near the main lining wall in the same shaft is of interest, and further investigations in this shaft may yield useful results.

Dr. Lambrechts mentioned the possibility of measurements of wall friction in the No. 1 Shaft, Vaal Reefs G.M. both prior to and subsequent to the adding of streamlined fairings to the structure. Tests, using a pitot tube situated right on the shaft wall to read total pressure, i.e. a so-called surface pitot tube, together with a static hole fairly close by would give a good indication of changes in $(\frac{dv}{dy})$ and thus in shearing stress at the walls resulting from the streamlining of the equipment. By suitably calibrating such a surface pitot tube actual shear stress values could be measured. In any opinion such tests would add considerably to the present meagre fund of knowledge regarding wall friction effects in shafts.

MINE VENTILATION OFFICIALS AND THE QUALITY OF MINE AIR

PRESIDENTIAL ADDRESS*

By R. S. J. Du Toit

1. INTRODUCTION

After much thought on a possible subject for my Presidential Address, I came to the conclusion that a useful subject would be the quality of mine air in relation to the duties of mine ventilation officials and in compiling the Address, I was fortunate to have ready access to the many early publications on conditions in the gold mines.

2. CONDITIONS IN THE EARLY DAYS

2.1 Accidents due to inhalation of Mine Gases

Sixty years ago, the quality of mine air was such that accidents due to inhalation of mine gases were " relatively frequent on the Rand, eighty-one fatal gassing accidents, resulting in 279 deaths, having occurred between 1904–7.

" A minority of these were due to simple misadventure, but in most cases neglect on the part of the workers of the most obvious and elementary precautions was responsible for their occurrence.

" Inadequate ventilation, and resulting imperfect removal of blasting fumes, as well as failure before lashing to wet thoroughly the broken rock by which such gases had been imprisoned, were important contributory causes."[1]

It should be remembered that by 1910, some producing mines were down to more than 4,000 feet, the average stoping depth being about 1,100 feet.

2.2 Drinking Water and Ventilation

By 1910, underground conditions with respect to drinking water were, in the words of the Mining Regulations Commission, " generally very unsatisfactory in view of the existing amount of faecal pollution, and of the readiness of both white and native miners to drink mine water when the liquids they took with them from the surface had been consumed."[2]

In 1910 the Regulations Commission concluded that good ventilation was not merely a legally recognized necessity for the preservation of health, but had an important economic aspect in its effect on the industrial efficiency of the workman and the cost of mineral production.[3]

2.3 Compressed Air

The Commission concluded that compressed air stirred up from the sides and floor

*Read at an Ordinary General Meeting of the Society on 27th October, 1962.

of the working place dust which was the principal cause of miners' phthisis.

The Commission also concluded that compressed air occasionally contained some of the poisonous gas CO derivded from the accidental combustion of the oil used for lubrication.[4]

2.4 The CO_2 Content

Some of you have probably also wondered, as I have, where the stipulation in Mines and Works Regulation No. 58 1(a) that the CO_2 content should not exceed " 20 volumes per 10,000 " (0·2 per cent.) comes from when it is known that up to 0·5 per cent CO_2 will not really harm one. Well, I found the answer to this question amongst the 1910 Regulations Commission's recommendations.

The relative recommendation reads:

" That the object of a quality standard is to fix the permissible amount of air vitiation, and that for this purpose the quantity of carbon dioxide present is accepted as bearing a roughly constant proportion to the amount of impurity present.[5]

". . . that in dead-ends, and immediately after blasting, the ratio of CO_2 to CO in the gases produced by explosives in local use averages 1 to 12, and that therefore CO_2 serves in some degree as an index of this danger (presence of CO).[6]

" That exhaustive inquiries made by the Mines Department show that a considerable body of carbonates which could give rise to CO_2 by the action of acid water, is present *in the workings* of one mine only, the remainder having either no carbonates at all, or only inappreciable quantities. . . .

" That in the Lydenburg and other districts . . . masses of carbonates occasionally exist in proximity to very pyritic reefs, and a considerable amount of . . . CO_2 may be locally produced.

" That . . . 20 parts of CO_2 per 10,000 is well within the limits of safety, is reasonable and easily obtainable, and should be enforced."[7]

2.5 Sanitary Inspection of Mines and the First Hint at Mine Ventilation Officials

The 1901 Regulations Commission concluded:

" That the action of the Municipal Council of Johannesburg in appointing well-qualified and carefully-selected mine sanitation inspectors has been productive of very marked improvement of both surface and underground conditions in the Johannesburg mines; that the extent to which these inspectors receive the support of the mine managers and officials is most satisfactory and encouraging, and that much benefit might be expected to follow similar appointments in other mining areas."[8]

The Regulations Commission obviously had a high esteem for sanitation inspectors and the first hint at the appointment of Mine Ventilation Officials was given by this body in 1910. The Comission concluded:

". . . there is considerable difficulty in keeping rock-drillers up to the mark, owing to their incredible indifference, not to say recklessness, and also, in some degree, to the absence of direct and responsible supervision in this respect; that we (The Mining Regulations Commission, that is) have, therefore (in a draft regulation), made such supervision a specified duty of the shift-bosses; and that if this measure fail of its object, then *the institution of a system of continuous independent policing will be imperatively called for* (author's italics); for nothing short of the strictest legal enforcement of the regulations in question will meet the necessities of the position in regard to miners' phthisis."[9]

2.6 Attitudes and Conditions by 1911

J. E. Vaughan,[10] Inspector of Mines, describes attitudes and conditions by 1911 in the following words:

" The majority of miners were against the use of water, saying they preferred to die of miners' phthisis than of pneumonia or rheumatism, and many of the mine officials regarded the introduction of water as unnecessary and a nuisance.

