

MEASURES FOR PREVENTING THE FORMATION OF DUST, AND PRECAUTIONS DESIGNED TO PREVENT PERSONS INHALING SUCH DUST AS MAY BE FORMED, AND THE REGULATIONS RELATING THERETO¹

BY MALCOLM FERGUSSON, CHIEF INSPECTOR OF MINES, UNION OF SOUTH
AFRICA, AND WALTER SCOTT, ASSISTANT CONSULTING ENGINEER,
CENTRAL MINING-RAND MINES GROUP OF MINES

MINERS' PHTHISIS COMMISSION'S FINDING

Little, if anything, had been done in the way of taking precautions to prevent persons from inhaling dust before the sitting of the Miners' Phthisis Commission in 1902-1903.

The finding of the Commission was that miners' phthisis was contracted as the result of miners inhaling dust-laden air, and the disease was to be found chiefly among rock-drillers in development ends, especially when employed on raising.

SOURCES OF DUST PRODUCTION

The chief sources of the dust inhaled by developers were as follows:

(a) *The drilling of dry holes* in raises and drive ends. In the former all the holes were drilled dry, in the latter the two top holes were drilled dry as well as the bottom cut holes. Holes inclined downwards had water poured into them by hand sufficient to prevent the drill from sticking. Samples of air taken close to the rock drill machine whilst boring a dry hole showed that there were 0.185 and 0.0839 grains per cubic foot of air respectively, and an

¹ The following notes will serve to give the reader a working knowledge of the steps which have been taken on the Witwatersrand on the subject matter of these notes. They will be found in some respects to overlap certain portions of the Historical Review of Mining Conditions on the Witwatersrand, p. 107, but this is clearly unavoidable.

analysis of air taken in a raise in similar circumstances gave as a result 0.072 grains per cubic foot.

(b) *The method of blasting* in development ends considered, at that time, to be necessary for obtaining good results.

It was the practice of the miner to charge up the cut holes completely, and the remaining holes partially, then to blast the cut and return to the end after a very short interval; he then completed charging up the remaining holes, i.e. put in the primer cartridges and tamped the charge, and blasted the round. Miners were even known to return after blasting the round to see how it had broken.

PRECAUTIONS

Among the first precautions taken to prevent the dust formed in drilling and blasting from being inhaled by the miner, was the use of inhalers and respirators.

Dr. Aymard's inhaler was a close-fitting mask placed over the nose and mouth of the rock-drill operator. This mask was connected to the air-cock operating the machine, whereby compressed air was supplied to the miner by means of a light flexible metallic tube about 6 inches long. It was not necessary for the mask to fit perfectly as the constant pressure of air prevented the ingress of dust. The objection raised to this form of inhaler was: first, the range of the wearer's movements was limited to the length of the flexible tubing; second, air from the compressors, at that time, occasionally contained dangerous quantities of CO and CO₂ due to having unsuitable lubricating oil in the compressors.

There were various makes of *respirators* used by the miners. The essential points which a respirator has to fulfil to be considered satisfactory were as follows:

- (a) It must fit closely to the face so that the whole of the inspired air would pass through the filtering material and not short-circuit between the face and the side of the mask.
- (b) The filtering material must be capable of arresting all the minute angular particles of dust in the air, but should not impede respiration.
- (c) The mask must be fitted with an outlet valve through which the expired air can escape freely.

From the original trials made with respirators, they were considered to have sufficient merit to permit the miner to return to the end of a drive shortly after blasting the cut to complete blasting the round, provided he wore a respirator. This was embodied in an addition to Regulation No. 146 of the Mines and Works Regulations gazetted on 29 December 1905, viz.:

- (6) After blasting in any end, raise or other place, no person shall return to that place until after the lapse of at least half-an-hour unless the air in such place has been cleared of the dust and smoke arising from such blasting, by efficient ventilation or other special means, or unless an efficient respirator or other apparatus is used to prevent the inhaling of such dust or smoke.

Also Government Notice No. 1278 of 1908, 146 (11), permitted a miner to enter a development end containing dust and fumes provided he wore a respirator. This practice was permissible until 30 October 1913.

The use of the respirator seemed a simple and effective solution of the whole matter, but it proved impracticable. The miners as a whole were averse to the use of respirators chiefly, perhaps, on account of the discomfort attending their use, e.g. extra effort required to inhale through the filtering material when working hard, and interference with speech and smoking. The valve was usually made of mica and got out of order very easily, so that the miner invariably replaced it by a piece of sponge. This was objectionable as it did not permit of the free escape of the CO₂ and moisture exhaled.

It was eventually ascertained that the filtering material did not arrest the very fine dust particles in size 10 microns and under, which were the most harmful, and the use of respirators was rapidly abandoned.

It is interesting to note here that in 1902 the Transvaal Chamber of Mines advertised a competition in papers in the United Kingdom, Europe, Australia, South Africa and America and offered prizes for the three best suggestions and devices for the prevention of miners' phthisis. There were 229 competitors' suggestions as under:

1. Respirators.	41
2. Dust extractors and hoods	35
3. Water drills	9
4. Jets delivering water inside the hole	4
5. Jets delivering water at the mouth of the hole	60
6. Sprays.	22
7. Atomisers	6
8. Medical	15
9. Miscellaneous.	37

The judges condemned as quite impracticable and useless Classes 1, 2, 8 and 9, but the others are all in general use in some form or other.

