PRESIDENTIAL ADDRESS

SOME UNANSWERED QUESTIONS REGARDING DUST AND PNEUMOCONIOSIS

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As the theme of my Presidential Address I am going to list " Twenty Questions." In the popular radio game of this name, the competitors may win valuable prizes. My twenty questions concern dust and pneumoconiosis. If they could all be answered positively the reward would be measured in millions of pounds — the sum which is spent annually in this country compensating those who contract pneumoconiosis in our mines. There would be an even greater reward from the humanitarian aspect — the gain in the health of the workers, the prevention of premature retirement due to lung disease of many people when they are at the most useful stage of their careers, and the prevention of the disruption in family life and security which must come when the breadwinner has to leave his employment due to ill-health and subsist on his pension.

I can only answer one of these questions with a definite " Yes "— the first one. In the case of some of the other questions I will say what is known or proved, but I cannot give positive answers to them. I will often state my own personal opinions. Perhaps some of those present today can provide some of the answers — I hope they will do so. It is by pooling our knowledge that we can best make progress. Perhaps by focusing attention on the questions which we cannot answer fully, this address may play a small, but useful part in the fight which has been carried on for such a long time against the dust in our mines. It is my hope that it will serve this purpose.

1.—Is there still a pneumoconiosis problem in South African mines?

This is the one question to which a definite answer can be given. The following table shows information taken from the annual reports of the Pneumoconiosis Board: —

Year	Nnmber of new cases compensated	Total amount paid in compensation
1947/1948	1,270	£1,492,000
1948/1949	1,662	£1,390,000
1949/1950	1,538	£1,270,000
1950/1951	1,771	£1,448,000
1951/1952	1,865	£1,580,000
1952/1953	2,063	£1,614,000
1953/1954	3,944	£2,313,000
1954/1955	5,614	£3,358,000
1955/1956	7,125	£3,905,000
1956/1957	6,129	£3,810,000

The standards of certification have changed somewhat in recent years, and the increased number of cases in the later years is probably due, to some extent at any rate, to these changes.

These figures show that without doubt pneumoconiosis is still a serious problem in South African mines.

2.—What causes pneumoconiosis?

It is easy to answer this by saying " DUST." That is implied in the name of the disease, but this is only part of the answer. We must also ask: " What kind of dust?" " What sizes of dust particles?" " How many dust particles?" " How should we measure this dust?" " Do other factors come in?" and so on. I will deal with these questions later.

A fuller understanding of the disease and how to reduce or eliminate it would be obtained if we know just how dust, once it has entered the lungs, acts on the tissues.

We all know that the theory of mechanical irritation or scratching by the dust was abandoned about thirty years ago in favour of the " solubility " theory. This theory is not fully accepted today, and there are other

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ideas — the protein absorption theory, the piezo-electric theory, the polymerisation theory and so on. I am not competent to discuss these theories or comment on them, but I am hoping one of our medical or biochemical friends will contribute to this paper and bring us up to date on this important, but, I believe, unsolved problem of exactly how dust does cause pneumoconiosis.

3.—What is the relationship between dust and pneumoconiosis?

This I regard as one of the major problems still to be solved. We have considerable information on it, but other facts are unknown.

We know that very large particles generally do not enter the lung and that, therefore, they are believed not to play a major part in causing silicosis. We believe that, in general, the finer the particles a given mass of rock is dispersed into, the more dangerous the dust. It seems reasonable to suppose that the more dust a man breathes (of a constant type and size, etc.), the quicker he will contract the disease.

We do not know whether one half-micron silica particle is more or less dangerous than one two-micron particle. We do not known if " peak-concentrations " are more dangerous than a steady average level of dust. We do not know if freshly fractured dust is more dangerous than old dust. Opinions, sometimes emphatic views, have been expressed on these subjects, but they often directly oppose each other. Such experimental evidence as there is, is often of doubtful value — for example, much of it is based on experiments on small animals exposed to enormous dust concentrations to produce quick results. Can we extrapolate these results to the human being, taking, say, 20 or 30 years to get even the first stage of pneumoconiosis? I believe such experiments are useful, but not necessarily conclusive.

