HISTORICAL REVIEW OF MINING CONDITIONS ON THE WITWATERSRAND AND THE CHANGES WHICH HAVE TAKEN PLACE SINCE THE EARLY DAYS OF THE FIELDS

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A review of mining conditions on the Witwatersrand from its inception to the present day is chiefly interesting on account of the rapid change which has taken place in these conditions and on account of the successive steps for the prevention of miners' phthisis which the change in conditions has necessitated.

At no time in the history of the Witwatersrand was the eventual development of the industry fully foreseen. As new problems arose, new methods were called for, and the dust prevention campaign led to sustained effort and continuous research.

In order, therefore, to present a complete picture of the changes which have taken place in mining conditions generally on the Witwatersrand, it is necessary to describe step by step the various phases through which the industry has passed.

Mining may be said to have started on the Witwatersrand in 1886, and the first stamp mill was started in the following year.

From this time up to the outbreak of the Anglo-Boer War in October 1899 it is estimated that an approximate total of 36 million tons was crushed, or a little more than is crushed per annum to-day.

The industry progressed slowly at first, and we find that the State Mining Engineer of the South African Republic in his report for the year 1898 records that there were employed only 9,854 whites and 73,354 natives in the mining industry; whilst the Government Mining Engineer of the Union of South Africa reported in 1928 that there were in the service of the mines of the Witwatersrand for that year 21,341 whites, 176 Asiatics and 194,362 natives

and other coloured persons. An analysis of the occupations of these employees would indicate that approximately 53 per cent. of the whites and 78 per cent. of the natives and other coloured persons were employed underground.

At first the workings were of course shallow, and in the oxidised or " free milling " zone, where the rock was relatively soft, friable and damp. The average depth to which this zone extended varied from place to place, but rarely exceeded 300 feet, and in some places was as little as 100 feet. From near the bottom of this zone the rock gradually became harder and more pyritic, until at vertical depths averaging in the neighbourhood of, say, 500 feet it had much the same characteristics as that which is being mined to-day.

By the year 1892 extensive deep-level companies had been formed, and drilling by machines had been introduced, principally at first for development work, and we find that the number of machine drills at work in 1896 was just over 1,000, increasing in 1899 to over 2,000 in number. These machines were of the rigged reciprocating type, and weighed up to 350 or even 400 lbs. each. They were operated mostly by miners from overseas with the assistance usually of two or three natives, but it was not until some years later that it became the practice for the natives themselves to operate the machines.

Though the " reef " had been intersected in deep boreholes, e.g. Rand Victoria Borehole in 1893, at a depth of 2,343 feet, and 1895 in the Bezuidenville Borehole at a depth of 3,127 feet, there had been very little thought for the ventilation of the mines as the depth and extent of workings increased, nor had the health of employees caused any anxiety in the minds of the managements or Government.

As long as the mines were working in the free milling zone very little dust was produced, and since the mines were shallow, and in consequence well ventilated, it is unlikely that the men came to any harm through dust.

We find that following the disturbances which gave rise to the Jameson Raid in 1895 the Government of the South African Republic appointed in April 1897 an Industrial Commission of Enquiry to look into the position of the mining industry. The records of that Enquiry can be searched in vain for any grievance as to conditions of health, or suggestion as to disability arising from the method of mining the banket.

It may be said that before the Boer War no one, or at least very few people, suspected that the mine dust was in any way injurious

to health. The few who did complain were mostly surveyors who had difficulty in taking some sights on account of the bad visibility caused by the dust, and they were laughed at and told that " everyone must eat a peck of dust before he died ".

The conditions in those days, however, if compared with present standards, would appear to be very bad. Much of the drilling, especially in development ends, was done dry; blasting was permitted at any time during the shift provided it did not interfere too seriously with work, and cases of gassing were frequent. Broken rock was shovelled in a dry condition, and, generally speaking, the mines were so dusty that workmen at the end of their shift looked like millers. The shifts were materially longer than at present, the average being in the neighbourhood of ten hours. Night shift for ordinary work was common practice and the interval between shifts was very short; indeed, on development work there was no interval at all in some cases, the common practice being for the miner to drill over the round, turn on the compressed air and blast the cut, returning in about half an hour to blast the round, having in the meantime sent word to his mate on the surface that it was time for him to come down. These men thus worked no regular shift, but relieved each other whenever they happened to finish a round.

The conditions under which they lived would also be described as bad in comparison with those of the present day. There were but few change-houses, and where these were provided the tendency was for the men to refuse to use them. Most of the men lived in single quarters provided by the mining companies, two, and sometimes three, in a room which, while perhaps adequate in size, would be said to-day to be insufficiently ventilated. In the earlier days these rooms were made of wood and iron, and the variations in temperature were considerable. As time went on, however, it became customary to line such rooms, first with matchboarding and afterwards with sun-dried brick and plaster.

In regard to social amenities, places of amusement, recreation facilities, etc., it could be said that these were non-existent, meagre, or confined to the towns, with the result that many of the men, and especially the single ones, tended to congregate in bars and to indulge in month-end orgies.