FUMES AND DUST FROM BLASTING

From the evidence given before the Miners' Phthisis Commission in 1902-1903, it is evident that up to that time there had been few restrictions of blasting operations, and that persons working underground had been very frequently exposed to smoke and fumes; this latter state of affairs was particularly marked at the end of the one shift and the beginning of the other.

The Commission in its report did not lay stress on the necessity of avoiding exposure of men to blasting smoke in the mine, except in the case of miners returning to dead-ends immediately after blasting. The danger from dust produced by blasting was not then fully realised, and, although progress was made in allaying dust produced by machines, etc., by the use of water, it took some years before the effects of dust from blasting were finally controlled. The following extracts from reports of inspectors of

mines clearly show that even as late as 1911 the conditions on some of the mines were still very bad:

In 1908-1909 it was a common practice on a certain mine to send the night-shift down against the day-shift coming up—naturally the night-shift had to inhale smoke from blasting.

Occurrence in 1911 and the years immediately preceding it:

While taking dust samples in a stope about 6 p.m. in an atmosphere which was full of smoke, the night-shift arrived to begin work, and I understand that this was a daily occurrence.

No real advance was made until the Medical Commission issued its report in 1912, and definitely concluded that not only men working rock drills, but all men working underground were liable to contract miners' phthisis.

From this conclusion it was perfectly clear that the problem had resolved itself into not only allaying the dust produced by drilling machines and the removal of the broken rock, but reducing the dust content of the whole mine atmosphere, which was permeated with very fine dust particles, blasting operations being the most prolific source of dust and the most difficult to contend with. It was impossible to reduce the dust in the air created by blasting to a safe limit, and the only method to overcome its deadly effect was to remove the men before the smoke enveloped them and to keep them out of the mine until the fumes and dust were dissipated.

DOUBLE SHIFTS

One factor which had a very marked effect on the health of the miner was the double shift worked on all the mines of the Witwatersrand, i.e. a complete cycle of mining operations, cleaning, drilling and blasting, was performed on two shifts in the twenty-four hours. Owing to the duration of each shift being nine and a half to ten hours, there was insufficient time between the shifts to permit of the smoke and fumes from blasting operations to be cleared out of the mine before the arrival of the following shift, and almost invariably the on-coming shift was exposed to smoke and fumes. On Saturdays the position was even worse, as the afternoon shift was lowered immediately after the blasting of the morning shift; this had to be done in order to get a full shift in by midnight, as it was, and still is, illegal to work on Sundays.

When it became known that these conditions were exceedingly

injurious to health, the necessary change-over to single shift could not be effected at short notice, but had to be done gradually.

Generally all the stope faces in the mine were being worked, and to obtain the required tonnage for the mill these faces had to be drilled and blasted twice in twenty-four hours; to maintain the stope faces, development ends were being pushed ahead on double shift.

Summing up the position, the mines had to continue double shift until such time as sufficient faces were available to permit the breaking of the necessary tonnage to keep the mill supplied on the one shift only.

ALTERATIONS NECESSARY FOR SINGLE SHIFT WORKING

A further factor which delayed the change-over was that the mines were only equipped for double-shift working. Considerable alterations and additions had to be made in the plant and in the mine itself, e.g. compressors had to be duplicated to meet the greater demand for compressed air. Hoisting arrangements could not cope with the full complement of men on the single shift; the capacity of ore bins underground was too small; the number of rock drills had to be increased, etc. Apart from the time required to effect these alterations, a large amount of capital had to be found before they could be carried out.

PROGRESS OF THE SINGLE SHIFT

In 1907 some of the mines resorted to what was virtually a sixteen-hour shift, i.e. two eight-hour shifts, the one shift following directly after the other, blasting operations being carried out at the end of the second shift only. This was undoubtedly a step in the right direction, as it gave an interval of eight hours for the smoke and fumes to clear away before the following shift was sent down.

The year 1910 registered a further advance, in that some of the mines were on single shift, blasting at the end of the shift, i.e. the major portion of the work in the mine was done on the day shift, with a limited complement of boys and men on night shift to do the cleaning out.

By 1913 the majority of the mines on the Witwatersrand had changed over to single shift, the full night shift of practically equal strength to the day shift having become a rarity.

There is no doubt that the elimination of the double shift was one of the most important steps taken to produce healthy underground conditions, as well as doing away with an unduly expensive night shift expressed in the following terms by a witness before the Mining Regulations Commission, 1907:

Nearly all miners sleep underground on night shift, the average time slept being about four hours.

DURATION OF SHIFT

The duration of the shift also had a very important bearing on the health of the miner. It might almost be considered, other things being equal, as a measure of the amount of dust inhaled by the miner.