The South African Pneumoconiosis Research Unit is undertaking a project to provide some evidence on this relationship, based on the actual conditions in which men work. I am connected with this project and gave some details of it in the Society's Journal in August, 1957.

Briefly what we are doing is to follow many different mining men during their whole daily underground shift, taking continuous dust samples in the air they breathe. We sample by means of the standard thermal precipitator, the modified thermal precipitator and the konimeter. We count our thermal precipitator samples both before and after acid treatment. We make accurate measurements of the sizes of the particles in the samples. We measure the variations in concentration during each shift. We express the dustiness in various ways — number concentration, size frequency, surface area, light extinction, etc.

We will obtain much information on the dust conditions to which the many different " occupational groups " of miners (e.g. stopers, trammers, skipmen, fitters, mine captains, etc.) are exposed. Later these results will be compared with some measurement of the dust disease found in each of these occupational groups. From these experiments we hope to learn a great deal more about the relationship between dust and pneumoconiosis, and let me repeat, *this is based on the actual conditions under which men work* — there is no extrapolation from short-term laboratory experiments on animals, etc.

4.—Do factors other than dust influence pneumoconiosis?

I think it is generally accepted that if two men were to work side by side throughout their working careers, they would not necessarily contract pneumoconiosis at the same time, or to the same degree.

It seems logical that there should be individual variations in susceptibility to this disease, as there are to other diseases. The man's physique must play a part, as the Pneumoconiosis Bureau pays considerable attention to this in deciding whether or not to accept a new applicant for underground work.

The man's working habits must surely play an important part in determining his likelihood of contracting pneumoconiosis. The man who rushes furiously around, breathing heavily, must breathe in much more air than his companion who carries on more quietly. On the other hand, the rapid breather has the air in his lungs for a shorter time, giving the particles less time to settle or diffuse to the walls of the alveoli! Which is more dangerous?

Do a man's living habits affect his chances of contracting pneumoconiosis? Surely the clean-living, athletic type is more resistant than your heavy drinker and smoker, who practically never breathes fresh air? Incidentally, I am told that when information was sought on this subject, the survey revealed that there were no miners who ever smoked more than three cigarettes a day or had more than a pint of beer per week!

When we also take into account the possible effects of the ranges of temperature, humidity and pressure to which the average underground worker is exposed, and the possible contact occasionally with various noxious gases, it will not be surprising to find that it is not dust exposure alone which determines any particular individual's likelihood of contracting pneumoconiosis.

One would like to know more of the effects these and other factors have on the disease.

5.—What properties of a dust determine its danger?

If we knew the answer to this question we would know how to sample our dusts to give much more reliable information.

Firstly, quite obviously the composition of the dust is most important. Quartz and asbestos are dangerous dusts; coal much less so, although it is doubtful if it is safe to breathe it in large quantities; other dusts, such as cement, have practically no pathogenic action. We do very little work on determining the composition of our mine dust, but since it is produced largely from siliceous rock, the need for this is less important in South Africa than in other countries where the rock mined vary considerably in composition. Nevertheless, I wish we had a rapid, accurate method of determining the composition of all our dust samples — the principal problem is to collect enough dust, in a reasonable time, for analysis by X-ray diffraction, or other methods.

Next, we have never settled the question of which parameter to use as a measure of dustiness. Should it be number concentration, surface area, or mass? I have expressed my views on this subject before. I think we should measure the surface area of the particles which can reach the alveoli of the lungs. There is strong evidence to support this view, and I am not alone in my opinions. Nevertheless we in this country, and the workers in many other countries, continue to use number concentration as the standard measure of dustiness. Some people argue that it does not matter what property of dust is measured; this is not the place to go into this argument, but I entirely disagree with them!

I consider that until we have settled this matter of which property correlates best with the danger of dust, we are working largely in the dark in trying to bring our dust concentrations below a safe level. We have reduced our dusts, measured on a mass concentration basis, well below the average level which many people would regard as safe (it is about one-quarter milligram of siliceous dust per cubic metre), but we still have cases of silicosis occurring.