" Water pipes were usually ½ inch in diameter, and when they choked, which was often, it was considered a good excuse for not using water, and, as a rule, no special effort was made to effect a speedy repair.

" The water supplied usually came from the pumps; it was neither filtered nor chemically treated and, as a rule, was filthy.

" No dust-sampling was done, except occasionally by an Inspector of Mines, and the apparatus used was so cumbersome as to excite derision on the part of mine officials and anathemas from the Inspector.

" No drinking water was provided, and if a drink was desired it had to be obtained from a convenient fissure, if such could be found.

" Although the greater part of the blasting was done at the end of the shift, blasting in development ends, pop-holes and box-holes frequently occurred during the shift.

" At the end of the shift the men usually waited at the stations in smoke and came up in it; doors to prevent smoke getting into the shaft were practically unknown. Blasting took place at the end of the day and night shifts, thus giving little time for the mine to clear of smoke.

" The majority of the mines relied entirely on natural ventilation, and a mechanically ventilated mine was looked upon as a curiosity.

" In the naturally ventilated mines, little or no attempt was made to course the air, which, in consequence, travelled to the surface by the shortest route, so that the deeper one went into the mine, the worse the ventilation became.

" In the artificially ventilated mines, with perhaps one or two exceptions, no great trouble was taken to circulate the air, doors were rarely kept in order, and some people appeared to think that the mere installation of a fan was sufficient to ensure that the mine was properly ventilated.

" Dead ends were ventilated by the exhaust from the machines, and, as a rule, mine officials made trouble if any air was allowed to escape merely to assist the ventilation.

" Miners and officials, with a few exceptions, were apathetic, and the feeling was general that to obtain high wages something must be risked . . . the majority of men felt *they* would never get phthisis, although their mates might."

(One wonders to what extent this attitude " that others might get pneumoconiosis but not I " has persisted throughout the years right up to the present and is perhaps likely to persist in the future?).

Vaughan also relates the following pathetic incidents during and immediately prior to 1911:

" A miner was running two . . . drills in a raise; water-pipes were laid on, but no water was coming through; the boys and man were white with dust. Upon my (Vaughan's) stopping the machines until the water came on, a mine official, who was present, told the men they had better apply to the Mines Department for their wages, as the mine would not pay them."

The other incident was as follows:

" A miner, running two machines in a drive, had water laid on, but was not using it. When asked for his explanation, he stated that if he used water he got rheumatism, and so would not use it, stating further that he had worked twenty years on the Rand and had never had phthisis and was not likely to get it. The same man died two months later from the effects of acute silicosis."

No wonder, therefore, that serious thought was given to get somebody on the mine staff whose primary consideration would be THE QUALITY of Mine Air.

2.7 Regulation No. 161 (10)

By 1916 came the recommendation from the Miners' Phthisis Prevention Committee[11]

". . . that in any mine employing 1,000 or more persons underground, the Government Mining Engineer be empowered to demand that an official shall be appointed whose duty it is to report upon the water service, ventilation, and prevention of dust."

The actual regulation was promulgated in 1917, virtually in the same words as it stands today, viz:

". . . 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. . . ."

Of special interest to us in 1962, is a foreword[12] to extracts from the regulations referring to the duties of " Dust Officials " prepared by 1919. This foreword gives the objects of these regulations as follows:

" The appointment of dust officials, with duties as specified in Regulation 161(10), has as its broad object the greater efficiency and better control of measures taken for the diminution and suppression of miners' phthisis. It is expected of such an official that he should promptly discover and have remedied as soon as possible any condition in the mine which is conducive of the disease, such as the existence of dusty conditions, a deficiency of the water supply, defective ventilation, or exposure of men to dust and fumes from blasting.

" If any person is found to be contravening any of these Regulations (which fall within the sphere of the dust official), the dust official should point out the fact to him, and, if necessary, the attention of the shift boss or a higher official should be also directed to the matter."

As far as I know, these are still the objects of this regulation in the year 1962.

2.8 1919

The danger from dust was, by 1919, well understood by the manual workers in the mines. Miners generally were not anxious to earn the money paid as " phthisis " compensation, and, on the whole, readily availed themselves of such means of dust prevention as were placed at their disposal. Also, ". . . the main principles of dust prevention and alleviation had been worked out . . . " there was ". . . little left to do but to apply those principles in detail and to continue testing individual operations and new methods."

This creates the impression that things were well in hand by 1919, but the following warning note was sounded at that time:

" It will be readily understood that the discovery of new methods or the design of new forms of apparatus for the prevention of dust does not immediately result in their adoption and use, in such an extensive field of mining as the Witwatersrand. The utility of these novelties has to be demonstrated, and they have to be brought to the notice of managers and consulting engineers and others in control of the industry. Thereafter, the great army of subordinate officials and white workmen, and of natives, have to be taught their use and to acquire an appreciative understanding of their value."[13]

This statement was made over 40 years ago and struck me as being as applicable now, as it was in those days.