Prior to the Anglo-Boer War, miners were scarce, and the tendency was for contractors to take on as much work as was given to them; this entailed long hours underground, and it was not an uncommon practice for a contractor to have two gangs of natives working, one on day shift and the other on night shift. Although the latter practice eliminated itself as the mines became deeper and access became more difficult, nevertheless the tendency for contractors to work long hours underground persisted and became an established custom.

Up to 1909, the mines were still working shifts of ten hours' duration; the hours were, day shift 7 a.m. to 5 p.m., night shift 7 p.m. to 5 a.m. On the day shift the men were allowed one hour on the surface for lunch. In 1910 the hour for lunch was done away with, thus reducing the over-all period to nine hours. This was a very much better arrangement, as the men were hoisted an hour earlier; this gave them more daylight for outside recreation. It also increased the interval between shifts.

The nine-hour shift continued until Act 12 of 1911 was passed, limiting the hours of employment of persons underground.

Act 12, 1911

9. (1) No person employed to perform underground work in any mine shall work, and no person shall cause or permit any person so employed to work, underground for a longer period than eight hours during any consecutive period of twenty-four hours, or forty-eight hours during any consecutive seven days, exclusive of time occupied in going to or from the working place.

There is no doubt that the reduction of hours could only do good from the point of view of the miners' health, and, as far as reducing

the amount of work done was concerned, had little effect, as it was balanced by closer supervision and improved organisation generally.

Difficulties were met with at first in arranging shifts and hours, but were finally overcome. The eight hours was from face to face, and this led to difficulties in regard to time spent underground by the miners, the contractors being only too willing to remain at work in order to get the best results, the increased overtime being attributed to travelling delays, etc.

Regulations

In order effectively to control and give effect to the eight-hour shift, the following Regulations were promulgated:

158. In addition to his other duties and responsibilities under these regulations, the manager shall:

(24) Provide on mines other than coal and base metal mines under section 9 (2) (c) of the Act:

- (a) That a notice shall be kept posted up at each shaft head, showing the time within which shifts will be let down and hoisted up at the shaft head.
- (b) That the average time in getting miners, as defined in Act 19 of 1912, from the shaft head to their working place at the commencement of their shift, and back again at the conclusion of such shift, shall together not exceed thirty (30) minutes per miner for any one shift. In special cases, after application made through the Inspector of Mines, the Minister may grant such extension of the period of thirty minutes as he may consider to be necessary. Notice of such application shall be posted up at the mine for fourteen days before the application is sent to the Inspector of Mines.
- (c) That the mine overseer, shift boss or other official appointed by the manager for the purpose shall satisfy himself that no white person not exempt under section 9 (2) of the Act remains underground after the ordinary hoisting of persons employed on that shift is concluded, and shall record in a book to be provided by the manager, the name of any such white person so remaining underground, and the time when such white person reaches the surface.

The effect of these Regulations was to give the white man an average period of eight and a half hours underground, including travelling from the surface to his working place and back again.

Original Arrangement arrived at between the Transvaal Chamber of Mines and the South African Mine Workers' Union

That from 1 January 1918 the underground working week shall be forty-eight and a half hours bank to bank, the length of each shift to be counted from the first skip down to the first skip up, and the Saturday shift to be at least one hour less than the weekday shifts. (In practice the hours are eight and a quarter bank to bank on weekdays and seven and a quarter on Saturdays, with some minor exceptions, e.g. certain shaft sinkers and developers.)

These are the hours prevailing on all the Witwatersrand mines at the present time.

CONDITIONS PREVAILING IN THE MINES

Generally the adverse conditions which had to be overcome may be summed up as follows:

- (1) All men on the outgoing shift were not hoisted before blasting took place, and were in the mine for some time after blasting operations had taken place, and in many cases were exposed to smoke.
- (2) Some of the persons had to be hoisted in the upcast shafts, where the conditions were bad.
- (3) The persons actually blasting were often unable to avoid the smoke from blasting.
- (4) Promiscuous blasting was practised more or less throughout the shift.
- (5) The oncoming shift was lowered before the air was sufficiently clear.

To overcome Nos. (1) and (2) the mines had to resort to hoisting as many men as possible in the downcast shafts.

Special cages and conveyances were made to hoist the workmen as quickly as possible before the smoke overtook them in the upcast shaft. Doors and regulators were put in to keep back the smoke or to deflect it. Mechanical ventilators were temporarily stopped to delay the arrival of smoke at the shaft; suitable waiting places were provided for the up-going shift and kept supplied with fresh air from the compressors.

No. (3) was overcome to a great extent by arranging the blasting of individual places in a suitable sequence commencing from the upcast side and travelling against the air currents.

No. (4): blasting, except where absolutely unavoidable and in isolated instances only, was confined to the end of the shift.

No. (5): blasting at the end of the day shift, and increasing the interval between that shift and the following oncoming shift, was finally overcome by doing away with the double shift and blasting at the end of the shift only.

The concentrated attention given to the problem of successfully combating miners' phthisis led to the carrying out of necessary experiments by individual mines. As the problem became better understood, the tendency was for successful innovations to be automatically adopted into general practice.

The progress of these changes is reflected in the history of the changes periodically embodied in the Mining Regulations.