On the medical side, the conditions on the Witwatersrand have never been very bad, except perhaps in the earlier days and during outbreaks of what was commonly called in those days " camp fever ". Men were quick to realise the advantages of sick benefit

societies, and these were brought into being at a comparatively early date, and it can be said that, generally speaking, they were functioning with some success, especially on the larger mines, as far back as 1895-1896.

It is not until the Government Mining Engineer of the Transvaal Mines Department, in his report up to June 1902, introduces the subject of the health of workmen that any appreciation seems to have been given to the matter. In his report first mention is made of " miners' phthisis " as a disease " which seems to be peculiar to men employed in rock drill work ". It must be understood that up to this time the breaking of ground in stopes was almost entirely done by hand labour, i.e. by native labourers drilling single handed. Machine drilling was confined to development work. Careful enquiry at this time elicited the fact that out of the 1,177 rock drill men employed on the Rand prior to the Anglo-Boer War, 225 or 16.75 per cent. were known to have died from miners' phthisis. The actual number may have been greater. It is certain, however, that if it had not been for the break in the working of the industry due to that war the mortality rate would not have been so fully realised. In considering this rate, however, it must be borne in mind that most, if not all, of the men concerned had worked previously in overseas mines in Cornwall, Australia, and elsewhere, and may have laid the foundation for their disease in these mines.

In 1902 the Governor of the Transvaal appointed a Commission to enquire into and report upon the prevalence and causes of the disease known as " miners' phthisis " and to make recommendations as to the preventive and curative measures which should be adopted. One outstanding result of their enquiry, which was made known in 1903, was that:

> 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;

and the Commission recommended, amongst other things, that:

(1) The discharge of minute angular particles of dust in the mine air should be prevented;

(2) The working places should be supplied with air in sufficient quantities to render harmless and sweep away all vitiated atmosphere.

The fact that other than rock drill miners were affected by this disease gave a spurt to improvements in the ventilation of workings

and in the use of respirators for those actively engaged in rock breaking.

Early development work was done by hand drilling, and headings were consequently on the small side. Practically all the early shafts were inclines with three relatively small compartments; and the drives were about 6 feet by 4 feet. When rock drills were introduced these dimensions were increased somewhat, but as a general rule the headings still remained small, namely, about 6 feet 3 inches by 5 feet 6 inches.

It can be said that most of the mines turned out to be poorer in depth than was expected, and this, together with heavy capital expenditure and other causes, necessitated increases in capacity materially beyond what the mines were originally laid out to produce, and brought about a congestion in the matter of handling rock, men and material.

In the year 1903 it was realised that, owing to the increasing average depth of the mine workings, it was no longer possible to allow the European miners to come up for their midday meal, and the fact that these men must in consequence remain in the mine for the whole duration of their shift was an additional urge towards the improvement in the distribution of the ventilating current, hitherto only due to the difference in pressure of the atmospheric conditions. Steps were taken to improve this pressure by various means, such for example as building up one or more of the compartments of the up-cast shaft; erecting drill sharpeners' furnaces at the bottom of the up-cast, and to a small extent in carrying light pipes from the face of drives to an up-cast shaft or raise.

Arising from the congestion referred to above, it was common practice for persons, and especially natives, to walk up long distances to get out of the mines. This position was gradually improved by the sinking of new shafts and the installation of larger and more powerful hoists, and in 1917 the Mining Regulations laid it down that the manager should provide arrangements for hoisting all persons when the height exceeds 500 feet measured vertically. (See Regulation 158 (25).)

In addition to the purity of the air, and freedom from gases due to the quantity of explosives used, attention was now first paid to the quality of the lubricating oils used in compressing air for the machines, through the exhaust from which it had been proved that in some cases dangerous gases had been disseminated into the mine atmosphere. At the same time attention was called to the use of damp and weak detonators, as well as to both the

overcharging and the undercharging of holes with nitro-glycerine explosives which result in the production of noxious fumes. In this same year (1903) the Chamber of Mines, a body formed in 1889 to represent the joint activities of the mining industry, offered prizes for the best method of allaying dust caused by machine drilling. The first prize was won for a water-spray or atomiser, and the second for a patented water-fed drill.

About this time improvements in machine drills designed to increase the speed of drilling began to make their appearance. The heavy old-fashioned type of reciprocating machines were gradually replaced by lighter and faster drilling ones, and a few machines of the Leyner hammer-drill type were introduced. These last-mentioned machines, however, employed hollow drill steel through which compressed air was blown in order to keep the drill bit free from chips, and they were thus, as dust producers, much worse than any of the machines which had hitherto been used. Indeed, they produced so much dust that it was usually impossible in development ends clearly to discern the operators. Dry air blowing machines of this type, however, did not remain in vogue for more than a few years.

It is at this stage that the industry was first confronted with the extreme conservatism of the operatives in the use of any dust-preventing devices. They objected to sprays designed to prevent the escape of dust formed in drilling and operated from the exhaust of the machine, on the ground that it made them too cold. They objected to sprays and the use of water generally, on the ground that it gave them rheumatism, and so on, and that they would just as soon die of miners' phthisis as of those other diseases which wet working places might cause; and they objected generally to any of the precautions which by occupying time tended to decrease their earnings. The Government, and indeed the industry itself, were forced therefore to recognise that outside the improvements in devices for dust allaying there would appear to be need for special legislation to enforce the use of any recognised means for the prevention of silicosis.