2.8.1 Comparison in (1919) with American Observations

An interesting comparison, made in 1919, concerned the conditions in American Mines of the Joplin District, U.S.A. where ". . . the amount of dust found in various operations was generally about ten times as large as . . . in the Witwatersrand (by 1919) . . . the average number of years worked underground (by the Joplin miners) of the ' no-phthisis ' group was 3·9 years, of the 1st stage group was 5·3 years, of the 2nd stage group was 6·9 years and of the 3rd stage group was 7·8 years."

According to the M.P.P.C., these figures " did not differ much from those found by the (S.A.) medical Miners' Phthisis Commission of 1912 for the Witwatersrand. . . ." The conclusion was drawn that since " the amount of dust found on the Witwatersrand during the working shift (by 1919) had diminished since 1912 and men were then (1919) rarely exposed to the enormous quantities of dust generated at blasting time, they had every reason to expect, at least, a great prolongation of the period required for contracting fibrosis . . .

" Further improvements on the (1919) conditions were expected, mainly from better organization, from continued vigilance and from improved appliances. In the matter of organization much useful work was already being done by the dust officials appointed under Regulation 161(10), and as these officials were expected to become better acquainted with the nature of their work and with its systematization, a higher state of efficiency was expected, necessarily to follow."[14]

The M.P.P.C. considered " unceasing vigilance " over all operations which could cause dust or create other unhealthy conditions was obviously necessary, and for this reason, especially, a rapid means of dust determination (i.e. the Konimeter, with untreated slides counted at x150 magnification under light field) was considered particularly useful; the dust official on every mine was required to personally sample and determine the amount of dust made in the various operations, and the simpler the apparatus and the method of determination, the more likely it was that it would be utilized as a method of control.[15]

2.8.2 The Knowledge of Ventilation Officials

Sad to say, however, the M.P.P.C. found it necessary to complain[16] that many of the ventilation officials had an insufficient knowledge of their duties.

That was the cold fact reported in 1919 and it would be appropriate to examine the position of the ventilation official of *today*, vis-a-vis the complexity of the problems and duties facing him.

Getting back to 1919, the M.P.P.C. decided to compile an abstract of all the regulations referring to the prevention of "miners' phthisis" and the Transvaal Chamber of Mines published this abstract in the form of a small pamphlet which was distributed to the mines.[17]

I was impressed to notice that the pamphlet dealt with 60 different duties,[18]—this by as early as 1919. A period of very active and energetic research concerning the quality of mine air followed, some of the highlights of which deserve mentioning here.

Mine ventilation officials were not necessarily solely responsible for the highlights mentioned, but they were very much involved.

2.9 The Position by 1937

2.9.1 Composition of airborne dust

By 1937 the composition of the dust in Witwatersrand mines had been investigated, and it was reported that the dust was essentially binary in composition, that the components were quartz and sericite; that other minerals, when present, occurred in negligible quantities, that sericite generally tended to increase relative to quartz as the texture of a dust in Witwatersrand mines became finer, i.e. the longer the dust remained suspended; that quartz appeared never to be completely eliminated, that quartz and sericite below one micron could often not be seen, much less differentiated, under the petrological microscope, and that it could not be ascertained in what proportions the two minerals occurred in the very finest, and probably the most harmful, portions of dust in Witwatersrand mines.[19]

2.9.2 Dust Determinations

By 1937 the thermal precipitator had been introduced, counting of dust strips being done after ignition only—acid treatment of t.p. slides had by then not been advocated.[20]

Investigations had revealed that the only significant increase in the dust content of the air in its passage through downcast shafts was at loading boxes; that the dust content of an air current passing along an airway diminished to an equal extent, whether the roof and walls were dry or wet; that on a number of mines the footwalls of stopes were being cleaned by means of compressed air during sweeping operations; that there had been an increase in the dust content in stopes and development ends over the period 1929 to 1936 — methods of reducing the dust content were, however, actively pursued; that the (unvented) long piston-type of rockdrill was a distinct improvement on the (unvented) short piston (in use by 1923) from the point of view of dust production and that this was due to the fact that, as the fluted portion of the long piston did not pass through the front cylinder washer on the return stroke, less air reached the front of the machine and consequently less air passed down the drill steel; that release ports in the fronthead of the machine did much to prevent appreciable quantities of air from passing down the hollow drill steel and unvented front heads were prohibited after 21st November, 1926; that short "wide" water tubes (i.e. passing 5,000 m.l. per minute at 40 lb. per square inch) were satisfactory, and that experience proved that any theoretical advantage of long tubes was lost by their tendency to become damaged in use; that sprays and atomizers merely removed a large proportion of the coarse airborne particles but very little of the fine dust; that flannel was a highly efficient filtering medium under favourable conditions; that respirators were impracticable except in certain circumstances and that the question of its fit constituted a considerable disadvantage.

(All this, and many more items of valuable information one finds in the 1937 publication which I often consult even in 1962, and every time I do so I am impressed anew by the mass of information contained in this publication that has stood the acid test of 25 years!)

From here I am taking a jump to 1962. This jump should not be interpreted as belittlement of what was done after 1937, but rather that what took place since 1937 has not yet reached the "out of print" status.

2.10 Present Day Dust Conditions

In contrast to the rapid improvements effected, especially in dust conditions, during the years which followed the appointment of mine ventilation officials, no material change in dust conditions seems to have occurred in large gold mines since about 1942—annual mean counts for stope working points being about 150 p.p.c.c.[21] according to Government Inspectors of Mines returns, and[22] somewhat higher, according to Mine Ventilation Officials returns.