Regulations

On the recommendation of the Miners' Phthisis Prevention Committee, the following Regulations were eventually framed, and were embodied in the amendments published on 30 October 1913:

61. No person shall work, or remain, or be permitted or ordered to work, or remain in any place in a mine, if the air contains dust smoke or fumes perceptible by sight, smell, or other sense.

101. (33) A ganger or miner . . . shall only blast at the end of the shift, except where necessary, and then only with the permission of the mine overseer or the shift boss.

158. The manager shall:

(4) Cause blasting operations and shifts to be so arranged that workmen shall be exposed as little as practicable to fumes and dust from blasting.

178.

(2) All Regulations referring to the prevention of miners' phthisis shall, so far as they concern coloured workmen, be translated into the more important native languages and kept posted up in the compounds.

The First Miners' Phthisis Prevention Committee investigated the extent to which men were exposed to the dust and fumes from blasting at the end of the shift, and dust samples were taken on all the mines for the purpose of determining the amount of dust present in the air breathed by the oncoming shift. They found that the air after blasting contained extremely large quantities of dust, and that the presence of smoke is a sufficient indication of the existence in such air of an amount of dust which is very dangerous to health. Five minutes in such an atmosphere has probably a worse effect than a full shift spent in drilling holes in a drive with water well applied. This indicated that very stringent measures had to be taken to prevent persons from being exposed to fumes from blasting.

Largely on the recommendation of the Miners' Phthisis Prevention Committee, further amendments were added to the Regulations and promulgated in 1917; their object was to improve the conditions in mines in respect of dust and ventilation. The following are those applied to prevent persons being subjected to fumes and dust underground:

60. In any mine included in the list of mines framed under section 2 of Act 19 of 1912 (mines in which miners' phthisis may be contracted):

(1) Blasting shall only take place once in every twenty-four hours, except as permitted under Regulation 106 (33), or for sinking vertical shafts, or after written permission has been obtained from the Inspector of Mines;

(3) No person shall blast or be permitted or caused to blast the cut and round separately on the same shift in the same development end.

106. (34) Shall . . . only blast at the end of the shift except for removing obstructions in ore passes or box holes, or for the purpose of making the hanging safe, or for blasting misfired holes in development faces, and then only with the permission, in each case, of the manager, mine overseer or shift boss.

158. The manager shall:

- (4) Cause the times of the working shifts and of blasting operations in every section of the mine to be so arranged that workmen shall not be exposed to fumes and dust from blasting, unless this is unavoidable;
- (5) Cause every person not engaged in blasting operations, or not required for the transport of the persons so engaged, to be hoisted to the surface or removed to the intake side of all places in which blasting is to be done, or to remain in a waiting place free from fumes and dust before blasting commences;
- (6) Cause every person engaged in blasting operations or required for the transport of persons so engaged to travel to the surface in the downcast shaft, unless they can be removed from the mine before the fumes overtake them or can remain in a waiting place free from dust and fumes, until these have dissipated;
- (7) Cause any person who is to work in the mine after blasting has taken place to enter the mine only after the places in which he has to travel or work are clear of fumes and dust, and after the expiry of an interval to be fixed for each mine by the Inspector of Mines;
- (8) Supply to the persons who have to carry on blasting operations, lighting torches, which in burning evolve not more nitrous fumes, expressed in terms of NO_2 , than one-half of 1 per cent. of the weight of substance burned.

161. (9) A shift boss or other official of at least equal rank shall be present underground at each working shaft at blasting time and shall not travel to the surface before the persons engaged in blasting operations.

(10) The manager shall, when the total number of persons employed underground, on any one shift, exceeds 1,000 persons, appoint one or more competent persons whose principal duty it shall be to examine and report to the manager on:

- (a) All matters relating to the mine's water supply, its quality, distribution and use,
- (b) The condition of the necessary appliances for using water at each working place, etc.;
- (c) The dust sampling of the mine;
- (d) The condition of the mine relating to ventilation and health, etc.

The manager shall, by letter, notify the Inspector of Mines of the person or persons so appointed from time to time, and the reports made by them shall be open to the inspection of the Inspector.

143. (2) (c) Any person who has knowledge of dust or fumes in the workings during working hours, etc., shall record the matter without delay in the record book.

(d) Verbal report of the above defective condition to be made to the shift boss or other official.

The following amendment was made as from 30 October 1913:

106. A ganger or miner who is the holder of a blasting certificate:

- (33) Shall not enter or allow any person to enter an end, raise, winze or other close place after blasting within thirty minutes after putting the water blast in action, and then only if the air is free from dust smoke, and fumes perceptible by sight, smell or other senses.

The practice of returning only when the drive, raise or winze was free of smoke, although an advance on the previous practice, was still unsatisfactory, as it frequently happened that the water blast was out of order when the miner blasted, or the water blast was put out of commission by the blast; the miners were very unwilling to lose the round, and there was nothing to prevent the men re-entering before thirty minutes had elapsed or before the smoke had been cleared out of the drive.

The practice of blasting the cut and round separately on the same shift was prohibited by Regulation 101 (3) from and after 1 January 1915, except with special permission from the Inspector of Mines.