Act No. 54 of 1903, and the Mines and Works Regulations promulgated thereunder, is the first step of a long series of legislative measures to control the conduct of mines in the direction of the use of the best form of preventive measures, which continuous research in the cause and prevention of miners' phthisis showed to be desirable.

Starting with Chapter VI of the 1903 Regulations, containing

four regulations on ventilation, and one reference, Chapter IX, Regulation 97 (8), that the ganger shall be responsible that no person enters the working place " until the fumes caused by the explosives shall have been sufficiently dissipated ", we have to-day Regulations in great number designed to control the ventilation; chemical analysis of air; limitation of blasting operations; exposure of persons to dust and fumes after blasting; the replacement of vitiated air by a certain volume of fresh air after blasting; the conditions for working in back stopes; the entry into working places; the use of water under adequate pressure in all working places; the use of water when tipping and handling broken ore; the use of water in drilling any hole; the clearing or blowing out of any hole after drilling; the use of tamping material in charging, and the quality of the lighting torch; the interval between blasting shift and return to work in the mine; the control of water blasts and auxiliary ventilation in development ends after blasting; etc. To ensure the proper observance of these precautions, responsibility is laid upon miners and officials of all grades from manager downwards. In a Code of Regulations, which twenty-five years ago could be comprised in a volume of 52 pages, we find now detailed Regulations for the health and safety of the mines comprising a volume of over 200 pages, of the same size, under Act No. 12 of 1911 and many subsequent revisions of the same under Government Notices.

It will be interesting to return to the history of the investigation into the disease of miners' phthisis, now bearing in mind that every relevant factor in prevention has in one way or another found its corollary in legislative injunction.

In 1907 the Government of the Transvaal appointed a Commission known as the " Mining Regulations Commission " to report on the working of the Mines, Works and Machinery Regulations, with special reference to (amongst other things) ventilation and the better protection of the health and safety of persons working in mines.

This Commission extended its enquiry over the years 1907-1910, and laid the foundation for the scientific investigation into the disease of miners' phthisis. We gathered that all true cases of miners' phthisis are primarily cases of silicosis, and that finally a tuberculous infection commonly becomes superimposed upon this condition and the symptoms and course of the disease alter accordingly. The suggestion arose also as to whether the exposure to noxious fumes might be a predisposing cause of miners' phthisis, and we were told that medical opinion was against exposure

to such fumes and that preventive measures should follow the lines of:

(1) The prevention of dust inhalation;
(2) The prevention or removal of noxious fumes resulting from explosives;
(3) The prevention of silicosis.

By amendments to the 1903 Regulations the responsibility of the manager had already been extended to the compulsory use of water with machine drills, and to the prohibition of the removal of dry and dusty rock unless it had been wetted so as to prevent the escape of dust into the air. It was now for the first time recommended that responsibility should be placed on the manager for supplying the necessary water and on the miner for its use; and that inspectors of the Mines Department were to be instructed to pay special attention to its use (24 December 1908). On the adoption of these recommendations, the supply of water had to be made continuous, and all places where development work was carried out and every dry and dusty stope (when the natural strata are not wet) had to be kept damp. Blasting had to be so arranged that men working in other places were exposed as little as practicable to dust and smoke. The use of water by the miner was tightened up, and in drilling holes with any percussion machines he was enjoined to use a water jet or spray, and he was not allowed to enter a working place after blasting until the fumes had been sufficiently dissipated, unless he was wearing an effective respirator or other apparatus to prevent the inhaling of fumes or dust.

The next step was to enact that the miner should keep the floor and sides of his working place within a distance of 10 feet sufficiently damp to prevent dust being raised by the exhaust from his machine. Further, that rock to be shovelled should not only be superficially damp but should be kept damp in the process of shovelling. To ensure that these precautions were being carried out, and to combat the seeming indifference of rock drillers, it was laid down that a shift boss should report to the manager daily whether the requirements of these Regulations were being observed or not.

At about this same period (1908) attention was directed to contrivances for the catching of dust caused by the drilling of holes. Some of these had been used in Western Australia and in Cornwall, as substitutes for water jets and sprays which in the drilling of steeply inclined holes caused discomfort to the workmen, added humidity to the atmosphere, and were thought to tend

towards the production of ankylostomiasis and other diseases. These devices took the form of flexible collars fitting tightly against the rock, and through which the drill steel operated. In some cases the dust was caught in a bag, and in other cases it was sucked away by an air jet ejector and led into some form of dust trap. None of these devices, however, were successfully adopted.

In most mines in those days, and especially in those mines where the capacity of the reduction plant had been increased, there was an inadequate number of working places from which to obtain the necessary amount of ore. This shortage of working faces necessitated a heavy development programme, and a double shift method of working with blasting at least twice every twenty-four hours.