Finally there may be many other properties of dust which affect its danger — the shape of the particles, the method of formation, the occurrence of acid or alkali salts breathed with the dust, the "freshness" of the dust (there is a theory that freshly broken particles are more toxic than "old" dust). What is the danger of coagulated dust? Is dry dust more dangerous than wet dust? A major problem is the danger to be assigned to submicroscopic particles (i.e. particles too small to be seen with the optical microscope, but revealed by the electron microscope). There are large numbers of them in our mine dusts, but what is their danger? For every statement that they are highly dangerous I can produce a quotation to the opposite; we badly need an answer to this question.

6.—What is the safe level of dustiness?

Although no legal limit of dustiness is set in our Mining Regulations, there is the figure of 200 particles per cubic centimetre (by konimeter count) used as an "unofficial standard" by the Mines Department. I do not know the basis on which this figure was determined, and as far as I know no one has ever claimed that if all dust concentrations were kept below this level at all times, there would be no pneumoconiosis. Alternatively, it is equally possible that this standard is too severe; that by trying to keep to it the mines are being set an unnecessarily difficult task.

This level may be, and probably is, the best possible guess as to the level to be aimed at. But it is, quite definitely, only an estimate. There is no scientific evidence which I know of which proves its validity.

Until we have a standard of maximum permissible dustiness based on careful scientific research, much of our dust control work is of doubtful value. The lack of a valid limit can be frustrating. How can we persuade everyone concerned to try to keep dust below some arbitrary level, when we cannot assure them that if these levels are attained, there will be no more dust disease? But if we were confident that our targets were based on carefully determined levels, and that once attained we could guarantee the eventual abolition of the disease, I am sure we would obtain the full support of all concerned — the workers and the management — in trying to reach these levels.

This is another of the objects of the "Occupational Dust Sampling Project" I have referred to above. When we have completed our work we should be able to define — for the first time — scientifically determined levels of dustiness which are necessary to ensure that no further cases of pneumoconiosis occur in our mines.

7.—Are we making the right measurements of dust?

This question cannot be answered properly until we have the answer to Question 5.

Let us review, however, what we are doing at present in our routine dust sampling.

We use an instrument — the konimeter — of very doubtful validity. We take a few snap samples (each over a period of a fraction of a second) at each sampling point. We proceed to treat the slide to remove various particles which are not to be included in the final count, because it is *believed* that they are not dangerous — this has never been proved, and I am frankly very critical of the acid-treatment process. We then examine what is left on the slide under a low power microscope, and we do not take into account the sizes of the different particles. We express our results in terms of number concentration.

Is this the correct method? Does it give us the right answer? Are better methods available? I do not criticise the adoption of these methods in the past — much good work was put into evolving them and developing the necessary apparatus. I do feel, however, that the time is ripe for a re-appraisal of the situation, and if the old methods are found wanting, for the development and introduction of new methods.

Again we shall obtain some information on this subject from our "Occupational Dust Sampling Project." We make our dust measurements in a number of different ways. We will be able to compare the results obtained in each of these ways with the disease produced in each occupational group; we will then ascertain which dust sampling method correlates best with the incidence of disease.

8.—Are we using the right dust sampling instruments?

Here again the answer cannot be given positively until we have obtained more information on the relationship between dust and pneumoconiosis, on the properties of dust which determine its danger, and on the safe levels of dustiness.

We cannot settle on the best design of dust-sampling instruments until we know exactly what we wish to measure, and the dust levels we need to measure accurately.

Although I pay tribute to its usefulness in the past, I am convinced that the konimeter is misleading us grossly at present. If fails to collect the fine dust particles, and it over-estimates the coarse particles, particularly if they are aggregated. Thus the ratio of konimeter count to thermal precipitator count is often less than 0·1 for drilling dust, and the ratio may range well over 5.0 for coarse dusts. I had a case recently where the thermal precipitator count was 50 particles per c.c., and the konimeter count taken at the same time was nearly 1,000 p.p.c.c.

I am convinced that far too little attention has been paid to the drilling dust problem, mainly because konimeter counts of such dust are generally low. I do not say that any efforts to suppress dust anywhere are wasted, but as a result of the konimeter exaggerating counts of dust caused, for example, by tipping, more attention has been paid to such dusts, often leading to the neglect of more dangerous dust conditions elsewhere.