By this time a considerable number of the mines had discontinued this practice and were blasting cut and round together, or had made provision for the cut being blasted on the one shift and the round on the following day by increasing the miners' working ends.

One or two mines continued to blast the cut and round separately on the same shift, availing themselves of the special permission granted under certain restrictions.

Finally the practice was totally prohibited in 1917.

With the improvements in drilling machines and methods applied at the present day, very little footage is lost by blasting cut and round together.

The 1925 Annual Report of the Transvaal Chamber of Mines Standing Committee on Dust Sampling records a steady and progressive decrease in the average amount of dust found in mine air since 1915.

Referring to Regulation 158 (8), the Miners' Phthisis Prevention Committee considered that exposure to nitrous fumes produced by blasting operations was a greater danger than that of possible chronic poisoning by carbon monoxide. The fumes of NO_2 are intensely irritating to the air passages and lungs, and the repeated inhalation of very small quantities would produce and maintain a chronic catarrhal condition, which would aggravate and accelerate the harmful effect of dust. As lighting torches were made up of blasting gelatine (a highly undesirable practice), it was advisable to limit the amount of NO_2 given off by torches.

The problem of extracting dust from mine air was also investigated by the Committee appointed to report on the ventilation of dead ends in 1924, but, although a certain amount of success was obtained, the experiments were not brought to a final conclusion.

This brings us up to date, and it seems as if only greater attention

to detail, and possibly various minor changes, can effect any appreciable improvement in conditions without radically altering our present system.

If preliminary investigations made along the lines recently suggested by Dr. Haldane with regard to dust dilution tend to support his hypothesis, it may be found possible to carry out practical tests on a working scale which if successful would lead to the complete elimination of miners' phthisis.

SUMMARY OF TESTS FOR DUST (BEFORE AND AFTER BLASTING)
PRESENT IN THE AIR OF WAITING PLACES OF THE SHAFTS OF
CERTAIN MINES OF THE WITWATERSRAND TAKEN 1914-1915
(MINERS' PHTHISIS PREVENTION COMMITTEE)

[Dust: mg. per c.m. = milligrams of dust (mineral) per cubic metre of air. Before blasting = Prior to shots being heard. After blasting = From time first shots heard up to the hoisting away of last cage load of employees.]

Mine	Average period occupied by sampling	Number of persons hoisted during sampling period				Dust samples (mg. per c.m.)			
		Upcast shaft		Downcast shaft		Upcast shafts		Downcast shafts	
		Whites	Natives	Whites	Natives	Before blasting	After blasting	Before blasting	After blasting
All	1 hr. 35 mins.	1,301	14,941	1,654	22,206	2.8	10.4	3.5	4.9

This table clearly shows the large number of persons who were hoisted in upcast shafts during blasting at this time, and the big increase in dust concentration to which they were exposed. In 1917 this was prohibited [see Regulation 158 (5)].

THE USE OF WATER FOR ALLAYING DUST

The use of water was recognised as the most efficacious method of allaying dust produced by the various mining operations. The best methods of applying it effectively were only arrived at after years of experience and innumerable experiments.

Among the devices first used for dust allaying were sprays and atomisers. In 1903 experiments with the various types were carried out to test their relative efficiencies as dust allayers, and

from the results of these tests Britten's atomiser was adjudged the best and awarded the Chamber of Mines first prize in the competition referred to previously.

At the outset water was not laid on to the working places; to operate the sprays and atomisers, drums were installed in the working place, and water carried in to them. These drums were connected to the compressed-air pipe, from which the necessary pressure was obtained to force the water out of the drum through a hose pipe to operate the atomiser or spray, which in turn was directed on to the collar of the hole being drilled whilst the drill was operating, thus damping the dust as it came out of the hole.

Sprays and atomisers were believed to be effective in allaying most of the dust produced during drilling and shovelling operations, and by 1906 many of the mines were equipped with them. Regulations were eventually promulgated to enforce their use. These devices were never popular with the miner; the atomiser charged the atmosphere with water, and everything within its range became saturated with water, including the miner's clothes; moreover in many cases the water was not clean, and the atomisers became choked and ceased to function. At their best, although allaying a considerable proportion of the dust formed, they did not prevent the very fine and most dangerous dust getting into the atmosphere. Gradually they were replaced by water jets, and ultimately (when water under pressure was available in abundance) by the hose pipe, sprays being retained only in such places as vertical shafts, and over ore boxes and ore passes.

ALLAYING DUST IN DEVELOPMENT ENDS

The first attempt to allay dust produced by blasting in the development ends was to place an atomiser about 70 feet from the face and put it into operation when the charge was lit up; the smoke and fumes from the blast passing through the atomised water were to a certain extent deprived of their dust content; this, however, had no effect on the broken rock and did not clear the end of the drive of smoke. To overcome this defect the water blast was devised and introduced on an experimental scale in 1907, and gradually became common practice throughout the Witwatersrand, its use being made compulsory by Regulation in 1911. The water blast is a simple device consisting of a single nozzle connected to both a water and compressed air supply by means of which a mixture of air and water is projected along

the drive to the face, wetting down the broken rock and displacing the gases produced by blasting operations.