According to some authorities, such dust concentrations seem too low to cause pneumoconiosis. (The fact that many cases of pneumoconiosis still arise, may perhaps be explained by the lesson in the story about the person who accepted the statement that the average depth of a certain river was 2 ft as applicable to every part of that river and so got drowned in it.)

However, one disquietening feature about dust conditions in large gold mines is the apparent absence of an improvement for many years; and if dust conditions have not improved for many years the question may well be asked: Why not?

Before giving you my opinion as to why there has been no improvement, I should like to say that in fairness to the gold mining industry, one can argue that as compared with conditions 20 years ago, rock is now being brought to surface over greater horizontal, as well as over greater vertical distances underground. Hence, with no deterioration in dust conditions, this does represent progress.

(Before continuing, lady and gentlemen, I should like to remind you that the opinions expressed in this address are my own and do not necessarily coincide with the official views of the Department to which I am attached.)

Economic considerations are probably the main reasons why there has been no dramatic reduction in dust conditions since the nineteen-forties but I am convinced there are others, such as the belief already referred to that pneumoconiosis is not likely to be caused by a dust concentration of a few hundred particles per cubic centimetre.

Another factor is the absence of official dust standards for the various classes of working places. At best, there is a sort of unofficial maximum allowable figure of 200 p.p.c.c.[23] (for normal work, such as stoping and development).

A further disquietening aspect is the possibility[24] that the routine dust results do not reflect the true position. Here I should say one gets the impression that high dust counts seem to figure less frequently among results recorded by routine observers than among those recorded by research observers for similar classes of working places. To this should be added the fact that the annual mean counts have "levelled out," with "no trend"[25] which does not help to put one's mind at rest because, like all other non-static situations, the chances seem to be in favour of a change, one way or the other, as opposed to a condition of "no change."

We have also to face in 1962, as has been the situation in the past, the problem of correlating recorded dust concentrations with pneumoconiosis.

Lack of correlation between dust conditions and pneumoconiosis is often quoted as proof that the instrument used and/or the technique employed is unsatisfactory. Having mentioned dust sampling instruments, I should like to quote two statements made at the International Pneumoconiosis Conference of 1959. When speaking on the subject of dust sampling instruments, Dr. F. C. Gilson, from Britain, said:

"It is important to obtain from the dust measurements a good estimate related to the man's exposure, because fundamentally we are interested in ensuring that we have, as a result of all the efforts put into dust measurement, a figure which gives a reasonably good measure of the actual exposure of the man."[26] This view was supported by Professor Theodore Hatch, from the U.S.A., as follows:

"Through the use of the physical instrument we should be trying to predict what would happen to a man if he were there in the place of the instrument." He continued: "We are sometimes inclined to forget this and get so enamoured of our beautiful physical devices that the point is overlooked that this is just a substitute for man;" and concluded: "The design of the instrument and the evaluation of its operating characteristics should be based more on the understanding of how man acts in the dusty atmosphere than on physics alone."[27]

But the instrument is not our only concern. Certain authorities even hold that routine dust results should not be used to compute dust exposures. Unfortunately, however, routine results are mostly the *only* results available, and this situation will continue for a long time to come in the case of many classes of mines. In view of this, I should like to plead with routine dust samplers to take and record routine dust results in such a manner as to be useful for purposes of computing dust exposures.

3. THE MOTIVES FOR TAKING DUST SAMPLES

This brings me to the motives for taking routine dust samples.

At the risk of being criticised for repeating the remarks I made at the Pneumoconiosis Conference, I think it is important to draw your attention to the three motives for taking routine dust samples. They are:

(a) Those taken to check prior information to the effect that conditions are unsatisfactory,

(b) those taken to check prior information to the effect that conditions are good, and

(c) those taken simply because a limiting frequency of sampling has to be maintained in order to get a sufficiently reliable mean.

The results recorded under (a) would tend to over-estimate the dustiness of a place, whilst those recorded under (b) would tend to under-estimate its dustiness; those recorded under (c) should give a true and unbiased estimate of the conditions.[28]

One cardinal point in this connection is that the motive for taking a particular set of samples will be known *before* setting forth to take the samples.

Hence, the classification of samples with respect to motive should be decided *before* leaving the office to take the samples.

Persons who take routine samples should be clear about the fact that those samples taken to check information regarding a departure from normal conditions received *prior* to a decision to take samples in that place, may not and *should* not, be recorded under " (c) "; *all* other samples, though, *should* be recorded under " (c) " even if the sampler could before taking samples, but *subsequent* to his decision to take samples, say with certainty that conditions would *not* be average. The only thing to decide the classification of the results according to the *motive* is the reply to the question: what moved me in the *first* place to take the samples? Nothing else!

One often comes across the attitude that every set of routine dust sampling results which are recorded should represent average conditions and that samplers are, therefore, entitled to omit results which are not considered average. Such a procedure is wrong for routine results which are utilized over a long period. On a purely short-term basis, unusual results may be excluded, but such results should be reintroduced for the long-term issue.

If assessment errors were not made, the results should be recorded for future reference even if unusual circumstances did exist at the time of sampling.