At about this same time and with a view to reducing the danger arising from the dust and fume caused by blasting, experiments were made with various methods of projecting into the air at the time of blasting in development ends a volume of finely divided water, and these experiments led ultimately to the general adoption of an apparatus known as a water-blast, which has now by regulation to be used at blasting time in all development ends and again before persons are permitted to re-enter.

When, as a result of the increased amount of development work, the number of working places became adequate, the custom of miners returning to their working places too soon after the blast was abandoned and single shift blasting introduced.

The consideration given to the incidence of tuberculosis by the Commission of 1907-1910 revealed the prevalence of this disease in particular amongst the native workers, and gave rise to the promulgation of preventive measures already known to be effective in combating this disease elsewhere than in mining. It initiated the examination of natives prior to engagement for mine work, and contemplated the possibility of having to take similar steps in the case of white workers. In both cases it was urged that infected workers should be excluded from the mines as soon as the disease had been diagnosed.

The sanitary arrangements underground were very bad in the early days. Indeed, it could be said that they were bad up to less than twenty years ago. At first no sanitary conveniences of any description were provided, and persons wishing to relieve themselves had no option but to walk out of the mine or to go into some disused workings. Afterwards it became customary for persons to use the rock boxes, so that the faeces would be hoisted with the ore. Later on, after the necessary provision of an adequate

number of latrines had been made, it was very difficult to break the natives of their bad habits and to educate them to use the latrines.

It was not until well after the Boer War that the mines began to provide drinking water underground. Prior to this the men made their own arrangements and either took water down with them or drank from one or other of the numerous water-bearing fissures.

Attention was now first drawn to the need for cleansing shaft stations and such waiting places as workmen were in the habit of using in the mines, whilst the housing conditions of both black and white were thoroughly reviewed. Change-houses for the white miners were made compulsory. Medical inspectors for the mines were recommended, and in the Johannesburg District this duty was taken over by the Medical Officer of Health of that town, and has been carried out very thoroughly ever since.

Another important consideration of the Commission was the duration of the working hours of mine employees. The chief ground for the reduction of working hours claimed by employees was that of health. The Commission found that there was no reason why work underground should be more unhealthy than work on the surface. In practice, however, this was found difficult to ensure. On the other hand, it was found that miners were not being employed more than eight hours a day at their work, the rest of the time being occupied in taking their meals, in getting to and from their working places, and in other ways. Recommendations were, however, drafted and later brought into force in Act No. 12 of 1911, limiting the hours of work to forty-eight hours per week, and the hours of certain employees to not more than ten per diem. The erection of underground drill sharpening shops was prohibited except under conditions controlled by the Mines Department.

This Commission, in investigating the quantity standard of air to be supplied in accordance with the 1903 Regulations, found that without detailed Regulations it was difficult to enforce. It turned its attention also to the quality of the air. It laid down a legal maximum for certain noxious gases, e.g. CO_2, CO, and nitrous oxides. It pointed out that suitable mechanical appliances should be erected and operated to direct the ventilating currents when natural ventilation failed to operate; that old workings should be closed off, and plans should be kept to show the necessary stoppings and methods of control. In development work where machines were operated suitable arrangements were to be furnished for removing the dust, smoke and gases after a blast, and no man should return until the air was clear of such.

Undoubtedly a great deal of valuable ground was covered by this Commission, and the book of Regulations which, as above referred to, had been contained in 52 pages, was extended to 136 pages of the same size. The responsibility of the mine managers was extended to include the supply of clean water and suitable waiting places for native workmen and causing them to wait there, and powers were given them to take such disciplinary steps to enforce the requirements of the Regulations as the Inspector of Mines might direct or approve.

During the period covered by the 1907 Commission the mining industry had passed from the control of the responsible Government of the Transvaal to that of the Union Government of South Africa. A greater change was, however, taking place in the personnel of the operatives. In the early days of the industry the skilled white miner was almost entirely recruited from overseas, either from Europe, and principally from England, or from Australia. Owing to the incidence of the disease of miners' phthisis amongst these men, and to other causes, the mining field was ceasing to be attractive, and during the industrial trouble which arose in the industry in 1907 a large number of South African nationals were for the first time engaged by the mines and drafted into the occupation of mining, very largely as supervisors of the native gangs, and primarily, of course, in the less skilled operations of tramming, shovelling and other underground work. The South African national naturally lacked the mining knowledge of the overseas miner who had been brought up to mining since his childhood, and hence at first a great deal of care and training was necessary. In the course of time, however, the South African national began to get educated in this work, and at present over 60 per cent. of the employees of the mines are South African born, whilst a much larger percentage of those working underground are of that class.

The Union Government in February 1912 appointed a Miners' Phthisis Prevention Committee " to enquire into, by experimental and other investigation, and to report from time to time upon the improvement of, the methods for the prevention of miners' phthisis in the Witwatersrand gold mines, and to advise upon the introduction of a systematic and uniform policy and the amendments to the Mining Regulations which may be necessary for combating the disease ". This Committee reported in March 1916 on its work up to the end of 1915, and finally in January 1919 on its conclusions. There were throughout this period preliminary

and special reports, as well as many memoranda submitted to the Government. Parallel with the growth of knowledge came legislative steps to enforce prevention, all the more necessary because of the change in the personnel of the miners and of the ignorance of the subject amongst them, now allied to the natural conservatism of the individual.