In my opinion, those who have defended the konimeter, and who are responsible for its continued use in our mines, have done a serious disservice to the science of dust sampling and the control of dust in our mines.

Greatly improved methods of dust sampling are already available; they may not be the final answer, but I can see no reason why they should not be introduced in the interim period.

I sincerely believe that if we used better dust sampling instruments now, we would achieve considerable advances in dust control underground almost immediately.

9.—Is our dust sampling strategy correct?

By strategy I mean — are we taking the samples at the right time and place, and in the correct numbers?

The normal procedure, on most gold mines, is for the dust sampler to go underground an hour or two after the main shift, spend, say, four to five hours underground (of which time probably, due to travelling, etc., less than two-thirds is actually spent in the working places) and return to surface some hours ahead of the mining gangs. Only a very small percentage of samples are taken at night-time or on early or late shifts. With such a sampling schedule, periods of excessive dustiness may well be missed, for example, when the gang first enters the working place and before watering down is completed.

There are a few ventilation departments which have altered their dust sampling schedules to cover a wider period of time. They arrange that the dust sampler regularly spends eight hours underground, sometimes starting very early, other times finishing late; he does this every second day, and spends the intervening day counting his slides, writing his reports, preparing his apparatus, etc. This appears to me to be a far sounder system than the normal one, and I would commend it to all mines.

Present dust sampling technique is also tied more or less to sampling "places" rather than "people." Is this wise? Surely we wish to know how much dust the "people" breathe, rather than dust concentrations in various "places." A given "place" may be producing a lot of dust, but if this all disperses into old workings where no one breathes it, do we need to measure it? What particular value is the "return air" sample taken at the top of a stope, if this air passes direct to the upcast shaft? It is much more important to know the amount of dust being breathed by the individuals in that stope. We also need to sample "processes" to determine the source of dust.

Mining regulations require dust samples to be taken in each working place at least quarterly. This may not be frequent enough; it may be more frequent than is really necessary. The "sampling effort" we can afford on dust control is necessarily limited — by shortage of staff, economic considerations, call of other duties, etc. It is highly desirable that we make the best possible use of the available effort. Even if we could take, say, double the half-million samples taken annually, the following argument will apply.

It is not necessarily the most efficient use of the available effort to spread it approximately equally over all working places.

Suppose a given place has been sampled several times and has given counts of, say, 50, 60, 40, 50, etc. (by konimeter) — it is almost certainly unnecessary to sample that place frequently in the future (unless, of course, some complete change in working practice or ventilation is made). Similarly, if another place has repeatedly given counts of 1,000, 1,000+, 900, and so on, we know it is bad, and until some definite action has been taken to improve conditions there, we are wasting our time taking many further samples there.

In neither of the above cases am I suggestion that all further sampling in these places should cease, I merely suggest the sampling effort there should be reduced and applied elsewhere. The places where most of the sampling effort should be concentrated is where border-line conditions occur, i.e. where counts are, say, 200 — 300 p.p.c.c. (accepting konimeter standards for the purpose of this discussion). In such places we should take frequent samples, say, weekly, to check that conditions do not gradually deteriorate, or to see if gradual improvement can be made until it enters the " safe " category, when the sampling effort allocated to it can be reduced to an occasional visit.

I believe that by a better allocation of our available sampling effort along these lines we can obtain more information for the same effort than we do by strict adherence to " once-per-quarter " samples at all places. This is an aspect of dust-sampling which has been studied in some detail by the British National Coal Board, and which they apply in their routine dust control work. The frequency with which they sample each working place is based on the use of statistical control charts.

10.—Should ventilation officials take dust samples?

The normal practice on our mines is to make the same man, or at least the same department, take the dust samples and be responsible for improving conditions.

This must surely place the man, or the department, in an invidious position. If he reports that dust counts are high, he is reporting, to some extent at any rate, that he is failing in his other duty. Will he then take the dust samples which will reveal this? If he takes them, will he always have the moral courage to report these high results to the Head of his Department? Will the Head pass them on to managements? Will management allow them to stay on record, and be forwarded in the monthly returns? At each of these levels there is always some danger of the suppression of bad results — it is so easy to suggest that bad conditions be checked again in a day or so, and there is always the chance (particularly with the variability in efficiency of the konimeter) that next day lower counts may be obtained, and these can then stay on the record, and the earlier ones ignored or "explained away." I have no doubt that many observers are scrupulously honest in their dust sampling — I cannot help feeling that a few might not be! There are very few checks made of their results.