4. MORE FROM THE SAME DUST SAMPLING EFFORT

In 1962 we are faced with the question: Can we, with the *same* effort and the *same* equipment, get more out of the routine dust sampling effort than we are getting at present? If so, what changes should be made?

To the first question I would say: " Yes, decidedly!"

My advice regarding the second question is that we should adopt a procedure which would label certain places " unsatisfactory " and others " satisfactory." In other words, we should establish targets for all the various classes of places.

Here I would like to plead for the term " unsatisfactory," to be viewed in its relative sense and that the attitude be taken that we want to reduce the dust in the airstream wherever it passes persons, from the top of the downcast shaft right along its passage through the mine.

A *single* maximum allowable concentration is applicable to chemical poisons which do no damage below a certain concentration and which have no cumulative effect, but it is not quite right to have a single maximum allowable concentration for a whole industry applicable to a material which has a cumulative effect, such as dust. Every class of place should have its target to aim at.

It seems to me that such dust concentration targets can best be determined in an indirect manner via the frequency distributions of the dust concentrations recorded in similar classes of places (such as has been advocated by myself for coal mines[29]), by deciding on a level in the cumulative frequency distribution to determine the target dust concentration.

Such a procedure establishes a specific target for *every* class of place.

With a target for every class of place, the number of samples taken in a specific working place should then be limited to the minimum number necessary to determine whether that place falls in the " satisfactory " or in the " unsatisfactory " category.

Satisfactory places should then be sampled less often than unsatisfactory places. The effort saved on satisfactory places should be spent:

(a) in checking the effectiveness of any improvements made in " unsatisfactory " places, and
(b) in resampling borderline cases.

If the existing staff position is such that a mine can only afford to sample each place once per quarter as called for by regulation. I feel sure the Inspector of Mines would view sympathetically an application for sampling satisfactory places less frequently than called for if made with the specific object of taking more samples in " unsatisfactory " and borderline places.

The level of the cumulative frequency distribution decided on to determine the limiting dust concentration should be in keeping with the desired rate of improvement.

A low level decided on, such as the 60/40 per cent. (60 per cent. below and 40 per cent. above) calls for drastic improvements, whereas a high level, such as the 90/10 per cent. level, will result in a slow rate of improvement. There is no reason why different levels should not be decided on for different classes of places.

I now want to return to the problem of obtaining truly representative dust results. To achieve this objective it seems essential that we get away from an arrangement where those who are responsible for routine dust determinations are also held accountable for the concentrations.

Is it not true that some routine dust samplers are today still liable to experience inconvenience when they return high dust counts?

If it is not possible to eliminate such inconvenience with the present set-up, the only alternative seems to be for routine samples to be taken by persons who are employed by central organizations which are not held responsible for the dust conditions.

5. BETTER USE OF ROUTINE DUST SAMPLING RESULTS

We have also to consider what better use can be made of the available routine dust sampling results. In this connection I am of opinion that the omission to publish the essential features of routine dust sampling results seems a pity, because although wrong use may be made of such results, the evil flowing from their omission seems greater. Hence, I would like to plead for information to be disclosed such as by publication. This information may be limited to the "C," or unbiased group of routine samples. Personally, I would like to see annual statements on the dust concentrations coinciding with a chosen level, say the 80/20 per cent. one, of the cumulative frequency distributions for the various classes of working places.

Another use to which routine dust-sampling results ought to be put is the computation of the dust exposures of individuals. Such an undertaking would be very valuable to the mining industry as a whole and mine ventilation officials seem in an ideal position for such an undertaking. This suggestion flows from my conviction that dust exposures computed from the routine results of the working places of an individual will bear a useful relationship to the amount of dust in his lungs.

This leads me to the principle of dust exposure control.

If a useful relationship does exist between dust exposure as computed from working place counts and pneumoconiosis, there is the possibility that one may reduce the incidence of pneumoconiosis without reducing the dust levels at all, but merely by ensuring that persons do not spend too much time in exceptionally dusty places. Such a procedure may involve an interchange of labour between places of high and places of low dust concentrations and will not be without its practical difficulties, but in support of the principle it may be stated that this procedure is recognized practice to limit radiation exposure.

In practice, some mineworkers limit their own total dust exposures by declaring themselves unwilling to continue as shaft-sinkers, stopers or developers lest they get pneumoconiosis and electing to be put in charge of drive or haulage operations.

Furthermore, an example of dust exposure control is to be found in West Germany. Some years ago such a system was brought into practice in that country where, according to published reports, working places in coal mines are classified into four groups with respect to dustiness: viz., low, medium, high and very high. The limits between the four groups were decided on arbitrarily from the frequency distribution of dust concentrations obtained in practice. Persons with lung changes due to dust have since then, only been allowed to work in places with low dust concentrations, and in spite of the criticism that could be levelled at the methods of dust determination and dust category classification, beneficial results based on medical findings were demonstrable after as short a period as 6 years[30]!

I think some thought might be given to the introduction of a similar system in South African mines.

6. THE PNEUMOCONIOSIS INCIDENCE OF THE BANTU LABOUR FORCE

While pondering the possibility of reducing pneumoconiosis by means of the direction of labour, I came across a statement made by the Director of the Pneumoconiosis Bureau in 1961 to the effect that the " relatively low incidence of uncomplicated pneumoconiosis among the Bantu labour force " was partly due to the fact that " the majority of these labourers engage in short-term work contracts, often with considerable breaks in their service in dusty atmospheres."[31]

Now, isn't this reduced pneumoconiosis due to reduced total dust exposures? I think it is, and although the low total dust exposure in comparison with White mine workers, is incidental, as the result of a way of living, I think it lends support to the idea of dust exposure control.