The material knowledge of the disease gained by this Committee was very great, but it may be said that in its conclusions it endorsed the already known fact that avoidance of the inhalation of air charged with injurious dust was the most important line of action towards the elimination of the disease amongst the operatives. With this fact in view, it was recommended that single shift blasting should be introduced; and the legal and moral responsibility of all mine employees was stressed as to the proper use of water for dust allaying purposes.

The Committee gained accurate knowledge of the incidence of the disease by medical examination of miners and a careful analysis of the silicotic condition of such men. Examination of the lungs of deceased miners gave rise to a knowledge of the size of the dangerous dust particles, and this led to the introduction of apparatus for the measurement of dust in the mine atmosphere.

At the same time it was first mooted that a careful selection of the recruits amongst the white miners would be an important preventive measure. It was also first suggested that main travelling shafts should be downcast and men should be kept out of upcast shafts after blasting " until the air is free from dust and fumes ". The Regulations drafted to carry out the preliminary recommendations of this Committee were coded in an issue of the Mining Regulations of 1913. Briefly, the use of water for dust allaying purposes was extended and its use detailed. For example, the area round a working place to 25 feet instead of 10 feet had now to be kept wet. No one should enter, or permit anyone to enter, a close place after blasting within thirty minutes, and then only if the air was free from dust, smoke and fumes perceptible by sight, smell or other senses. The manager was called upon to arrange the time for blasting operations so that workmen should be exposed " as little as practicable " to the fumes and dust from blasting. The manager should supply a constant supply of " clean and odourless " water in pipes of not less than a certain size and not less than a certain pressure, such pipes to be carried to not less than a certain distance from the face. Water blasts were to be installed in every development end. No person should be allowed to remain in the

mine if the air contained dust, smoke or fumes perceptible by sight, smell or other senses. The cross ventilation of miners' back-to-back quarters was provided for. Miners must acquaint their native workmen of the requirements of the dust-preventing Regulations. The manager shall keep all main travelling ways wet as far as practicable; shall cut off from the ventilating currents old stopes; shall place ring sprays in downcast shafts not naturally wet. After 1 January 1915 no one shall be permitted to blast the cut and round separately in the same shift in the same development end. Finally, provision should be made for recording the measurement of dust in the mine air as periodically determined. The use of a water jet with a percussion machine should be coupled with " or the use of a drill with axial water feed ". The collaring of holes with machines should have a special volume of water used in the process of collaring. The tube used for drilling holes should be inserted in the hole so that the water might be brought to the cutting edge of the drill. After a certain date only an axial water feed machine should be used for raising. The Inspector of Mines should fix an interval of time for each mine between the time of blasting and the next on-coming shift of workmen. An official should be appointed to each mine to report upon the water service, ventilation and prevention of dust.

It is useful to record the improvement over this long period of the conditions in the mines in the direction of dust prevention as reflected in the opinion of Mr. J. E. Vaughan, who had been away from the Rand as Inspector of Mines in Natal for some years and returned to note the marked improvement, and reported to the Government Mining Engineer under date May 1918 (*vide* Appendix No. 8, page 97, *Final Report of the Miners' Phthisis Prevention Committee*, Johannesburg, 10 January 1919). Improvement was noticeable in the attitude of the operatives to the many increased Regulations and the observance of them. There were improvements also in the water supply, dust sampling, and general cleanliness of the mines and working places. Water was everywhere being used; the air of the mines was free from visible dust; no dust was noticeable in the nostrils of the operatives. Improvements could still be made in the direction of the ventilating currents.

During this period there had been a further revision of the Mining Regulations. In 1913 the book was enlarged from 136 pages to 177, and in 1917 by a further addition up to 194 pages. There were of course additions for safety purposes other than those for the prevention of miners' phthisis.

The principal alteration in connection with Chapter VI on ventilation was that the amount of fresh air to be supplied for every person employed underground should be not less than 30 cubic feet of air per minute during the full period of twenty-four hours. The current should be suitably split and each ventilating district should receive its standard. Determinations of the quantity actually circulating should periodically be made. The replacement of air after blasting in dead ends was regulated and no working in back stopes was allowed without conditions imposed by the Mines Department. Provision was made for the duties of the ganger (Chapter IX) to wash over the face and immediate vicinity with water under adequate pressure before work was commenced. He was not allowed to use a percussion machine other than an axial water-fed machine without an additional water hose, nor a hand drill without a wet swab. Nor could he blow out a hole with compressed air unless he had first applied sufficient water to prevent the formation of dust. No person should allow water to run to waste. He shall report any cases of gassing, however slight.

It must not be supposed that all this time progress in the combating of the disease of miners' phthisis was confined only to such bodies of men as were working on the Government Miners' Phthisis Prevention Committee. The Chamber of Mines in 1914 appointed a Standing Committee on Dust Sampling. This Committee undertook the standardisation of methods for the determination of dust in the mines. It carried out periodic dust surveys of all the mines and created a laboratory for accurately determining the samples. At the same time it embarked upon a considerable field of research work, as well as being available for testing any dust preventive devices submitted to it or to the industry. Some of this work is carried on to-day by this Committee, and some has devolved upon the dust inspectors appointed on each mine according to the Mining Regulations. A ventilation expert attached to the Committee lectures to these mine dust inspectors, and the standard of knowledge is improving.