At one time dust sampling on the mines was carried out by an independent central body which had nothing to lose by always reporting conditions as they found them. Their reports may not always have pleased the managements of the mines, but no doubt they achieved a great reduction in dust where it was reported. I would like to see some return to this system, say on a Group basis, and used to check a given portion of the mines own sampling effort.

11.—What processes cause most dust?

Undoubtedly blasting causes most dust, but fortunately men are seldom exposed to the terrific concentrations (250,000 p.p.c.c. or more) which may exist immediately after the blast.

Any further answer to this question depends on how the measurement is made, and what treatment the slides have been subjected to. If the slides have not been acid-treated then thermal precipitator measurements will indicate drilling as the next highest common source of dust. If the slides are acid-treated, drilling will be ranked very low in order of dustiness.

The reason for this discrepancy is that very large numbers of dust particles are produced by the atomisation of water at the front-head release ports of the rock drill. The fine droplets tend to evaporate very rapidly — within a few seconds usually. If the water is perfectly clean there is no dust left behind in the air. If the water contains inorganic salts in solution, and nothing else, then the particles left behind in the air will consist of these salts, and it is the object of the acid-treatment to remove these particles, which otherwise would be included in the dust count. This practice would be perfectly sound if these were the only contaminants in the water. But if the water also contains rock particles in suspension they, too, will be left behind in the air after the water has evaporated, and they will form the nucleus of a complex particle with an inner core of rock particle surrounded by a layer or skin of the salts originally in solution. Acid-treatment also tends to remove these particles from the slide because after the outer layer of salt is dissolved the inner nucleus of a rock particle is no longer in contact with the slide and the rock particles fall away from the slide, particularly since we acid-treat our slides in a vertical position. A further complicating factor is that such particles also normally contain some silica in a highly soluble form, this is silica which was originally in solution in the water and which has come out of solution when the water droplet evaporates. Most mine water contains appreciable quantities of rock particles in suspension. A common " deep-cell " count is five to ten million particles per cubic centimetre of water, and this method fails to reveal the finer particles; the true number, down to about 0.1 micron diameter, is about ten times the deep-cell count. My criticism of counting samples " after acid-treatment " is that most of the rock particles produced from the atomisation of water will not remain on the slide; there is certainly no evidence that they are not dangerous.

There is little doubt that the " before acid-treatment " count over-estimates the concentration of dangerous dust particles, because some of the particles counted may be pure inorganic salts, believed to be harmless; at the same time the " after acid-treatment " count is an under-estimate of the silica particles because some of them, possibly many of them, are lost in the treatment process.

An improved way of treating our dust samples is urgently needed; it should remove *all* inorganic salts, but leave behind *all* rock particles originally in the sample, including those produced from the atomised water. Efforts to develop such a process have so far not been successful.

Until this important matter is settled, and also the question of what measurement of dust to make, there will always be controversy as to which processes cause most dust, and considerable uncertainty as to which dust-producing processes should receive priority attention.

12.—Are we controlling dust adequately?

We cannot claim to be doing this as long as frequent cases of pneumoconiosis continue to occur in our mines.

Dust and ventilation personnel, speaking generally, do make a very definite and conscientious effort to locate and correct bad dust conditions. In general they receive full support from mining personnel. But it is not always possible to locate all the bad places, and even when they are located, it is not always possible to reduce dust concentrations below the desirable limits. It must also be borne in mind that the konimeter may often fail to reveal bad conditions, e.g. if the dust is very fine.