Before leaving the question of dust exposure versus pneumoconiosis, I wish to draw attention to another side of the present pneumoconiosis incidence among Bantu mine workers. The reason for doing so is that the portion of his working life spent at mines seems likely to increase in future as the Bantu becomes more westernized and that the pneumoconiosis incidence for the Bantu can be expected to be as high if not higher than that of the European for the same period of uninterrupted employment.

At the reasonable incidence of, say, 8 per 1,000 for the 280,000[32] Bantu at work underground on large gold mines, the disturbing figure of about 2,200 Bantu cases of uncomplicated pneumoconiosis may be produced annually by arge gold mines alone if the Bantu did not alternate periods on the mine with long periods at home.

This figure of about 2,200 should be compared with 500 Bantu with ' uncomplicated ' pneumoconiosis certified during the year ending 31st March, 1961[33] of whom about 50 per cent. had service on gold mines only.

7. CHANGES IN THE PNEUMOCONIOSIS ACT

I now want to touch on the Pneumoconiosis Act which came into force on 1st October, 1962; it incorporates some very important changes. Two of them are:

(a) That the Minister of Mines may recover from the owner of a controlled mine such sums as he deems necessary for research in connection with any matter affecting the health of persons employed at that mine or for the medical treatment of persons.[34]

(b) That the Act calls for the establishment of a " Pneumoconiosis Risk Committee " whose duty it shall be to establish " by whatever means the committee deems fit " the pneumoconiosis risk to which persons employed in dusty atmospheres at that mine are exposed and the committee may estimate different risks in respect of individual mines or parts of mines or classes or groups of mines or occupations or localities at mines."[35]

I will say no more about this Act but to plead that mine ventilation officials make and record their dust observations in such a manner as will assist the Risk Committee in making its determinations.

8. THE FIELD OF TECHNOLOGY TO BE COVERED BY MINE VENTILATION OFFICIALS

Having dwelt on the dust hazard associated with mine air, I now want to consider the field of technology which mine ventilation officials have to cope with.

Persons whose responsibilities are connected with the quality of mine air must have sound knowledge of an impressive list of subjects. In broad groups they are:

1. The Mines and Works Regulations on dust, ventilation and gases;
2. The use, installation and maintenance of ventilation appliances;
3. The laws of air flow and ventilation networks;
4. Basic physics and the physics of air;
5. Dust, gases and radio-activity;
6. A working knowledge of mathematical statistics and their application to observations;
7. Pressure surveys;
8. Heat in mines and its effect on humans;
9. Fire-fighting and fire precautions.

There we have nine major subjects and the list is not quite complete.

9. STATUS AND AUTHORITY

The situation at present is that mine ventilation officials have to keep a watchful eye over the quality of mine air which affects the safety and health of thousands of persons. All that is required by regulation for a Ventilation Official to be appointed is that he be considered " competent " by the manager of the mine.

Competency in the wide field of technology that mine ventilation officials have to cope with can only be proved by actual examination. Fortunately, the necessary facilities for conducting examinations are provided by the Transvaal & O.F.S. Chamber of Mines. The decision to provide such facilities was a wise and laudable step, but the time seems ripe now to give *legal* support to the principle that all mine ventilation officials should be in possession of a certificate signifying their competency.

In conclusion, I want to state that there seems no doubt about the fact that the quality of the air of the large gold mines improved vastly as a direct result of the appointment of mine ventilation officials, as called for by regulation since 1919. This regulation gave mine ventilation officials a certain status where none existed before.

On the strength of this experience, my argument is that any increased status and, I should say, increased authority bestowed upon mine ventilation officials at this stage of the mining history of South Africa will without any doubt result in a further material improvement in the quality of mine air. The blessings which will flow from such improvement are numerous and well known and will not be enumerated here.

There are difficulties in the way of increased status and especially of increased authority of mine ventilation officials, but I am confident that the difficulties can be overcome by the mining industry and the authorities concerned.

Before leaving the rostrum, I wish to place on record my thanks to the Government Mining Engineer for his permission to deliver this address.

10. REFERENCES

1. Final Report of the Mining Regulations Commission, 1910, Vol. I (out of print), recommendations No. 174, 175 and 176, p. 269.
2. *Vide* 1, rec. No. 93.
3. *Vide* 1, rec. No. 114.
4. *Vide* 1, rec. No. 117.
5. *Vide* 1, rec. No. 122.
6. *Vide* 1, rec. No. 126.
7. *Vide* 1, rec. No. 130, 131 and 137.
8. *Vide* 1, rec. No. 108.
9. *Vide* 1, rec. No. 24.
10. Final Report of the Miners' Phthisis Prevention Committee, January, 1919. (Out of print), pp. 97 and 98.
11. General Report of the Miners' Phthisis Prevention Committee, 1916. (Out of print), p. 44.
12. *Vide* 10, Appendix No. 10, p. 103.
13. *Vide* 10, p. 57.
14. *Vide* 10, p. 58.
15. *Vide* 10, p. 58.
16. *Vide* 10, item No. 186.
17. *Vide* 10, item No. 186.
18. *Vide* 10, pp. 103–110.
19. The Prevention of Silicosis on the Mines of the Witwatersrand, 1937 (out of print), pp. 56 and 57.
20. *Vide* 19, p. 85.
21. Annual Reports of the Government Mining Engineer, Department of Mines, Section V on: Pneumoconiosis and Health.
22. KITTO, P. H.: " Commonwealth Conference." *The Mining Journal*, Oct. 1961, p. 369.
23. BEADLE, D. G.: " Presidential Address." *Journal of the M.V.S. of S.A.*, 1958, p. 201.
24. LAMBRECHTS, J. DE V.: " Presidential Address." *M.V.S. Bulletin*, August, 1954, p. 129.
25. GRAVE, D. F. H.: " Presidential Address." *Journal of the M.V.S. of S.A.*, Dec., 1961, p. 243.
26. Proceedings of the Pneumoconiosis Conference, Johannesburg, 1959, p. 4.
27. *Vide* 26, p. 4.
28. *Vide* 26, p. 26.