When water was first used for dust prevention and allaying, little or no effort was made to ensure its suitability for that purpose, and the nearest water available was used irrespective of whether it was clean or otherwise. As time went on it came to be recognised that dirty water when atomised might actually put dust into the mine air rather than allay it. The practice for some years past has been to use only clean water free as far as possible from fine silica particles, and approved by the Committee.

Through the chemical analysis of mine waters; of different kinds of mine rock; through the analysis of the dust produced by different kinds of machines; the analysis of air samples and the constant improvement of sampling methods, whether by sugar tube or konimetry, this Committee has a fine record of close and conscientious observance of the dust conditions of the mines. It is dealing to-day with dust particles both in quantity and magnitude of such small dimensions that the dust in the atmosphere of the mine can be compared to a possibly noxious gas which must be swept away and replaced by fresh air, rather than that any further means of allaying it could be attempted with success.

The Chamber of Mines also in December 1915 introduced on its own initiative a scheme for annual holiday leave, where under all mine employees, subject of course to certain conditions, receive an annual holiday on full pay (not exceeding 22s. per day). Under this scheme underground employees receive fourteen consecutive days' leave (of which the twelve weekdays are on pay) after one year of continuous employment; twenty-one days' leave after two years of such employment, and twenty-eight days' leave after three years, and there can be no doubt that this welcome break is of considerable value in preserving the health of mine employees.

The managers of the mines, several of whom had contracted the initial form of the disease of miners' phthisis, i.e. silicosis, were as a body very active in their insistence upon the best-known methods of dust prevention being strictly enforced. The method of single blasting has already been referred to, and was undoubtedly a most important factor introduced on the initiative of the managers themselves. Another important innovation was their recommendation in July 1915 (*vide Time and Labour Saving*, Association of Mine Managers, 1916) that a Central Bureau for the systematic examination of the physical fitness of men engaged in underground work should be established. This suggestion was adopted in 1916 by the Union Government, who in 1912 had framed legislation for the compensation of persons suffering from miners' phthisis. The trend of the Union Government's legislation in the matter of compensation for miners' phthisis does not come within the scope of this historical review of mining conditions on the Witwatersrand, and is therefore being dealt with under another heading. It must, however, be remarked that there is but little doubt that, following the increases in the amount of compensation awarded under the

Miners' Phthisis Acts, a number of persons, not realising the seriousness of silicosis and its tendency to progress into miners' phthisis, carelessly or deliberately and to the danger of others exposed themselves to dust and fume with a view to obtaining compensation. This particular phase lasted for some time, but it is not suggested that anything of the kind has been done in more recent years.

Following the efforts of the Miners' Phthisis Prevention Committee (1912-1918) previously referred to, the Mines Department instituted a systematic survey of the mines to ascertain in what way the provisions of the Regulations were being observed. This was found to be helpful to individual managers, and attention was particularly directed to ventilation, water blasts, night shift work, machine drills, shaft sinking and organisation, which still left room for improvement. In the matter of machine drills the Leyner type and axial water feed machines were rapidly replacing the reciprocating type of machine, and it was noticed that whilst the speed of drilling operations was increased by the application of water through the hollow-drill steel to the cutting edge, large quantities of dust were created by these machines through the passage of air down the hollow steel and the blowing up of small bubbles of air containing dust through the sludge discharged in drilling. These bubbles burst and, though containing exceedingly fine particles of dust, created a dangerous atmosphere for the operatives. It was found that, even in shaft sinking, where the shaft bottom was covered with water, the atmosphere at the shaft bottom contained dangerous quantities of dust when this type of machine was in use.

A long investigation commenced into the use of the Leyner type of machine and into the nature of the dust produced by it. It was found that by the use of a long piston the excess air could be prevented from passing down the drill to the cutting edge, and legislation was introduced to prohibit the use of any other than this type of machine, at first only in development work, and subsequently in all kinds of work, unless the machine was fitted with a front head release ring for the escape of air.

It followed from this investigation that the Government Mining Engineer should have power to prevent the introduction of any type of machine which might be dangerous to the operatives in its dust-creating properties, and also that for similar reasons he should have power to prohibit after due notice any type of machine already in use. Such powers were accordingly taken by the Government Mining Engineer under the Mining Regulations in 1922.

At this stage it will be of interest to point out that the heavy reciprocating drills of the early days drilled holes averaging from 6 to 7 feet in length with a diameter of about 2½ inches at the collar and about 1⅜ inches at the bottom. These machines in stoping rarely drilled more than four or five such holes during a shift.

The present-day hand-held jackhammers drill holes averaging from 3 to 4 feet in depth with a commencing diameter of about 1¼ inches and a bottom diameter of about 1 inch, and it is a common thing for these machines to drill as much as 120 feet in a shift; the average for the whole Rand being in the neighbourhood of 75 feet per machine shift.