Even if bad conditions are located there may be several reasons why they cannot be cured immediately. If may not be possible to obtain or install the necessary equipment right away, e.g. ventilation piping or filters — ventilation departments usually have to depend on other departments to carry out this work. There may not be available sufficient additional quantities of fresh air to dilute the dust. The problem may be an involved one beyond the scope of the particular ventilation department to deal with it. Most ventilation staff are perfectly competent to deal with straightforward problems such as stopes or development ends, but they may find it more difficult to suggest the best solution to a strongly up-casting tip, or a dust problem in, say, a uranium extraction plant. The Mining Group system helps here by providing points of contact to discuss these specialised problems. It might be desirable to extend this by providing a pool of experts on various subjects on which the mines could call when necessary.

There is another aspect to this matter. Mining methods are continually changing, particularly in the direction of increased mechanisation. It is a continual challenge to the dust engineer to keep up with these changing methods; he may feel he has just caught up with the dust on his mine, when the mining people introduce some new machine, say, a mechanical loader, or a pneumatic stower, which creates a new dust problem. Or in the desire to get a new mine into production, multiple shaft blasting in development work will be introduced, and this creates additional ventilation problems. One appreciates the need for these improved mining methods, but they do not as a rule make dust control any easier!

13.—Do we pay sufficient attention to mine water?

Under question 11 I described how the rock particles suspended in mine water can become airborne in considerable quantities by atomisation at the front-head release ports of a rock-drill. Unfortunately, with our routine method of "acid-treating" all our dust samples before counting them, most particles produced in this way are removed from the slides and not included in the final count. Their presence, and potential danger, is, therefore, likely to be overlooked. I am sure that if such particles were included in our dust counts, far more attention would be paid to the importance of providing really clean water for rock-drills.

How many water samples are taken each month on the average mine of the water actually supplied at the rock-drills? Some information I have on this subject indicates that on many mines the taking of such samples is not a normal routine. Some mines limit their water sampling to the main storage dams, usually taking the sample in the upper levels of the dam, but this ignores the fact that the water drawn off from the bottom may be considerably dirtier, or that it might be contaminated en route to the working places. Many more water samples should be taken where the water is actually used.

One reason for mines taking a minimum of water samples is that the standard deep-cell method of examining such samples is tedious and time-consuming. Most of the mines of the Rand Mines Group have introduced nephelometers for the purpose of checking the quantity of dust in suspension in water samples; this instrument gives the result in under one minute, and has resulted in many more water samples being taken and assessed. The ideal to be aimed at is that a water sample should be taken at every rock-drill and water blast found underground during the observer's shift.

If this is done regularly, and unsuitable water supplies thus detected and reported, improvements are bound to follow. Dirty water supplied to rock-drills is not always detected and is then a major source of dust in mines.

14.—Can we prevent all dangerous dusts?

I doubt if anyone would care to undertake to prevent *all* dust in any mining process, and it should not be necessary to do so. There is almost certainly some level of dustiness which the average human lung can tolerate, and there is no need to reduce the dust count much below this level — the average non-mining citizen in Johannesburg probably breathes air containing on average, say, 50 particles per c.c. of siliceous dust (by thermal precipitator count) without suffering any noticable lung disease.

Secondly, it is not necessary to actually prevent the formation of dust if we either dilute it sufficiently by adequate ventilation (see question 16) or arrange that people do not breathe it (see Question 15).

I recently had the opportunity of visiting the zinc and silver mines at Broken Hill, in Australia. At one time silicosis and lead poisoning (due to breathing lead dust) were serious occupational diseases in those mines. Today they have no cases of any dust disease. They have achieved this remarkable result by applying rigid dust control underground — on an underground visit I saw electrostatic precipitators, multiple vertical flannel bags, doors covering the tops of ore-bins which closed as soon as the ore had been tipped, efficient ventilation of all working places, conscientious use of water at all times before lashing ore, wet drilling without front-head release ports on the machines, and an extremely dust-conscious labour force. I was most impressed with their efforts — on one mine they even crush the ore underground, and I could see no signs of dust anywhere around the crushers. As a result of their efforts they appear to have solved their dust problem completely.

I do not know how successfully we could remove all dust in our mines. I would like to see the experiment carried out where a particular stope is tested very carefully for its dustiness under normal working conditions, say, by having twenty thermal precipitators sampling in it during all working hours for a week, by which time a complete picture of the dust conditions there would be obtained, both on a time basis and on what one might call a "dust-contour" basis, which would show how the dust built up and flowed through the stope. Then I would like to see every possible method of suppressing dust applied conscientiously and thoroughly in that same stope for another week, and the same series of dust samples taken to determine the improvement. Would there be any improvement? Would it be 5%, 20% or 100%? I do not know. I would like to know the answer.