29. Du Toit, R. S. J.: *Journal of the M.V.S. of S.A.*, April, 1961, p. 64, item 4.
30. Dust and Silicosis Conference in Essen, West Germany, April, 1961, Glückauf, 13 September, 1961, *Zusammenfassung*, p. 1144.
31. Report of the Pneumoconiosis Bureau, for the period 1st April, 1960 to 31st March, 1961, The Government Printer, Pretoria, p. 17.
32. Annual Report of the Transvaal and Orange Free State Chamber of Mines, 1960, p. 101.
33. *Vide* 31, tables XI and XII, p. 17.
34. The Pneumoconiosis Act, No. 64 of 1962, Government Gazette No. 262 of 15th June, 1962, Section 102.
35. *Vide* 34, Section 64 and 66.

VOTE OF THANKS

Mr. A. B. Daneel*

Mr. Chairman, Gentlemen,

I am most grateful for the opportunity of congratulating Mr. du Toit on his attaining the high honour which your Society has bestowed on him, an award which is very well deserved. I would like also to congratulate Mr. du Toit on his address which has, I think, provided much food for thought and has served to highlight a number of important factors. Not the least important of these, by any means, emerges from the most absorbing historical review with which Mr. du Toit opened his address. It is interesting to hear, for example, that, in 1919 "the main principles of dust prevention and alleviation had been worked out and there was little left to do but to apply those principles in detail and to continue testing individual operations and new methods." The major means of reducing dust inhalation to a minimum, therefore, were recognized more than fifty years ago and they are as valid today as they were then. The difficulties of implementing dust suppression measures, as reported forty or fifty years ago, also have a familiar ring about them.

Mr. du Toit has rightly drawn attention to the lack of improvement in dust levels in our gold mines over the last twenty-odd years. This is perfectly true, as can be seen by reference to the average dust counts extracted annually over this period. It might, therefore, be as well to point out that potential dust production has increased considerably in recent years as underground operations have become more and more highly mechanized and as productivity has increased. By way of illustration, the consumption of electric power by mines per ton of ore milled, which is a fairly good index of the degree of mechanization, has increased as follows:

73 kWhr per ton in 1951
88 kWhr per ton in 1956
108 kWhr per ton in 1961

The numbers of scrapers and other machinery in use in mines have increased during the last four years, from 1957 to 1961, as follows:

Scrapers: From 7,055 to 11,207
Loaders: From 665 to 961
Diesel locos: From 1,365 to 2,093

These increases are all of the order of 50 per cent. The number of rockdrills in use has remained fairly constant, i.e. 12,641 in 1957 as against 12,850 in 1961, so the quantity of rock broken has not changed very materially.

Countering these factors, the quantity of ventilating air circulated in mines has increased from 31·9 million c.f.m. in 1957 (4·3 c.f.m. per ton) to 39·5 million c.f.m. in 1961 (4·6 c.f.m. per ton), while the number of dust extraction plants in use underground has increased over the same period from 771 to 835, the increase in air handling capacity of these plants being from about 5 to about 7 million c.f.m.

It might therefore be argued that the lack of improvement in average dust levels does, in fact, record some measure of success of the efforts which have been made to combat increasing dust production by modern mining methods.

It might be as well to mention, in passing, that diesel smoke is known to contaminate dust slides and so inflate dust counts. Is it possible that the increasing numbers of diesel locos in use has something to do with the apparent lack of improvement?

It is, however, quite obvious that the Mining Industry cannot accept the present static position as satisfactory and, as long as pneumoconiosis cases continue to occur, an all-out effort must be made to eliminate this shadow on the good name of the mines.

It might be appropriate here to draw attention once again to the cost to the Industry of pneumoconiosis compensation. One way of indicating the extent of the Industry's liability in this regard is to state

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that the total liabilities of the compensation fund, out of which benefits under the Pneumoconiosis Compensation Act are paid, are of the order of R100 million.

Scientists in the fields of physics and pathology have been working on the problem here and in every other important mining country of the world for decades, and the major principles of the causation of pneumoconiosis are known, although much remains to be done before all aspects are thoroughly understood. One fact, however, seems quite clear. If there is no dust, there will be no pneumoconiosis.