Another point which may have some bearing on miners' phthisis is that prior to the outbreak of the Great War in 1914 the mines used blasting gelatine almost exclusively for development work, and 60 per cent. gelignite for stoping, the average strength of the explosives used being in the neighbourhood of the equivalent of 81 per cent. nitro-glycerine, whereas to-day the average strength used is in the neighbourhood of 55 per cent. nitro-glycerine. Another way of illustrating this change would be to say that prior to 1915, 0.83 lb. nitro-glycerine was used to break a ton, whereas the average consumed now is in the neighbourhood of 0.58 lb. nitro-glycerine per ton broken.

The so-called " contract " system has been a feature of mining on the Witwatersrand since the early days of the fields. It has been alleged that this system, which is in reality a method for paying European miners at piece-work rates, was to some extent responsible for the causation of miners' phthisis, in that men were induced under it to neglect precautions for the prevention of dust for the sake of additional gain. This matter of underground contracts was enquired into by a Government Departmental Committee in 1917, and this Committee found that the " contract system is not necessarily deleterious as regards the health or safety of those concerned, or morally unsound and against the public interest ". (Conclusion No. 2.) (See paragraphs 32 and 33 of the report of the Committee.)

A further Miners' Phthisis Commission was appointed in 1920, primarily to deal with legislation for compensation. It went also fairly thoroughly into the preventive measures in use at the time. We find in this Commission's interim report the first reference to the suggestion that " the use of water for dust allaying is nearing the limit of its effectiveness and that therefore additional

methods, amongst which ventilation ranks foremost, will have to be relied upon for further progress in this direction". This knowledge was given to the Commission by the work of a Joint Committee of members of the Mines Department and the Chamber of Mines Dust Sampling Committee, who in particular investigated the efficiency of water blasts in development ends and the amount of air required after the blast to clear the end of dangerous dust particles (Reports 13/10/1922). This arrangement for attacking problems in ventilation was found to be useful, and was extended during the year 1923 to testing the best method of ventilating a close end when work was being carried on, especially drilling by machines. The quality of the intake air was thoroughly investigated and much knowledge obtained as to the direction in which improvements in the health conditions of the operatives could be made.

In improving the Leyner type of machine and reducing its dust-producing properties when air was allowed to pass down the hollow-drill steel, it was noted that the size of hole in the drill steel and the pressure of water were important factors in dust control. Whilst the long piston type was compulsory for use in close ends, the Government Mining Engineer intimated to the industry in April 1925 that he thought the time had arrived for prohibiting all machine drills passing air down the hollow jumper and that only machine drills approved by him should be permissible in all classes of work. He agreed to tests being made as to the relative importance of the many variables in the matter, but hinted that the adoption of a front head release to all machines immediately would appear to be justified, and arrangements to carry out this were made law as from 23 October 1926.

The tests conducted extended over a period of about two years, and were made in a test chamber at the Consolidated Main Reef mine, under the control of an Investigating Committee composed of members of the Central Mining and Investment Corporation's engineering staff and the Chamber of Mines Dust Sampling Committee. A report issued in July 1927 demonstrated that with release ports, maximum bore water tube and an extra hose for collaring, the dust produced by rock drills would be reduced to such a small amount as to render it a very minor factor in the production of silicosis.

This conclusion is of importance when it is considered that from 1923 onwards the number of jackhammer machines introduced into the mines increased, until to-day in many mines all ground is

broken by machine drills of this type. The care of the water tube is an important factor and has been very largely brought under control by the increase in length of the front head bushing and shank of the machine drill by which, primarily, better alignment of the drill steel is obtained.

Under the provisions of the Miners' Phthisis Acts Consolidation Act, No. 35 of 1925, a permanent Committee was appointed to watch the methods of preventing miners' phthisis already in force and to investigate any new ideas. Representation on the Committee is given to all bodies of workers, and it is hoped that the improvements in the future may come from such a body. For the present the Committee is chiefly concerned in the standardisation of methods of measurement of the dust contents of the air by the method of konimetry. It has also conducted certain investigation into the quantity of dust present in the intake air of the mines and the increase in dust contents of this air in its passage through the mine.

Difficulties in the maintenance of proper water tubes in machines have caused the Government Mining Engineer to give notice to the industry in June 1928 that the development of external water feed devices should be advanced as rapidly as possible and that the use of internal water tubes would be prohibited after some future and possibly early date.

The most recent difficulty is to combat the incidence of tuberculosis, and a Tuberculosis Research Committee is now sitting. It has promulgated the opinion that " the excessive use of water underground may do more harm than good in the efforts towards the prevention of this disease, and that it certainly is liable to produce deleterious effects on health in other directions, especially in the production of tuberculosis, a disease intimately associated with silicosis ".

To sum up, it may be said that the steps taken to combat miners' phthisis on the Witwatersrand have been as follows:

1. The prohibition of promiscuous blasting during the shift.
2. The prohibition of blasting the cut and round separately on the same shift in the same development end.
3. The limitation of blasting (except in a few special circumstances) to one period only in each day, and the provision of a period of several hours (from three to seven depending on circumstances) after each blast during which persons are not allowed in working places, and the dust and fumes caused by blasting can be swept away.
4. The provision of waiting places which can be kept free from dust and fumes, so that at the end of the shift all workers can be hoisted without coming into contact with such dust and fumes.