15.—Can we prevent exposure to dangerous dust?

It may not always be possible to prevent dangerous quantities of dust being formed, but it might be relatively simple to prevent persons being exposed to such dusts.

The outstanding example of this principle is, of course, the precautions taken in South African gold mines against exposure to blasting dust and fumes.

If we could positively identify the next most serious source of dust to which men are exposed, somewhat similar arrangements might be made. For example, suppose drilling dust was so identified. It might be possible to arrange that all drilling was done at a time when no other persons were exposed to the dust, i.e. a special drilling shift of a few hours could be introduced after the cleaning and loading gangs had withdrawn from the working places. The drill operators could work on the fresh air side of the machines, or if several machines were in operation on the same face the upstream operators could be protected by fresh air supplies fed specially to them or, as a last resort, by respirators.

If we had the requisite information, I am sure that the mining engineers would cooperate and develop suitable mining procedures to remove as many men as possible from the dusty process, whatever it was found to be.

Today is the day of automation, and if the dustiest processes were clearly identified, is it not possible to hand them over to a machine, operated from afar by a human being, and watched by television? In an age which produces earth satellites, this should not be a mere fantasy.

16.—Why can we not dilute all dust clouds by more ventilation?

As a first approximation at any rate, if we double the quantity of air circulating, we will halve the dust concentration. By providing enough air, at all working places, it should be possible to reduce all dust concentrations below dangerous limits. This is one possible direct answer to the dust problem.

I have a great respect for the Ventilation Engineers in this country — they already provide enormous quantities of air, at reasonable temperature, at great depths below surface and at considerable distances away from the shafts. I would like to hear from one or more of them today as to why they cannot solve the whole dust problem for us?

17.—Can we undertake drier mining without increasing dust concentrations?

As our deep-level mines became deeper (one has recently passed the 11,000 ft below surface mark) there is a constant demand for drier mining to alleviate the heat problem. Since the earliest days of interest in the dust problem, the widespread use of water for dust suppression has been so impressed on miners, that it is difficult to re-educate them now to use less water.

Nevertheless, it would probably be possible to reduce water consumption very considerably without dust concentrations increasing. Dry shafts and dry intake airways assist considerably in reducing heat flow into the air, and providing no excessive spillage of ore in transport in them takes place they do not cause much dust. The footwalls of airways which are also used for travelling can be treated if necessary with hygroscopic salts to bind the dust and prevent it becoming airborne. Drains must, of course, be properly covered.

In the working places, some water must be used to ensure adequate dust suppression, but far more water is used than is necessary. For example, rock piles must be adequately wetted before they are lashed, but this is often done by an over-generous application of water to the outside of the pile at the beginning of the shift, when much water runs to waste, and later in the shift the unwetted inside of the pile is handled, causing more dust than is necessary. Continual application of small quantities of water are more effective in both respects. It is a common sight to see water hoses left running practically throughout the shift, serving no useful purpose. One would imagine self-closing taps would be fitted when efforts to reduce the heat are being made.

The new types of "sealed-spline" rock drills have a double advantage. They cause less dust and atomise smaller quantities of water into the atmosphere. They, therefore, materially assist in "drier mining" conditions.

One serious problem connected with drier mining is that reduction in use of water often leads to small concentrations of coarse dust being released. These may be visible to the eye, and often cause alarm, and are, of course, prohibited by Mining Regulations. At the same time they are probably far less dangerous than the much higher concentrations of finer dust, quite invisible to the eye.

18.—Is our propaganda against dust adequate?

To really solve the dust problem in mines calls for a united effort by everyone concerned, from Consulting Engineers at Group Head Offices, managements on the mines, officials, miners, and, as important as any of these in the campaign against dust, the native labourers.

It is common experience that to obtain the co-operation of all concerned in any project, constant propaganda is necessary. The people concerned have many other problems to deal with, particularly the constant call for more tonnage, and unless they are constantly reminded of this particular problem, they may overlook the need for continual and adequate dust suppression.