Going a stage further, certain authorities feel that if all underground workers were exposed to a constant dust concentration of 150 ppcc, there would still be no pneumoconiosis. But cases still occur. The cause, then, must surely lie in the high dust concentrations which make up the " tail " of the frequency distribution curve, and which represent a fairly small fraction of all the dust samples which are taken. Chop off this " tail " and you have the problem beaten! Sir Basil Schonland, who examined the research organization of the Mining Industry in 1961, stated:

> " The main problem in pneumoconiosis research is not a medical one, but one of improving conditions in certain special areas underground. If this improvement can be made the disease will probably assume quite minor proportions. To effect the further reduction in dust in these areas will, however, involve the Industry in propaganda, education and a tightening up of regulations, all domestic matters which are not simple since they may affect production."

What means, then, can be adopted to attain this goal? I would suggest that the problem is clear, the measuring techniques are available, the major means of dust suppression are known and that what is required is an all-out effort. Mr. du Toit has made a number of suggestions as to how this effort might be strengthened, and I would commend them for careful study and consideration.

It is the prerogative of the person who proposes the vote of thanks to disagree with the President of the Society on any point in his address, and I must say that I find little with which to differ. I do, however, feel compelled to say that it seems unlikely that the Native labour force of the Mining Industry, which is, and always has been, essentially a migratory labour force based on a rural subsistence, will alter in character to the extent of becoming urbanized. I feel, therefore, that Mr. du Toit's fears of a possible 2,200 Native cases of pneumoconiosis per annum are unjustified.

I have one other major point of difference. Mr. du Toit has pointed out that dust samplers should sample and record dust conditions in such a manner that truly representative results are obtained, that samplers should accordingly not be held accountable for dust conditions nor should they be held responsible for rectifying bad conditions—a very reasonable argument. It seems, therefore, a bit hard on mine ventilation officials to be asked by Mr. du Toit, somewhat later in his address, to make and record dust observations in such a manner as will assist the Pneumoconiosis Risk Committee in making its determinations of the relative risks on individual mines. This amounts to asking the official to carve the stick to beat his own back or, alternatively, encouraging him to record false results.

In conclusion, may I state that I have found Mr. du Toit's address most stimulating and thought-provoking. Many valuable suggestions have been made by Mr. du Toit as a result of long experience in his unique position in the Mines Department and these suggestions merit the most careful consideration by all concerned. I am confident that all members of the Society would wish to join me in congratulating Mr. du Toit on his excellent address, and I have much pleasure in proposing a hearty vote of thanks and wishing him a happy and fruitful year of office as President of your Society.

F. C. Startup*

Mr. Chairman, Lady and Gentlemen,

It has given me great pleasure to be called upon to second the vote of thanks to our President for today's address, and I should like to take this opportunity of congratulating him on his election.

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One cannot fail to be impressed by the recurrence in recent Presidential addresses of what might be termed " The Dust Hazard and its Abatement" theme. That it should be referred to by so many holders of the high office of President of this Society, all acknowledged authorities on the subject, is surely indicative of the importance of this aspect of the ventilation officials' job.

I do not wish to deal with any portion of the address in detail. That Mr. du Toit has been able to place in our hands a considerable amount of information not readily available is a tribute to the painstaking research he has undertaken to gather the material for this address.

Whether it was done with intent I do not know, but this address is one which should appeal strongly to the more junior members of our Society who enter the ventilation departments of our mines with little or no knowledge of the development of the science of ventilation with particular reference to dust suppression on the gold mines of the Witwatersrand and who have perhaps no very clear idea of what their work and observations are intended to achieve. Many of them will, I think, learn for the first time of the early difficulties encountered, of the steps taken and of the progress that has been made in reducing the dust hazard in mining and combating the incidence of pneumoconiosis.

The summary of the duties of " Dust Officials " from the General Report of the Miners' Phthisis Prevention Committee 1916, can with advantage be studied by all junior ventilation officials today.

When Mr. du Toit poses the question, " If dust conditions have not improved for many years: why not?" We may not all agree with his own answer and proposed remedies, but to me the value of this part of his address lies in the fact that it presents a clear picture of the problem. It enables each one of us to consider it and perhaps to evolve his own solution. From this, some new direction for investigation and possible improvement may well emerge.

For these reasons and others I have not mentioned, it is a privilege for me to second the vote of thanks to the President for his address.

SUGGESTED ANSWERS TO MINE VENTILATION CALCULATIONS IN MINING AND MINE VENTILATION—PART II, MINE MANAGER'S EXAMINATION. (METALLIFEROUS MINES), AUGUST, 1962.

By W. L. le Roux*

Question 1.

A barometer read 24·580 in. Hg. at the surface of a downcast shaft at 10 a.m. and 24·375 in. Hg. at 12 noon, the air temperature remaining constant. At the bottom of the shaft the barometer read 30·780 in. Hg. at 10 a.m. and 30·740 in. Hg. at 12 noon with the fan stopped.

At 10 a.m. the air volume flowing at the bottom of the shaft was 300,000 c.f.m. and, with the fan stopped at 12 noon, 120,000 c.f.m. was flowing. The fan is situated on surface.

Calculate (a) The fan water gauge in the downcast shaft;
(b) The total water gauge in the downcast shaft.

(20 marks)

Answer 1.

Barometric Pressures	*10 a.m.* Fan running 300,000 c.f.m.	*12 Noon* Fan stopped 120,000 c.f.m.
Surface	24·580 in. Hg.	24·375 in. Hg.
Underground	30·780 in. Hg.	30·740 in. Hg.
Difference	6·200 in. Hg.	6·365 in. Hg.

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