INSTALLING PIPE LINES FOR WATER SUPPLY

By 1906 many of the mines were using dust-allaying appliances for certain classes of work, and, as previously explained, the water supply to operate the various appliances had to be carried by hand into the working place: a very unsatisfactory practice and not conducive to obtaining the best results, specially in places difficult of access such as raises. The mines realised the necessity of a better water supply and commenced to lay water pipes into the working places, obtaining water chiefly from underground sources, and by 1908 a large number of the mines were so equipped, and Regulations were promulgated for the enforcement of this practice. The Mining Regulations Commission's report was issued in 1910, and at that time efforts were directed principally to allaying the dust produced by drilling and shovelling operations, it being assumed that these were the two chief sources of phthisis-producing dust.

The Medical Commission report of 1912 dispelled this illusion, and from then the attack on dust became more general, i.e. water had to be used freely to water down each working place after blasting operations before work commenced. The water service had to be further improved to supply the greater demand, and in most cases clean water was taken down the shafts supplying underground reservoirs made for the purpose, and distributed at suitable pressure to the working places, travelling ways and all other places when its use was considered necessary.

The introduction of an adequate water supply was the key to the solution of dust elimination. By the abundant use of water the dust is not only allayed, but washed down into the drains and sumps, from where it is either bailed or pumped out of the mine.

WATER FEED ROCK DRILLS

The "Water Leyner" rock drill was first introduced into the mines as far back as 1902. The principle of this machine as a dust allayer was accepted as correct at the time and its maker was awarded the Chamber of Mines second prize. The conservativeness of the miner, the poor class of material of which hollow drill steel was then made, and the lack of a satisfactory water

supply delayed its successful introduction. In 1913 the "Water Leyner" drill and the Atlas drill, both passing water down the drill steel, were introduced on a number of the mines, and were very welcome from a health point of view. As time went on, reciprocating machines, both in stoping and development, were gradually eliminated by the water-fed machines, which apparently cut down dust production considerably.

At the end of 1916 a drilling machine known as the "dry" jackhammer was used; it worked with a hollow jumper, but exhaust air and not water passed down it. If a plentiful supply of water was turned into the hole by means of a jet, the dust results were at first considered satisfactory, but it was afterwards found that the air passing down the steel ejected considerable quantities of dust on escaping into the atmosphere. This led to experiments being carried out in 1919 with "wet" jackhammers, i.e. "axial water feed machines", and some of the mines changed over to these "wet jacks" in 1920, and gradually they replaced the "dry" type. The advent of the "Kotze" konimeter revealed the fact that internal water-feed machines produced extremely fine dust of the most injurious nature which had hitherto passed unnoticed. This defect was to a certain extent overcome in 1922 by re-designing the rock drill machines, fitting them with dustless pistons and later by the introduction of release ports into the front head of the machines. The former reduced the amount of air escaping from the cylinder to the chuck cavity, and the latter allowed most of the escaped air to pass out of the chuck cavity instead of passing through the axial hole in the drill steel. To reduce the amount of air passing down the steel, Regulations were promulgated prohibiting the use of short pistons in certain classes of work, enforcing the adoption of release ports, and requiring all machines to be tested by the Mines Department and approved before being passed for use underground. At present endeavours are being made to develop a satisfactory external water-feed machine, which will practically prevent any air passing through the steel, the sludging being done by water only.

OTHER SOURCES OF DUST

(a) *Dirty water supply.* — The machines atomise a certain amount of water, leaving the solid matter suspended in the air. The only check on this is to take samples of the water periodically and analyse them for solid matter (silica).

(b) *Blowing out drill holes.* — If this is done dry, it releases enormous quantities of dust, which should be washed out by water jets, avoiding the use of air if possible.

(c) *Blowing out sockets.* — Air should be avoided and water only used to wash them out.

REGULATIONS

Government Notice 1278 of 1908: Amendment to Regulation 146

Recommendations of the Mining Regulations Commission:

- (5) Every place where development work is carried on, and where the natural strata are not wet, and every dry and dusty stope shall be adequately supplied at all times with suitable clean water. Such supply shall be continuous and shall be sufficient for effectively damping the broken ground and for allaying the dust caused by drilling operations.
146. (ii) The ganger or miner in charge of workmen shall be responsible that the following provisions be observed:
 - (1) No person shall in the drilling of holes use any percussion machine drill, unless a water jet or spray or other means equally efficient is provided and used so as to prevent the escape into the air of dust caused by the drilling.
 - (2) No person shall in any part of a mine remove any broken rock or ground, if such rock or ground is in a dusty condition, until it has been effectively damped so as to prevent the escape of dust into the air during removal.

Act 12 of 1911

60. In development faces and in winzes a water blast or similar apparatus for laying dust after blasting must be used.

101. (1) No person shall in the drilling of holes use or cause or permit to be used any percussion machine drill unless a water jet or spray or other means equally efficient is provided and used, so as to prevent the formation of dust by drilling, and unless the floor, roof and sides of the working place, to a distance of at least 25 feet from the face, be kept constantly wet.