Is enough being done to make, and keep, everyone dust conscious? Again I think particularly of the native labourer who is probably ignorant of the real danger of dust. One sees plenty of posters drawing attention to the danger of accidents in mines, many of them designed specifically to educate the native. One would like to see a parallel effort to educate everyone on dust.

About 20 years ago two excellent publications were put out in South Africa. The first was a comprehensive technical book on "The Prevention of Silicosis on the Gold Mines of the Witwatersrand," which was invaluable to anyone desirous of improving his knowledge on the subject of dust. This book still remains the best available reference on the subject, but has long been out of print; many parts of it still apply, but other portions of it are out of date and need revision. One hopes it will be brought up to date and re-issued before long — if I may make one suggestion, it should be in loose-leaf form so that when sections or chapters require revision they can easily be replaced without affecting the rest of the book.

The second publication of that period was a small pocket size booklet of about 20 pages, issued by the Chamber of Mines, in both official languages, and given to every European miner. It set out in simple language some of the important properties of dust, and probably served a very useful purpose in educating them. There has been a whole generation of new miners since, and one would like to see this booklet revised and brought up to date, and again issued on a wide scale. An even simpler version, with, say, its contents given mainly in the form of diagrams, might be produced for the native workers.

19.—How can we persuade everyone to tackle the dust problem?

I have already discussed propaganda against dust, and if a proper campaign was undertaken it would be most beneficial.

Propaganda alone may not be sufficient. Most officials, for example, are well aware that dust is dangerous and that they should take all possible action to stop it; but not all of them co-operate as well as they might in tackling the dust problem.

Can every dust inspector honestly say that he is regarded as a friend by all mining staff, and that he is welcomed whenever he visits a working place because the mining people realise he is there to help them, and improve their working conditions? Is he not sometimes regarded as a nuisance, or someone who will get them into trouble with managements by adverse reports?

Which is the best way to deal with bad dust or ventilation conditions when they are found? To report them direct to management and have top level pressure put on the miner to put things right — or to take it up with the miner himself, try to persuade him to improve conditions on his own and not report officially on what has been found, unless the miner continually refuses to improve conditions? I have heard many arguments for and against both methods. I would like to hear discussion on this point as members of this Society have a great deal of experience on this subject.

I am satisfied that it does require the co-operation of everyone underground to overcome completely the dust problem. How can we best get this necessary support?

20.—Can we cure pneumoconiosis?

The word "cure" can have various meanings. Firstly, if a man has actually contracted pneumoconiosis, it might be possible to find treatment or drugs which reverse the changes in the lungs and cure him of the disease. There have been claims that this has been done, but they are regarded with scepticism by many people. I hope one of the doctors engaged on medical research will give us more information on this possibility. The whole science of medicine has advanced so tremendously in recent years that this hope may not be a vain one.

Secondly, there has been a long-standing claim that the inhalation of aluminium dust will prevent the formation of pneumoconiosis, even though the men continue to breathe the same amount of siliceous dust. Experimental proof of this, in a properly controlled experiment, appears to be lacking. In fact, in the only properly controlled test of aluminium therapy, of which I know, there was no proof of its beneficial effect. The danger of relying on such antidotes is that if they are applied, there will be a grave risk that other measures against dust will be relaxed; i.e. that if the miners are being treated daily with aluminium dust, other efforts to stop dust underground will not be carried out as energetically as before. I think that the best that can be said for aluminium therapy is that it is "not proven."

Thirdly, we could interpret this question as meaning "can we stop pneumoconiosis by dust control?" I am not pessimistic over this possibility. When we have learnt more about how dust acts, when we know what we should measure, when we have introduced better dust sampling methods, when we have found out ways of controlling or reducing all types of dust, when we are rigidly applying all these methods in all working places, when we have the active support of all mining personnel in tackling the dust problem — then I am convinced there will be no more pneumoconiosis in our mines.

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Finally, I have followed the lead of a previous President of this Society (Mr. J. de V. Lambrechts) in not avoiding controversial matters where I think it is better to ventilate them. In return I will welcome criticism of my own ideas expressed herein.