advanced state of this disease. Both lungs were very heavy and quite black, and there existed on both sides adhesions between lungs and walls.

By cutting the lung some black fluid exuded. The lungs were very hard and difficult to cut, only very little emphysematous lung-tissue being left. The mediastinal glands were enlarged and of the same consistence as the lungs. In the apices of both lungs were a few small cavities with caseous matter.

Pathological diagnosis: Anthracosis and Silicosis of both lungs. Tuberculosis apic. pulmonum. I kept part of one lung and preserved it.

Besides Band, there were four more boys in the Compound of the Lancaster West Gold Mining Company, Limited, suffering from Silicosis, viz. :—

Wasket, died 27-12-02; no *post-mortem* examination.

English, Shangaan, died 20-1-03, had been a long time under my observation. *Post-mortem* examination showed very advanced state of Silicosis, also cavities in apices. No Anthracosis. This boy was, before the war, machine-drill boy at the Modderfontein Gold Mining Company.

Knife was a long time in the Compound Hospital and went home after his time expired. He had been machine-drill boy at Nigel Deep.

Stick, under observation for 12 months and also went home. He was formerly machine-drill boy at one of the Central Witwatersrand Mines.

H. ROSENBERG, M.D.,
Medical Officer,
Lancaster West Gold Mining Company, Limited.

Krugersdorp, 14th April, 1903.

Appendix G. Accidents Due to Combustion within Air-Compressors.

Appendix G.

Notes on Accidents Due to Combustion Within Air-Compressors.

By Albert R. Ledoux, New York City.

(Albany Meeting, February, 1903.)

With the improvements in design and efficiency of machinery the element of danger in its use is becoming less, but it is a question whether the strain involved in operating modern plants is not increasing somewhat the danger of accident due to human fallibility.

I propose to describe a somewhat uncommon casualty resulting from a not infrequent incident in the use of air-compressors, and partly due to lack of judgment of the engineer and lack of care in operation. It is not necessary to state the location of the mine in which the accident occurred nor the makers of the compressor, and the object of this brief paper is more to draw out suggestions from members more familiar than am I with the practical handling of mining machinery than to point a moral.

The compressor in question was a three-drill machine of standard make. At the time of the accident it was furnishing air to a single drill working in an upraise from a well-ventilated tunnel, and giving ventilation to a winze below the tunnel where two men were hand-drilling. The compressor also furnished power to a small hoist in the winze, but the hoist was only operated occasionally, and never while the drills were working. The drills were located about 1,200 ft. from the compressor. The engineer testified that he never had been short of air, and that there had been no complaints that the machine was inefficient. The engineer testified, further, that the water used in cooling the air-cylinder had never become greatly heated, but that he used a mixture of good cylinder-oil and of a lighter grade known as "Atlantic Red." The valve of the compressor was set to blow off at 80 lbs. He was eating his luncheon in the boiler-room when he heard a "crack like a pistol," and, going into the engine-room, found water spurting out of the jacket about two feet from the end of the compressor; he tightened the jacket and stopped the leak, and found that the jacket was perfectly cool. He next noticed that "grease began to fry on the pipe and receiver."

He next saw that the air-pipe had become red-hot, the heat extending to a point where the pipe went through a wooden partition, setting fire to it. Then he noticed that the pressure was going down "just as quick as if someone had opened a valve outside," which, in fact, is what happened. He stopped the engine, but, getting the signal for more air, started up again. It is well to note at this point that the intake of the compressor was in the engine-room, the temperature of which usually stood at 115° F.

Let us now see what occurred in the mine. What happened at the bottom of the winze cannot be better told than in the testimony of one of the miners at the Coroner's inquest: "I was turning a hole and my partner was striking the drill; he says, 'We ain't got much air here this morning; I will ring for some more air.' He rang, started to strike again, and struck two or three blows; straightened up and took a couple of breaths of air, and started in to strike again, and then quit. I had been joshing him, and says, 'You ain't as tough as you used to be.' I stood up, picked up a pick,

struck two or three blows, and felt that the air was bad. Just then the air stopped, and the hoist-tender hollered to us that there was no air and we had better come up. I looked around and seen my partner standing in the corner. He was all trembling, and I caught him as he fell over."

These two men were gotten up by heroic work on the part of comrades, and their lives were saved. But not so fortunate were the men in the upraise. There were four of them here, and when they felt the air getting bad they opened the valve full,—of course, only increasing the difficulty. They were experienced miners, and at first could not understand what was the matter with them, because their candles continued to burn as usual. This was due, undoubtedly, to the fact that they were working in an upraise, and that the heavy carbonic-acid gas sank, and perhaps to the fact that carbonic oxide may have been generated through incomplete combustion or the reduction of the carbonic acid, first formed, by the glowing carbon in the pipe.

Two men were killed and four others barely escaped with their lives, as a result of the combustion of the oil, deposited carbon and organic dust accumulated in the compressor, receiver and pipe. Explosions of air-compressors due to this cause have been frequent, and lives have been lost thereby; and what is known as the "flaming" of compressors or cylinders is an every-day experience, and in some cases the rupture of the air-pipes, but, so far as I can ascertain, without the serious consequences described in the present case.

I shall leave to those better qualified than I the discussion of the best means of preventing such catastrophies. Among those which suggest themselves are the taking in of the air from a point where its temperature is as low as possible, the introduction of auxiliary coolers, the use of as heavy oil as possible,—yet never in excess,—the cleaning out of cylinders, receivers and pipes, and especially a warning to the engineer to be very sure, when he receives a signal for more air, that the actual shutting-down of the compressor may not be more essential. In this case, had he shut down it is probable that no lives would have been lost, for with the stopping of the air the miners would have at once returned to the tunnel level.