When hand drills are used for drilling dry holes, a swab shall be provided and used around the drill at the collar of the hole.

(2) No person shall in any part of the mine move any broken rock or ground if such rock or ground is in a dusty condition, unless and until it and the floor, roof and sides of the working place, to a distance of at least 25 feet, have been effectively wetted and kept wet, so as to prevent the escape of dust into the air.

Amendment Published on 31 October 1913

106. A ganger or miner who is the holder of a blasting certificate:

- (32) Shall, at any mine included in the list of mines framed under section 2 of Act 19 of 1912, not enter nor allow any person to enter any end, raise, winze or other close place after blasting

within less than thirty minutes after putting the water blast in action, and then only if the air is free from dust, smoke and fumes perceptible by sight, smell or other senses.

- (34) Shall in all development faces (except in the case of a winze being worked on single shift) immediately after lighting up, put into action the water blast, which he shall previously have tested. If as a result of such test, the water blast shall be found to be not in order, no blasting shall take place.

109. The following plans shall be kept in the office at every mine:

- (2) (b) A plan showing all the water pipes with their dimensions as well as all tanks, reservoirs, fixed and continuous sprays, and other devices for allaying the dust.

158. (6) (a) Provide or cause to be provided an adequate and constant supply of water which is clean and odourless at every working place which is not naturally wet. Such supply shall be sufficient for effectively wetting the broken ground and for preventing the formation of dust caused by drilling operations. Such water shall be supplied in metal pipes not less than one inch in diameter, at a pressure of not less than 30 lbs./sq.in. at each working place, when all sprays and jets supplied from the same pipe are working. Such pipes shall reach to within 50 feet from the face and from there a sufficient length of hose shall be provided and used to bring the water up to the face.

(b) Cause the surface in all working places, travelling ways and shafts, which are not naturally wet, to be kept wet as far as practicable.

(d) Provide in shafts, which are not wet, ring sprays at suitable points to prevent dust being carried with the air current.

(e) Provide a water blast as near as practicable to all development faces (except winzes worked on single shift).

161. (9) Each shift boss shall at the end of the shift pay special attention to the requirements of Regulation 106 (32).

Amendment Published on 30 May 1917

Regulation 60 to be amended to read:

- (2) Every drive, cross-cut, raise, incline shaft, and winze, and every working place in which there is no through ventilation current, shall be furnished, at a distance not exceeding 50 feet from the face, with a water blast, approved by the Inspector of Mines, which shall be continuously applied for at least thirty minutes after blasting, for the removal of dust and fumes, where the distance of such working place from the point at which there is connection with the general air current of the ventilating district exceeds 300 feet; an additional water blast shall be placed and used not more than 200 feet and not less than 100 feet from the water blast at the face.

Regulation 62:

- (3) No person shall stope or be caused or permitted to stope above any drive or level where there is no through connection from the stope to the drive or level above, except by permission of the Inspector of Mines, and then only on the condition that the ventilation of such stope is adequate, that the number of persons working therein is limited, and that when machine drills are used, such machine drills are provided with axial water feed.

Regulation 101: section (1) to be amended to read:

(a) No person shall in the drilling of holes use or cause or permit to be used any percussion machine drill other than an axial water feed drill, unless a separate water hose, furnished in the case of dry holes, with a narrow pipe at least 24 inches long, for inserting in the hole when drilling, is provided for each machine and used, so as to prevent the formation of dust.

(b) In collaring by means of a percussion machine drill, other than an axial water feed drill, the narrow pipe shall be removed from the hose, and the water from the hose shall be turned directly on to the collar.

(c) No person shall use or cause or permit to be used any hand drill unless water is applied or a wet swab is used around the drill at the collar of the hole, so as to allay the dust.

(d) No person shall use or cause or permit to be used, for the purpose of rising or of boxholing, any machine drill other than one with axial water feed.

(e) No person shall commence or continue to drill any hole, or cause or permit such commencement or continuation of drilling, unless the floor, roof, sides and broken rock of the working place to a distance of at least 25 feet from such hole have been thoroughly wetted and kept wet.

(f) No person shall blow out or be caused or permitted to blow out any hole with compressed air unless he has applied sufficient water in case there is not already a sufficiency to prevent the formation of dust during the process of blowing out.

Section (3): No person shall in any part of a mine perform or be caused or permitted to perform work of any kind liable to create dust, unless and until the floor, roof and sides of the working place to a distance of at least 25 feet have been effectively wetted and kept wet, unless such working place is naturally sufficiently wet to render the formation of dust impossible.

Regulation 106 (34) to be amended to read as follows:

(34) Shall at every mine included in the list of mines framed under section 2 of Act 19 of 1912 only blast at the end of the shift, except for removing obstructions in ore passes or box holes or for the purpose of making the hanging safe, or for blasting misfired holes in development faces, and then only with the permission in each case of the manager, mine overseer or shift boss. Before blasting such obstructions in ore passes or boxholes or for making the hanging safe, the ganger shall wet the ground thoroughly within at least 25 feet of the obstruction. When blasting misfires he shall observe the precautions prescribed in Regulation 106 (33).