5. The provision of improved water feed drills designed to prevent the formation of dust in drilling.
6. Improved ventilation and better distribution of the air available so as to first dilute and then remove the vitiated atmosphere.
7. The use of water in all cases for the prevention of the formation of dust, and for the allaying of such dust as may be formed in the various operations.

There is also another feature which must have had a most important effect on the mines of the Witwatersrand, namely, the establishment of the Miners' Phthisis Medical Bureau for the initial examination of all persons who wish to commence mining, and for the periodical examination of those who are engaged in that pursuit. This matter, however, falls under another heading and will not be dealt with in this historical review.

In regard to 7 above, namely, the use of water, it may be said that one of the outstanding features of the preventive measures which have been adopted on the Witwatersrand is the extent to which the use of water has been carried. Only a comparatively short time ago the mines were most prodigal in the use of water, which, without being exactly wasted, was "slopped about" everywhere, and no effort made to prevent the mine air becoming saturated, or nearly so, with water. Recently, however, and especially in the hotter and deeper mines, it has been borne in upon those responsible for their management that water in excess of that which served a useful purpose was being used, and that some of the ventilation and other problems connected with deep level mining were thereby being accentuated, and efforts were commenced to reduce excessive and unnecessary use of water. Great care will be necessary in introducing any changes; for having educated all operatives in the use of water; having provided the water at suitable pressure in every working place; and having encouraged its use by many contrivances, it will not be an easy problem to limit its use without endangering the effectiveness of the present organisation. The operatives do, however, require relief from the lack of cooling power in the ventilation currents of air in mines working at great depths. Any reduction in the saturation of the air will be beneficial in this direction. New legislation is being considered to impose a katathermometer standard on the management, and methods of mining are already being adopted which will facilitate the sweep of air up the working place, and if such a practice can be made general it is possible that the excessive use of water can be limited without re-creating the dust evil. A review of the history of the incidence of miners' phthisis

cannot close with a claim that it has been overcome. That the dangers are much lessened is readily acknowledged, but much yet remains to be added to the sum of human knowledge, and perhaps not least is the desire to find immunity from this disease for the operatives, white and black, of the Witwatersrand mines.

This historical review in the changes which have taken place in the mining conditions on the Witwatersrand would not be complete without some further reference to the changes which have taken place in the methods of working *vis-à-vis* their possible bearing on the matter of miners' phthisis. The more important of these changes may be summarised as follows:

1. The introduction of heavy rigged reciprocating machines operated by Europeans to replace native hand drillers in the wider and harder stopes.
2. The change-over to similar machines of a lighter type operated by natives under the close supervision of Europeans.
3. The change-over to machines of the hammer drill or Leyner type, including the change-over to air-fed hand-rotated hammer drills. Some of these machines used air only through the drill steel; others air and water, and some, especially the last mentioned, solid steel.
4. The elimination of machines which used air only through the drill steel and the substitution of machines using air and water or water only, with the simultaneous introduction of hand-held hammer drills.
5. The elimination of all forms of reciprocating drills and drills using solid steel, and the more general adoption of hand-held drills of the jackhammer type.
6. The introduction and general adoption of the cradle as well as hand-held machines designed to minimise the amount of air passing down the drill steel and to use as far as practicable water only.

Simultaneously with the changes enumerated above there has been a change over from hand drilling to machine drilling. This change is illustrated in the following tabulation:

Period: six months ending	Fathoms broken in straight stoping:	
	by hand	by machines
31 December 1914	52 per cent.	48 per cent.
31 December 1924	22 ,, ,,	78 ,, ,,
31 December 1926	12 ,, ,,	88 ,, ,,
31 December 1928	7 ,, ,,	93 ,, ,,

There have, of course, been a large number of other important changes of far-reaching effect, other than the ones referred to herein, but with the exception of the fact that the mines have become more extensive, deeper and consequently hotter, these other changes can have but little, if any, bearing on the miners' phthisis position.

Conclusion

The dust and ventilation problems on the Witwatersrand to-day can be said to be totally different from those prevailing at the beginning of this century. The systematic efforts which have been made since 1911 have resulted in the disappearance, for all practical purposes, of visible dust underground. Similarly, it can be claimed that, owing to improved organisation and mechanical ventilation, exposure to fumes or gases rarely occurs on these fields. Yet the main problem is far from being solved. The greatest obstacle to improvements at the present day lies in the fact that the workings are so far flung and so extensive as to make the cost of adequate ventilation for sweeping out the remaining invisible dust prohibitive on most mines.

The natural limitations consisting of the great depth of workings, narrow reef and large blocks of unpayable ground (particularly on the Far East Rand) in turn prevent any radical changes in mine layout.

It must, therefore, be realised that further improvements can only be gradually introduced. The definitive progress shown in the past, however, gives rise to the hope that such improvements will be effected and that thereby the incidence of miners' phthisis will be further reduced.