Regulation 143:

(b) Any defect in the mine water service or dust-allaying devices, or in any appliances provided for the health or safety of persons working underground, shall be recorded in the record book by the employee having knowledge of such defect immediately on coming off shift.

Regulation 158:

- (6) (a) to be amended by the deletion of the words "which is not naturally wet" and the substitution therefore of the words "which is not sufficiently wet to make the formation of dust impossible";
- (b) to be amended by the deletion of the words "as far as practicable" and the addition of the words "or regularly washed down".

To be amended by the addition of the following new subsection:

- (f) Provide or cause to be provided at every ore bin, ore pass, or grizzly, unless exempted by the Inspector of Mines, a constant supply of clean water, which shall be applied during working hours at the openings of such ore bins, ore passes, and grizzlies, by means of efficient atomisers, which shall at all times be kept in good working order.

Regulation 158 to be amended by addition of the following section:

- (23). Cause any surface dump as the Inspector of Mines may direct to be sprayed with a sludge of black soil, or otherwise dealt with in a manner satisfactory to the Inspector, so as to prevent the dissemination of dust or sand from it.

Regulation 161 to be amended by the insertion of the following section:

- (10) (a) All matters relating to the mines water supply, its quality, distribution and use.
- (b) The condition of the necessary appliances for using water at each working place and elsewhere.

Government Notice 1571 of 26 November 1918

Regulation 158: section (10) to be amended by the addition of the following subsection:

- (g) Provide and cause to be used in every crusher station and ore sampling room, appliances, such as suction fans, atomisers and sprays, which may be necessary for the effective prevention of dust arising from the operations conducted in such station or room.

Government Notice 1730 of 26 October 1921

Amendments to Mines and Works Regulations

101. (5) (a) No new type or make of machine drill may be used on the scheduled mines without the prior approval of the Government Mining Engineer, or may be continued in use unless that approval is ratified by him within one year, and after at least twenty (20) of the machine drills so previously approved have been in regular use on the scheduled mines to his knowledge for a period of six months.

(b) The Government Mining Engineer may prohibit the use of any type or make of machine drill in use on any scheduled mine. Such prohibition (etc.).

Government Notice 1863 of 16 November 1921

Regulation 102 is hereby amended as follows:

102. (3) At any mine the ganger or miner making the examination prescribed in sections (1) and (2) shall also *thoroughly wet* the roof, sides and floor, as well as the broken rock, before admitting to the working place the members of the gang, other than those required to assist him in making safe.

Government Notice 511 of 21 March 1923

Regulations 60 (2), 101 (1) (a), 101 (1) (b) and 161 (10) to be deleted and the following substituted therefor:

60. (2) Every tunnel and development end, such as a drive, cross-cut, raise, incline shaft or winze, shall be furnished *with a water blast* approved by the Inspector of Mines. Such water blast shall discharge within a distance of not more than 50 feet of the face being advanced, and shall be applied so as to effectively wet the face and broken rock for at least fifteen minutes immediately after blasting, and again for a further period of fifteen minutes *immediately prior to entry* by any person, provided that the Inspector of Mines may give written permission to the manager to vary these conditions on any mine or part therefor.

101. (1) (a) No person shall, in drilling a hole, use or cause or permit to be used any percussion machine drill using solid steel, *unless a water hose is provided for each machine*, and used so as to prevent the formation of dust. When drilling a dry hole the *water hose shall be furnished with a narrow pipe* at least 24 inches long, which shall be inserted in the hole. In collaring, except in the case of jackhammers in stopes, the full bore of the hose must be used for supplying water to collar.

101. (4) (b) No person shall, in drilling a hole, use or cause or permit to be used any axial water-feed drill, unless an adequate supply of water flows through the drill steel. In every tunnel and development end, such as a drive, crosscut, raise, incline shaft or winze, and in every stope included under Regulation 62 (3) no person shall, in drilling a hole, use or cause or permit to be used any axial water-feed drill, unless an additional water-hose is provided and the water from it turned directly on to the collar while collaring. No drill steel shall be used in any *axial water-feed drill, unless the diameter of the axial hole is at least one-quarter of an inch* throughout its whole length, when the diameter of the drill steel is one and one-eighth inch or over, and at least three-sixteenths of an inch, when the diameter is less than one and one-eighth inch.

161. (10) In any mine included in the list of mines framed under section 2 of Act 19 of 1912, the manager shall, when the total number of persons employed underground on any one shift exceeds one thousand persons, appoint one or more competent persons whose principal duty it shall be to examine and report to the manager on:

- (a) All matters relating to the mine's water supply, its quality, distribution and use.
- (b) The condition of the necessary appliances for using water at each working place and elsewhere.

On 4 July 1923 the following machines were prohibited:

(a) The short-piston Leyner drill, in all development work, except shafts and winzes, after 10 March 1924.

(b) The Model 21 Waugh Turbro drill (Standard) in all classes of work, after 10 January 1924.

Government Notice 2046 of 8 December 1923

Prohibiting the use of any machine drill used with either shell or cradle which passes or is designed to pass air through the drill steel with or without water in all development work except shafts and winzes, after 10 March 1924.
